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Annual Economic Report

June 2018

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Conventions used in the Annual Economic Report

$	US dollar unless specified otherwise
mn	million
bn	billion (thousand million)
trn	trillion (thousand billion)
% pts	percentage points
bp	basis points
lhs, rhs	left-hand scale, right-hand scale
sa	seasonally adjusted
yoy	year on year
qoq	quarter on quarter
...	not available
.	not applicable
–	nil or negligible

Components may not sum to totals because of rounding.

The term "country" as used in this publication also covers territorial entities that are not states as understood by international law and practice but for which data are separately and independently maintained.

Country codes

AE	United Arab Emirates	FR	France	NL	Netherlands
AO	Angola	GB	United Kingdom	NO	Norway
AR	Argentina	GR	Greece	NZ	New Zealand
AT	Austria	HK	Hong Kong SAR	PA	Panama
AU	Australia	HR	Croatia	PE	Peru
BA	Bosnia and Herzegovina	HU	Hungary	PH	Philippines
		ID	Indonesia	PK	Pakistan
BE	Belgium	IE	Ireland	PL	Poland
BG	Bulgaria	IL	Israel	PT	Portugal
BR	Brazil	IN	India	QA	Qatar
CA	Canada	IS	Iceland	RO	Romania
CH	Switzerland	IT	Italy	RU	Russia
CL	Chile	JP	Japan	RS	Republic of Serbia
CN	China	KR	Korea	SA	Saudi Arabia
CO	Colombia	KW	Kuwait	SE	Sweden
CY	Republic of Cyprus	KZ	Kazakhstan	SG	Singapore
CZ	Czech Republic	LT	Lithuania	SI	Slovenia
DE	Germany	LU	Luxembourg	SK	Slovakia
DK	Denmark	LV	Latvia	TH	Thailand
DZ	Algeria	LY	Libya	TR	Turkey
EA	euro area	MK	Macedonia, FYR	TW	Chinese Taipei
EE	Estonia	MT	Malta	US	United States
ES	Spain	MX	Mexico	VE	Venezuela
EU	European Union	MY	Malaysia	VN	Vietnam
FI	Finland	NG	Nigeria	ZA	South Africa

Currency codes

AUD	Australian dollar	EUR	euro	JPY	Japanese yen
CHF	Swiss franc	GBP	pound sterling	USD	US dollar

Advanced economies (AEs): Australia, Canada, Denmark, the euro area, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom and the United States.

Major AEs (G3): The euro area, Japan and the United States.

Other AEs: Australia, Canada, Denmark, New Zealand, Norway, Sweden, Switzerland and the United Kingdom.

Emerging market economies (EMEs): Argentina, Brazil, Chile, China, Chinese Taipei, Colombia, the Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Russia, Saudi Arabia, Singapore, South Africa, Thailand and Turkey.

Global: All AEs and EMEs, as listed.

Commodity exporters (countries whose average share of commodities in export revenues in 2005–14 exceeded 40%): Argentina, Australia, Brazil, Canada, Chile, Colombia, Indonesia, New Zealand, Norway, Peru, Russia, Saudi Arabia and South Africa.

Country aggregates used in graphs and tables may not cover all the countries listed, depending on data availability.

Annual Economic Report 2018: Editorial

Starting this year, the traditional BIS Annual Report – comprising an analysis of the global economy and a presentation of the BIS's activities – will be split into two separate publications. In addition, the economic part, renamed Annual Economic Report, has been restructured. The first three chapters review global developments, prospects and risks, while two special chapters focus on topical issues, with analyses of macroprudential frameworks and cryptocurrencies. This editorial summarises the content and key messages.

The global economy: developments, prospects and risks

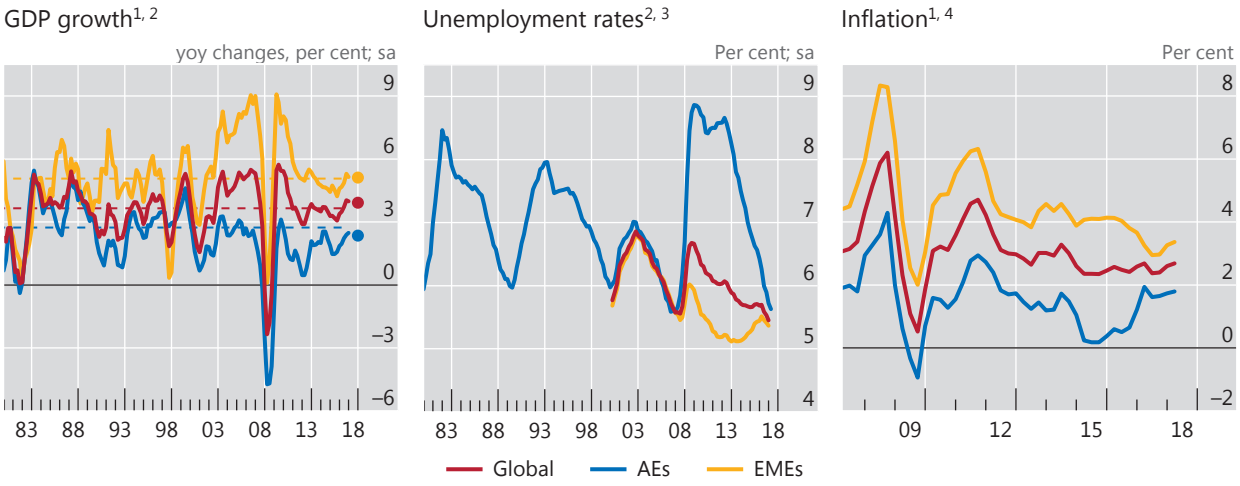
It is now 10 years since the Great Financial Crisis (GFC) engulfed the world. At the time, following an unparalleled build-up of leverage among households and financial institutions, the world's financial system was on the brink of collapse. Thanks to central banks' concerted efforts and their accommodative stance, a repeat of the Great Depression was avoided. Since then, historically low, even negative, interest rates and unprecedentedly large central bank balance sheets have provided important support for the global economy and have contributed to the gradual convergence of inflation towards objectives. Still, central banks were largely left to bear the burden of the recovery, with other policies, not least supply side structural ones, failing to take the baton. These actions by central banks helped lay the groundwork for the resumption of growth that we now see. But, in the process, they have been one factor behind the legacy of swollen private and public sector balance sheets and higher debts that shapes the road ahead. As the global economy reaches or even exceeds potential, it is time to take advantage of the favourable conditions to put in place a more balanced policy mix to promote a sustainable expansion. However, the path ahead is a narrow one.

The dividends of past policies were clearly in evidence in the year under review – a vintage one for the global economy (Graph E.1 and Chapter I). The expansion strengthened and broadened. Global growth rates were roughly on a par with pre-crisis long-term averages, and the expansion was highly synchronised across countries (Graph E.1, left-hand panel). Unemployment continued to decline, reaching multi-decade lows in a number of economies, including some of the largest (centre panel). Overall, headline inflation rates moved closer to central bank objectives, although core inflation remained more subdued. In fact, the year capped a steady improvement in the global economy that has been evident for some time. As already noted two Annual Reports ago, the picture then was considerably better than the gloomy rhetoric indicated. And in last year's Report we highlighted how talk of secular stagnation had given way to renewed optimism and a revival of animal spirits.

For the next couple of years, consensus forecasts see the trend continuing, marking one of the longest postwar expansions (Graph E.1 and Chapter I). Despite the softer patch in the first quarter of 2018 and some jitters in emerging market economies (EMEs) (see below), the forecasters' central scenario is still for global growth to exceed potential, reducing unemployment further, with economies testing capacity limits. Investment is expected to strengthen, boosting productivity over time. And fiscal expansion should provide additional near-term stimulus: quite

The global economy strengthens further as inflation converges

Graph E.1



In the left-hand panel, the dots indicate Consensus Economics forecasts for 2018; the dashed lines indicate 1982–2007 averages.

[1] Weighted averages based on GDP and PPP exchange rates. [2] For the euro area, weighted average across individual countries before 1995. [3] Weighted averages based on labour force levels; definitions may vary across countries. [4] Consumer prices.

Sources: IMF, *International Financial Statistics* and *World Economic Outlook*; OECD, *Main Economic Indicators*; CEIC; Consensus Economics; Datastream; Global Financial Data; national data; BIS calculations.

apart from the measures in the United States, the OECD foresees an easier fiscal stance in around three quarters of its members this year and next. At the same time, inflation is forecast to edge up.

The current scenario is somewhat unusual in the postwar period (Chapter I). It is not common to anticipate such strong growth so late in the expansion, when capacity constraints start biting, with only modest signs of an inflation threat. The reasons for this picture are much debated. There may be more slack than meets the eye: the crisis may have left a legacy of discouraged workers ready to re-enter the labour force as conditions improve; the investment pickup may be erasing some of the crisis scars, raising potential; and longer-term demographic factors and pension reforms may also be at work, as indicated by the widespread increase in participation rates among the older segments of the population, with the United States a notable exception. Moreover, as emphasised in previous Annual Reports, the persistent influence of globalisation and technological advances on inflation should not be underestimated, not least through their impact on workers' and firms' pricing power.

Buoying the expansion, and partly as a result of the heavy reliance on monetary policy to support the post-crisis recovery, financial conditions once again played a key role in the year under review (Chapters I and II). At least until recently, global financial conditions remained very easy. In fact, they loosened further even as US monetary policy proceeded along its very gradual and well anticipated normalisation path. True, long-term US Treasury yields moved up. But term premia remained historically low and equity price valuations quite rich, except when assessed in relation to the prevailing low interest rates. Importantly, credit spreads have been unusually compressed, often at or even below pre-GFC levels, and the corresponding markets appear to have become increasingly illiquid. Moreover, for most of the year under review the US dollar depreciated, supporting buoyant financial conditions especially in EMEs, which post-crisis have borrowed heavily in that currency and during the past year saw strong portfolio inflows. These buoyant conditions in EMEs, however, reversed more recently (see below).

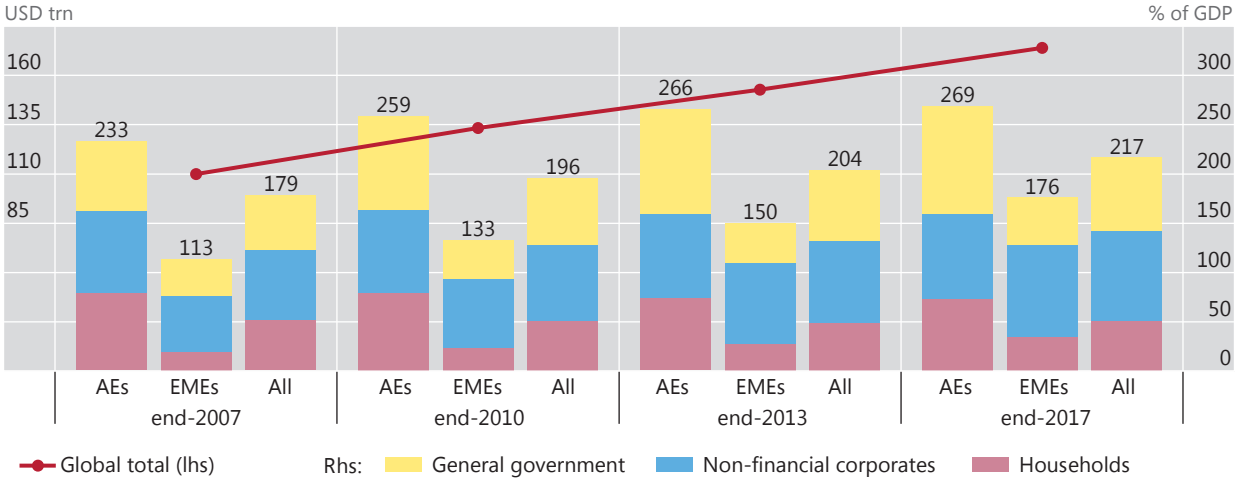
In the Report, we also assess the risks ahead in some detail (Chapter I). The conclusion is that medium-term risks are material, although there are cross-country differences. In some respects, the risks mirror the unbalanced post-crisis recovery and its excessive reliance on monetary policy. Where financial vulnerabilities exist, they have been building up, in their usual gradual and persistent way. More generally, financial markets are overstretched, as noted above, and we have seen a continuous rise in the global stock of debt, private plus public, in relation to GDP (Graph E.2). This has extended a trend that goes back to well before the crisis and that has coincided with a long-term decline in interest rates (Chapter II).

In some countries largely spared by the GFC, for quite some time there have been signs of a build-up of financial imbalances. This is because, in contrast to countries at the heart of the turmoil, no private sector deleveraging has taken place, so that the financial expansion has continued. The signs of imbalances have taken the form of strong increases in private sector credit, often alongside similar increases in property prices – the tell-tale sign of the expansion phase of domestic financial cycles, qualitatively similar to those observed pre-crisis in the economies that subsequently ran into trouble. Fortunately, much has been done to strengthen the financial system's resilience. The post-crisis financial reforms, not least Basel III and the implementation of macroprudential frameworks, have substantially bolstered the banking system (Chapters III and IV). And in China, the largest economy where the signs of imbalances are evident, the authorities have taken steps to rebalance the expansion and rein in some of the more serious financial excesses.

Against this backdrop, a number of developments could lead to the materialisation of risks, threatening the economic expansion in the medium term (Chapter I). In all of them, financial factors seem destined to play a prominent role, either as a trigger or as an amplifying mechanism. Indeed, the role of financial forces in business fluctuations has grown substantially since the early 1980s, when financial liberalisation took hold. And post-crisis the weight of non-bank intermediaries, such as asset managers and institutional investors, has risen substantially, and is likely to influence the dynamics of any future episodes of financial stress, in familiar but also some unexpected ways (Chapter III).

Global debt continues to rise[1]

Graph E.2



[1] Weighted averages based on GDP and PPP exchange rates. The sample includes all reporting economies except Ireland, owing to large data fluctuations caused by the restructuring of large multinational corporations.

