
BANK OF ENGLAND

Financial Stability Paper No. 34 – October 2015

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# The resilience of financial market liquidity

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Liquid financial markets help facilitate the financing of investment in the real economy and thereby support economic growth and stability. Financial markets have been affected by a number of structural changes over the past few years. Innovation has generated a broad trend towards fast, electronic trading. And necessary regulation implemented in response to the global financial crisis to ensure the safety and soundness of core intermediaries has discouraged them from market making as principal – though this may also reflect greater risk aversion on their part. These developments, alongside occasional bursts of volatility associated with short-term illiquidity, have led to concerns that market liquidity may have become more fragile. Although episodes of heightened volatility and short-term illiquidity are not necessarily in themselves threats to financial stability, they could become so if they were to persist, amplify or spill over. This paper draws together a body of analysis looking across such episodes to contribute to the ongoing debate in this regard in the United Kingdom and internationally, rather than making specific policy suggestions.

No market can be guaranteed to be perfectly liquid. It is important, therefore, that the liquidity characteristics of different financial assets are well understood and priced accordingly, including where they may have changed over the past few years. **Overall, the 'normal' level of liquidity in markets that are less reliant on core intermediaries appears to have increased – but in some cases, to the detriment of resilience. In contrast, the 'normal' level of liquidity in markets that are more reliant on core intermediaries appears to have fallen – but with a likely increase in the resilience of those markets via the resilience of the core intermediaries themselves**. This is consistent with recent episodes of volatility and illiquidity having centred on fast, electronic markets, including exchange-traded venues. While the particular triggers and factors at play in each episode have differed, a number of common lessons can be drawn out:

- Weaknesses in trading infrastructure that become exposed in stressed circumstances can impede market access, exaggerate market moves and undermine confidence among investors.
- Consensus views among investors can jeopardise market liquidity if there is a rush to exit commonly held positions. The reliability of non-bank market makers in such circumstances can be uncertain.
- Investor behaviour that distorts prices in one market can be rapidly transmitted to others via arbitrage activity. In other circumstances, the absence of arbitrage activity can lead to large pricing anomalies, reinforcing uncertainty among investors. And while the use of circuit breakers can forestall disruption in the market to which they are applied, they can have adverse knock-on consequences.
- Bank and non-bank companies' ability and willingness to put capital at risk as principal has changed. Market participants should factor these changes into their investment decisions.

So far, none of the post-crisis episodes of heightened volatility and short-term illiquidity have originated in predominantly dealer-intermediated markets, but that is not in itself a cause for comfort. For example, the resilience of corporate bond market liquidity could be tested in the event of a large order flow imbalance arising through selling pressure from funds offering investors short-term redemptions.

It is uncertain how the structure of financial markets will evolve. While the broad trend towards fast, electronic trading may continue, the inherent characteristics of some financial assets, such as corporate bonds, are naturally suited to dealers and other companies temporarily putting capital at risk to facilitate transactions between investors. In such markets, the development of direct electronic trading approaches between investors that do not rely on intermediaries putting capital at risk might therefore best be seen as complements rather than substitutes.

Further investigation is warranted as market structure evolves. Particular areas, as highlighted in this paper, might be to better understand:

- How well investors understand and price the liquidity risk of the assets in which they are invested;
- The constraints and incentives faced by traditional dealers to act as principal to facilitate transactions;
- How key types of principal trading firm might react in different market conditions, with a view to identifying the circumstances under which they could amplify and stabilise movements in prices; and
- The role of circuit breakers in financial markets and the circumstances under which they can contribute to cross-market contagion.

## 1 Introduction

Liquid financial markets are essential to any well-functioning financial system and are an important element in the provision of 'market based finance'. The ability to safely and reliably trade securities issued by non-financial and financial institutions helps facilitate the financing of investment in the real economy and thereby supports economic growth and stability. In June 2015, the Bank of England published a paper ahead of an Open Forum,[1] which outlined some key attributes of real markets that work for the good of the people, with market liquidity being integral to two such attributes: resilience and effectiveness. *Inter alia*, **Effective** markets ensure that capital and risks are competitively priced and properly allocated. A prerequisite for this is that markets are **Resilient**, providing predictable access and liquidity for borrowers and investors.[2]

In the United Kingdom, the Bank of England Act 1998 as amended by the Financial Services Act 2012 gives the Financial Policy Committee (FPC) responsibility to identify, assess, monitor and take action in relation to financial stability risks across the whole financial system.[3] In 2014, the FPC identified the fragility of market liquidity as a key risk to its medium-term priority of ensuring the resilience of market-based finance. It provided a summary of the issue in its December 2014 *Financial Stability Report*[4] and commissioned further work from the Bank and the Financial Conduct Authority (FCA) in its March 2015 Statement. The FPC provided a summary of its findings in its September 2015 Statement.

Financial markets have been affected by a number of structural changes. A process of continuous innovation has generated a broad trend towards fast, electronic trading in a number of forms. And necessary regulation implemented in response to the global financial crisis to ensure the safety and soundness of core intermediaries upon which the financial system relies has discouraged them from some financial market activity, including the 'warehousing' of risk through market making – though some of these trends pre-date the emergence of the new regulatory regime and may reflect broader changes in their attitude towards risk-taking. Indeed, it is clear that market liquidity and other risks were under-appreciated prior to the global financial crisis.

Overall, markets that are less reliant on intermediaries putting capital at risk to facilitate transactions between investors (such as equities) appear to have become more Effective in 'normal' times given the generalised move towards fast, electronic trading – i.e. the 'normal' level of market liquidity appears higher. But this needs to be weighed against a possible deterioration in Resilience – i.e. the possibility that such markets have become more susceptible to order flow imbalances, which are not easily observed or anticipated but can quickly lead to large movements in prices when they occur. In contrast, markets that are more reliant on intermediaries putting capital at risk (such as corporate bonds) appear to have become less Effective in 'normal' times – i.e. the 'normal' level of market liquidity appears lower. But to the extent that this is associated with the necessary re-regulation and increased resilience of intermediaries operating at the core of the financial system, the Resilience of those markets has likely improved.

To ensure that financial markets can best serve the evolving needs of the real economy, it is imperative that core intermediaries are resilient and financial innovation is allowed to flourish. But vigilance is required to ensure that systemic risks do not build. Lessons from experience, including the global financial crisis, should continue to be taken seriously. Bursts of volatility associated with short-term illiquidity in a number of financial markets over the past few years have led to concerns that market liquidity may have become more fragile. Although such episodes are not necessarily in themselves threats to financial stability – indeed, volatility should be expected in well-functioning markets in which asset prices respond to news – it is important to understand ways in which volatility and illiquidity could persist, become amplified and spill over to other markets. There are three concerns. Volatility and illiquidity could:

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[1] See www.bankofengland.co.uk/markets/Pages/openforum.aspx.
[2] The other pre-requisite for Effective markets is fairness, including clear and consistently applied standards. The Fair and Effective Markets Review (FEMR) highlighted how market structures offered opportunities for abuse, standards were poorly understood and lacked teeth, and there was limited reinforcement of standards through market discipline. The FEMR report is available from www.bankofengland.co.uk/markets/Pages/fmreview.aspx.
[3] See Box 9, 'Financial stability risk and regulation beyond the core banking sector', from the June 2014 *Financial Stability Report*.
[4] See Box 4, 'Drivers of market liquidity', from the December 2014 *Financial Stability Report*.

- lead to broader contagion – for example, by changing the value of securities pledged as collateral in securities financing and derivative markets, impairing the ability of financial institutions to finance themselves and manage their risks;
- affect conditions in primary markets, including through increasing new issuance premia or, in extremis, preventing some companies from being able to raise market-based finance; and/or
- discourage participation in financial markets, so that they are no longer Effective.

All these risks crystallised to different degrees in markets during the global financial crisis. Currently, a key concern is that, against the backdrop of the so-called search for yield in response to generally low market interest rates, a reversal in risk-seeking behaviour by investors could test simultaneously the Resilience, and hence Effectiveness, of a number of key market segments.

This paper examines the Effectiveness and Resilience of financial markets specifically through the prism of market liquidity.[5] Section 2 begins by describing the evolving structure of liquidity provision across a range of markets, in the context of Effectiveness. Section 3 discusses some fragilities of different market structures and the potential risks to their Resilience. Section 4 illustrates some of these insights drawing upon selected well-known episodes of heightened volatility and illiquidity experienced over the past few years. Section 5 concludes.

## 2 Effective markets and the evolving structure of market liquidity

### Effective markets

*Effective markets* are resilient and fair, have the right infrastructure, and continually innovate to ensure that **capital and risks are competitively priced** and properly allocated. Market liquidity contributes to Effective markets by allowing investors to transact in reasonable size at or close to mid-market prices prevailing prior to the trade. Such 'transactional efficiency' is desirable for many reasons. For example, it facilitates the transmission of monetary policy by affecting the speed and completeness with which changes in policy interest rates and other monetary operations are reflected across financial markets.[6] More generally, transactional efficiency contributes to price discovery, or the process of price formation, amongst tradable financial assets. Uncertainty about the ability to undertake necessary transactions at reasonable prices, meanwhile, can undermine participation and price discovery in financial markets, and hence the proper allocation of capital and risks – for example, by deterring savers from investing in, and borrowers from funding via, financial markets and by leading to inefficient amounts of self-insurance.

Not all financial assets can or should be equally liquid in the sense outlined above. Different markets may be more or less liquid according to the *inherent liquidity characteristics* of the assets being transacted, as indicated in **Table 1**.

#### *Transactional efficiency in Effective markets*

The structure of financial markets should accommodate the *inherent liquidity characteristics* of different financial assets appropriately. This implies that there is no single approach to the provision of liquidity across different markets that mean they are necessarily Effective. For example, assets whose inherent liquidity characteristics attract a set of participants with diverse beliefs and investment horizons are likely to be traded more frequently. This, in turn, should raise the likelihood of finding an instant match between a prospective buyer and seller at any point in time, meaning there is less need for intermediaries to 'warehouse' the risk that prices move against the transaction in the period until a match can be found.

[5] It explains some of the themes recently described in: Cunliffe, J (2015), 'Market liquidity and market-based financing', *Speech given at the British Bankers Association International Banking Conference*, London; and Shafik, M (2015), 'Dealing with change: liquidity in evolving market structures', *Speech given at the AQR Asset Management Institute at the London Business School*, London.

[6] The greater stability in consumer prices that follows is, in turn, important for supporting sustainable growth in output and employment, and hence for achieving economic and financial stability more generally.

**Table 1 Factors affecting the inherent liquidity characteristics of financial assets**

| Factor | Characteristic |
|---|---|
| ***More inherently liquid:*** | |
| Standardisation | Standard terms and structures increase price transparency and the pace of price discovery, thereby attracting a larger pool of buyers and sellers. |
| | e.g. government bonds, equities, foreign exchange and futures. |
| Benchmarks and indices | Assets that are designated benchmark instruments and those included in indices tend to attract a larger pool of buyers and sellers. |
| | e.g. government bonds and large-cap equities. |
| Availability of hedges | Investors tend to be more willing to add an asset to their portfolios the more readily the associated risks can be hedged. |
| | e.g. government bonds and large-cap equities. |
| Collateral eligibility | Assets that can be posted as collateral against securities financing transactions[(a)] and derivatives transactions experience greater demand. |
| | e.g. government bonds and Agency securitisations. |
| ***Less inherently liquid:*** | |
| Exposure to tail events | Demand for assets exposed to tail risks (e.g. high credit risk, counterparty risk and/or embedded leverage) falls in times of stress. |
| | e.g. high-yield/EME bonds, financial debt and over-the-counter (OTC) derivatives. |
| Complexity and opacity | Complex and/or opaque assets are less well understood and the risks can be more difficult to manage, so reducing the pool of potential buyers. |
| | e.g. securitisations. |
| News-insensitive cash flows[(b)] | Assets with relatively news-insensitive cash flows may be less attractive to more active investors seeking to profit from information, but more attractive to buy-and-hold investors seeking predictable, long-dated cash flows. |
| | e.g. investment-grade corporate bonds. |

Source: Bank of England.
(a) Securities financing transactions refer to transactions undertaken to borrow cash or securities through the repo and securities lending markets.
(b) High-quality government bonds such as US Treasuries are an exception here, including because changes in their prices most closely reflect changes in market participants' expectations about the future path of monetary policy and/or prospects for inflation and economic growth.

Frequent trading should also minimise the need to transact in larger trade sizes. In contrast, assets that tend to be traded primarily by 'buy-and-hold' investors may naturally require greater warehousing of risk to facilitate the matching of trades at or close to prevailing mid-market prices and to limit the market impact of even reasonably-sized trades. By way of illustration, there is a sharp contrast between the frequency of trading in equities and corporate bonds. For example, McKinsey has estimated[7] that New York Stock Exchange (NYSE) and NASDAQ-listed equities trade around 3800 times per day, compared to around 85 times per day and 65 times per day for the most liquid US investment-grade and high-yield corporate bonds respectively.