Sources: IMF, *World Economic Outlook*; BIS total credit statistics; BIS calculations.

One possible trigger of an economic slowdown or downturn could be an escalation of protectionist measures. Its impact could be very significant, if such escalation was seen as threatening the open multilateral trading system. Indeed, there are signs that the rise in uncertainty associated with the first protectionist steps and the ratcheting-up of rhetoric have already been inhibiting investment. Moreover, were the recent reversal in the US dollar depreciation to continue, trade negotiations would become more complicated.

A second possible trigger could be a sudden decompression of historically low bond yields or snapback in core sovereign market yields, notably in the United States. This could take place in response to an inflation surprise and the perception that central banks will have to tighten more than anticipated. In the United States, the prospective heavy issuance of government debt, combined with the gradual unwinding of central bank purchases, could add to this risk. Importantly, the surprise need not be a large one, as indicated by the financial markets' wobble in February in response to slightly stronger than anticipated US wage growth. And the impact would spread globally, given the weight of the US economy and the dominant role of the dollar in global financial markets.

A third trigger could be a more general reversal in risk appetite. Such a reversal could reflect a range of factors, including disappointing profits, the drag of the contraction phase of financial cycles where these have turned, a souring of sentiment vis-à-vis EMEs, or untoward political events threatening stability in some large economies. From this perspective, recent events in the euro area are a source of concern, as reflected in the widening of spreads on Italian and Spanish bonds. In contrast to the snapback scenario, this third trigger would usher in a further compression of term premia in those core sovereign markets that benefited from a flight to safety.

Indeed, in April signs of strain did emerge in the most vulnerable EMEs, beginning in Argentina and Turkey, as the US dollar began to appreciate and financial conditions in international markets started to tighten. At the time of writing, it is too early to tell whether the strains will remain contained or will spread further. Most EMEs are better placed to confront financial stress now than they were in the mid-1990s. They have taken steps to strengthen their defences, by building reserves, adopting more systematic macroprudential measures (Chapter IV), improving their current account positions and adopting more flexible exchange rate regimes. This should provide them with some more room for manoeuvre were global financial conditions to tighten further.

Nevertheless, some pitfalls remain. The shift in the pattern of financial intermediation towards greater borrowing through the bond market has reduced rollover risk but introduced greater duration risk. Portfolio investors with limited tolerance for losses may amplify price fluctuations should they attempt to reduce exposures simultaneously. More generally, non-banks have been the largest borrowers; if they found themselves under financial strain, they might curtail operations and employment. A slowdown in the real economy may be the risk to watch for if EMEs continue to experience tightening financial conditions.

Looking further ahead, if the global economy successfully navigates the choppy waters just described, the expansion could continue. But then, almost inevitably, supported by easy financial conditions, financial imbalances and, above all, the aggregate debt-to-GDP ratio could rise further. Financial market complacency, low volatility and excessive risk-taking would continue. Limited market discipline would induce further poor resource allocation, including through the survival of ultimately unprofitable firms and weaker incentives for sovereigns to ensure fiscal space. All this would make the subsequent adjustment more painful. Such a further rise in global debt would be especially worrying (Chapter I). Not only would it make

it harder to raise interest rates to more normal levels without threatening the expansion, given the associated rise in debt service burdens – a kind of "debt trap". It would also narrow the room for manoeuvre to address any downturn, which will come sooner or later.

What can policy do to ensure the current expansion is more sustainable and balanced? The question is especially pressing, given that compared with pre-crisis the room for policy manoeuvre has indeed narrowed considerably (Graph E.3). Public sector debt in relation to GDP has increased further, constraining fiscal policy (left-hand panel). At the same time, interest rates are significantly lower, constraining monetary policy – a phenomenon exacerbated in advanced economies by the much larger central bank balance sheets (centre panel). Building room is a priority.

There are several possible lines of action that, if combined, would support each other (Chapter I). Their common theme is to focus firmly on longer horizons, since both monetary and fiscal expansions work to a considerable extent by borrowing demand from the future. And when the future becomes today, there is inevitably a price to be paid. This puts a premium on taking advantage of the current highly favourable conditions to redress the balance. Such policy adjustments would be consistent with the implementation of a broader macro-financial stability framework, in which the various policies would work in tandem to ensure macroeconomic and financial stability while raising long-term sustainable growth (Chapter IV).

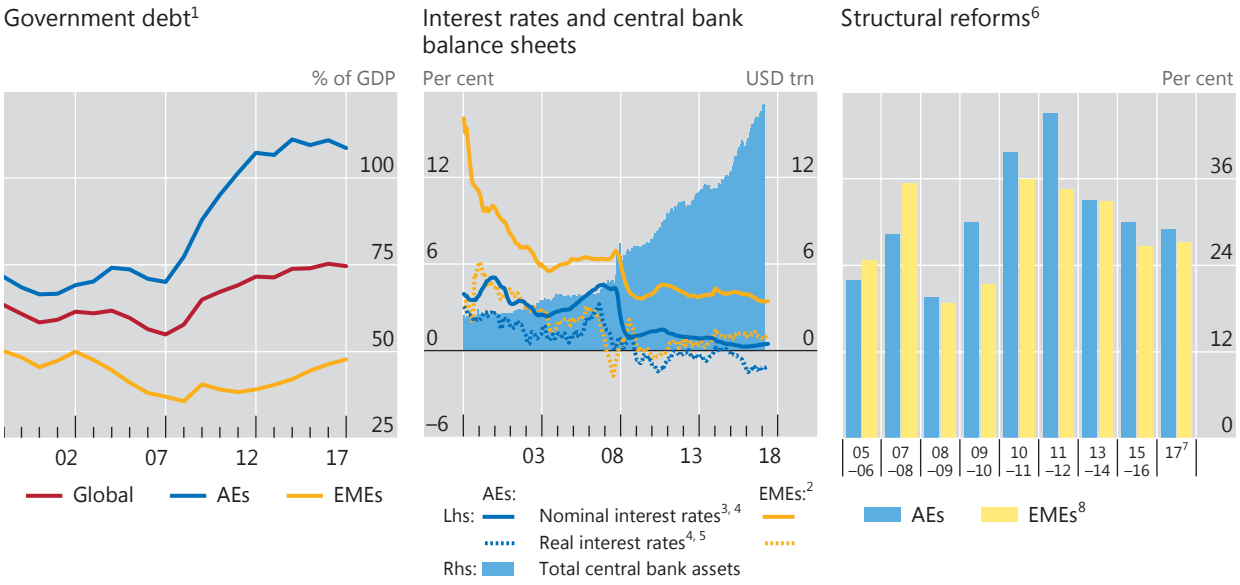
The first line of action is to redouble efforts to implement structural policies – the only way to raise sustainable growth without generating inflationary pressures. This is essential, as economies are already operating at or beyond standard estimates of full employment and potential output even though post-crisis growth has been, on balance, rather disappointing – an indication of supply constraints. In particular, structural policies can alleviate the dilemmas monetary policy is currently facing and that are narrowing its room for manoeuvre. The essence of the reforms is to make product and labour markets more flexible, enabling them to allocate resources more efficiently and to absorb technical innovations more easily. One important element here is also to safeguard the open multilateral trading order that has served the global economy so well during the past decades. Unfortunately, the post-crisis record in structural reforms has fallen far short of what is desirable: since 2011 the pace has actually slowed down (Graph E.3, right-hand panel). Moreover, recent protectionist rhetoric and actions do not augur well.

The second line of action is to strengthen further the resilience of the financial system (Chapters III and IV). This requires completing and consistently implementing the post-crisis financial regulatory reforms. Ideally, where appropriate, this should be supported by steps to remove structural impediments to banks' efforts to attain sustainable profitability, which is critical to absorb any losses smoothly and swiftly should these materialise at some point. Examples of such steps include tackling the obstacles to the necessary consolidation and cost cutting. Sustainable profitability is especially important at the current juncture: banks have been facing the dual challenge of persistently and unusually low interest rates eating away at their net interest margins, and growing competition from new technology-savvy players – big tech and fintech. Strengthening resilience also calls for the active deployment of macroprudential measures in those economies where financial imbalances have been building up and the improvement of macroprudential frameworks more generally. In both cases, the non-bank sector, notably asset managers and institutional investors, deserves closer attention, to complete unfinished business there.

The third line of action is to ensure the sustainability of public sector finances and to avoid procyclical fiscal expansions. The importance of this issue cannot be

Narrowing room for policy manoeuvre and waning structural reforms

Graph E.3



[1] General (if not available, central) government core debt at market (if not available, nominal) value. Weighted averages based on GDP and PPP exchange rates. Backdated using central government debt (% of GDP) or total government debt securities (% of GDP) based on data availability. [2] A few outliers for which the nominal interest rate exceeded 60% are omitted from the sample. [3] Policy rate or closest equivalent. [4] Simple monthly averages across economies. [5] Nominal interest rate less consumer price inflation. [6] OECD reform responsiveness indicator (RRI), measured based on a scoring system in which policy recommendations set in the context of *Going for Growth* take a value of one if significant action is taken and zero if not. Simple averages across economies. The sample sizes for country groups vary across time. [7] Sum of the RRIs for the reforms that are fully implemented or being implemented. [8] Except HK, MY, PE, PH, SA, SG, TH and TW.

Sources: IMF, *International Financial Statistics* and *World Economic Outlook*; OECD, *Going for Growth*; Datastream; Global Financial Data; Oxford Economics; national data; BIS policy rate statistics and total credit statistics; BIS calculations.

emphasised enough. Public debt has risen to new peacetime highs in both advanced and emerging market economies. And, as history indicates, fiscal space is likely to be overestimated in countries where financial imbalances have been building up. With due regard for country-specific circumstances, fiscal consolidation is a priority.

The final line of action concerns monetary policy. Monetary policy normalisation is essential in rebuilding policy space. It can create room for countercyclical policy, help reduce the risk of the emergence of financial vulnerabilities, and contribute to restraining debt accumulation. That said, as discussed in detail in Chapter II, given the unprecedented starting point, the uncertainties involved and persistently low inflation in many jurisdictions, the path ahead is quite narrow, with pitfalls on either side. It requires striking and maintaining a delicate balance between competing considerations, notably achieving inflation objectives in the short run and avoiding the risk of encouraging the further build-up of financial vulnerabilities in the longer run.

While the right approach will naturally depend on country-specific conditions, a couple of general observations are possible. One is that treading the path will call for flexibility in the pursuit of inflation objectives. This applies in particular to moderate inflation shortfalls, given the benign structural disinflationary pressures still at work. The other is that policymakers will need to maintain a steady hand, avoiding the risk of overreacting to transitory bouts of volatility. After all, given initial conditions, the journey is bound to be bumpy. Financial market ructions will no doubt occur. Higher volatility per se is not a problem as long as it remains contained; it is actually healthy whenever it helps inhibit unbridled risk-taking.

Special chapters

Macroprudential frameworks

The implementation of macroprudential frameworks represents a major and welcome element of the post-crisis financial reforms. It has stemmed from the recognition that the pre-crisis approach to regulation and supervision was insufficient, as it was largely focused on an assessment of the risks incurred by individual institutions on a standalone basis. Such a (micro-oriented) approach can miss and fail to manage vulnerabilities at the system-wide level – the main source of systemic crises with serious macroeconomic costs. A prominent source of such crises is the procyclicality of the financial system, ie its tendency to amplify financial expansions and contractions, which can in turn amplify business fluctuations. The financial cycle is a reflection of such forces.

The activation of macroprudential measures is especially important at the current juncture. It can help contain the financial vulnerabilities bequeathed by the unbalanced post-crisis recovery and mitigate the build-up of further risks. And, in the process, it can support monetary policy along its normalisation path, increasing the room for manoeuvre. Current favourable economic conditions provide a window of opportunity for active deployment that should not be missed.

Against this backdrop, Chapter IV takes stock of the experience so far with macroprudential frameworks and explores the way forward. It reaches a number of conclusions. First, while implementation issues are challenging, the authorities have made substantial progress. Issues include identifying the build-up of systemic risks in good time to take remedial action, choosing appropriate instruments, political economy constraints on their deployment, and establishing effective governance arrangements. Second, so far the tools at the authorities' disposal have largely targeted banks; there is a need to extend them to other financial institutions, not least to the asset management sector. Third, macroprudential measures have succeeded in strengthening the financial system's resilience, but as deployed so far their restraining impact on financial booms has not always prevented the emergence of the familiar signs of financial imbalances. Fourth, this suggests that macroprudential measures are most effective as part of a more holistic macro-financial stability framework, also involving structural, fiscal and monetary policies. Finally, there is scope to further strengthen international cooperation in this area.

Cryptocurrencies

Cryptocurrencies promise to replace trust in long-standing institutions, such as commercial and central banks, with trust in a new, fully decentralised system founded on the blockchain and related distributed ledger technology (DLT). The transformative nature of this promise makes this development of core concern to central banks.

Chapter V evaluates whether cryptocurrencies can deliver on their promise as a form of money. Looking beyond the hype, it finds that this is not the case. Much has already been said about the impractical nature of cryptocurrencies as a means of payment, the scope for fraud and the enormous environmental cost. As the BIS General Manager put it recently,[1] cryptocurrencies have become a "combination of a bubble, a Ponzi scheme and an environmental disaster".

The chapter highlights the further economic limitations of cryptocurrencies. These relate to their limited ability to satisfy the signature property of money as a coordination device and their questionable promise of trust. Cryptocurrencies

cannot scale with transaction demand, are prone to congestion, and fluctuate greatly in value. And trust in them can evaporate at any time, owing to the fragility of the decentralised consensus mechanisms used to record and validate transactions. Not only does this call into question the finality of individual payments, it also means that a cryptocurrency can simply stop functioning, resulting in a complete loss of value.

The decentralised technology of cryptocurrencies, however sophisticated, is a poor substitute for the solid institutional backing of money through independent and accountable central banks. DLT itself, however, does have promise in applications other than cryptocurrencies. Examples include, in particular, simplifying administrative processes in the settlement of financial transactions. But this still remains to be tested.