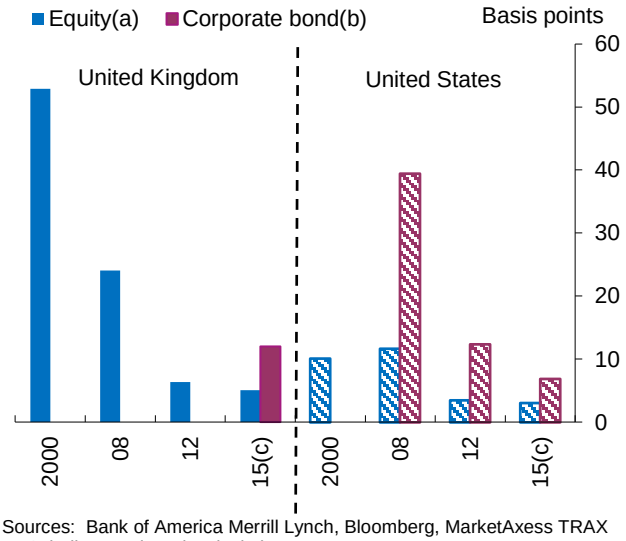
Given the inherent liquidity characteristics of a financial asset, the structure of financial markets further reflects investors' preferences as to how they choose to transact in the asset. Such preferences can change according to economic circumstances. Investors' choices will likely represent a trade-off between three broad considerations:

- *Execution costs*: In most circumstances, the financial cost of undertaking a transaction is likely to be the key determinant of how an investor chooses to execute a given trade, often expressed in the form of 'bid-offer spreads'. Such spreads reflect the difficulty with which prospective buyers can be matched with sellers via an intermediary putting capital at risk or alternative matching arrangements. In markets where near-immediate matching is possible, bid-offer spreads are likely to be lower than in markets where intermediaries need to warehouse risk for longer periods of time. For example, bid-offer spreads are generally lower in equity markets than in corporate bond markets (**Chart 1**) given the latter are more heavily reliant on intermediaries warehousing risk.

[7] McKinsey (2013), 'Corporate Bond E-Trading: Same Game, New Playing Field'.

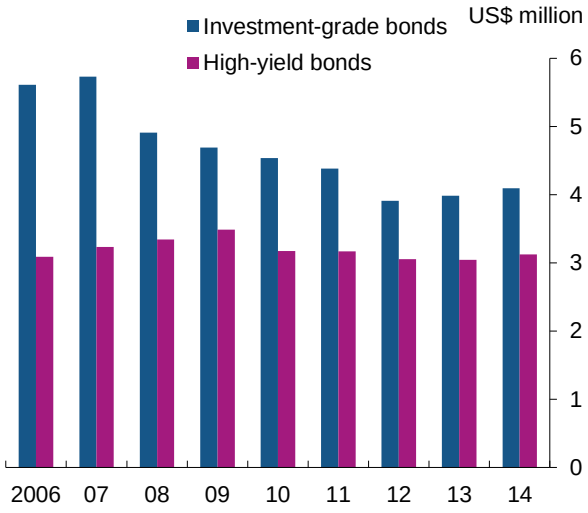
- *Transparency*: In most cases, greater pre and post-trade transparency should support confidence among investors about the price at which reasonably-sized transactions can be executed, thereby enhancing participation, price discovery and liquidity. That said, there are circumstances where price transparency can be detrimental – for example, when an investor needs to trade in large size in inherently illiquid assets. In such cases, investors might be willing to trade on venues offering lower price transparency (even if they expect that pricing might be less competitive) to mitigate the risk that a trade being visible moves market prices against them or, in extremis, makes execution impossible.
- *Immediacy*: Often, concerns about the possible adverse effects of price transparency in some circumstances can be alleviated if investors are willing to trade more slowly. For example, a large trade can be split into a series of smaller trades and executed over a longer period. In some dealer-intermediated markets, such as corporate bond markets, average large trade sizes have fallen over the past few years (**Chart 2**).[8] While this reduces the dealers' exposure to risk, it exposes the investor to the risk that prices move against them while the set of smaller transactions is completed.

**Chart 1 Bid-offer spreads for selected assets**




Sources: Bank of America Merrill Lynch, Bloomberg, MarketAxess TRAX BASI indices and Bank calculations.
(a) Bid-offer spreads as a proportion of mid price on the constituents of the FTSE 100 and NASDAQ 100, weighted by daily trading volume.
(b) Indicative bid-offer spreads quoted as absolute differences in yields.
(c) 2015 year-to-date.

**Chart 2 Average large trade size in US dollar-denominated corporate bond markets[(a)]**




Sources: FINRA and Bank calculations.
(a) Issued by US or foreign companies and registered with the SEC or covered under Rule 144a, with remaining maturity greater than one year. 'Large' trade means a par value more than US$1 million.

## The evolving structure of markets

The structure of financial markets is continually evolving, reflecting a process of ongoing innovation, changing preferences among investors and regulatory influences. There are a number of possible trading mechanisms that lie on a spectrum from quote-driven markets intermediated by dealers to order-driven markets traded on exchanges. There are various underlying features that distinguish between different mechanisms – including the degree of price transparency and immediacy with which transactions take place, as explained above – though at the boundaries, distinctions become blurred.[9] Most financial assets are traded in more than one way, as shown in **Table 2**.

Looking across markets, the broad direction of travel over the past few years has been from left to right in **Table 2** – from intermediated, voice and electronic quote-driven trading to non-intermediated, more fully electronic order-driven trading. As Section 4 will explain, recent episodes of volatility associated with short-term illiquidity have centred on the latter. It is therefore useful to examine individual market segments to document how transactions have historically occurred and how that has been changing.

[8] Trade sizes have also fallen in other markets. For example, in developed markets, average trade sizes for exchange-traded equities have fallen from around US$15,000 in the years immediately prior to the crisis to around US$6,500 since 2009. Off-exchange average trade sizes are larger, at around US$13,000, but have been flat overall since 2011.
[9] In many cases, the distinction between these categorisations is hard to make and necessarily involves some judgement.

**Table 2 Selected cash securities and derivatives markets**

| Features of market | OTC | | | Non-OTC | Size[c] (US$ trillion) |
|---|---|---|---|---|---|
| | Intermediated by dealers | Other trading approaches | | Traded on exchanges[a] | |
| | | Electronic matching systems[b] | Exchange-like | | |
| | Quote-driven | Largely order-driven | Order-driven | | |
| | Less transparent and immediate | Mixed transparency and immediacy | More transparent and immediate | | |
| | Voice and electronic | Electronic | | | |
| | Request-for-quote<br>- with intermediary (voice)<br>- via single and multi-dealer platforms (electronic) | Live executable price, all-to-all platforms, and other matching systems | Central limit order book | | |
| | Intermediary capital required to temporarily warehouse risk | No intermediary capital required to temporarily warehouse risk – though traditional intermediaries are often active participants | | Regulated exchange as counterparty | |
| ***Cash securities*** [d][e] | | | | | |
| US equities | 17% | 11% | | 72% | 20 |
| US corporate bonds | 96% | 3% | <1% | | 7.9 |
| US Treasuries | 65% | | 35% | | 13 |
| UK gilts | 90% | <10% | <1% | | 2.2 |
| German Bunds | >95% | | <5% | | 1.3 |
| Foreign exchange | 60% | 25% | 15% | | |
| ***Derivatives*** [e][f] | | | | | |
| Equities | 52% | | | 48% | 15 |
| Credit | >99% | | | <1% | 16 |
| Interest rates | 90% | | | 10% | 563 |
| Foreign exchange | >99% | | | <1% | 76 |
| Commodities | >99% | | | <1% | 2 |

Sources: Bank of America Merrill Lynch, Bank of England, Bank for International Settlements, Bloomberg, Debt Management Office, Federal Reserve Bank of New York, German Federal Ministry of Finance, ICAP BrokerTec, McKinsey and Greenwich Associates, SIFMA and Bank calculations.
(a) Public exchanges only. FEMR (see the link in footnote 2) defined exchanges as: a traditional form of regulated multilateral trading system, often also associated with the primary issuance of securities; subject to a range of regulatory requirements relating to, for example, pre and post-trade transparency, non-discriminatory access, and monitoring and governance. The particular features described here are complementary to this definition.
(b) Excluding key electronic request-for-quote systems, for example as available via Bloomberg and Tradeweb. Including dark pools, electronic communications networks and dealer-to-client platforms offering live executable prices.
(c) Cash securities figures refer to total market value outstanding. Derivatives figures refer to total notional amount outstanding.
(d) Proportion of trading volumes.
(e) Including dealer-to-client and inter-dealer markets.
(f) Proportions of notional amounts outstanding inferred from BIS statistics, which divide derivative markets into those traded OTC and those traded on exchanges. This may overstate the importance of OTC markets, categorised here as 'intermediated by dealers'. Excludes exchange-traded funds.

### *Quote-driven markets intermediated by dealers*

In some markets, dealers play a particularly important role as intermediaries between clients wishing to execute trades. This involves them deploying capital to warehouse risk, typically for short periods, by building and releasing inventories as supply and demand for securities in the secondary market varies. Such markets have historically been associated with comparatively low pre and post-trade price transparency, which can undermine confidence among investors about the value at which transactions can take place. But as noted previously, it also means that such markets can more readily facilitate larger transactions at or near current mid-market prices, other things being equal. Dealer-intermediated markets are therefore particularly well suited to assets that are less inherently liquid. The economics of market making are summarised in **Box 1**.

Historically, dealers have been particularly important in fixed income and currency markets.

**Corporate bond** trading continues to be predominantly undertaken by voice, though electronic request-for-quote (RFQ) has increased over the past few years via multi-dealer platforms, driven by clients' desire for greater transactional efficiency and speed. Dealers have also sought to reduce the amount of principal-based market making they undertake in favour of an agency model, whereby they closely match client orders. This has been manifest in the greater speed with which dealers seek to pass on rather than warehouse risk and their preference to break up large trades into smaller transactions (**Chart 2**). Electronic

**Box 1**

**The economics of market making**

From a regulatory perspective, the term 'market maker' refers to a '*person who holds himself out on the financial markets on a continuous basis as being willing to deal on his own account by buying and selling financial instruments against that person's proprietary capital at prices defined by that person*' (EU, MiFID2). Traditionally, this role has been fulfilled by banks. In recent years, new participants have emerged as important market makers in some market segments. This Box describes a simplified model of a market maker's marginal costs and, through this lens, examines the impact of the structural developments discussed in Section 2.

In a competitive market, the price at which a market maker is willing to provide liquidity services should largely reflect its marginal costs. Given the expected holding period for a particular position, a market maker's bid-offer spread should reflect the following factors.

- *Market risk:* Compensation for the possibility that prices move against the intermediary during the period it retains exposure that cannot be hedged efficiently or at reasonable cost.

- *Funding and capital costs:* If positions are to be held overnight or longer, a market maker will need to finance the trade and hold equity to guard against potential losses.

In addition, a market maker's bid-offer spread may reflect:

- *Informational content:* The extent to which they are willing to provide more competitive quotes, or 'pay up', to see order flow in RFQ-dominated markets, thereby providing them with superior information to other market participants.

- *Client relationship considerations:* The extent to which a market maker may be willing to partially subsidise a given transaction for other commercial reasons.

- *Other costs:* Including the cost of staffing a trading desk, related compliance requirements and IT costs.

Some of these factors will shift on a daily basis – for example, the volatility and likely holding period of a given position. Others, such as funding and capital costs, may change more slowly. Given these considerations, a consequence of requiring market makers to hold more capital is that the marginal cost of providing intermediation services is higher. This underpins the concern expressed by market participants about the willingness of banks to make markets following the necessary post-crisis regulatory reforms.

It is possible that these effects may be offset, in part, by the impact of another important structural change over the past decade – technological development. In the above framework, improvements in technology will impact many of the factors that determine a market maker's marginal costs. More sophisticated trading systems can facilitate better market and liquidity risk management – for example by drawing on statistical analysis to better identify cost-effective hedging strategies or taking advantage of new matching systems to reduce the time spent searching for an investor with opposing needs. And a shift to electronic rather than voice trading will likely reduce other costs, including staffing.

Opportunities for technology to lower costs and improve efficiency may still be available. Examples include the refinement of cross-asset auto-hedging strategies and better utilisation of the informational content of electronic trading flows. In some instances, non-traditional market makers have been among the first to take advantage of such opportunities. And while the emergence of new participants can present challenges to those seeking to understand risks to the financial sector, increased competition in and of itself ought to bear down on the cost of liquidity for end-users.

trading is more prevalent in Europe than the United States[10] because of: fragmentation of issuance across countries and currencies; language barriers making voice trading more difficult; and a larger presence in Europe of retail investors wishing to trade in comparatively small amounts. It is usually the newest ('on-the-run') issues that are electronically traded, typically in sizes below €1 million.

**UK gilts** are still largely traded by voice in the inter-dealer market, which accounts for roughly two thirds of total turnover. Inter-dealer brokers (IDBs) act as intermediaries between Gilt-Edged Market Makers (GEMMs), allowing them to trade anonymously with each another. But this structure is also evolving. For example, to enhance liquidity and aid price discovery, some IDBs introduced electronic matching sessions between buyers and sellers in the second half of 2014 – which now account for up to one fifth of daily inter-dealer volume. In the dealer-to-client space, which accounts for around one third of total turnover, over half of trading by value is undertaken via electronic multi-dealer trading platforms including Tradeweb and, to a lesser extent, Bloomberg. Some GEMMs use automatic quoting methods for smaller trade sizes,[11] sometimes automatically hedging the resulting transactions using futures, though more manual hedging mechanisms persist.

Trading in **European government bonds** has also recently started to move towards multi-dealer electronic RFQ, driven in part by: dealers' investment in technology to facilitate automatic pricing and hedging; a move by some clients to encourage dealers to demonstrate best price execution and reliable audit trails for regulatory reasons; and regulatory initiatives aimed at improving transparency.[12] In the **US Treasury market**, around half of dealer-to-client transactions are undertaken electronically, often using automated quoting and hedging systems. And while the dealer-to-client market remains dominated by traditional market makers, non-banks have recently made tentative steps towards offering liquidity directly to end-users via platforms such as Bloomberg and Tradeweb.

Despite instruments in the **spot foreign exchange** (FX) market being highly commoditised and homogenous, over half of trading continues to be dealer-intermediated RFQ, of which more than two thirds is by voice.[13] Most of this is concentrated in a handful of dealers, creating broad reliance on a few key intermediaries. Factors affecting the evolution of the spot FX market are described later in this section.