The emergence of cryptocurrencies calls for policy responses. A globally coordinated approach is necessary to prevent abuses and strictly limit interconnections with regulated financial institutions. In addition, delicate issues arise regarding the possible issuance of digital currencies by central banks themselves.

Endnote

[1] See A Carstens, "Money in the digital age: what role for central banks?", lecture at the House of Finance, Goethe University, Frankfurt, 6 February 2018.

I. A stronger expansion: how to make it last

In the year under review, the global economy outperformed expectations. Growth strengthened and broadened; inflation remained subdued despite a further drop in unemployment rates; and, for most of the period, global financial conditions eased further even as monetary policy inched towards normalisation. Despite some loss of momentum in early 2018 and a deterioration in market sentiment, especially vis-à-vis emerging market economies (EMEs), most countries are expected, at the time of writing, to grow at above-potential rates in 2018 and 2019, and inflation is expected to pick up only moderately.

From a longer-term perspective, the global economy has been reaping the dividend from the post-crisis measures taken by monetary and regulatory authorities. Prolonged very easy monetary policies have underpinned the global recovery. And banking systems are now better capitalised and more resilient, and thus better positioned to support the economy (Chapter III).

The key challenge now is to sustain the higher growth beyond the near term. So far, the recovery has been too dependent on central banks' actions and unconventional policies, leaving some problems in its wake. Financial vulnerabilities have been rising. Financial markets appear overstretched. In some economies, credit has expanded strongly, often alongside large property price increases and sometimes heavy foreign currency borrowing. Globally, aggregate total non-financial debt has risen further relative to income. The room for fiscal and monetary policy manoeuvre is more limited than pre-crisis and, partly because policy has failed to address structural impediments, long-term potential growth rates are lower. And more recently, increasing protectionist pressures have challenged the international trade system that has buttressed global growth post-WWII. All this suggests that downside risks to growth are material, as has recently been confirmed by financial strains in some EMEs.

With this backdrop, policy should take advantage of the cyclical upswing to mitigate risks and to rebuild room to address any future downturn. Specifically, fiscal policy should be oriented at regaining space while structural policies should boost growth potential. The precious open multilateral trading system should be fully preserved. Macroprudential measures should be used to help strengthen further the financial system's resilience and mitigate financial excesses (Chapter IV). And with due regard for country-specific circumstances, it would be desirable to continue the process of monetary policy normalisation. The path ahead is a narrow one (Chapter II).

The chapter first describes how the macroeconomic and financial landscape has changed over the past year. It then discusses the near-term outlook and the policies needed to make growth more sustainable. Finally, it deals with the risks ahead.

The global expansion strengthens amid low inflation

Over the past year, global economic activity accelerated. From 3.2% in 2016, global GDP growth is estimated to have risen to 3.8% in 2017, 0.4 percentage points above forecasts made at the end of 2016 and close to its long-run average. Despite losing some momentum in the last quarter of 2017 and the first quarter of 2018, especially in the euro area, growth remained above potential in most countries.

The growth pickup was more synchronised and more evenly spread across regions and countries than in the past few years. Growth in EMEs returned to rates closer to historical averages, recovering almost completely from the lows in 2014 and 2015. It also resumed in major commodity exporters, such as Brazil and Russia, after unusually long and deep recessions. And it beat forecasts in the euro area, Japan and China, while being approximately in line with them in the United States, Asia (excluding China) and Latin America (Graph I.1, left-hand panel).

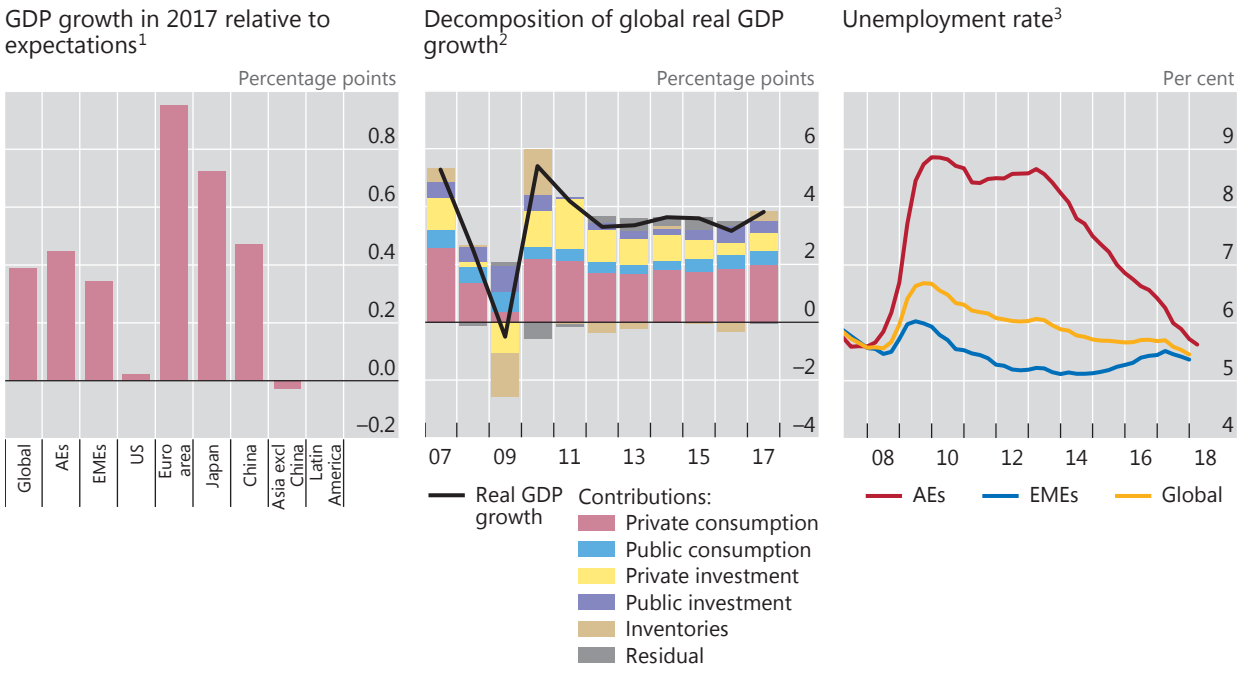
The recovery was more evenly balanced also in terms of spending components. Along with inventories, private fixed investment contributed a larger share of global GDP growth than in 2016 (Graph I.1, centre panel). Its strong recovery, especially in the non-residential sector, accounted for most of the higher growth in advanced economies. In EMEs, private consumption was relatively more important. Investment overall also rebounded somewhat, but its evolution varied more across countries. In particular, investment fell as a share of GDP in China, as the economy continued to rebalance, while remaining subdued among commodity exporters.

As a result of these developments, manufacturing output and global trade expanded strongly. After several years of trailing behind services, manufacturing activity recorded the highest growth rates since 2014. And, with an annual increase of almost 5% in 2017, global trade increased at its fastest rate in years, benefiting manufacturing exporters, especially in East Asia. All of this contributed to a rebound in commodity prices, which in turn supported the gradual recovery in commodity-exporting countries.

As growth gathered pace, unemployment rates plunged to post-crisis lows (Graph I.1, right-hand panel). Remarkably, in some major economies, such lows were

GDP growth improves, investment strengthens and unemployment declines

Graph I.1



[1] Actual growth in 2017 relative to consensus forecast for 2017 in December 2016; aggregates are weighted averages based on GDP and PPP exchange rates. [2] Weighted averages of real GDP growth rates and contribution rates based on GDP and PPP exchange rates. [3] Weighted averages based on labour force levels; definitions may vary across countries.

Sources: IMF, *World Economic Outlook*; OECD, *Economic Outlook*; World Bank; Eurostat; Consensus Economics; Datastream; national data; BIS calculations.

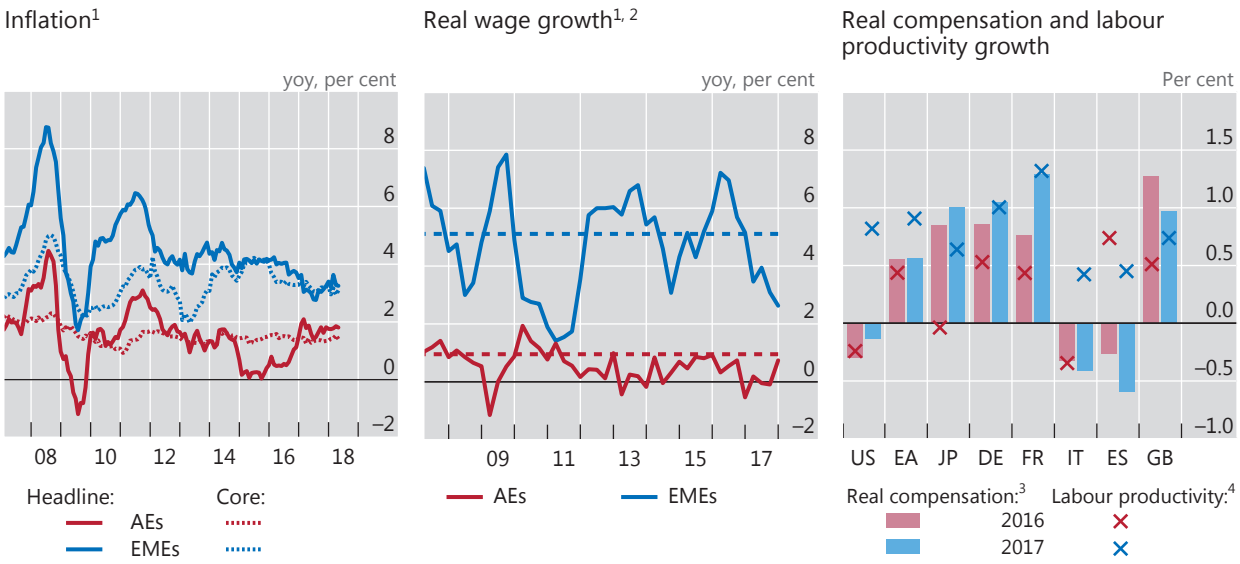
also close to postwar troughs. For example, in April 2018 unemployment reached 3.9% in the United States, the lowest except in 2000, 1966–69 and in the 1950s; 2.5% in Japan, the lowest in 25 years; and 3.4% in Germany, the lowest in almost 40 years. In these economies, labour shortages became evident, especially among specialised and highly skilled workers. Unemployment rates also declined rapidly in several EMEs. Standard estimates of the output gap (albeit highly uncertain) corroborate the view that several economies might have moved closer to full capacity. That said, the recovery did not advance as well everywhere. Despite Germany's strong performance, and no doubt hindered by structural factors, the unemployment rate in the euro area remained at 8.5% in April, with a wide dispersion across member countries.

Against this backdrop, headline inflation moved up to almost 2% in advanced economies and slightly above 3% in EMEs. In both cases, the rebound in energy prices pushed average headline slightly above core inflation (Graph I.2, left-hand panel). While the increase in headline inflation has been relatively broad-based across major advanced economies, core inflation has varied significantly. With a few exceptions, core CPI inflation generally remains subdued. Over the past 12 months, it rose slowly in the United States and Japan, reaching 2.1% and 0.4% respectively in April. In contrast, over the same period, it oscillated around rates near 1% in the euro area.

Relatively low core inflation has generally reflected subdued wage growth. Over the past year, real wage growth in advanced economies picked up but remained below average (Graph I.2, centre panel). In some economies, including the United States and the euro area, real compensation growth was substantially lower than productivity gains, while in other advanced economies it was either just above or in line with productivity gains, thereby putting little or no upward pressure on unit labour costs (Graph I.2, right-hand panel). Real wage growth in EMEs was below historical averages.

Inflation remains low and wage growth subdued

Graph I.2



The dashed lines in the centre panel indicate averages over the period Q1 2000–latest for AEs and Q1 2001–latest for EMEs.

[1] Weighted averages based on GDP and PPP exchange rates; definitions may vary across countries. [2] Deflated by GDP deflator. For AEs, compensation growth per employee as defined by OECD *Economic Outlook*. For EMEs, wage growth; definitions may vary depending on data availability. [3] Compensation per employee as defined by OECD *Economic Outlook*; deflated by GDP deflator. [4] Real output per employee.

Sources: OECD; Datastream; national data; BIS calculations.

Low wage growth in the face of fast declining unemployment is somewhat puzzling. True, historically wage growth has typically lagged behind inflation and productivity growth, a pattern that has coincided with a secular erosion of labour's income share. But evidence also indicates that the link between wage (or unit labour cost) growth and measures of labour market slack, albeit much weaker than in the past, is still present. Based on historical correlations, wage inflation should have been higher.

A number of factors may help explain the low wage inflation. To begin with, labour market slack may be larger than headline figures suggest, partly reflecting hysteresis effects from the Great Financial Crisis (GFC) as well as structural changes in labour markets. In some countries, broader unemployment measures, which include discouraged and part-time workers, are significantly higher than headline unemployment rates (eg close to 8% in the United States). Post-crisis, participation rates have generally increased, except in the United States, where they are more than 3 percentage points lower than in 2008. Part of these increases reflects a higher participation of workers over 55 years old.[1] As a result, firms might still be facing a relatively elastic labour supply, allowing them to fill vacancies without having to offer significantly higher wages.

Another reason is that globalisation, even if it may have slowed in the last few years, continues to make labour markets highly contestable.[2] Since the integration of China and the ex-Soviet bloc in the early 1990s, the world economy has been able to count on a much larger labour pool. In addition, a much greater share of production now takes place through value chains spread across many countries. To the extent that production can be outsourced to countries where labour costs are lower, workers face competition not only in their local labour market, but also externally. Hence, assessing labour market slack only by looking at domestic unemployment measures may be misleading. There is indeed some evidence that global value chains have made local production costs more sensitive to foreign factors and, relatedly, that unit labour costs have become more synchronised across countries.[3]

At the same time, other structural forces such as the adoption of new technologies have been gathering strength. The room for automating jobs has been increasing not only in manufacturing but also in services sectors.[4] Although hard evidence is still scant, recent technological diffusion can surely put downward pressure on wage growth by further reducing labour's bargaining power. Meanwhile, by improving productivity, technological diffusion may help prevent inflation from rising, thus reducing wage demands. Technological diffusion could also lead to changes in product market structure. There is evidence that concentration in some economic sectors is on the rise, as fewer and more efficient firms gain ground at the expense of others.[5] Productivity gains by a small number of firms may, at least initially, partly feed into lower prices, both directly and indirectly, by putting pressure on incumbents.[6]

Financial conditions remained very easy for most of the year

The global recovery was supported by very easy financial conditions which, in fact, eased further for most of the period under review. Only well into the first quarter of 2018 did signs emerge that a significant change in those conditions could be in the offing, especially for EMEs.

The monetary policy stance of major central banks remained very accommodative, although it diverged somewhat across areas (Chapter II). The Federal Reserve continued its very gradual tightening. The ECB extended the time frame of its asset

purchase programme, albeit reducing its pace slightly. The Bank of Japan left its easing stance essentially unaltered. And the People's Bank of China kept its benchmark policy rates unchanged while expanding its use of central bank lending facilities.

The government bond markets' reaction to these policy adjustments and the unexpectedly stronger growth outlook was, for most of the period in review, rather limited. In the United States, 10-year yields increased modestly until the turn of the year, when they began moving up steadily, reaching values close to 3% at the end of April. Even so, long-term yields in the United States and other major economies remained very low by historical standards (Graph I.3, first panel). In the United States, the yield curve remained relatively flat, reflecting unusually low term premia (Chapter II), whereas term spreads in the euro area stayed relatively high after the sharp steepening of the yield curve last June (Graph I.3, second panel).

Compressed long-term yields and term premia in the United States were to some degree surprising, given the monetary policy tightening and fiscal expansion there (Chapter II). At least two forces appear to have been at work: the persistent impact of relatively looser monetary policy in the euro area and Japan; and investors' expectations that inflationary pressures would remain under control even as growth strengthened, so that monetary policies would not need to adjust.[7]

Along with low bond yields, broader financial market indicators underscored the very easy financial conditions. Based on a composite index, financial conditions in the United States actually continued to loosen until the end of 2017

Global financial conditions remain very easy in 2017 and early 2018

Graph I.3

The dashed lines in the fourth panel indicate averages over the period 1 June 2005–30 June 2007.

[1] Yield to maturity. For AEs, long-term historical values of 10-year government bonds in local currency, since January 1993; for EME local, JPMorgan GBI-EM Index, seven- to 10-year maturity, since January 2002; for EME USD, JPMorgan EMBI Global, seven- to 10-year maturity, since January 2001. [2] Difference between the 10-year and the two-year government bond yields. [3] Federal Reserve Bank of Chicago's National Financial Conditions Index; positive (negative) values indicate financial conditions that are tighter (looser) than average. [4] Option-adjusted spreads.

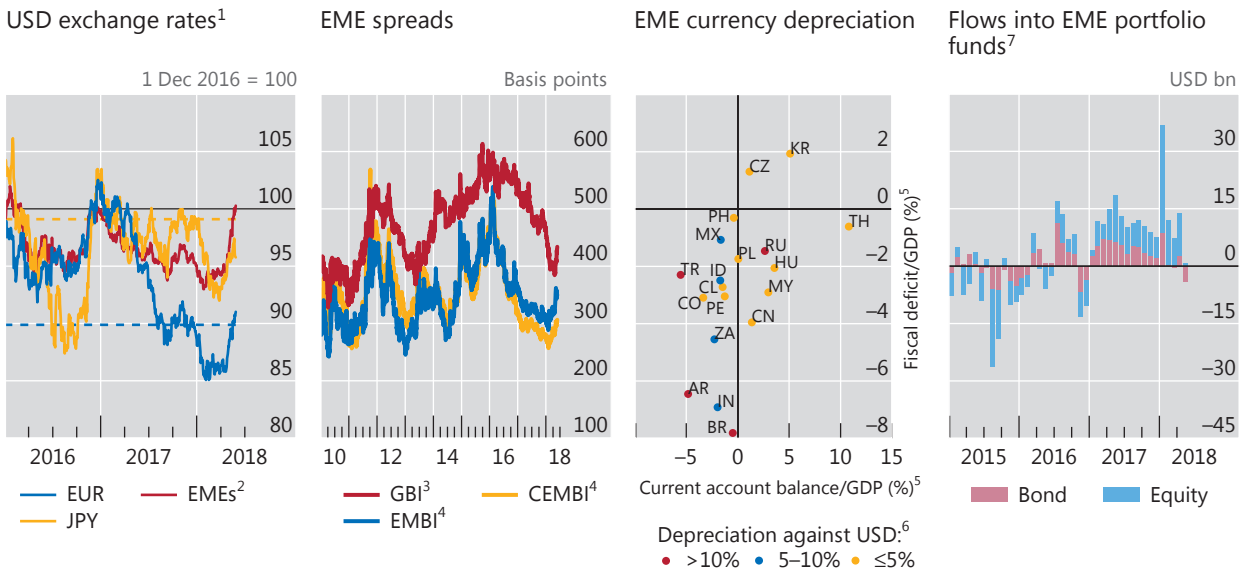
Sources: Bloomberg; Datastream; ICE BofAML Indices; JPMorgan Chase; BIS calculations.

(Graph I.3, third panel) and, despite some subsequent tightening, they remained easier than during most of the pre-crisis period. In both the United States and the euro area, high-yield and investment grade credit spreads narrowed further till end-2017 (fourth panel) along with rising stock prices and low market volatilities. Such very easy financial conditions underwent some reversal in the first quarter of 2018, after a spike in stock market volatility, related to the liquidation of funds with values linked to volatility, led to a sharp drop in equity prices. While this episode highlighted the potential for disruptive market dynamics (Chapter III), it was a healthy correction that remained largely confined to equity markets.[8]

Until early 2018, the easing of global financial conditions had also gone hand in hand with a prolonged depreciation of the US dollar (Graph I.4, first panel). From December 2016 to March 2018, the dollar lost about 8% of its value in trade-weighted terms, of which more than half corresponded to a strengthening of the euro, the renminbi and the yen. It is unclear what explained the depreciation. The tightening of US monetary policy and the implied widening of short-term interest rate differentials relative to other major economies would have suggested an appreciation. However, it is not unusual for the dollar to depreciate when monetary policy tightens: in half of the past tightening cycles, the dollar depreciated, including in 2004–06, when the dollar lost about 7% in trade-weighted terms. This suggests that other factors are relevant. In 2017, one such factor was the unexpected strengthening of the global economy relative to the US economy. This may have boosted investors' risk appetite for non-US assets, including fixed income in EMEs, while bringing forward the expected timing (and possibly raising the expected speed) of a withdrawal of monetary policy stimulus in other major economies,

A stronger dollar puts vulnerable EMEs under pressure

Graph I.4



The dashed lines in the first panel indicate the long-term average for JPY (January 1987–May 2018) and EUR (January 1999–May 2018).

[1] An increase indicates an appreciation against the stated currency. [2] Simple average of AR, BR, CL, CN, CO, CZ, HK, HU, ID, IN, KR, MX, MY, PE, PH, PL, RU, SA, SG, TH, TR and ZA. [3] For JPMorgan GBI-EM index (local currency-denominated), spread over seven-year US Treasury securities. [4] For JPMorgan EMBI Global (USD-denominated) and CEMBI (USD-denominated) indices, stripped spread. [5] 2017 data. [6] Depreciation of the stated country currency against the US dollar over the period 1 February–25 May 2018; CZ, HU and PL adjusted for euro depreciation over the same period. [7] Monthly sums of weekly data across major EMEs up to 23 May 2018. Data cover net portfolio flows (adjusted for exchange rate changes) to dedicated funds for individual EMEs and to EME funds with country/regional decomposition.

Sources: IMF, *World Economic Outlook*; Bloomberg; EPFR; JPMorgan Chase; national data; BIS calculations.

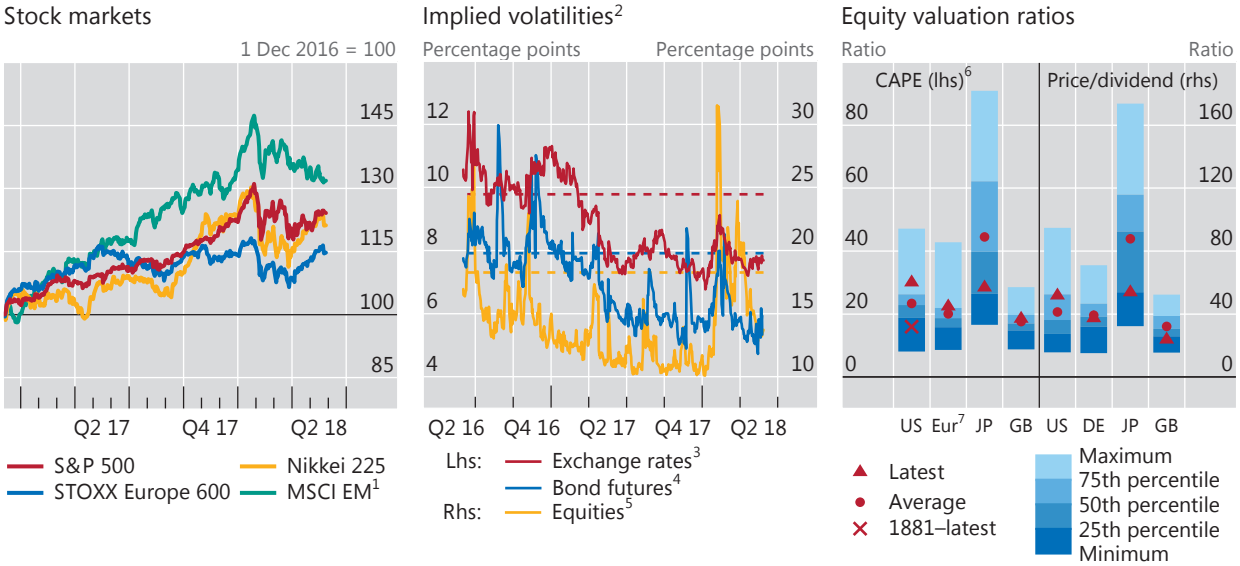
especially the euro area.[9] Uncertainties related to the US Administration's policies, especially concerning trade, but also fiscal policies, may also have played a role.

While supported by improved growth, financial conditions in EMEs largely mirrored the depreciation of the dollar. They eased significantly until the early months of 2018, as indicated by the large drop in the spreads on local currency bonds (over 130 basis points from January 2017 to February 2018) as well as dollar-denominated bonds (Graph I.4, second panel). Then, in the first quarter of 2018, as the dollar reversed course and started to appreciate (Graph I.4, first panel) and US long-term yields rose, conditions tightened considerably, with EME currencies coming under pressure, especially those of countries with weaker current account and/or fiscal positions (Graph I.4, third panel). Tensions were acute in Argentina and Turkey, with the former turning to the IMF for support in May. After staying positive for an unprecedented 16-month spell, portfolio inflows came to a sudden halt and reversed in May (Graph I.4, fourth panel). Dollar-denominated bond spreads widened more, on average, than local currency ones (Graph I.4, second panel).

At the time of writing, it is hard to tell how the tightening of financial conditions will unfold across regions. In major advanced economies, credit spreads have increased only modestly, while equity markets have resumed their upward trajectory (Graph I.5, left-hand panel). Implied volatilities have also quickly subsided, remaining below recent historical averages (Graph I.5, centre panel). That said, concerns about stretched valuations remain, especially in the United States, where the cyclically adjusted price/earnings ratio has exceeded its post-1982 average and is almost twice its long-term 1881–2017 average (Graph I.5, right-hand panel).[10] In the euro area, the spread of Italian sovereign debt relative to German bunds widened considerably in May, following political events. And in EMEs, conditions

Stock market valuations remain stretched

Graph I.5



[1] MSCI Emerging Markets Index, in US dollars. [2] The dashed lines represent simple averages over the period January 2010–May 2018. [3] JPMorgan VXY Global index, a turnover-weighted index of the implied volatility of three-month at-the-money options on USD currency pairs. [4] Implied volatility of at-the-money options on long-term bond futures of DE, GB, JP and US; weighted average based on GDP and PPP exchange rates. [5] Implied volatility of the S&P 500, EURO STOXX 50, FTSE 100 and Nikkei 225 indices; weighted average based on market capitalisation. [6] For the period December 1981–April 2018; for each country/region, the cyclically adjusted P/E (CAPE) ratio is calculated as the inflation-adjusted MSCI equity price index (in local currency) divided by the 10-year moving average of inflation-adjusted reported earnings. [7] European advanced economies included in the MSCI Europe index.

Sources: Shiller database, www.econ.yale.edu/~shiller/data/ie_data.xls; Barclays; Bloomberg; Datastream; BIS calculations.

have continued to deteriorate, and could do so further should the US dollar extend its appreciation.