**OTC derivatives** account for the bulk of notional amounts outstanding in derivative markets globally, the majority of which relate to interest rates and foreign exchange. They are heavily reliant on dealer-intermediated RFQ trading. In some market segments such as foreign exchange, position taking, trading and price discovery occurs primarily through these markets rather than the cash market.[14] Given their bespoke nature, trading in OTC derivatives has historically been undertaken by voice. But recent regulatory changes, including Dodd-Frank in the United States, have mandated a switch to multi-dealer electronic trading platforms with pre-trade transparency for key products. Currently, these still primarily operate via RFQ, but it is possible that trading could shift to a central limit order book model over time, with the new electronic venues already having prompted the emergence of non-traditional market makers.

### *Order-driven markets traded on exchanges*

In exchange-traded markets, investors can use so-called 'market orders' to transact quickly at the best price available from the central limit order book, which tracks the prices at which other investors would be willing to buy and sell securities. Participants are also allowed to place so-called 'limit orders', enabling them to buy or sell a security should market prices fall or rise to pre-specified levels, thereby contributing to the overall provision of liquidity. Exchange-traded markets typically exhibit a high degree of pre and post-trade price transparency. They are therefore generally suited to more inherently liquid securities, such as those with

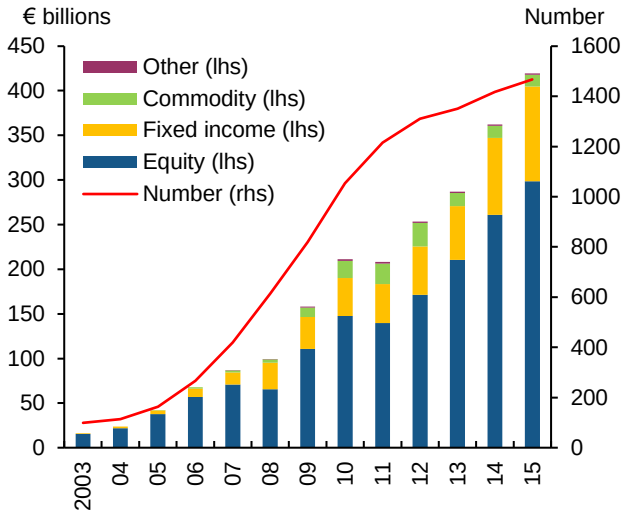
[10] In Europe, trading via electronic multi-dealer platforms accounts for roughly one third of volumes in corporate bonds, with the majority of the remainder voice traded.
[11] For example, a £20 million transaction in gilts with maturities around 10 years.
[12] More than half of dealer-to-client transactions in European government bonds were undertaken electronically in 2014, up from around two fifths in 2008. Clients continue to rely on voice trading with dealers for larger transactions. And voice trading continues to dominate the inter-dealer market in German Bunds.
[13] Dealer-intermediated RFQ includes here the BIS-defined execution methods of 'voice direct', 'voice indirect', 'electronic direct other' and 'undistributed'.
[14] Precise estimates are hard to construct, but roughly two thirds of all FX trading activity may occur in derivative markets, the vast majority of which are traded OTC, with the remaining third in spot (cash) markets.

standardised terms and structures, and for which there is reliable two-way trading interest for reasonably-sized trades across a large pool of buyers and sellers (see **Table 1**).

The majority of **cash equities** are exchange-traded, with the remaining activity split between dealer intermediation and other trading approaches. Over the past decade or so, regulation has played an important role in shaping the nature of participation on equity exchanges. For example, in 2001, the NYSE reduced the minimum increment for trading in listed US equities to 1 cent from one sixteenth of a US dollar. This, alongside technological improvements and the growth of multilateral trading venues, has led to the emergence of high-frequency principal trading firms (PTFs)[15] as major participants in the trading of cash equities. Such participants engage not only in arbitrage-seeking and directional risk-taking activity but also market making. PTFs may now account for between two thirds and three quarters of trading volumes in exchange-traded equities, a marked increase from a small base in the early 2000s. **Box 2** describes the activities of PTFs in further detail.

Some **derivatives**, including futures and listed options, are exchange-traded. For example, futures on US Treasuries, UK gilts and European government bonds are traded on the Chicago Mercantile Exchange (CME), the Intercontinental Exchange (ICE) and Eurex respectively. These exchanges have become a focal point for position-taking activity and price discovery for government bonds over the past few years. Market participants attribute this to a number of factors, including reduced liquidity in cash bond markets as dealers have pulled back from principal-based market making, alongside increased demand for greater price transparency. In the futures markets, only a limited number of transactions are conducted bilaterally through dealers, including larger trades. By definition, **exchange-traded funds** (ETFs) are also traded on exchanges. They have grown rapidly over the past decade (**Chart 3**) and, like some futures contracts, act as a focal point for trading in some asset classes.

**Chart 3 European ETFs by asset class[(a)]**




Source: Deutsche Bank.
(a) Figure for 2015 as of mid-August.

### *Other trading approaches*

Alongside quote-driven dealer-intermediated markets and order-driven exchange-traded markets, a number of other electronic venues offer a mix of their features and connect a wide range of market participants.

In fixed income markets, electronic and automated trading on exchange-like venues is most widespread and has been increasing comparatively quickly for the **inter-dealer market in cash US Treasuries.**[16] Trading of on-the-run benchmark US Treasuries in the inter-dealer market is now almost completely electronic. It occurs primarily via two electronic platforms – BrokerTec and eSpeed – and includes both primary dealers and non-primary dealers, some of which are sophisticated PTFs. Transactions are facilitated by a central limit order book that allows for anonymous trading between participants with complete price transparency. There are important similarities to exchange-traded markets, but without the same forms of regulation and protections such as circuit breakers (see Section 4). Amongst other things, these exchange-like venues allow market participants to trade using algorithms. A significant share of market making is conducted using automated, high-volume and so-called 'low-latency' techniques, which seek to take advantage of fleeting arbitrage opportunities between prices across electronic venues.

[15] PTFs have often been referred to as high-frequency traders (HFTs). This paper uses the former description to distinguish more clearly between participants such as banks using high-frequency approaches to manage aspects of their businesses and non-bank companies trading at high-frequency as their primary business model.
[16] For a more detailed overview of electronic and automated trading in the US Treasury market, see Potter, S (2015), 'Challenges posed by the evolution of the Treasury market', *Remarks at the 2015 Primary Dealer meeting*, New York City.

## Box 2
## High-frequency principal trading firms and market liquidity

### What are high-frequency principal trading firms?

Principal trading firms (PTFs) are investment firms that trade on a proprietary basis using sophisticated technology to generate, route and execute trades automatically at far higher speeds than traditional investors. Strategies include: market making (warehousing investment risk, albeit for very short periods), exploiting arbitrage opportunities (trading to profit from anomalies between prices of securities with identical or similar payoffs) and trading on information (taking outright positions). Because of the high speed at which PTFs operate, they typically have very short holding periods – minutes or less – and end the day with small positions to avoid carrying the risk that prices move against them overnight. PTFs operate predominantly on exchanges and in exchange-like markets featuring central limit order books, such as equities and cash US Treasuries.

### Why is high-frequency trading relevant?

PTFs have recently attracted interest from regulators and academics,[17] especially since the 2010 flash-crash in a benchmark derivative contract linked to the S&P500 (see Section 4). For example, PTFs feature in the revised text of the European 'Markets in Financial Instruments Directive' (MiFID2), while the number of research papers on the subject has been increasing. A key question from a financial stability standpoint is how and to what extent PTF activity affects market Effectiveness and Resilience. Put differently, it is important to understand why it matters if some market participants can trade much faster than others, assuming that speed is the only differentiating factor. In a multi-venue trading environment, PTFs can play an important role as arbitrageurs.

### What might be the effect on market liquidity?

Empirical research has found that, on average, PTFs are associated with improved market liquidity as measured by bid-offer spreads – reducing the cost of trading for all market participants.[18] There are two reasons why this might be the case. First, PTF market makers can achieve comparatively low operating costs per transaction due to automation. This allows them to charge a narrower bid-offer spread as compensation for providing market making services. Second, their speed allows them to update or cancel their (limit) orders quickly as news arrives, meaning their quotes are less likely to be stale when they are executed.[19] Some recent research also suggests that directional risk-taking PTFs may contribute to fast and efficient price discovery.[20]

From a financial stability standpoint, we are interested in more than average behaviour, which by definition is dominated by normal times. A key question is whether PTFs contribute to two-sided markets at the point when they are especially important – in a stressed environment. The concern here is two-fold: (i) that PTFs might temporarily exit financial markets when previous short-term empirical relationships start to break-down, reducing overall participation and liquidity; and/or (ii) PTFs might exacerbate price spirals by selling into a falling market as new empirical regularities take hold, explicitly undermining liquidity. This behaviour is not unique to PTFs, but they may withdraw from markets more quickly than other market participants. And their typically thin capitalisation means that they are less well placed to warehouse risk positions over time. The flash-crash in 2010 is an important example of the potential adverse interplay between transaction orders by fundamental participants and PTFs. It matters because even short-term dislocations in prices that do not lead to more persistent effects could be damaging if they undermine confidence in the Resilience of financial markets. And if such dislocations became locked-in (say, by inducing wider selling pressure), the ensuing mark-to-market losses could trigger further adverse behavioural responses.

Taken together, these considerations suggest that PTFs can positively influence market functioning in a number of circumstances. But uncertainty remains about their behaviour in stressed conditions.

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[17] For example, Barclays was the subject of a complaint and summons filed by the New York Attorney General alleging misleading representations to clients about the presence of PTFs in the US arm of the firm's Liquidity Cross (LX) broker-crossing network.
[18] For example, Benos, E and Sagade, S (2012) find that the participation of market making PTFs is empirically associated with smaller bid-offer spreads in a sample of UK equities. In reality, the relationship between spreads and PTF activity is likely two-way, with PTF activity affecting spreads and *vice versa*.
[19] This effect has been explicitly modelled by Jovanovic, B and Menkveld, A (2011) and empirically documented in a number of instances and trading venues – e.g. by Hendershott, T, Jones, C and Menkveld, A (2011) for the NYSE, Riordan, R and Storkenmaier, A (2011) for the Deutsche Boerse, and Hasbrouck, J and Saar, G (2013) for the Nasdaq.
[20] See Benos, E, Brugler, J and Hjalmarsson, E (2015), 'Interactions among high-frequency traders', *Bank of England Working Paper*, No. 523.

Roughly one third of overall volumes in **spot FX** occur in the inter-dealer market, of which approaching two thirds occurs via exchange-like venues.[21] This is possible because, like equities, FX instruments are highly commoditised and homogenous. Market access for non-bank financial institutions has been facilitated over the past few years by improvements in technology and the financing and settlement services available from prime brokers.[22] But the broad drive towards greater price transparency has increased concerns among some investors about their ability to execute orders efficiently because of the possibility that PTFs and other market participants taking directional positions could move prices against them. This has pushed volumes towards less transparent venues. For example, some major global banks have internalised increasingly large proportions of flows in particular currency pairs within their single-dealer platforms. Concerns related to greater price transparency may also partly explain the continued prominence of dealer-intermediated RFQ trading for spot FX, as described previously.

Margins on market making activity across exchange-like venues for spot FX are thin. Banks and non-banks use automated market making tools and various communication channels to facilitate transactions at high speed. Participants will typically broadcast their interest to transact simultaneously on multiple platforms and withdraw as soon as their order is 'hit', giving the illusion of more trading interest than is actually present – sometimes referred to by market participants as a 'liquidity mirage'. Competition is intense, and fleeting price developments on one platform are quickly reflected on others.

For **equities**, regulation has played a major role in affecting the growth of other trading systems since the late 1990s.[23] The proportion of overall volumes traded in equities outside of public exchanges has risen substantially, from a very small base in the late 1990s to more than one quarter today across a number of venues. The multiplicity of venues in equity markets allows investors to choose where and how to transact according to their business needs and preferences – for example, dark pools that do not display orders to other participants minimise informational leakage, allowing some large transactions to occur closer to the prevailing mid-market price than might otherwise be the case. But because it takes time for brokers to identify and route client orders to the particular venue offering the best possible price at any given moment, there can be fleeting arbitrage opportunities for fast investors, including so-called 'latency arbitrage PTFs', able to respond to such order flows across venues. This is not necessarily problematic from a financial stability standpoint if such opportunities are brief and price discovery and efficiency are not materially impaired. But for this to be ensured, reliable participation by other short-term investors is needed to knit together the multiple pools of liquidity.

In the **corporate bond** market, the fall in average trade sizes and the increase in electronic dealer-intermediated RFQ has coincided with the emergence of some other trading systems, including so-called 'all-to-all' platforms that allow investors to trade directly with each other rather than via an intermediary. Such venues have been growing over recent years, albeit from a small base.