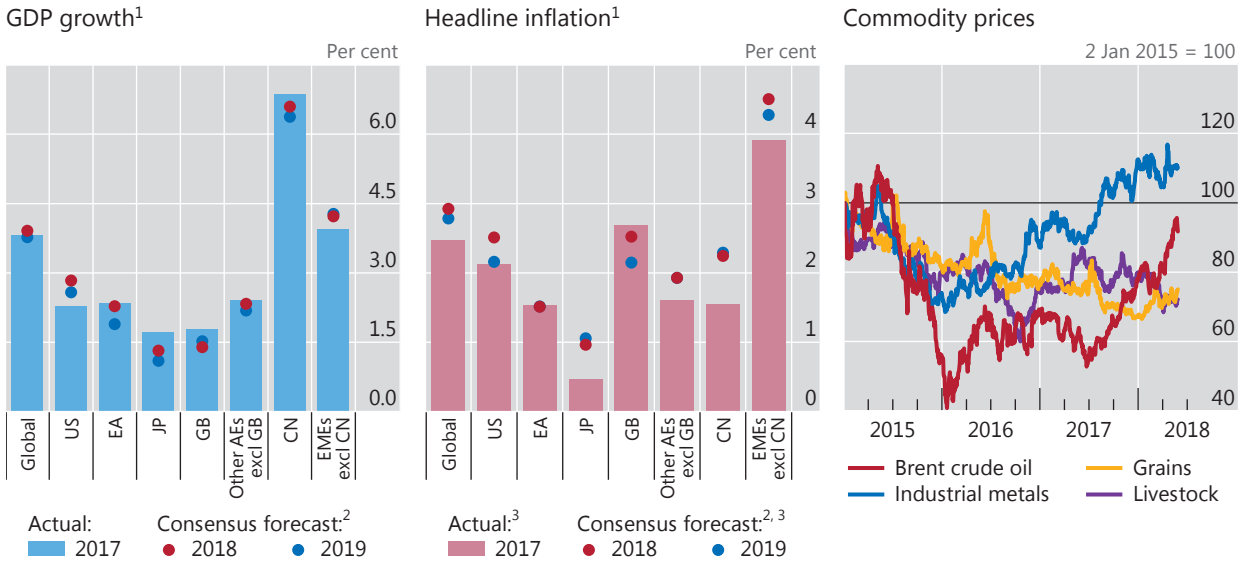
The near-term outlook

The global economy's unexpectedly strong performance over the past 12 months had led analysts to repeatedly revise upwards growth forecasts for 2018 and 2019 in most countries. This pattern prevailed until the first quarter of this year, when a number of indicators signalled a possible loss of momentum. While growth expectations have since been revised down in a number of countries, the prospects for the global economy overall remain upbeat. Based on consensus forecasts, global growth is currently forecast to rise to 3.9% in 2018, from an estimated 3.8% in 2017, before returning to 3.8% in 2019 (Graph I.6, left-hand panel).

The expected increase in global growth masks some differences across economies. In the United States, forecasts have been upgraded substantially since the announcement last December of the tax reforms and the spending stimulus: GDP is currently expected to expand by 2.8% in 2018 and 2.6% in 2019, from 2.3% in 2017. By contrast, euro area GDP is expected to grow by 2.3% in 2018, the same as in 2017, followed by a slowdown to 1.9% in 2019, with forecasts revised down in early 2018. In Japan, growth is expected to slow from 1.7% in 2017 to 1.3% in 2018 and 1.1% in 2019. In other advanced economies, growth is expected to decline over the next two years. And in EMEs, excluding China, growth is expected to rise to 4.2% in 2018 and 4.3% in 2019 (Graph I.6, left-hand panel).

These near-term forecasts are above long-run potential growth estimates in most countries, which are lower than pre-crisis and unlikely to go back up fully, given demographic headwinds and other structural impediments. For instance, based on long-term consensus forecasts (six to 10 years ahead), long-run growth is currently estimated to be 2.1% in the United States, compared with over 3% pre-crisis;

The near-term outlook for growth and inflation is positive for most countries — Graph I.6



[1] Aggregates are weighted averages based on GDP and PPP exchange rates. [2] As of May 2018. [3] Based on average of monthly year-on-year changes in CPI, except for AR, BR, CL, CO, MX, PE and RU (December-to-December changes).

Sources: IMF, *World Economic Outlook*; Bloomberg; Consensus Economics; national data; BIS calculations.

1.3% in the euro area, against 2% pre-crisis; and 0.7% in Japan, less than half the pre-crisis estimate. In EMEs, depending on the country, long-run growth expectations have dropped by between one fifth and one half from pre-crisis levels.

The outlook for inflation is generally consistent with projected stronger growth (Graph I.6, centre panel). Headline inflation is expected to increase in most countries, reflecting partly the reduction in output and labour market slack and partly the recent increase in the price of oil and other commodities. In particular, consensus forecasts see headline (CPI) inflation reaching 2.5% in 2018 in the United States, before dropping to 2.2% in 2019; and close to 1% in Japan in 2018 and 2019. In the euro area, by contrast, headline inflation is expected to remain unchanged at around 1.5% in both 2018 and 2019, albeit with significant variations across member countries. In line with the pickup in short-run inflation expectations, market-based measures of long-term ones have also moved up over the past 12 months in both the United States and the euro area; at the same time, consensus forecasts for inflation six to 10 years ahead have remained remarkably stable. The increase in oil and industrial metal prices over the past year should support the projected increase in headline inflation going forward (Graph I.6, right-hand panel).

In the near term, a number of mutually reinforcing factors should help support the global expansion. First, globally, low unemployment rates, some pickup in wage growth and limited expected increases in inflation should sustain household spending. Second, above-average business confidence readings and continued very accommodative financial conditions should support fixed capital investment. The recent reform of the tax regime in the United States is likely to be an additional driver of investment spending, especially in the short run. Third, thanks to the post-GFC financial reforms, banking systems are generally better capitalised and more resilient (Chapter III). Fourth, over the next two years, fiscal policy is set to turn strongly procyclical in the United States and mildly expansionary in Germany, while becoming broadly neutral in other economies.

At the same time, looking beyond the near term, such a strong projected momentum at an advanced stage in the upswing, alongside mild inflationary pressures, is quite unusual by historical standards (Box I.A). It is possible, as argued before, that there is more slack than conventional measures indicate. Moreover, to the extent that current investment raises productivity, albeit with a lag, there may be room for the economy to continue expanding at above-average rates beyond the near term. That said, there are questions about the sustainability of the current expansion. Strong investment and fiscal expenditure could, at a certain point, push the economy up against capacity constraints. This could lead to the emergence of stronger inflationary pressures than seen so far. And even without those pressures, it may become increasingly difficult for firms to find quality inputs and meet earnings expectations.

Over long horizons, the only way to ensure sustainable higher non-inflationary growth is through structural reforms. As examined in more detail in previous Annual Reports,[11] while the necessary measures are country-specific, they share a number of features. Their common denominator is fostering entrepreneurship and the rapid take-up of innovation, limiting rent-seeking behaviour and promoting the flexible reallocation of all factors of production. Unfortunately, although the pace of structural reforms picked up in the immediate aftermath of the GFC, especially in countries that were hardest hit, it has slowed significantly since then. It is now the slowest since 2011.[12] Naturally, the incentive to carry out politically difficult reforms wanes in good times, when they may appear less pressing. But it is then that any short-term adjustment costs can be borne more easily.

Making growth more sustainable also requires rebuilding the room for countercyclical policy, which has narrowed considerably relative to the pre-crisis period. This involves work on several fronts.

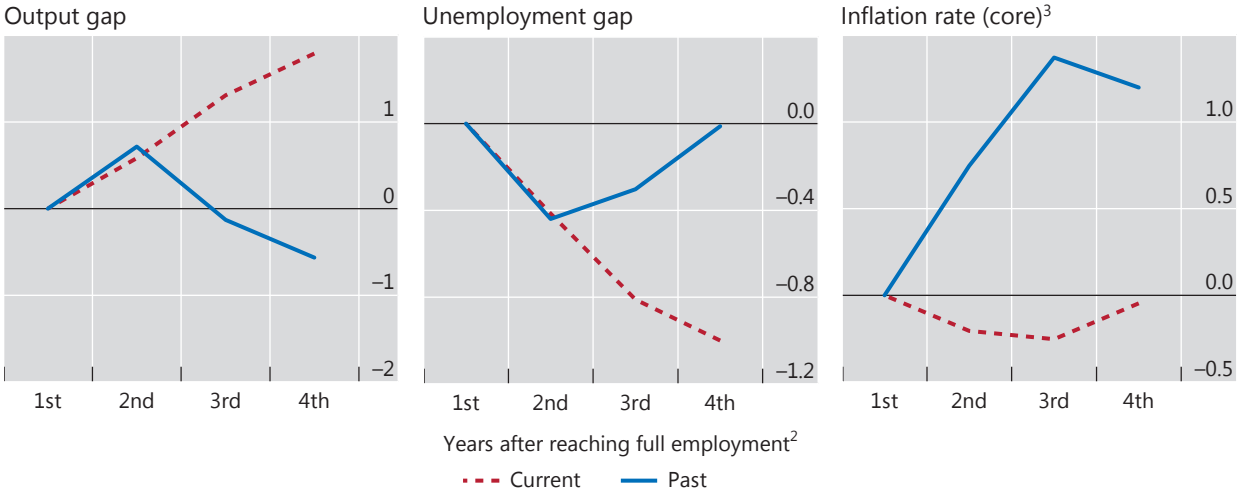
Evidence of unusual late-business-cycle momentum – a historical perspective

Global growth has picked up and broadened over the past year. This box compares recent developments with those of the past and finds that the current momentum in the recovery is unusually strong so late in the cycle.

Since last year, there has been greater confidence that both output and unemployment rates will far exceed conventional benchmarks for potential output and full employment. Graph I.A.1 highlights these developments in the euro area, Japan, the United Kingdom and the United States. Relative to the averages of previous cycles (blue lines), these economies are forecast to carry far more momentum and hence to exceed those benchmarks much further in the years ahead (red lines).

Recovery carries more momentum at this late stage in the cycle than in the past[1]

In percentage points — Graph I.A.1



[1] Past cycles cover the period 1960–2008 for EA, GB, JP and US, and the current cycle 2009–19 for GB, JP and US only (OECD projections for 2017–19). Weighted averages based on current GDP and PPP exchange rates. For EA before 1990, weighted averages of DE, FR and IT based on GDP and PPP exchange rates. [2] Measures the deviation of each series relative to that in the first year. Horizontal axis defined as starting at the first year when the unemployment rate in each economy fell below the NAIRU. For "Current", the first year is 2015 for GB, 2014 for JP and 2016 for US. The dashed line includes the projections. [3] For JP, data start in 1971 and are adjusted for the effect of the 2014 consumption tax increase.

Sources: Bank of Japan; IMF, *World Economic Outlook*; OECD, *Economic Outlook 102* and *Main Economic Indicators*; Datastream; national data; BIS calculations.

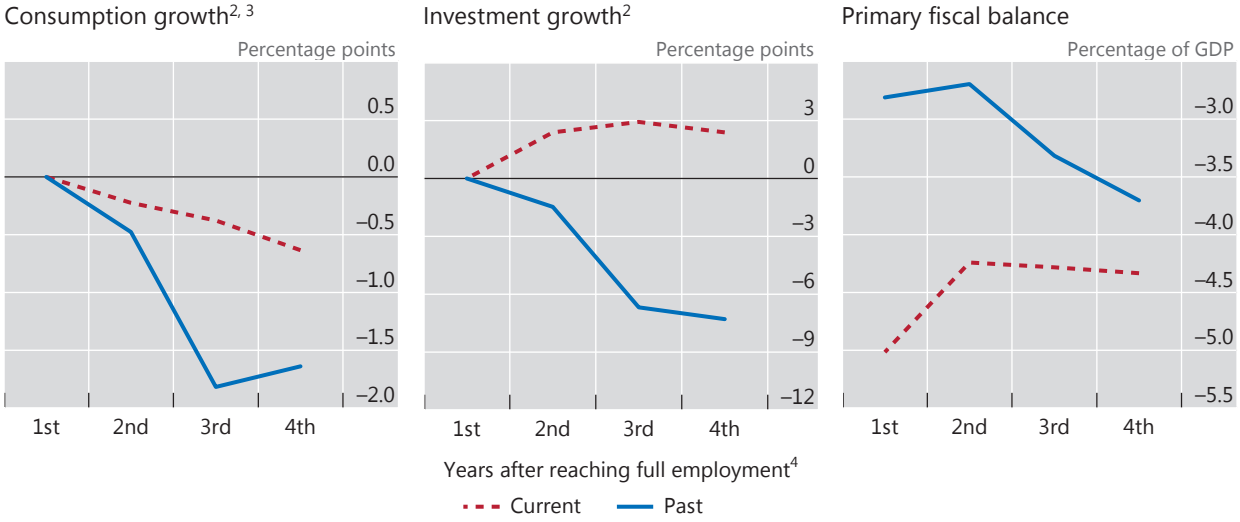
Investment and fiscal spending are two key drivers of this late-cycle momentum. Graph I.A.2 shows the main components of domestic demand for these major economies. While consumption growth exceeds the average of past cycles, both investment and fiscal spending are unusually strong. The late-cycle surge in investment reflects a delayed recovery after rather anaemic activity during most of the post-crisis period. The depreciation of the capital stock, the rise in capacity utilisation and the need to adopt new technologies are continuing to support this leg of the upswing. Similarly, current fiscal deficits are much higher than in previous cycles, and projections indicate a much more procyclical stance this time around.

Other supportive conditions are in place, not least buoyant consumer and business sentiment. The recent levels compare favourably with past cyclical highs (Graph I.A.3). As in the past, this heralds further gains in employment and incomes that, in turn, will tend to boost confidence further. This mutually reinforcing process, especially in periods of relatively easy financial conditions, suggests that there is more underlying economic momentum in the pipeline.

That said, questions remain about whether the stronger momentum can be maintained. Admittedly, it is always difficult to draw precise parallels between current macro-financial conditions and those that, in the past, derailed recoveries. Moreover, as discussed in Box I.B, there are reasons to believe that the nature of the business cycle, and in particular the role of inflation and financial factors, has changed over time. And, last but not least, there is considerable uncertainty about the measurement of full employment and potential output as events unfold, ie in

Main components of domestic demand contributing to late-cycle strength[1]

Graph I.A.2

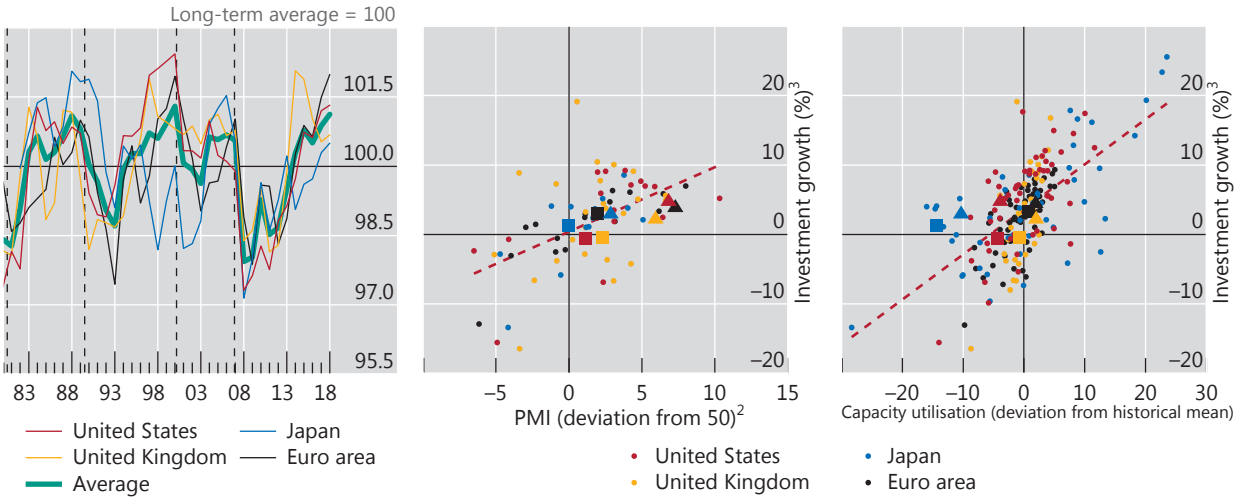


[1] Past cycles cover the period 1960–2008 for EA, GB, JP and US, and the current cycle 2009–19 for GB, JP and US only (OECD projections for 2017–19). Weighted averages based on current GDP and PPP exchange rates. For EA before 1990, weighted averages of DE, FR and IT based on GDP and PPP exchange rates. [2] Measures the deviation of the growth rate relative to that in the first year. [3] For JP, adjusted for the effect of the 2014 consumption tax increase. [4] Horizontal axis defined as starting at the first year when the unemployment rate in each economy fell below the NAIRU. For "Current", the first year is 2015 for GB, 2014 for JP and 2016 for US. The dashed line includes the projections.

Sources: IMF, *World Economic Outlook*; OECD, *Economic Outlook 102*; Datastream; BIS calculations.

Consumer confidence and business conditions suggest more momentum in the pipeline

Graph I.A.3



The dashed lines in the left-hand panel indicate the start of US recessions defined by the NBER. In the centre and right-hand panels, the square (triangle) markers refer to 2016 (2017) data.

[1] The series starts in 1992 for GB, 1999 for EA and US, and 2002 for JP. For EA, weighted average of DE, FR and IT based on GDP and PPP exchange rates. [2] Purchasing Managers' Index (PMI) varies between 0 and 100, with levels of 50 signalling no change on the previous month in the manufacturing sector. Readings above 50 signal an improvement or increase and those below 50 signal a deterioration or decrease on the previous month. [3] Real private fixed non-residential investment. [4] The series starts in 1961 for US, 1968 for JP, 1971 for EA and 1985 for GB. For EA before 1990, weighted average of DE, FR and IT based on GDP and PPP exchange rates.

Sources: OECD, *Economic Outlook 102* and *Main Economic Indicators*; Datastream; IHS Markit; national data; BIS calculations.

"real time".① Even so, historical experience tends to suggest that output and employment exceeding those benchmarks tend to increase the likelihood of a subsequent downturn.② Put differently, under those conditions it may prove more difficult for policy to ensure a smooth transition back to a balanced, sustainable growth path.

① Estimates of potential output and the natural rate of unemployment are subject to real-time uncertainty. For example, the structural changes discussed in the main text suggest that currently there may be more slack in the economy than conventionally measured. There are also reasons to consider that real-time benchmarks may be biased upwards because of the way trends are calculated (the "endpoint problem"). All else equal, if a recession were to materialise, current gaps would tend to be revised down. What happened in the wake of the Great Financial Crisis was no exception to this pattern. See D Staiger, J Stock and M Watson, "How precise are estimates of the natural rate of unemployment?", in C Romer and D Romer (eds), *Reducing inflation: motivation and strategy*, University of Chicago Press, 1997; M Watson, "How accurate are real-time estimates of output trends and gaps?", *Federal Reserve Bank of Richmond Economic Quarterly*, vol 93, no 2, Spring 2007; F Grigoli, A Herman, A Swiston and G Bella, "Output gap uncertainty and real-time monetary policy", *IMF Working Papers*, WP/15/14, January 2015; and E Rusticelli, D Turner and M Cavalleri, "Incorporating anchored inflation expectations in the Phillips curve and in the derivation of OECD measures of the unemployment gap", *OECD Journal: Economic Studies*, vol 2015/1, 2015. ② See M Jackson and T Pietro, "A forest fire theory of the duration of a boom and the size of a subsequent bust", June 2017.

First, in countries where financial vulnerabilities are building up (see below), macroprudential measures can be very helpful in rebuilding policy buffers and can help rein in financial excesses (Chapter IV). Indeed, in many countries major efforts to implement macroprudential frameworks have been an essential complement to the financial reforms aimed at strengthening individual institutions and key infrastructures (Chapter III). The measures are particularly well suited to target specific vulnerabilities, such as in the mortgage market, and can significantly improve the trade-offs the authorities need to make when articulating a balanced policy response to the macro-financial challenges they face. At the same time, they do not always address the root cause of the problems and have so far proved more effective in strengthening resilience than in succeeding, on their own, in fully preventing the build-up of financial imbalances (Chapter IV).

Second, fiscal space needs to be preserved or rebuilt, naturally with due regard for country-specific circumstances. Public debt has risen to new post-WWII highs in both advanced and emerging market economies. Against the backdrop of falling long-run potential growth rates, such higher levels of debt are likely to have reduced fiscal space. The need to build fiscal space is especially important in those economies where fiscal solvency has already been called into question, as during the euro area debt crisis, and where financial expansions may be disguising the true state of public finances, not least owing to temporarily buoyant tax revenues. Besides the need for fiscal space for the macroeconomy more generally, sound public finances are also an essential backstop for the financial system.[13]

Finally, monetary policy normalisation, too, is essential. It would create room for countercyclical policy when needed in the future, help reduce the risk of the emergence of financial vulnerabilities and contribute to restraining debt accumulation. That said, as discussed in detail in Chapter II, given the unprecedented starting point, including high debts and persistently low inflation in many jurisdictions, the path ahead for monetary policy is quite narrow. It calls for striking a delicate balance between competing considerations while taking heed of country-specific conditions.

The risks ahead

Against the backdrop of positive near-term prospects, what might be the risks ahead? In order to understand them better, it is essential to pay particular attention to financial factors. Since at least the 1980s, their relevance for business cycle

fluctuations has grown (Box I.B). The GFC is just the most recent and prominent example. In addition, with financial conditions having been so easy for so long, the possibility of a reversal with macroeconomic consequences cannot be ruled out. The recent wobbles in EMEs confirm this possibility.

To be sure, the trigger for a materialisation of risks need not be financial at all. Of particular concern today would be an escalation in trade tensions, which would negatively affect business confidence and investment. Were this seen as threatening the current multilateral trading system, the impact could be very significant. Another possible trigger could be inflation surprising on the upside. Or worries about fiscal sustainability may return, not least in high-debt slow-growing economies. Political events may put some countries under strain. And spending may simply flag as business profitability disappoints. But, even if not acting as triggers, financial factors are likely to be powerful amplifying forces.

In order to explore these issues further, after examining the background risks that could arise from the state of financial cycles around the world, we focus on two specific risk scenarios: a snapback in bond yields sparked by an inflation surprise in major economies; and a sharp reversal of risk appetite unrelated to such a surprise. We then turn to the question of the longer-term evolution of risks, should the non-inflationary expansion continue and, given historically low interest rates, support the build-up of financial imbalances and debt – private and public. All of these issues are especially pressing due to the more limited room for policy manoeuvre.

How have financial cycles played out so far?

The term "financial cycle" generally refers to the self-reinforcing interactions between perceptions of value and risk, risk-taking and financing constraints that can amplify business cycle fluctuations and are reflected in the joint behaviour of credit and asset prices (Box I.B). Empirical work indicates that the financial cycles that pose the greatest risk for economic activity are best captured more specifically by combining information from medium-term fluctuations in credit and property prices, although equity prices naturally also play a role. Graph I.7 illustrates the state of the financial cycle aggregating across different countries in broadly similar phases, using a simple measure that combines the relevant information (see Box I.B for further details).

The graph indicates that in major advanced economies financial cycles are at a relatively early stage of the expansion. This set of countries includes some of those at the heart of the GFC and that have seen some private sector deleveraging since then. In particular, at least at the aggregate level, no worrisome boom is evident in the United States and the United Kingdom: this is because, while property prices have recovered strongly from their post-crisis lows, credit-to-GDP ratios remain well below their pre-crisis peaks (not shown). Similarly, in some large advanced economies less severely affected by the GFC, such as Germany and Japan, the financial cycle is also on an upswing. This suggests that, in the near term, the cycles will not act as a headwind to economic activity and could support it further.

By contrast, in several advanced small open economies that avoided the crisis, strong financial cycle expansions seem to be coming to an end. After a period of rapid increase, growth in credit to corporates and households has decelerated since 2016, while growth in property prices has slowed or turned negative. However, household credit as a ratio to GDP remains at historical highs in Australia, Canada and some Nordic countries (Graph I.8, left-hand panel). To mitigate these vulnerabilities, national authorities have been encouraging banks to tighten their lending standards or have adopted macroprudential measures (Chapter IV).

Box I.B

The changing nature of the business cycle and its link to the financial cycle

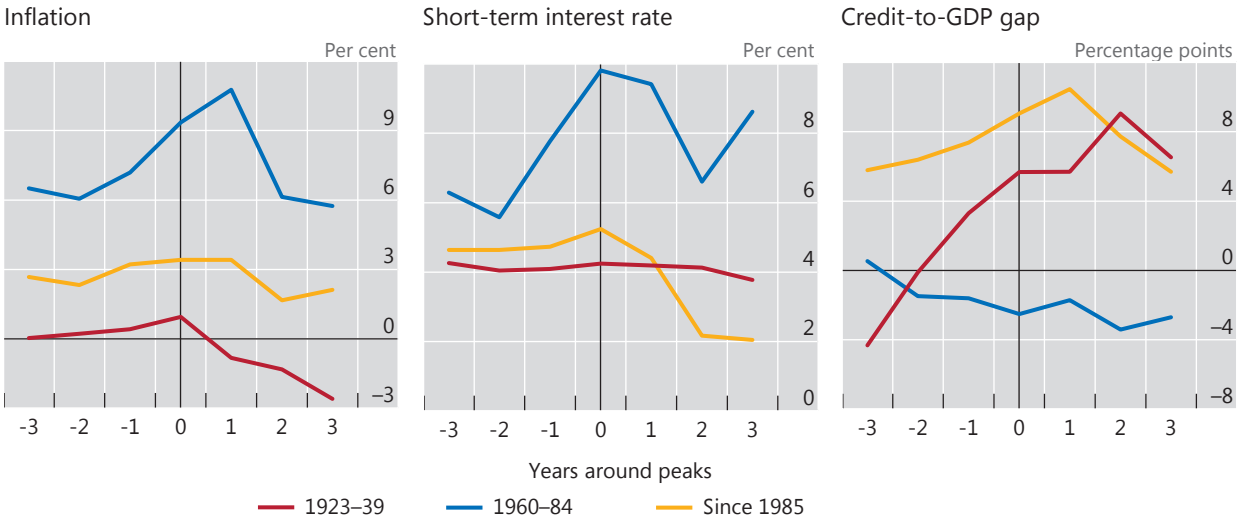
Since the early 1980s, a number of important changes have made financial factors more important in driving business cycle fluctuations while reducing the relevance of inflation as an indicator of unsustainable expansions. First, financial markets have been liberalised, starting around that time. Without sufficient safeguards, this change created the potential for larger booms, followed by busts, in credit and asset prices – that is, larger financial cycles. Second, starting roughly at the same time, inflation-focused monetary regimes became the norm. Central banks' focus on inflation control led them to gradually downplay the role of monetary and credit aggregates and to rely almost exclusively on microprudentially oriented supervision and regulation to affect financial behaviour during financial booms and hence minimise any fallout as booms turned to busts (Chapter IV). This meant that they had little reason to tighten policy if inflation remained low, even as financial imbalances built up. Finally, from the 1990s on, the entry of China and former Communist countries into the world economy, the international integration of product markets and technological advances have boosted global supply and productivity. Along with greater central bank credibility, this has made it more likely that inflationary pressures would remain mute even as expansions gathered pace. It also means that financial booms can build up further and that a turn in the financial cycle, rather than rising inflation, may bring about a downturn in economic activity.①

These factors were clearly present also in the run-up to the Great Financial Crisis. Short-term output volatility as well as the level and volatility of inflation remained low (the so-called Great Moderation). At the same time, leverage in the financial and non-financial system rose. When the financial cycle turned, financial stress emerged and the economy experienced a serious recession.