### Transactional efficiency versus resilience in Effective markets

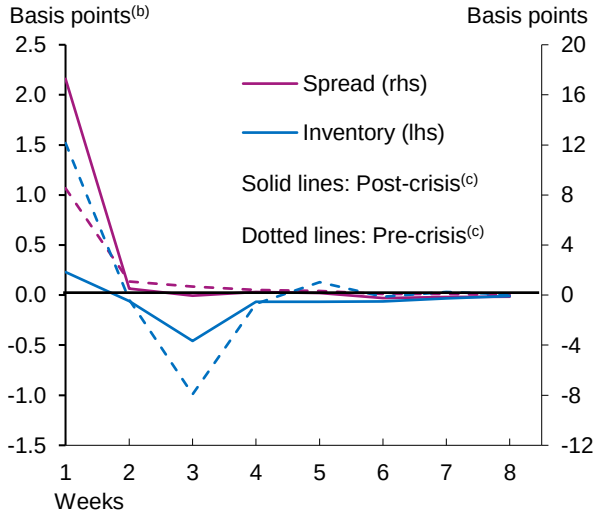
It is uncertain how the structure of financial markets will evolve.[24] The development of alternative electronic trading venues can, in principle, support transactional efficiency by drawing in a wider variety and larger number of market participants than would otherwise be the case, boosting market liquidity in a number of circumstances. But technology and operational requirements mean that participation in such venues is not costless. This could result in a greater reliance of some investors on others for trade execution and market access – unless direct trade matching venues between prospective buyers and sellers come to account for a

[21] Including Reuters and EBS.
[22] The BIS Triennial Survey 2013 noted that '… *top players on EBS are now high-frequency trading firms, providing liquidity not on their own accord but mostly through bank prime brokerage facilities (i.e. trading in a bank's name). The majority of volumes in normal periods are driven by these non-bank HFTs (primarily a few large players)*'.
[23] Regulation Alternative Trading Systems (1998) sought to reduce barriers to entry among equity trading venues. It required venues to display best price quotes to all their participants once average daily volumes reached a certain level. Regulation National Markets System (2005) introduced the Order Protection Rule that required brokers to execute market orders from clients at the best price offered electronically on any venue in the United States. And the Markets in Financial Instruments Directive (2007) was designed to promote competition between venues.
[24] A number of market participants have recently made suggestions that, in their view, would enhance market liquidity. For example PricewaterhouseCoopers has set out four ways in which market liquidity issues could be incorporated into ongoing banking sector and financial market reforms. And BlackRock has advocated, amongst other things, large liquid benchmark issues in bond markets and greater use of all-to-all trading venues.

much large proportion of overall volumes. Multiple venues can also bring risks from fragmentation, whereby a lack of continuity in trading and pricing across different platforms can mean that developments in one part of the market fail to be checked in the absence of certain key participants. In extreme cases, problems could be transmitted across the entire market.

In particular regard to market making, market participants expect that increased balance sheet costs will likely encourage banks to continue to pull back from such activity in fixed income and currency markets, providing opportunities for non-bank firms to step in. An implication of the pull-back by banks is that pricing and volatility could, at least in the near term, be more sensitive to trading activity.[25] This can be seen, for example, in the greater responsiveness of US dollar-denominated corporate bond spreads to changes in demand from asset management companies, accompanying a lower response of dealer inventories, since the global financial crisis (**Chart 4**). This is not necessarily problematic. To the extent that lower transactional efficiency in some markets is the price of ensuring they exhibit greater resilience in stressed conditions via a more resilient core, it may even be desirable.[26]

**Chart 4 Sensitivity of US dollar-denominated corporate bond spreads and dealer inventory to reduced demand from asset management companies**[(a)]




Sources: Bank of America Merrill Lynch, Dealogic, EPFR Global, Federal Reserve Bank of New York, SIFMA and Bank calculations.
(a) Sensitivity of US dollar-denominated high-yield corporate bond spreads and US primary dealers' inventory in these securities to a one standard deviation decline in demand for corporate bonds from asset management companies as a proportion of market size.
(b) Fraction of market size.
(c) Pre and post-crisis defined as 2004-06 and since 2012 respectively.

It is important that market participants factor these changes into their investment decisions. The development of direct electronic trading between investors in markets that have historically been dealer-intermediated might best be seen as complements to, rather than substitutes for, dealers and other companies temporarily putting capital at risk to facilitate transactions – because in some instances, that naturally suits the inherent liquidity characteristics of an asset. Corporate bond markets are one example where it seems unlikely that dealer intermediation will be replaced, in part given the lack of standardisation in the primary issuance market.

Factors affecting the Resilience of financial markets more generally are unpacked in the next section.

## 3 Resilient markets and risks to market liquidity

### Resilient markets

*Resilient markets* provide **predictable access and liquidity** for funding, investing, saving and risk transfer, and are underpinned by robust infrastructure. Market liquidity contributes to Resilient markets by ensuring that changes in prices are orderly and largely reflect changes in valuation factors such as the outlook for future cash flows.[27] This is desirable because it allows borrowers to plan investment in productive opportunities and provides investors with the confidence to finance those investments. Uncertainty around the prices at which securities can be issued and sold, on the other hand, impairs the process of matching borrowers and investors.

[25] The impact on UK asset price volatility of unexpected changes in prices, including in response to trading, is described in Salmon, C (2015), 'Financial market volatility and liquidity – a cautionary note', *Speech given at the National Asset-Liability Management Europe symposium*, London.
[26] Similar points to this have recently been made by a number of policymakers. See, for example, Dudley, W (2015), 'Regulation and liquidity provision', *Remarks at the SIFMA Liquidity Forum*, New York City.
[27] In principle, it is desirable for investors to be able to transact at the 'fundamental' value of a security, reflecting its inherent liquidity characteristics and broader market conditions. But notions of fundamental value are notoriously complex. Even the so-called 'weak' form of price efficiency is difficult to assess empirically though, arguably, it is not necessary for markets to be Resilient. The Efficient Market Hypothesis essentially states that prices of liquid financial securities fully reflect all available information. Its so-called 'weak' form limits the information set to all past prices and returns, with the implication that future prices cannot be predicted from past prices. Its 'semi-strong' form states that prices adjust to all new public information quickly, such that excess returns cannot be generated by trading on this information. And its 'strong' form states that prices reflect all relevant information, both public and private, meaning that it is impossible for any investor to generate excess returns systematically. Evidence for the weak form is clearest.

The prices of all financial assets are sensitive to shocks that affect the outlook for valuation factors. Prices can therefore never be perfectly predictable. This is not a risk *per se*, though it is a concern if price developments are driven by **order flow imbalances** – whereby the market is unable to readily absorb an excess of supply of particular assets in the secondary market relative to demand, or *vice versa*.

Some financial asset markets may be more inherently vulnerable than others to the emergence of order flow imbalances – for example, if enough investors do not fully appreciate or sufficiently price an asset's inherent liquidity characteristics, perhaps based on an assumption that they can be sold more quickly near mid-market prices than can be achieved in practice. Broad factors affecting the vulnerability of asset markets to order flow imbalances are described in **Box 3**.

Order flow imbalances can generate excessive buying pressure from investors seeking returns in good times that have little intention of bearing the associated liquidity risk should it look like crystallising, and selling pressure from those same investors when the inherent liquidity characteristics of the underlying financial assets are revealed in the event of a shock. While it is obviously desirable that an under-pricing of liquidity risk corrects, a concern from a financial stability standpoint is that price adjustments overshoot. This may deter investors from investing in new issuance of financial assets, particularly where they are least inherently illiquid, such as EME bonds.

No market can be guaranteed to be perfectly liquid under all circumstances. There is always the potential for order flow imbalances to arise, if only as a consequence of fundamental news. The question of Resilience is whether or not such imbalances are likely to persist and multiply, or dampen quickly.

### Risks to market liquidity

The vulnerability of market liquidity to order flow imbalances is affected by the mix of amplifiers, linkages and stabilisers present in and across markets. These factors emanate from various sources – including the structure of markets and the behaviour of all investors – and not just from the core intermediaries traditionally relied upon to intermediate risk. As explained in this section, regulation focused on banks has helpfully reduced the extent to which they might amplify movements in financial market prices. And while regulation does appear to have affected the extent to which banks are willing to act as stabilisers relative to the period before the global financial crisis, this might re-introduce a healthier degree of risk into financial markets that other market participants should take into account in their investment decisions.

#### *Amplifiers*

*Amplifiers* are market dynamics that act to reinforce buying or selling pressure in response to an initial price move. The precise nature of such amplifiers is likely to depend on the structure of the market and the nature of the investors participating in it.

As discussed in Section 2, market Effectiveness relies heavily on the intermediation services provided. For more automated trading venues, an obvious fragility lies in the infrastructure itself. Such venues rely on complex systems, raising the possibility of **disruptions to critical trading infrastructure**, manifest through IT disruptions and so-called 'latency problems', arising in the event of unusually high demand for transactions. Further problems could materialise to the extent that market making is dominated by participants, including non-banks, with **limited capacity to put capital at risk**. In the context of a fast-moving market, it would be reasonable to expect such market makers to pull back, if only temporarily, to avoid inadvertently building up large inventories. Even markets that are less reliant on intermediaries and feature a number of electronic means of trading may be collectively reliant on just a few venues. For example, the viability of some off-exchange venues in equity markets could be compromised if the highly transparent, quickly-executable prices provided by exchanges became temporarily unavailable. Investors

**Box 3**

**The vulnerability of markets to order flow imbalances**

There are a number of factors affecting the vulnerability of markets to order flow imbalances, including: the eligibility of the associated securities as collateral; the degree and form of financial engineering; the extent of liquidity mismatches among funds invested in the market; and other drivers.

- *Eligibility as collateral:* A natural demand for financial assets arises, supporting their liquidity, when they can be pledged as collateral to secure financing through repo markets or to make margin payments against derivative transactions (**Table 1**). For example, there is a tight association between amounts of financing extended by US primary dealers against US Treasuries and trading volumes in the underlying cash market (**Chart A**).[28] But this relationship relies both on eligibility and the volume of such transactions being maintained, which may not be the case for lower quality collateral. During the global financial crisis, for example, securitisations became a less widely-accepted source of collateral at reasonable haircuts, exacerbating the reduction in liquidity in those markets.[29]

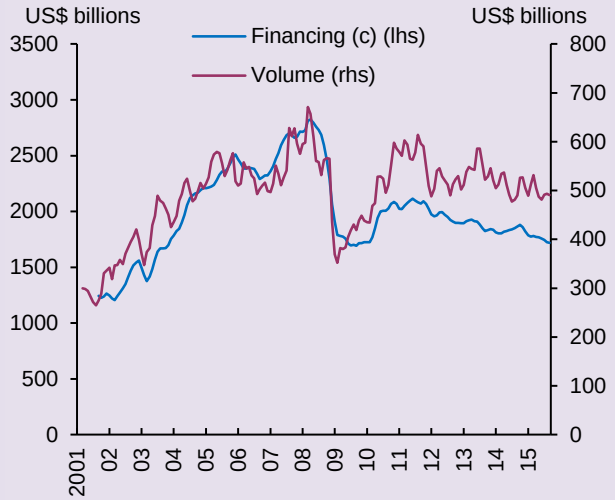
- *Financial engineering:* Financial engineering can appear to transform liquidity and other risks associated with financial assets. A well-known example of this is the securitisation technology that allowed the created securities to be much more easily tradable than the assets backing them. During the global financial crisis, these markets broke down and have yet to recover fully, prompting the regulatory authorities to develop criteria around securitisations that, among other things, may bolster their liquidity in the future.[30] ETFs are another form of financial engineering that have grown rapidly over the past decade, from a small base in the early 2000s to approaching US$3 trillion globally today. As noted in Section 2, by definition, ETFs are exchange-traded. This can confer on these funds greater apparent liquidity than the underlying assets they hold. While equity funds still account for the majority of ETFs, the share of fixed income ETFs has grown substantially – in Europe, from around 5% in the early 2000s to around one quarter today (**Chart 3**).[31]

- *Fund liquidity mismatches:* Fund liquidity mismatches occur when investors in funds are offered a greater degree of access to their cash than is consistent with the ease with which the assets in which they are invested can be sold at reasonable prices. The vulnerability this creates is that investors may demand to redeem their cash in response to large price falls, leading to selling pressure in those markets in which funds are invested. Sharp outflows were a feature of the global financial crisis, for both hedge funds and US money market funds (MMFs) (**Chart B**). Together, these funds account for a comparatively small proportion of assets under management, and measures have since been taken to reduce the likelihood of such sharp outflows – in the shape of regulatory reform for MMFs,[32] and increased 'gating' for hedge funds.[33] A more prescient concern revolves around open-ended mutual funds, which typically offer near-term redemptions to investors. As described in the July 2015 *Financial Stability Report*, global assets under management have grown significantly over the past decade, to around US$70 trillion. Within that, the share of funds typically offering investors near-term redemptions has increased, from just below 40% a decade ago to approaching half.

[28] Government bonds are a very widely used form of collateral in the financial system. They account for between one half and two thirds of collateral used in repo markets in Europe and the United States.
[29] Haircuts for bank financing of banks and non-bank counterparties against securitisation collateral rose abruptly during 2008. By 2012, they far exceeded haircuts on other fixed income collateral, standing at around 13-15%. Gorton, G and Metrick, G (2009), 'Securitized banking and the run on repo', *NBER Working Paper*, No. 15223 was one of the first academic studies documenting the link between perceptions of bank counterparty risk and the abrupt tightening of collateralised funding conditions during the crisis.
[30] In July 2015, BCBS and IOSCO published a final version of a consultation paper on criteria developed to identify securitisation structures that are simple, transparent and comparable – including a high-level summary of respondents' feedback to a version of the document published in December 2014. It is available from www.bis.org.
[31] The share of commodity ETFs in Europe has also grown overall, but it has been on a downward trend since 2011 and it accounts for a smaller fraction of total assets held.
[32] Reforms have sought to reduce the susceptibility of MMFs to runs. IOSCO issued final policy recommendations in October 2012 that provide the basis for common standards of regulation and management of MMFs across jurisdictions, including a conversion of funds from stable to floating NAV.
[33] In 2006, reportedly very few hedge funds had enacted gates and other discretionary liquidity provisions. By 2009, this had increased to almost one third.