Graph I.B.1 illustrates some of these changes for a group of advanced economies, focusing on the behaviour of key variables around business cycle turning points. In the period 1960–84, inflation was higher and tended to increase by several percentage points, peaking soon after output; the short-term nominal interest rate also tended to increase by several percentage points, closely tracking inflation; and there was no credit boom – in fact, the credit-to-GDP gap tended to decline slightly after the business cycle turned. By contrast, since 1985 inflation has been lower and remarkably stable around business cycle peaks; the short-term interest rate has increased only modestly; and credit has boomed in the upswing, as indicated by the positive and large credit-to-GDP gap. Interestingly, these patterns resemble those observed between the two world wars, given that the 1920s saw a large credit boom against the backdrop of low inflation, a high degree of global trade and financial integration, as well as a monetary regime that de facto kept a lid on inflation.② Similar patterns were also in evidence pre-WWI (the classical gold standard) – the previous era of globalisation.③

The evolution around peaks in the business cycle in advanced economies[1]

Graph I.B.1

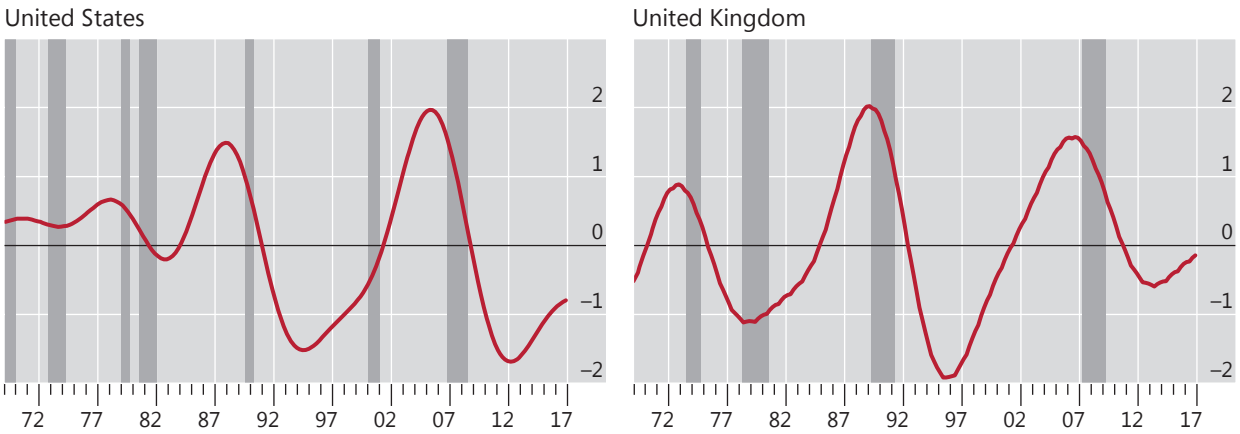


[1] The horizontal axis denotes years around peaks in the business cycles, with the peak date set at zero (vertical lines). Lines show the median evolution across countries (AU, CA, DE, DK, FI, FR, GB, NO, SE and US) and events in the respective time period.

Sources: National data; BIS calculations.

Financial cycles[1]

In standard deviations — Graph I.B.2



The shaded areas represent recessions based on ECRI.

[1] Financial cycles are measured by frequency-based (bandpass) filters capturing medium-term cycles in real credit, the credit-to-GDP ratio and real house prices. Financial cycles are normalised by country-specific means and standard deviations.

Sources: Economic Cycle Research Institute (ECRI); national data; BIS; BIS calculations.

One noteworthy mechanism behind the interaction between the financial and business cycles operates through the accumulation of debt and the subsequent increase in debt service burdens. That is, in the upswing of the financial cycle, new borrowing and rising asset prices boost economic growth. Over time, however, the accumulation of debt implies ever larger debt service commitments. These commitments have a strong and long-lasting negative impact on expenditures of indebted households and corporations. Hence, once the financial cycle turns, the positive effects of new credit on spending fade while the negative ones of the debt service burdens grow.④ It is therefore unsurprising that measures of financial cycle expansions, not least those that include the evolution of debt service burdens, can be useful leading indicators of subsequent economic downturns and that they also help explain the length and depth of the Great Recession.⑤

When focusing on the financial fluctuations that cause the greatest damage to economic activity (and the financial system), empirical research suggests that a promising strategy is to represent the financial cycle through medium-term fluctuations in credit and property prices. In turn, these fluctuations can be identified through a range of methodologies.⑥ A simple one, used in Graph I.B.2 and Graph I.7 in the main text, relies on statistical filters to extract cyclical fluctuations over periods from eight to 32 years in real credit, the credit-to-GDP ratio and real property prices. It then combines these cyclical components into a single series. To facilitate comparison across countries, it is also useful to normalise the cyclical components by country-specific means and standard deviations, so that a value of one indicates that cycles are, on average, one standard deviation higher than normal.

As an illustration, Graph I.B.2 shows the evolution of the financial cycle in the United States and the United Kingdom. It is evident that the downswings of the financial cycle – characterised by high debt service, deleveraging and falling asset prices – are closely associated with the economic downturns that have occurred in these countries since the mid-1980s, with some of these coinciding with serious financial strains. This also holds true for other advanced economies not shown here.

① For a discussion of policy regime changes and their implications for monetary and financial stability, see eg C Borio and P Lowe, "Securing sustainable price stability: should credit come back from the wilderness?", *BIS Working Papers*, no 157, July 2004; C Borio and W White, "Whither monetary and financial stability? The implications of evolving policy regimes", *BIS Working Papers*, no 147, February 2004; and C Borio, "Monetary and prudential policies at a crossroads? New challenges in the new century", *Moneda y Crédito: Revista de Economía*, vol 224, 2007. ② See eg B Eichengreen and K Mitchener, "The Great Depression as a credit boom gone wrong", in *Research in Economic History, Vol 22*, Emerald Group Publishing Limited, 2003, pp 183–237. ③ See eg W Huffman and J Lothian, "The gold standard and the transmission of business cycles, 1833–1932", in D Bordo and A Schwartz (eds), *A retrospective on the classical gold standard, 1821–1931*, NBER, 1984; and C Goodhart and P Delargy, "Financial crises: plus ca change, plus c'est la meme chose", *International Finance*, vol 1, 1998. ④ See eg BIS, *86th Annual Report*, June 2016, Box III.A; M Drehmann, C Borio and K Tsatsaronis, "Characterising the financial cycle: don't lose sight of the medium term!", *BIS Working Papers*, no 380, June 2012; and S Claessens, A Kose and M Terrones, "How do business and financial cycles interact?", *Journal of International Economics*, vol 87, 2012. ⑤ For evidence of the negative effects of high debt

service burdens on household consumption and investment, see M Drehmann, M Juselius and A Korinek, "Accounting for debt service: the painful legacy of credit booms", *BIS Working Papers*, no 645, June 2017. M Juselius and M Drehmann, "Leverage dynamics and the real burden of debt", *BIS Working Papers*, no 501, May 2015, show that, even with real-time estimates, the predicted adjustment to leverage and the debt service burden from 2005 onwards implies paths for credit and expenditure that closely match actual developments before and during the Great Recession in the United States. More generally, for evidence of the negative effect of debt on growth, see also O Jorda, M Schularick and A Taylor, "The great mortgaging: housing finance, crises and business cycles", *Economic Policy*, vol 31, January 2016; A Mian, A Sufi and E Verner, "Household debt and business cycles worldwide", *Quarterly Journal of Economics*, vol 132, 2017; IMF, "Financial conditions and growth at risk", *Global Financial Stability Report*, October 2017, Chapter 3; and M Lombardi, M Mohanty and I Shim, "The real effects of household debt in the short and long run", *BIS Working Papers,* no 607, January 2017. © See references in footnote 4.

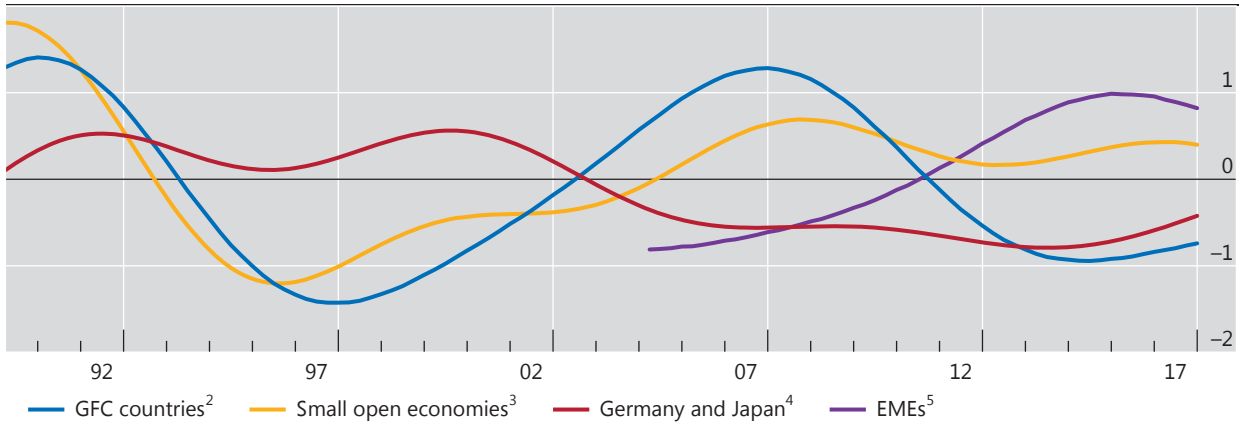
In a number of EMEs, the financial cycle appears to have already turned.[14] In 2017, credit and property prices expanded at a much lower rate than their average since 2010, and in several cases even contracted. China is a case in point, as after a very rapid increase its overall credit-to-GDP ratio peaked at the beginning of 2017. In particular, credit to the corporate sector fell sharply as the authorities intensified measures to encourage deleveraging and reduce financial stability risks.

Aggregate financial cycle measures can help to identify whether slow-moving financial factors are supporting or depressing growth and to spot risks ahead. They are, however, only a first step in the analysis of financial vulnerabilities. In several advanced economies, even in those where the financial cycle is still on an upswing, pockets of financial fragility have surfaced.

One example is the continuous deterioration of non-financial corporate balance sheets in the United States, the United Kingdom and, to a lesser extent, France and other European countries. The deterioration is evident in the steady increase in leverage, a significant drop in interest coverage ratios and a decline in the share of firms rated A or higher. In the United States, in particular, corporate leverage today is at its highest level since the beginning of the millennium and similar to that prevailing after the leveraged buyout boom of the late 1980s. This is so even after accounting for large corporate cash balances.[15] And the large share of

The financial cycle supports growth in advanced economies[1]

In standard deviations — Graph I.7

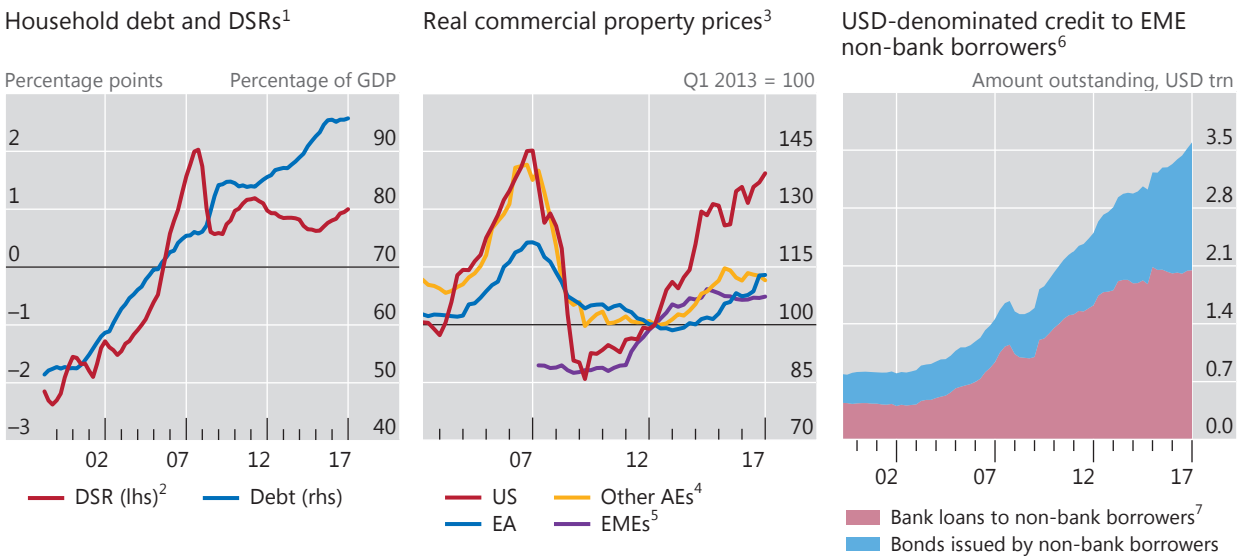


[1] Financial cycles are measured by frequency-based (bandpass) filters capturing medium-term cycles in real credit, the credit-to-GDP ratio and real house prices. Financial cycles are normalised by country-specific means and standard deviations before simple averages are taken for country groupings. [2] ES, FR, GB, IT and US. [3] AU, CA, CH, FI, NO and SE. [4] Germany and Japan are aggregated together as their respective cycles have been asynchronous with other AEs. [5] BR, CL, CO, HK, ID, KR, MX, MY, PE, SG and TH.

Sources: National data; BIS; BIS calculations.

Areas of vulnerability: commercial property, household debt and EME dollar debt

Graph I.8



[1] Simple averages of AU, CA, FI, NO and SE. [2] Average difference of the debt service ratio (DSR) from country-specific averages since 1999. [3] Definitions vary across countries; deflated by CPI; data extended using residential property prices if ending prior to end-2017. Aggregates are weighted averages based on GDP and PPP exchange rates. [4] AU, CA, CH, GB and JP. [5] BR, HK, ID, KR, PH and SG. [6] Non-banks comprise non-bank financial entities, non-financial corporations, governments, households and international organisations. [7] Loans by LBS-reporting banks to non-bank borrowers, including non-bank financial entities, comprise cross-border plus local loans.

Sources: Bloomberg; national data; BIS global liquidity indicators and locational banking statistics (LBS); BIS; BIS calculations.

firms rated just investment grade (BBB) is especially vulnerable to a deterioration in their ratings to below investment grade.