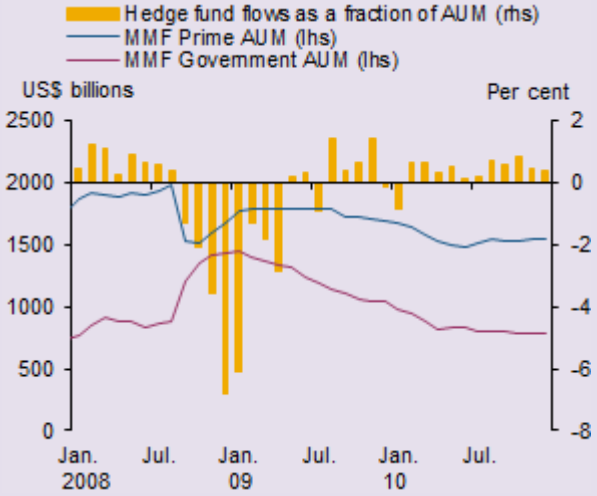
- *Other drivers:* Accommodative conventional and unconventional monetary policy internationally since the crisis necessary to secure economic recovery has intentionally lowered market interest rates and increased the amount of cash available for the purchase of risky assets. A corollary of this has been the so-called search for yield among investors, which may have partly masked the inherent fragilities to order imbalances in some market segments, including advanced economy and emerging market economy (EME) bonds.[34]

**Chart A US Treasury financing and trading volume[(a)(b)]**




Sources: SIFMA, Federal Reserve Bank of New York and Bank calculations.
(a) Three month moving averages.
(b) Includes TIPS and Floating Rate Notes.
(c) Sum of reverse repo agreements and other financing transactions.

**Chart B Global hedge fund and US MMF outflows during the global financial crisis**




Sources: Crane, BarclayHedge and Bank calculations.

may also be quicker to pull back from less transparent or 'dark' venues in a stressed economic environment when uncertainty about appropriate valuations increases.[35]

A second set of amplifiers are ostensibly behavioural, but arise as a mechanical response to **reductions in funding** as prices fall. All cash securities are 'funded' in the sense that an agent in the real economy makes a decision to invest, or a financial intermediary chooses to lend to a leveraged investor to do so. Problems can arise when these decisions are revised during times of stress, thereby adding to selling pressure. One such example relates to the fragility mentioned in **Box 3** of fund liquidity mismatches between assets and liabilities. In this case, funds could be forced to sell assets in response to redemptions from investors suddenly alert to their inherent illiquidity. Another example relates to the financing of leveraged investors, in which case a fall in collateral values would automatically reduce the amount of funding available to them at short maturities to finance their holdings of assets, via repo markets and margin lending.[36]

A third set of amplifiers relates to so-called 'crowded trades' that arise as a result of discretionary **speculative and procyclical behaviour among investors**. These trades can lead to large, simultaneous demand to buy or sell securities – causing prices to become misaligned with underlying fundamental factors in the upswing and accentuating the depth of any subsequent market correction. There are three broad categories:

- *Correlated trades*, which are prevalent in a range of financial markets and trading venues. Such trades arise when the demand for an asset ceases to fall materially as prices rise, and *vice versa*. In faster moving markets, algorithmic trading often keys off momentum factors, which have the potential to be

[34] See also the June 2015 *Financial Stability Report*, which noted that investors may be more willing '… to accept higher credit and liquidity risk in order to improve investment returns, in an environment of low risk-free interest rates and large-scale purchases of assets by central banks …'.
[35] The finding that dark pools can attract orders away from a transparent central limit order book-driven market has been described in the academic literature. See for example Buti, S, Rindi, B and Werner, I (2013), 'Dark pool trading strategies, market quality and welfare', *IGIER Working Paper*, No. 421.
[36] Margin lending refers to the practice by which prime brokers lend to clients, usually hedge funds, against a pool of assets such as equities.

common across traders. In slower moving markets, correlated trades may be associated with various non-bank financial companies that trade in tandem according to industry standards or benchmarks.[37] There has been evidence of correlated trading over the past few years in some investor segments, including equity (and to a lesser extent debt) funds investing in EMEs (**Chart 5**). This has coincided with growth in the passively-managed investment universe, including ETFs.

- *Consensus trades*, which occur when investors take positions on the basis of prevailing market norms as opposed to conviction in their view of the future path of economic conditions.[38] These positions may be particularly susceptible to comparatively little news. They are difficult to identify and measure, but are consistent with periodic concerns cited by market participants. The large fall in US Treasury yields on 15 October 2014, described in Section 4, is an important recent example.
- *Risk-based trading strategies*, which refer to portfolio allocation decisions that are strongly related to contemporaneous measures of risk. For example, some investors may reduce their holdings of securities as their volatility increases, and *vice versa*, potentially exacerbating the change in volatility. A number of models historically used to inform portfolio allocation decisions have this property, including Value-at-Risk (VaR). For example, in 2003, during the so-called 'VaR shock', Japanese government bond prices exhibited increased volatility as interest rates rose, mechanically forcing some Japanese banks to reduce their holdings, thereby amplifying the move. More recently, market participants have focused on so-called 'risk parity' funds, which explicitly follow a strategy of risk-based trading. Investors following such strategies manage around US$400-600 billion of assets globally. A persistent increase in volatility could have particularly important effects if it caused a wide range of investors to adjust their portfolio allocations.[39]

Another important illustration of procyclical behaviour prior to the global financial crisis was the rapid expansion of dealers' inventories of fixed income corporate securities, which may have been partly symptomatic of directional risk-taking, including in inherently less liquid assets. This is a clear example in which market liquidity and other risks were under-appreciated. Inventories were rapidly unwound between 2007-09 as risk sentiment among investors and market conditions deteriorated. For example, while in the five years preceding the crisis US primary dealers' holdings of corporate securities increased almost five-fold, they had fallen to around one quarter of their peak by 2009 and have drifted down overall since (**Chart 6**, blue). Most of this fall pre-dates the emergence of the new regulatory regime, suggesting that it may partly reflect a broad reduction in the willingness of dealers to warehouse asset positions following the experience of the global financial crisis. The reduction in dealers' inventories has reduced their exposure to market risk, which can be highly procyclical, thereby strengthening the core of the financial system. And it has not persistently been to the detriment of transaction volumes, which have recovered (maroon), suggesting that inventories have been worked harder – the value of transactions per unit of inventory in corporate securities now stands at around 30 compared to six at the time of the crisis.[40]

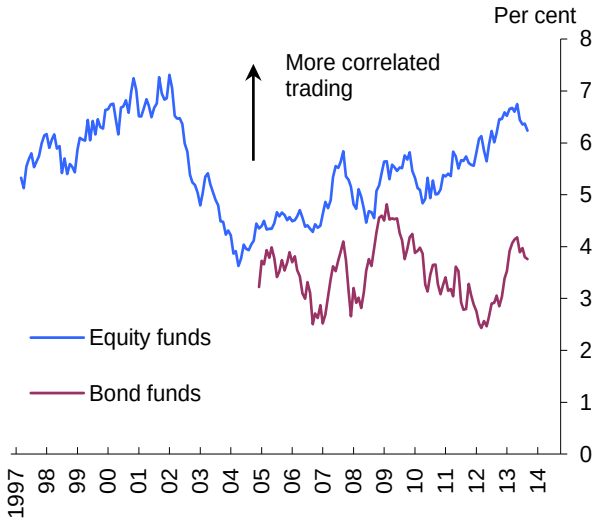
### *Linkages*

*Linkages* are market dynamics that transmit volatility or large price moves from one market to another. Some such linkages are mechanical in nature, while others emanate from the behavioural actions of investors. **Box 4** provides some historical context for these linkages.

Mechanical linkages include **pricing linkages** whereby valuations in one asset market are reflected in another. For example, government bonds (or interest rate swaps) are typically used as a reference asset to value expected cash flows on other securities. Hence, disruption to these markets can quickly transmit to others. More generally, pricing linkages occur through arbitrage activity, whereby investors seek to take

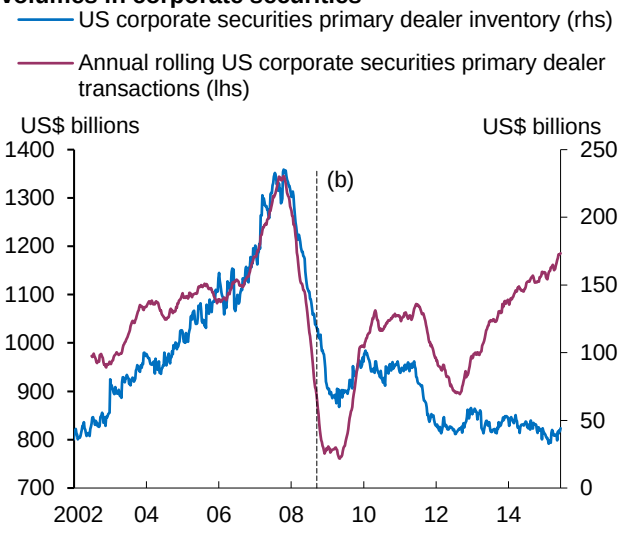
[37] Regarding industry standards, insurance companies and pension funds, for example, have similar liabilities that they seek to match with assets that have similar risk, maturity and cash profiles. Their investment decisions are further influenced by a handful of consultancy firms, and they face similar regulatory constraints. Regarding benchmarks, investment funds' mandates often include peer or industry-wide comparisons. Underperformance arising from deviating from such benchmarks, where it is allowed, could cause damage to franchises.
[38] See, for example, the discussion in the Markets and Operations section of the Bank of England 2014 Q1, *Quarterly Bulletin*, Vol. 54, No. 1.
[39] For example, Mohamed El-Erian wrote in the Financial Times on 5 October 2015 that '… a significant shift [in volatility] affects the methodology that anchors the 'neutral' asset allocations of many institutions'.
[40] See also the July 2015 *Financial Stability Report*, page 17.

**Chart 5 Correlated trading among equity and bond funds investing in EMEs[(a)]**




Source: IMF Global Financial Stability Report, April 2014.
(a) Measure calculated following Lakonishok, Shiefer and Vishny (1992). It assesses the strength of correlated trading among mutual funds investing in emerging markets, controlling for overall trends in their trading.

**Chart 6 US primary dealer inventories and transaction volumes in corporate securities[(a)]**




Sources: Federal Reserve Bank of New York and Bank calculations.
(a) Inventories measured as US primary dealer net positions in US corporate securities, which include corporate bonds and non-Agency RMBS and CMBS, with a remaining maturity of at least twelve months.
(b) Lehman Brothers files for Chapter 11 bankruptcy protection.

advantage of pricing discrepancies between securities with identical or similar payoff structures. Derivatives markets, for example, are closely linked to the underlying securities against which their payoffs depend, and hence can play an important role in price discovery. During times of stress, this can act as a stabiliser – for example, if price discovery in the derivatives market transmits back to the cash market, thereby ameliorating an initial disruption. But it can also act as a source of contagion – for example, if disruption in the cash market is transmitted to derivatives markets, and this in turn precipitates hedging activity in the underlying market.

A second class of linkages between markets is more behavioural in nature and arises from **capital and funding linkages**. In the case of capital, contagion between markets can arise when volatility in one market results in bank and non-bank companies being less willing and able to put capital at risk in other markets. This can undermine arbitrage activity, so that prices become detached across markets. Contagion can also spread when dislocations in some financial markets disrupt others via short-term funding arrangements. Cross-currency carry trades, whereby investors borrow short-term in a low-yielding currency to finance investments in a higher-yielding currency, are an important example here. A pull-back in short-term funding upon which other investors rely, for example in repo markets, is another.

A final source of cross-market contagion emanates from **collateral linkages.** As noted in **Box 3**, collateral eligibility can be a source of fragility for some markets, particularly in the event that eligibility is no longer maintained during times of stress. But margin calls against falling collateral values more generally, for example on repo transactions, can cause contagion if firms are forced to liquidate their investments in other financial assets in order to meet those calls. Derivative transactions can also lead to contagion via collateral linkages – for example, when volatility in cash markets leads to increased margin calls against derivative contracts. These calls could be exacerbated for highly-leveraged firms if their own counterparty risk rises in response to the initial disruption to markets.

### *Stabilisers*

*Stabilisers* are market dynamics that act to accommodate buying or selling pressure in response to an initial price move, thereby moderating the impact of that move. Similarly to amplifiers, the precise nature of such stabilisers is likely to depend on the structure of the market and the nature of the investors participating in it. The evolving structure of markets discussed in Section 2 touched upon a number of features of automated markets that can effectively act as mechanical stabilisers, providing a break on heavy buying or selling

## Box 4
**Linkages across markets**

### Pricing linkages
The sell-off in US Treasury and mortgage-backed securities (MBS) markets in 1994 provides an important historical example of the effects on broad market prices of a reinforcing cycle of pricing linkages, specifically reflecting **hedging demand and discounting effects**.[41]

In February 1994, the prospect of rising inflation led the Federal Open Market Committee (FOMC) to begin tightening monetary policy. The US yield curve steepened sharply, with ten-year yields eventually reaching a peak of just over 8% in November 1994. Developments in market interest rates partly reflected the structure of the US housing finance market – specifically, the importance of the MBS market. An investor in MBS has effectively sold each borrower in the underlying pool of (typically fixed-rate) mortgages that backs the security an implicit option to repay their debt early. As market yields rise, it is less likely that homeowners will choose to refinance their existing debts because it is more difficult for them to find cheaper deals. Lower pre-payment rates increase the expected average maturity of cash flows generated by such loan pools, increasing the duration of the MBS. In response, investors sought to maintain the average duration of their portfolios by selling US Treasuries further along the maturity spectrum, putting further upwards pressure on yields. Rising volatility and yields in US fixed income markets was accompanied by falling asset prices more broadly.

### Capital and funding linkages
The global financial crisis provides a number of important examples of generalised market stress having reduced the **willingness and ability of banks and non-bank companies to put capital at risk**. One such example[42] is the rapid drying-up of investor demand for structured financial instruments internationally as default losses on securities backed by US sub-prime mortgages began to accelerate in the second half of 2007, leading investors to doubt the credit ratings attached to such instruments generally and increase their demand for hedging.[43] Consistent with this, demand for residential mortgage backed securities (RMBS) in the United Kingdom fell sharply. Analysis at the time suggested that even under a severe scenario where UK mortgage arrears rose to around three quarters of their early 1990s peak, credit losses would have eroded only a fraction of AA-rated tranches and remained well below those required to erode AAA-rated tranches.

There have also been a large number of episodes historically where the unwinding of **fragile short-term funding arrangements** propagated and amplified stress across markets. One such example is the 1997-98 Asian financial crisis in which a number of countries experienced rapid capital outflows as perceptions of risk in local investment assets increased, putting pressure on exchange rates that were pegged to the US dollar. And in 2007 Q3, crowded positions that had built up in yen-funded cross-currency carry trades were abruptly unwound as risk sentiment among investors began to turn, leading to a sharp appreciation of the yen and volatility in associated exchange rates with knock-on effects on other asset prices.[44]

### Collateral linkages
As described in the Bank's Open Forum document,[45] the tensions that arose in securities financing markets during 2007-08 as uncertainty grew about the creditworthiness of structured products that had been used as high-quality collateral to secure funding, including outside the banking system, triggered pernicious spirals of rising margins, declining liquidity and falling asset prices. Since the crisis, the FSB has agreed numerical haircut floors for non-centrally cleared securities financing transactions where non-banks receive financing from other companies – as a backstop measure, over and above market discipline, to truncate the leverage available to them against non-government collateral. The FSB has also agreed methodological standards

[41] See, for example, Box 1 from the December 2010 *Financial Stability Report*.
[42] See Box 1 from the October 2008 *Financial Stability Report*.
[43] Going into the crisis, the ABX credit default swap index had become a widely used hedging tool and barometer of valuations for different tranches of securitisations backed by US sub-prime mortgages. For a time, the ABX index was used as proxy hedging tool for non-US mortgage-backed exposures.
[44] See, for example, the October 2007 *Financial Stability Report*.
[45] See www.bankofengland.co.uk/markets/Pages/openforum.aspx.

for how market haircuts should be set.[46] Some policymakers have recently suggested that it would be useful to consider the possible role of countercyclical macroprudential tools in this area.[47]

Reforms to the OTC derivatives market since the crisis have also sought to alleviate risks from destabilising margin dynamics, which could otherwise prompt investors to sell assets simultaneously in a stress. For example, the Bank for International Settlements' Macroeconomic Assessment Group on Derivatives (MAGD)[48] found in August 2013 that exposures and hence margins would be dramatically reduced by the move towards central clearing and the associated multilateral netting. It is important that these benefits are not offset by undue procyclicality in CCPs' approaches to setting margin requirements. In this respect, some researchers have suggested that greater disclosure about the relevant properties of CCPs' margin models could help derivative users anticipate, and hence prepare for, potential margin calls.[49] Although some less standardised derivatives remain non-centrally cleared and are concentrated in a handful of large dealers, a very large pick-up in interest rate volatility would be required to provoke disruptively large margin calls. Most jurisdictions are in the early stages of adopting margin requirements for non-centrally cleared derivatives, which will be phased-in between September 2016 and 2019.[50]

pressure when it occurs. The obvious examples here are **circuit breakers**, which are specifically designed to attenuate destabilising momentum in prices. These can take many forms but they are most common in centralised markets and often involve pauses in trading when certain conditions are met, such as when prices move beyond a pre-defined limit within a given period. Another potential break to buying or selling pressure can materialise from **limit orders**, which may have been placed by investors to benefit from selling or buying demand for assets at low or high prices. These orders are most likely to be prevalent in fast-moving markets or unlit pools of liquidity such as dark pools.

Behavioural responses are linked primarily to the diversity of the investor base in a particular asset. A more diverse investor base can stabilise markets by increasing the likelihood that a buyer appears when an existing owner wants to sell, and *vice versa*. **Diversity of belief and investment horizon** is especially important as a counteracting influence to correlated and consensus trades. Such diversity arises when investors interpret information differently or act on it over different timescales.[51] For example, price falls of a given size are likely to be perceived as more important sell signals by investors trading at higher frequencies than by buy-and-hold investors. Equally, investors trading at high frequency and looking to take directional risk may be more willing to return to the market following a much larger price shock that prompts buy-and-hold investors to sell. Other things being equal, the presence of both types of investor might therefore be expected to be more stabilising than if a market is dominated by one type alone.

Another potentially powerful stabiliser resides in the **ability and willingness of investors to demand assets in a falling market**, and *vice versa*. Over short-term horizons, this role has traditionally been assumed by dealers in some markets – who can moderate momentum in markets by building up and releasing inventories as overall supply and demand for securities in the secondary market vary.

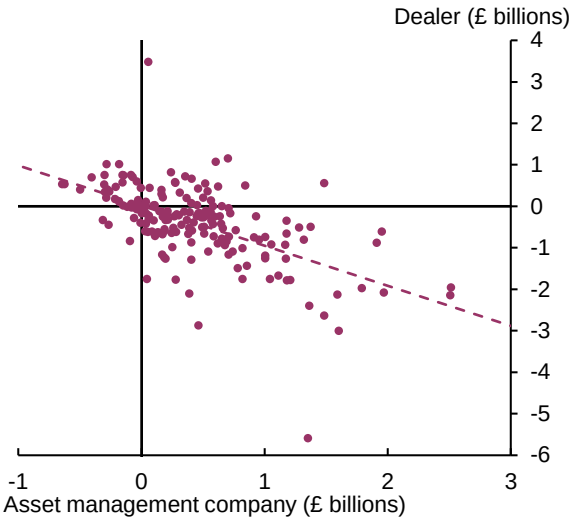
- Evidence over the period since October 2011 confirms that dealers have continued to accommodate near-term demand to trade sterling-denominated corporate bonds from other institutional sectors, particularly asset management companies (**Chart 7**), which have often been net sellers of such securities when prices have fallen, and *vice versa*. Few sectors other than dealers have reliably acted counter-cyclically and in material size over that period, though in principle, proprietary risk-takers like hedge funds could choose to step into falling markets if prices became clearly detached from fundamentals – provided they did not face funding or risk management constraints.

[46] See the regulatory framework document published by the FSB in October 2014, www.financialstabilityboard.org/wp-content/uploads/r_141013a.pdf.
[47] See, for example, the written evidence provided to the Treasury Committee by Alex Brazier in March 2015 available at www.bankofengland.co.uk.
[48] MAGD was a BIS-led study (available from www.bis.org) to assess the macroeconomic costs and benefits arising from OTC derivative reform. The main benefit identified was a sharp reduction in the potential transmission of counterparty credit risks through the system, arising in large part from the benefits of multilateral netting through greater central clearing of derivatives.
[49] Murphy, D, Vasios, M and Vause, N (2014), 'An investigation into the procyclicality of risk-based initial margin models', *Bank of England Financial Stability Paper*, No. 29.
[50] See Financial Stability Board (2015), 'FSB Chair's letter to G20 on financial reforms – progress on the work plan for the Antalya summit', October.
[51] See Anderson, N and Noss, J (2013), 'The Fractal Market Hypothesis and its implications for the stability of financial markets', *Bank of England Financial Stability Paper*, No. 23.

- There does, however, appear to have been a clear change in dealers' behaviour since before the global financial crisis. As noted earlier in this section, their inventories have become less responsive to disposals of US dollar-denominated corporate bonds by asset management companies (**Chart 4**, blue). Consistent with this, spreads on such bonds have become more responsive (maroon).[52]

Over longer-term horizons, work published by the Bank of England in 2014[53] found some evidence of procyclical investment behaviour by insurance companies in the United Kingdom and internationally. The evidence for pension funds was mixed, though there is some academic evidence to suggest that defined benefit pension funds have acted counter-cyclically in the past,[54] perhaps reflecting the need for trustees to meet before material changes in investment allocation can be made. Many defined benefit pension funds have in place triggers that would prompt them to rebalance their portfolios towards fixed income securities from equities if rising long-term market interest rates were to reduce their deficits sufficiently. Sovereign wealth funds could, in principle, also act as stabilisers over the longer-term, though this may be compromised by a broad trend towards market valuation and performance metrics.

**Chart 7 Net purchases of sterling-denominated corporate bonds by asset management companies and dealers[(a)(b)]**




Sources: Financial Conduct Authority and Bank calculations.
(a) FCA-regulated reporting entities transacting in sterling-denominated corporate bonds of all credit ratings issued by UK and foreign companies. Data from October 2011 to March 2015.
(b) Controlling for gross primary corporate bond issuance.

## Outlook for market resilience

It is not difficult to envisage a range of risks threatening the functioning of financial markets – even in those that are typically viewed as being reliably liquid. The financial system is constantly innovating, which brings benefits for borrowers and investors, but such innovation can also bring with it greater vulnerabilities. The behaviour of all participants in the market is key – from retail investors in mutual funds, to investors following procyclical strategies, to professional market makers and other intermediaries. Among these participants, some will tend to amplify volatility in financial markets and others will tend to stabilise it. Moreover, global financial markets are highly interconnected, which means that there are various mechanisms for transmitting shocks from one to another.

The likelihood of risks crystallising, particularly in combination, may be relatively low. That said, the sheer complexity of the financial system means it is impossible to assess with any confidence when a shock that increases volatility, for example, is likely to transform into an event where market liquidity is materially impaired and when it is not. The experience of the global financial crisis is informative in this regard. It is important that authorities and market participants act to reduce key vulnerabilities where possible in ways that do not unnecessarily impair the functioning of the financial system. Procyclicality is an obvious area where incentives should be considered carefully. It is in this spirit that authorities internationally are examining in detail the risks arising from the mutual fund industry.

However, it is also important to maintain some perspective, recognising that markets need not only to be Resilient but also Effective. This means that financial innovation must be allowed to flourish, in order that markets can best serve the needs of the real economy. Financial intermediation, by definition, creates a

[52] See also Baranova, Y, Chen, L and Vause, N (2015), 'Has corporate bond market liquidity fallen?', *Bank of England Bank Underground*, 27 August. This is qualitatively consistent with recent findings described in the IMF's April 2015 *Global Financial Stability Report* that mutual fund flows affect market prices.
[53] See the paper published in July 2014 by the Bank of England and the Procyclicality Working Group, chaired by Andy Haldane, available from www.bankofengland.co.uk.
[54] See, for example, Blake, D, Sarno, L and Zinna, G (2014), 'The market for lemmings: is the investment behaviour of pension funds stabilizing or destabilizing?', *Pensions Institute Discussion Paper*, PI-1408.

certain degree of liquidity risk as it seeks to match borrowers wishing to finance long-term investments with investors seeking the ability to redeem their investments. Hence, it will never be possible, or desirable, to eliminate all sources of risk to market liquidity. But vigilance is required, and lessons from experience should be taken seriously, which is the subject of the following section.

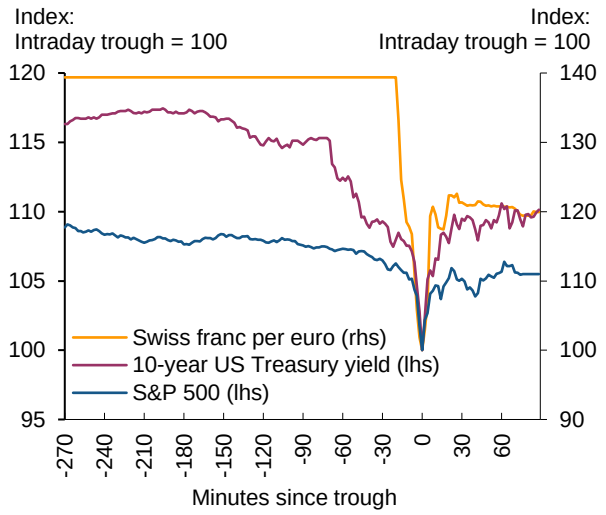
## 4 Lessons from recent episodes of heightened volatility

There have been a number of episodes of volatility associated with short-term illiquidity over the past few years that may shed light on how the evolving structure of markets (Section 2) may combine with risks (Section 3) to threaten the overall Effectiveness of markets. While these episodes have generally proved to be short-lived and without immediate consequences for financial stability, they are nevertheless instructive in illuminating the liquidity characteristics of different assets and the fragility of different market structures. As such, they offer some indication as to the potential risks to market liquidity. In the following, recent episodes are ordered according to the degree to which they represented disruptions in individual markets versus spreading to other markets. In each case, the key amplifiers and linkages are described along with a description of how each episode was stabilised. **Table 3** summarises these episodes along the dimensions outlined in Sections 2 and 3.

### The Swiss franc: a disruption to critical trading infrastructure

The removal of the SNB's peg of the Swiss franc to the euro on 15 January 2015 had not been anticipated by market participants and so, in that sense, the rapid adjustment that followed was not surprising. But what was revealing was the amplifying impact of a temporary disruption to the critical trading infrastructure on which Swiss franc trading relies. Several banks suffered from 'latency problems', meaning that pricing on their electronic platforms could not keep up with the pace of market developments. And a number of major automatic trading platforms tripped built-in circuit breakers or were manually suspended from streaming prices in the period immediately after the announcement – contributing to uncertainty and prompting further disorderly flows. While the severe illiquidity was short-lived, the greater dependency of the market on automated pricing facilitated sharp price movements. These moves were partially unwound by the end of the day (**Chart 8**, orange), beginning when market users reverted to more traditional transaction methods such as voice trading. Spillovers were largely confined – there was short-term panic across all Swiss exchange rates, money and equity markets, but effects on broader currency and fixed income markets were limited.[55]

**Chart 8 Intraday movements in selected asset prices from the recent past[(a)]**




Source: Bloomberg.
(a) Shows the flash-crash in US equity markets on 6 May 2010 (blue), the flash-rally in the US Treasury market on 15 October 2014 (maroon) and the removal of the Swiss franc peg to the euro on 15 January 2015 (orange).

**A lesson from this episode is that weaknesses in trading infrastructure that become exposed in stressed circumstances can impede market access, exaggerate market moves and undermine confidence among investors.**

### Government bonds: procyclical trading strategies and limited capital to put at risk

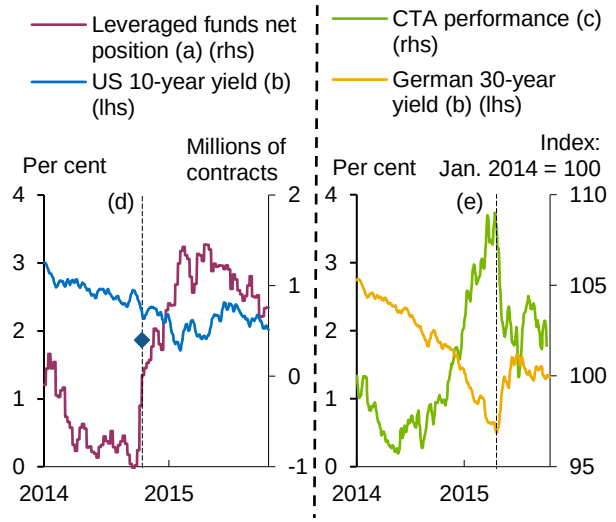
On 15 October 2014, yields on ten-year US Treasury bonds fell by around 30 basis points within an hour and a half, before retracing most of their moves by the end of the day (**Chart 8**, maroon).[56] The episode was

[55] See also: the Markets and Operations section of the Bank of England 2015 Q1 *Quarterly Bulletin*, pages 79-80; and the FEMR final report, Box 6.
[56] There have been a number of recent studies, including: the Joint Staff Report published by the US authorities on 13 July 2015; and Bouveret, A, Breuer, P, Chen, Y, Jones, D and Sasaki, T (2015), 'Fragilities in the US Treasury market: lessons from the flash rally of October 15, 2014', *International Monetary Fund Working Paper*, No. 15/222.

precipitated by a handful of moderately poor data releases that led to a reappraisal by investors as to when US monetary policy might be tightened, causing them to seek to unwind simultaneously what had become crowded short positions, including by some leveraged investors in the futures market (**Chart 9**, left panel). Although no single large trade triggered the sharp fall in yields, market depth immediately prior to the event was low.

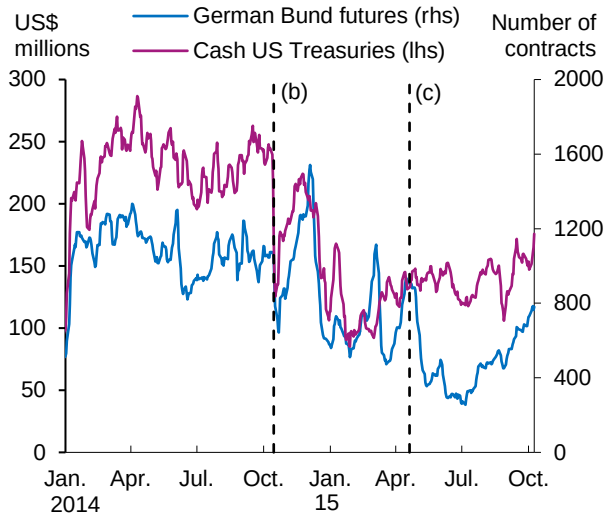
Amid the emerging volatility, PTFs withdrew some limit orders and traditional broker-dealers changed the terms of their market making, including by widening bid-offer spreads and withdrawing from selling into the rising market – which likely contributed to a further decline in market depth, including in the cash market (**Chart 10**, maroon). Some such participants reportedly bought into the rising market for various reasons,[57] boosting volumes and exacerbating moves. The reasons for this likely included: to unwind short positions that they had initially built up from market making activity as prices began to rise; as part of deliberate momentum-following strategies; and to hedge positions predicated on continued low volatility. Throughout the event, prices in the cash and futures market tracked each other closely via arbitrage pricing linkages.

**Chart 9 Developments in US and German government bond markets since 2014**




Sources: Bloomberg, Hedge Fund Research and Bank calculations.
(a) Series show net positioning of the CFTC 'leveraged funds' commitment of traders reporting category aggregated across the three-month Eurodollar and 2, 5, 10 and 30-year US Treasury futures contracts.
(b) One-week moving average.
(c) HFRX Macro: Systemic Diversified CTA Index, shown as a one-week moving average.
(d) 15 October 2014 'flash rally' in US Treasuries. Blue diamond shows the intraday trough in the 10-year yield.
(e) 20 April 2015: start of rise in German government bond yields.

**Chart 10 Market depth in US Treasuries and German Bunds[(a)]**




Source: JPMorgan.
(a) One-week rolling average of the volume available to transact at the three best bid and ask prices, averaged daily. US and German series refer to the benchmark 10-year government bond in cash and futures markets respectively.
(b) 15 October 2014 'flash rally' in US Treasuries.
(c) 20 April 2015: start of protracted rise in German Bund yields.

The abrupt fall in US Treasury yields was ultimately arrested as remaining limit orders to sell in both the cash and futures market came into view on central limit order books as prices rose. In the event, given that prices fell back, most such orders resting away from the mid-market price were not executed. Despite the sharp increase in volatility, market safeguards in the futures market did not halt trading because prices continued to move in small increments.[58]

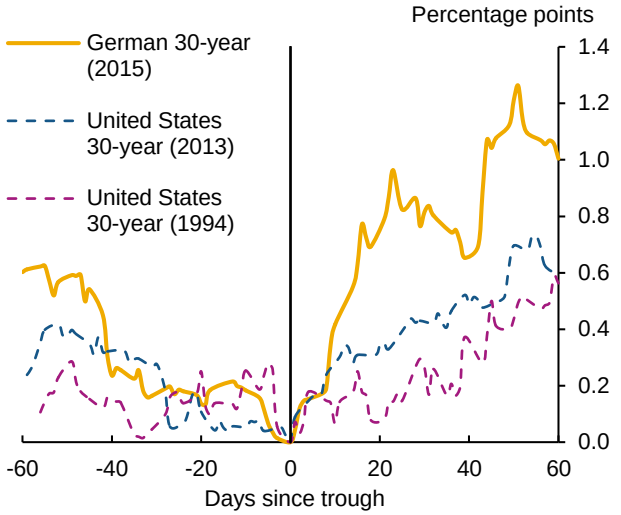
US Treasuries are a major source of collateral. Had these moves occurred at the end of the day and been widely reflected in margin requirements against repo or derivative transactions, and particularly if the crowded trades had been in the other direction leading to price falls rather than rises, the market disruption could have been more widespread with more persistent effects. Even still, there were temporary spillovers to

[57] The fall in *yields* meant that *prices* rose. Market participants therefore often refer to the event as a 'flash-rally'.
[58] At the time, the relevant market safeguards in place on the CME for interest rate futures would have only halted trading in response to large movements in prices in either direction in a very short space of time or as a result of one large stop order. Such safeguards have been employed on several occasions over the past few years, typically in response to important US data releases. In December 2014, the CME introduced additional measures in a number of markets, including interest rate futures.

the following day – risky asset prices fell internationally, yields on euro area government bonds widened relative to German Bunds and various metrics of liquidity stress ticked up.[59]

Between April and June 2015, German Bund yields rose sharply and more quickly than those in some other major government bond markets. While market participants partly viewed the rise in Bund yields as a correction to a surprisingly large fall that occurred in 2015 Q1, it was likely amplified by: (i) the unwinding of crowded trades in both the cash and futures market that had built up in anticipation of asset purchases by the ECB; and (ii) selling by automated, trend-following investors in the futures market, including commodity trading advisers (CTAs)[60] and investors targeting risk-based metrics, as recent cumulative returns unwound (**Chart 9**, right panel). Long-dated Bund yields rose most sharply, reportedly reflecting the large volume of positions being unwound in the 30-year futures contract. The moves were exacerbated by the increase in yields on shorter-dated bonds, which rose above the ECB's deposit rate floor and hence brought them into scope for asset purchases.[61] Eurex, on which Bund futures are traded, saw a pickup in volumes against declining market depth (**Chart 10**, blue).

**Chart 11 Selected historical examples of cumulative changes in 30-year government bond yields[(a)]**




Sources: Bloomberg and Bank calculations.
(a) Series show difference in percentage points from lowest value over the relevant period. Troughs are on 10 January 1994 (maroon), 2 May 2013 (blue) and 20 April 2015 (orange).

The rise in yields was larger than that seen in previous sell-offs in long-dated government bonds (**Chart 11**). It was ultimately arrested by the gradual re-emergence of demand for Bunds across a number of investors.[62]

**A lesson from these episodes is that consensus views among investors can jeopardise market liquidity if there is a rush to exit commonly held positions. The reliability of non-bank market makers in such circumstances can be uncertain.**

### Equity markets and derivatives: pricing linkages and circuit breakers

There are a number of examples since the global financial crisis of dynamics in equity derivative markets affecting conditions in cash markets and *vice versa*.

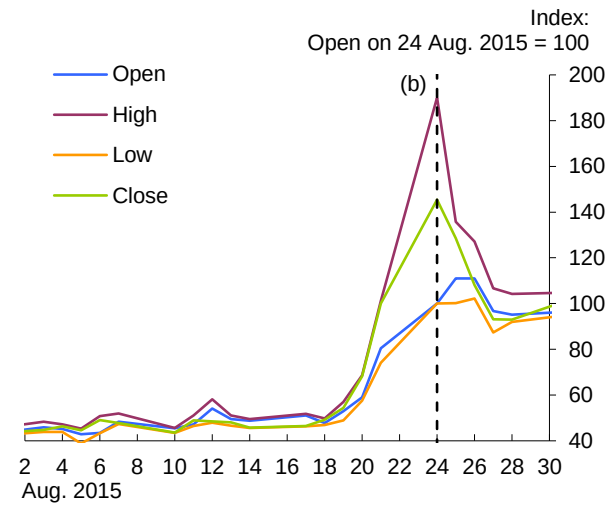
On 6 May 2010, trading in the S&P500 E-mini futures contract on the CME became temporarily dominated by PTFs seeking to offload positions simultaneously that they had absorbed moments earlier in response to an unusually large programme of sales originated by a mutual fund. At the same time, some participants stepped back from market making, including other PTFs and traditional broker-dealers. This resulted in a sharp downward spiral in prices that was amplified by the same mutual fund automatically increasing its sell orders as trading volumes rose.[63] Cash equity prices tracked down in tandem (**Chart 8**, blue) through arbitrage activity. The fall in prices was arrested by an automatic five second pause in trading before a series of stop-loss orders could be triggered that would have otherwise exacerbated the acute downward

[59] For example, Libor-OIS spreads and cross-currency basis swap spreads.
[60] CTAs are a classification of company from US regulation that provide advice or services related to futures trading, including hedge funds. The term does not necessarily refer to firms trading commodities.
[61] The ECB had said it would avoid buying bonds as part of its asset purchase programme with yields below the rate on its deposit facility. As Bund yields fell generally during 2015 Q1, an increasing proportion of shorter-dated bond yields fell below this level, generating an expectation among investors that purchases would move further along the maturity spectrum, putting further downward pressure on long-term yields. This dynamic went into reverse.
[62] Demand from insurance companies and pension funds was reportedly weak during this episode because, even following the rise in Bund yields, they remained insufficiently attractive relative to their fixed liabilities.
[63] This finding – that PTFs contributed to the perniciousness of the 2010 flash crash by demanding immediacy of trading ahead of other investors – is examined extensively in Kirilenko, A, Kyle, A, Samadi, M and Tuzan, T (2014), 'The flash crash: The impact of high frequency trading on an electronic market', available from www.cftc.gov.

pressure. This so-called 'stop logic' functionality built into the CME's Globex trading system reduced the immediacy with which participants were able to transact, restoring more orderly pricing.[64]

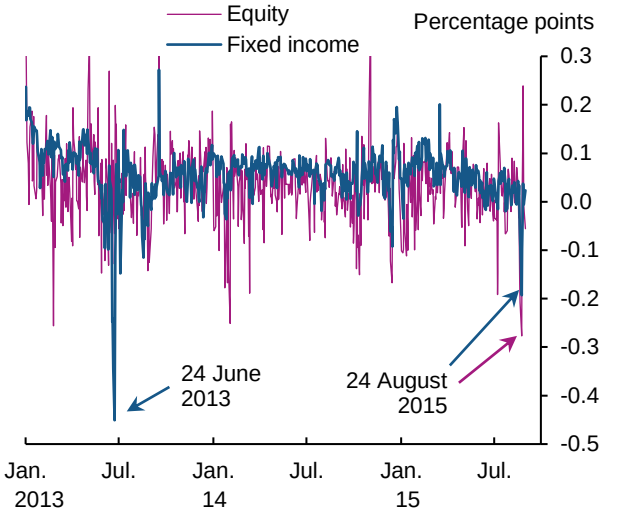
During the summer of 2015, equity markets exhibited considerable volatility internationally, particularly on 24 August, against the backdrop of concerns among market participants about a possible slowdown in economic growth in China. In overnight trading on 23 August, US equity futures prices fell and hit their so-called 'limit down' of 5%, at which point trading is halted. This created uncertainty about the price at which cash US equities would open in New York the next morning (in the event, also initially around 5% lower), leading to high short-term volatility and poor price discovery. A consequence of this was that fewer than half of S&P500 equities were open for normal trading on the NYSE until around 9:36am on 24 August. This had knock-on consequences for other derivative markets. Option-implied equity volatility spiked (**Chart 12**) to its highest level since 2009. And market makers became less able to take advantage of arbitrage opportunities between the shares issued by equity ETFs and the assets they track, leading to large discounts relative to net asset values (**Chart 13**, maroon).[65] Orderly conditions re-emerged as more equities opened for normal trading,[66] contrarian investors re-entered the market and intermediaries were again able to undertake arbitrage activity between equities and related securities.

**Chart 12 S&P500 option-implied volatility during August 2015**[(a)]




Source: Bloomberg.
(a) VIX index, which measures market expectations of 30-day volatility as conveyed by S&P500 index option prices.
(b) 24 August 2015.

**Chart 13 Deviations from net asset values in equity and fixed income ETF markets**[(a)]




Sources: Bloomberg and Bank calculations.
(a) Average across the 50 largest equity and fixed income ETFs globally by assets.

**Lessons from these episodes are threefold. Investor behaviour that distorts prices in one market can be rapidly transmitted to others via arbitrage activity, including between derivative and cash markets. In other circumstances, the absence of arbitrage activity can lead to large pricing anomalies, reinforcing uncertainty among investors. And while the use of circuit breakers can forestall disruption in the market to which they are applied, they can have adverse knock-on consequences.**

## Fixed income and currency markets: capital and funding linkages

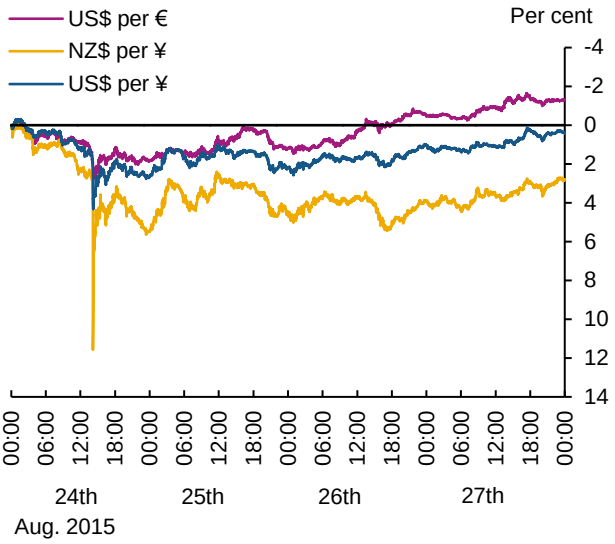
The volatility in equity markets on 24 August 2015 quickly spread to other markets via a number of channels, including bank and non-bank market intermediaries being less able or willing to put capital at risk. The apparent weakening of the arbitrage relationship between fixed income ETFs and the prices of the securities

[64] See also the Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues published on 19 May 2010 available at www.sec.gov.
[65] The prices of some individual ETFs fell very sharply in early morning trade on 24 August 2015, in some cases by up to 50%, far outstripping the falls in the assets they tracked.
[66] All S&P500 equities were open for trading on the NYSE by 10:00am.

they track, leading to large discounts relative to net asset values (**Chart 13**, blue), is indicative of this effect – unwinding as equity market volatility subsided.

Alongside these developments, there was a sharp fall in net speculative positions in the euro and the yen, which had been used to finance cross-currency carry trades. The resulting depreciation in the US dollar versus the yen was pronounced, which market contacts suggest was amplified by investors mechanically unwinding positions as they hit stop-loss limits. Exchange rates involving the New Zealand dollar were also strongly affected (**Chart 14**) because New Zealand dollar-denominated assets had been popular investments in carry trade strategies. These developments were associated with high volumes, though depth away from mid-market prices quickly declined as demand for transactions became increasingly one-sided. For example, liquidity via electronic platforms rapidly disappeared as market makers withdrew. And speculative investors were reportedly unwilling to step in, in some instances because they were unable to given the scale of the movements in prices and in others because they were unwilling to put capital at risk having borne losses from other unanticipated currency movements in the recent past.

**Chart 14 Intraday movements in selected foreign exchange rates[(a)]**




Sources: Bloomberg and Bank calculations.
(a) Intraday data using one minute intervals, showing cumulative changes since midnight on 24 August 2015. All times are in UCT.

During the so-called 'taper tantrum' in summer 2013, uncertainty about the outlook for US monetary policy caused significant volatility and illiquidity in some fixed income markets. Amongst other developments, liquidity in fixed income ETF markets deteriorated as banks and non-bank intermediaries became less willing to put their capital at risk, leading to unusually large discounts to net asset values (**Chart 13**, blue).

**A lesson from these episodes is that bank and non-bank companies' ability and willingness to put capital at risk as principal in the face of large-scale order flow imbalances has changed. Market participants should factor these changes into their investment decisions.**

## 5 Conclusions

Over recent years, financial markets have been affected by a number of structural changes. A process of continuous innovation has generated a broad trend towards fast, electronic trading. And necessary regulation implemented in response to the global financial crisis to ensure the safety and soundness of core intermediaries upon which the financial system relies has discouraged them from some activities in financial markets, including market making as principal – though some important trends pre-date the emergence of the new regulatory regime and may reflect their changing attitudes towards risk-taking. Indeed, it is clear that market liquidity and other risks were under-appreciated prior to the global financial crisis. These developments, alongside bursts of volatility associated with short-term illiquidity in a number of financial markets over the past few years, have led to concerns that market liquidity may have become more fragile.

Short-term episodes of volatility and illiquidity are not necessarily in themselves threats to financial stability. But it is important to understand the causes of such events to help identify the ways in which they could persist, become amplified and spill over to other markets. These eventualities could undermine the overall Effectiveness of markets, to the detriment of economic growth and stability, by tripping mechanisms that lead to broader contagion, affecting conditions in primary markets, and/or discouraging participation in financial markets generally, undermining pricing efficiency and risk transfer.

No market can be guaranteed to be perfectly liquid. It is important therefore that the liquidity characteristics of different financial assets are well understood and priced accordingly, including where they may have changed over the past few years. **Overall, the 'normal' level of liquidity in markets that are less reliant on core intermediaries putting capital at risk to facilitate transactions between investors appears to have increased – but in some cases, to the possible detriment of resilience. In contrast, the 'normal' level of liquidity in markets that are more reliant on core intermediaries being willing and able to warehouse risk appears to have fallen – but with a likely increase in the resilience of those markets via the resilience of the core intermediaries themselves**. This is consistent with the observation that recent episodes of volatility and illiquidity in financial markets – including those involving the Swiss franc, US Treasuries, German Bunds, equities and ETFs – have centred on fast, electronic markets, including exchange-traded venues. Although the particular triggers and factors at play in each event have differed, often materially, there are common lessons that can be drawn out:

- Weaknesses in trading infrastructure that become exposed in stressed circumstances can impede market access, exaggerate market moves and undermine confidence among investors.
- Consensus views among investors can jeopardise market liquidity if there is a rush to exit commonly held positions. The reliability of non-bank market makers in such circumstances can be uncertain.
- Investor behaviour that distorts prices in one market can be rapidly transmitted to others via arbitrage activity. In other circumstances, the absence of arbitrage activity can lead to large pricing anomalies, reinforcing uncertainty among investors. And while the use of circuit breakers can forestall disruption in the market to which they are applied, they can have adverse knock-on consequences.
- Bank and non-bank companies' ability and willingness to put capital at risk as principal in the face of large-scale order flow imbalances has changed. Market participants should factor these changes into their investment decisions.

So far, none of the post-crisis episodes of heightened volatility and short-term illiquidity have originated in predominantly dealer-intermediated markets, but that is not in itself a cause for comfort. For example, the resilience of corporate bond market liquidity could be tested in the event of a large order flow imbalance arising through selling pressure from funds offering investors short-term redemptions.

It is uncertain how the structure of financial markets will evolve, though market participants expect that increased balance sheet costs will likely encourage banks to continue to pull back from market making in fixed income and currency markets, providing opportunities for non-bank firms to step in. Alongside this, the broad trend towards fast, electronic trading looks likely to continue. That said, the inherent liquidity characteristics of some financial assets, such as corporate bonds, are naturally suited to dealers and other companies temporarily putting capital at risk to facilitate transactions between investors. In such markets, the development of direct electronic trading approaches between investors that do not rely on intermediaries putting capital at risk might best be seen as complements rather than substitutes.

Further investigation is warranted as market structure evolves, including to understand risks in dealer-intermediated markets that have not yet crystallised. Particular areas, as highlighted in this paper, might be to better understand:

- How well investors understand and price the liquidity risk of the assets in which they are invested;
- The constraints and incentives faced by traditional dealers to act as principal to facilitate transactions;
- How key types of principal trading firm might react in different market conditions, with a view to identifying the circumstances under which they could amplify and stabilise movements in prices; and
- The role of circuit breakers in financial markets and the circumstances under which they can contribute to cross-market contagion.

**Table 3 Key features of selected episodes of volatility and illiquidity in financial markets**

| Episode | | Trigger | Amplifiers and linkages | | Stabilisers |
|---|---|---|---|---|---|
| Post-crisis | **Swiss franc**<br>15 Jan. 2015<br><br>*Fundamental economic news led to over-shooting in prices* | Removal of the peg of the Swiss franc to the euro | Critical trading infrastructure | Latency problems meant that pricing on several banks' electronic platforms could not keep up with the pace of market developments. A number of major automatic trading platforms tripped built-in circuit breakers or were manually suspended from streaming prices in the period immediately after the announcement. | Market users reverted to more traditional transaction methods such as voice trading. |
| | **US Treasuries**<br>15 Oct. 2014<br><br>*Modest economic news exposed crowded positions* | Handful of moderately poor data releases | Procyclical trading strategies and limited capital to put at risk | Unwind of crowded short positions, exacerbated by PTFs withdrawing some limit orders and traditional broker-dealers widening bid-offer spreads and withdrawing from selling into the rising market – contributing to a decline in market depth. | Participants entered sell orders near market prices as remaining limit orders to sell came into view. Limit orders resting far above the pre-rally mid-market price were ultimately not executed. Market safeguards in the futures market were not tripped. |
| | **German Bunds**<br>Apr. 2015<br><br>*Little economic news led to a persistent sell-off* | Little economic news, but against the backdrop of a previous fall in yields | | Rise in German Bund yields likely amplified by: (i) the unwinding of crowded trades in the cash and futures market that had built up in anticipation of asset purchases by the ECB; and (ii) selling by automated, trend-following investors in the futures market. | Gradual re-emergence of demand for German Bunds across a number of investors. |
| | **S&P500 flash crash**<br>6 May 2010<br><br>*Single investor tripped PTF-driven spike down in prices* | Unusually large programme of sales by a mutual fund | Pricing links and circuit breakers | Trading in the S&P E-Mini futures contract on CME became temporarily dominated by PTFs seeking to offload positions simultaneously after absorbing initial selling pressure. Contagion spread to the cash market via arbitrage activity. | Five second pause in Globex trading system. |
| | **Equities, ETFs**<br>24 Aug. 2015<br><br>*Adverse interaction between deteriorating risk sentiment and circuit breakers across markets* | Halt in trading in US futures before the cash market opened | | In overnight trading on 23 August, US equity futures prices fell to their 'limit down' of 5%, at which point trading was halted – creating uncertainty about the price at which cash US equities would open in New York the next morning, leading to high short-term volatility. The NYSE suspended trading in more than half of stocks within the first ten minutes of trading. Large discounts to NAV arose for some equity ETFs as market makers were less able to undertake arbitrage activity. | All S&P500 equities were open for trading on the NYSE by 10:00am. Contrarian PTFs re-entered the market. Intermediaries were again able to arbitrage between cash equity and ETF markets, closing discounts to NAV. |
| | | | Capital and funding links | Bank and non-bank intermediaries became less willing to put their capital at risk in other markets, leading to discounts to NAV in the fixed income ETF market through a weakening of the forces of arbitrage. And investors unwound carry trades funded in yen and euro, leading to sharp intraday appreciations in those currencies. | The fall back in volatility and disruption in equity markets encouraged short-term market participants to again take risk in other markets. |
| | **Taper tantrum**<br>From 21 May 2013<br><br>*Uncertainty about the path of US monetary policy led to volatility and illiquidity in some fixed income markets* | News from the FOMC | Capital and funding links | Increases in government bond yields led to broad-based falls in the prices of other assets, including through discounting effects. Amongst other developments, fixed income ETFs saw reduced liquidity, with occasionally large discounts to NAV, as bank and non-bank intermediaries became less willing to put their capital at risk. Cross-currency carry trades were rapidly unwound. | Uncertainty about the FOMC's reaction function fell back following its Statement on 18 September 2013.[a] |
| Crisis and pre-crisis | **MBS hedging**[b]<br>1994<br><br>*Movements in market interest rates amplified by hedging dynamics* | | Pricing links | FOMC tightened US policy interest rates more quickly than market participants had expected, beginning in February 1994, putting upwards pressure on US Treasury yields that was amplified by MBS investors hedging the duration of their portfolios by selling US Treasury bonds further up the maturity spectrum.[c] | Broad demand for US Treasuries eventually emerged as prices fell, despite Community Bankers US Government Fund breaking the buck and Orange County filing for bankruptcy protection. |
| | **Dislocation in securitisation markets and run on ABCP vehicles**<br>2008<br><br>*Demand to hedge sub-prime securitisations and doubts about credit ratings led to acute funding problems* | Concerns about possible credit losses for securitisations backed by US sub-prime mortgages | | One-sided demand for hedging via the ABX exacerbated falls in market prices. Confidence in credit ratings for other securitised products was undermined, leading to a collapse in investor demand across other securitisation markets. | Unprecedented policy support by authorities internationally, including capital injections, funding liquidity support and guarantees of liabilities across banks and some non-banks. |
| | | | Capital and funding links | Sharp falls in investors' willingness and ability to: (i) put capital at risk in securitisation markets where credit risk very likely remained low; and (ii) roll funding to ABCP vehicles. | |

Source: Bank of England.
(a) The 18 September 2013 FOMC Statement said that '… purchases are not on a preset course, and the Committee's decisions about their pace will remain contingent on the Committee's economic outlook …'
(b) See also the December 2010 *Financial Stability Report*.
(c) See also the description in Box 4.

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