Another potential area of rising vulnerabilities is commercial real estate. Real commercial property prices have risen significantly in advanced economies. In particular, in the United States they are close to pre-crisis peaks (Graph I.8, centre panel). At the same time, nearly 50% of banks' real estate exposures are to commercial real estate, up from 40% five years ago. Values there seem particularly vulnerable to rising long-term yields. Some research suggests that, in the United States, a 200 basis point increase in long-term yields would lead to a more than 25% drop in commercial property prices.[16]

A third example concerns foreign currency borrowing in EMEs. There, the post-crisis financial cycle expansions went hand in hand with rapid growth in non-banks' US dollar borrowing, which continued throughout 2017. According to the BIS global liquidity indicators, the outstanding stock of US dollar credit to non-bank EME borrowers has roughly doubled since 2008 and currently stands at $3.6 trillion. As the dollar weakened in 2017, the annual growth rate of dollar-denominated credit to EME non-bank borrowers almost tripled from 3.1% at end-2016 to 8% at end-December 2017. Growth was especially pronounced in international debt securities, which expanded at an annual rate of 17% in December 2017 (Graph I.8, right-hand panel). Moreover, estimates indicate that borrowing through FX swaps, not covered by these statistics, was of a similar magnitude to that visible on balance sheets.[17]

These trends mean that EMEs have become more exposed to an appreciation of the dollar and to reversals in international investors' risk appetite, as recent events have confirmed. Consistent with this, there is a growing body of evidence indicating that post-crisis the value of the US dollar versus a broad basket of other currencies has become an important driver of global banks' leverage and cross-

border capital flows, more so than the VIX (Chapter II).[18] Meanwhile, the greater participation of foreign investors in local currency markets compared with pre-crisis might not necessarily act as a stabilising factor, as it may expose EMEs to a greater risk of capital flight.

Several developments in EMEs have reduced risks relative to previous episodes of large-scale foreign exchange borrowings, but they have not eliminated them altogether. Important mitigating developments include the large accumulation of foreign exchange reserves by EME central banks and, compared with the turbulence in the 1990s, more flexible exchange rate regimes. The active deployment of macroprudential measures should help too (Chapter IV). At the same time, these economies are not immune to a more general tightening of financial conditions, should the dollar continue to appreciate (see below and Chapter II) and a major shift in portfolio diversification be triggered among institutional investors.

Snapback risk

So far inflation has been rather unresponsive to the continuing tightening in product and labour markets, but at some point pressures could mount and inflation could surprise on the upside. For example, the longer the expansion continues, the more likely it is that capacity constraints will bite. This is especially so if, as projected, slack declines further at the global level: this would limit the safety valves available to individual countries and possibly generate additional pressures on commodity prices. In addition, if, as some evidence suggests, workers' and firms' expectations have become more backward-looking since the GFC, the lag before inflation emerges may simply be longer.[19]

To be sure, while inflation surprises cannot be ruled out, they are unlikely to be large. The secular structural forces keeping a lid on inflation will not vanish any time soon (see above). The increasing relevance of shale oil, given its greater responsiveness to prices, coupled with advanced economies' lower oil dependence than in the past, should dampen inflation spikes linked to sharp oil price increases and make them less persistent.[20] And while an escalation of protectionist measures could well reverse part of these trends, a persistent impact on inflation would take time to emerge.

That said, even small changes in the inflation outlook (or monetary policy response) could elicit an outsize market response. Very compressed (even negative) term premia point to the potential for a quick and sharp reversal – a snapback – as illustrated during the market ructions in early February this year. Market participants clearly see low inflation stretching out into the future, and may also have taken considerable risks owing to investment strategies, such as benchmark-hugging and other forms of herding, that can amplify market moves. For similar reasons, credit and liquidity risks may also be underpriced. The underpricing may be more severe in sectors and countries where debt levels and credit flows have grown strongly post-crisis, including EMEs.

A snapback could be rapidly transmitted to other major bond markets, especially if it took place in the market of the dominant international currency – the US dollar. For one thing, term premia tend to be quite correlated internationally, even when the expected interest rate component of bond yields is not.[21] This could lead to an undesired steepening of yield curves even in countries where output is still at or below potential and inflation remains well below objectives. Moreover, the increase in yields could be compounded by an appreciation of the dollar and capital outflows from countries with large dollar-denominated liabilities.

The effects of a snapback in bond yields on individual countries would depend on several factors. One is the size of debt and financial imbalances. The most

exposed to such risks are naturally sectors and countries where debt in relation to income is high or short-run refinancing needs are large. Among these are several small open economies and, in particular, EMEs where the financial cycle has peaked (Graph I.7), dollar debt is high, current account deficits are large and foreign exchange reserve buffers small. This assessment is confirmed by a simple sensitivity analysis (Graph I.9). In some small open advanced economies that have seen the largest increases in debt post-crisis, higher interest rates would push debt service burdens well above long-run averages, thus dampening consumption and investment (Box I.B). A second factor is the extent to which lenders could absorb any credit losses. In most countries, banks are generally better capitalised than pre-crisis, especially in countries hard hit by the GFC (Chapter III). However, post-crisis, a greater share of credit has been intermediated by non-banks, especially the shadow banking system.[22] A third factor is the participation of foreign investors in local markets, as the asset management industry has grown rapidly in recent years and become more global in its investment. This makes markets more vulnerable to a reversal in flows and an evaporation of liquidity in times of stress (Chapter III). While these risks are hard to assess, a combination of these factors would make a country especially vulnerable.

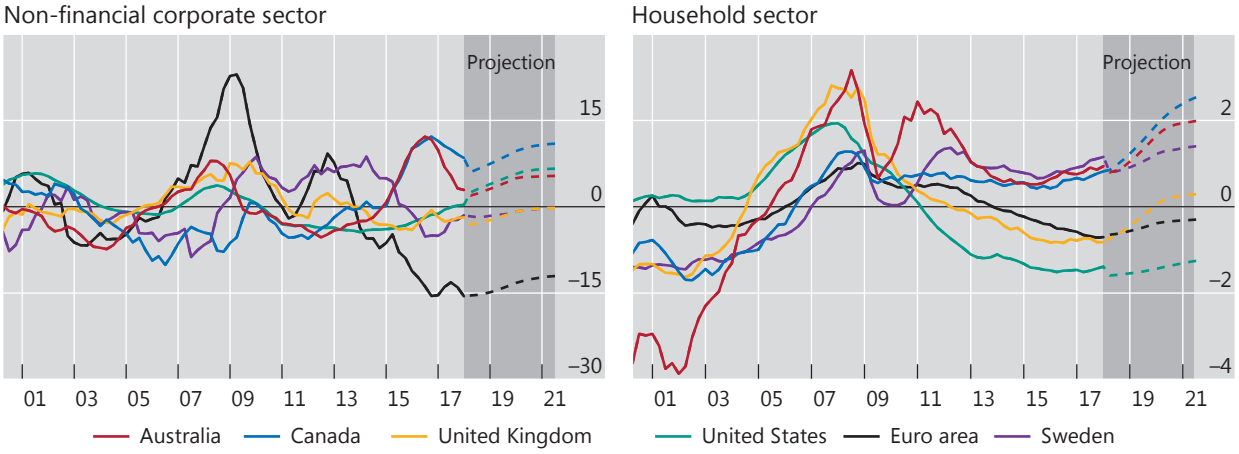
Reversal of risk appetite

A generalised sharp tightening of financial conditions may occur even if there is no inflation or monetary policy surprise in the large economies that are home to international currencies. In some EMEs it could be induced, for instance, by the domestic financial cycles contracting, given signs that they may have turned (Graph I.7). In advanced economies, worries about fiscal sustainability may return, especially in countries with high debt and slow growth and/or facing politically challenging circumstances. More generally, even in the absence of inflationary pressures, sentiment-driven swings in business or residential investment could

Vulnerability of debt service ratios to rising rates varies by country[1]

In percentage points

Graph I.9



[1] Difference of debt service ratios from country-specific averages since 1999. Projections keep the credit-to-income ratio fixed and assume that the average interest paid on the stock of debt increases in line with historical experience if short-term money market rates gradually rise by 150 basis points over 1.5 years and then remain unchanged until Q2 2021. The pass-through from money market rates to average interest rates is based on simple regressions using earliest available data for each country and up to 2017. Projections start in Q1 2018.

Sources: Datastream; Global Financial Data; national data; BIS; BIS calculations.

initiate a contraction, not least if profits were to disappoint and undermine stretched equity valuations.[23]

A severe tightening of financial conditions could play out somewhat differently from a snapback in bond yields in the major advanced economies. In particular, as international investors retreated from the countries affected, stronger flows to safe haven countries could well depress term premia there.

Despite the positive effects of safe haven flows, growth in receiving countries could be more adversely affected than in the past even if the shock originated in EMEs. The latter now account for 60% of global GDP and have contributed more than two thirds of its growth since 2010. In various adverse scenarios that hit growth in EMEs, model-based simulations indicate that growth in major economies could be reduced by up to 1 percentage point, possibly a conservative estimate.[24] Given the currently lower potential growth rate of several advanced economies, the risk of downturn could be material if the original contraction was large enough.

Risks from the further build-up of financial imbalances and debt

Even if a soft landing scenario in the global economy materialises in the near to medium term, downside risks could increase over the longer term. In particular, the combination of a non-inflationary expansion and low interest rates would be likely to encourage the further, gradual build-up of financial imbalances and debt accumulation more generally, creating the conditions for a more costly contraction further down the road.[25] In addition to private sector debt accumulation, procyclical fiscal policies, facilitated by current low borrowing costs, could lead to a further rise in public debt, especially if, as evidence indicates, the financial expansion has flattered the fiscal accounts.[26] While supportive of growth in the short run, expansionary fiscal policies could force retrenchment in the future and further limit any room for policy manoeuvre. Indeed, a growing body of studies documents how higher leverage, in both the private and public sectors, can boost growth in the short run, but at the cost of lower growth on average, including deeper and prolonged recessions, in the future.[27]

From a long-term perspective, the continuous accumulation of debt is worrying for at least two reasons. First, the higher the debt, the more sensitive the economy and financial valuations are to higher interest rates, reducing the level of interest rates an economy can bear. This, in turn, makes it more difficult to raise them, favouring further debt accumulation – a kind of "debt trap" (Chapter II). Second, higher debt – private and public – narrows the room for policy manoeuvre to address any downturn.

This broad analysis of risks, financial and real, points to a clear message. While the global economy has made substantial progress post-crisis and near-term prospects are positive, the path ahead is a narrow one. The risks highlight the importance of taking advantage of the current upswing to implement the necessary measures to put the expansion on a stronger footing and to rebuild policy buffers. Such buffers are essential to regain the room for policy manoeuvre to tackle the next downturn, which will surely come at some point.

Endnotes

[1] The participation rate of workers aged 55 to 64 increased from 56% in 2008 to 62% in 2016 on average across OECD countries. In Germany, it increased from about 60% in 2008 to over 70% in 2016. Given their shorter expected tenure, this group of workers tends to command lower wages relative to younger groups. See B Mojon and X Ragot, "The labor supply of baby-boomers and low-flation", *Sciences Po OFCE Working Paper*, no 9, 2018-01.

[2] For example, the diffusion of global production chains has slowed post-crisis. That said, costs have not fully converged across countries, suggesting room for further integration. Even without the greater contestability of labour markets due to globalisation, existing competitive pressures may interact with other factors to keep inflation weak. One example concerns the formation of inflation expectations embedded in wage negotiations. Due to existing competitive pressures, workers may be (temporarily) more reluctant to ask for wage increases in line with inflation targets. Thus, inflation expectations may have become more inertial (or appear as de-anchored), reflecting more heavily past inflation outcomes than inflation targets.

[3] See BIS, *87th Annual Report*, June 2017, Box IV.B. Evidence on the relevance of measures of global slack in Phillips curves is mixed. C Borio and A Filardo, "Globalisation and inflation: new cross-country evidence on the global determinants of domestic inflation", *BIS Working Papers*, no 227, May 2007, and R Auer, C Borio and A Filardo, "The globalisation of inflation: the growing importance of global value chains", *BIS Working Papers*, no 602, January 2017, found that the expansion of global value chains accentuated the importance of global factors relative to domestic pressures. Other studies have questioned the quantitative relevance of this channel, eg J Ihrig, S Kamin, D Lindner and J Marquez, "Some simple tests of the globalization and inflation hypothesis", *International Finance*, vol 13, issue 3, Winter 2010; ECB, "Assessing labour market slack", *ECB Economic Bulletin*, issue 3/2017, Box 3; and D Brouillette and L Savoie-Chabot, "Global factors and inflation in Canada," *Bank of Canada Staff Analytical Note*, no 2017–17, October.

[4] According to a detailed study of some 800 occupations in 46 advanced and emerging market economies, about 60% of occupations have at least 30% of their content that can be automated based on existing technologies (McKinsey Global Institute, *A future that works: automation, employment, and productivity*, January 2017).

[5] See eg D Andrews, C Criscuolo and P Gal, "Frontier firms, technology diffusion and public policy: micro evidence from OECD countries", *OECD Productivity Working Papers*, no 2, November 2015.

[6] For example, the rise of e-commerce (the "Amazon effect") seems to have lowered retail price inflation in the United States by at least 0.1% per year between 2011 and 2015, without counting for the indirect effects; see eg K Kliesen and C Gascon, "An examination of current economic conditions in the nation and in the Memphis area", *Regional Economic Briefing*, Federal Reserve Bank of St Louis, October 2017.

[7] Other factors may have also contributed, including the US Treasury's decision to shift its issuance towards shorter maturities and a possible continued strong demand for long maturities by insurers and pension funds needing to meet regulatory standards and to match their long-term liabilities.

[8] See "Volatility is back", *BIS Quarterly Review*, March 2018, pp 1–15.

[9] The dollar value may have been influenced not only by the expected beginning of normalisation in the euro area, but also by its expected path. That is, investors seem to have expected that once normalisation began in the euro area, it would proceed at a more rapid pace than in the United States.

[10] Strong dividends lent some support to US equity valuations. However, dividends per share of US equities have been growing at a much faster rate since the GFC. High dividends per share have also been supported by large stock repurchases since the early 2000s. The latter may be further strengthened by the repatriation of offshore savings following the US tax reform.

[11] See eg BIS, *83rd Annual Report*, June 2013, Chapter III.

[12] See OECD, *Going for Growth 2018*, March 2018.

[13] See BIS, *86th Annual Report*, June 2016, Chapter V.

[14] Early warning indicators for systemic banking crises also point to the build-up of vulnerabilities in several EMEs: see I Aldasoro, C Borio and M Drehmann, "Early warning indicators of banking crises: expanding the family", *BIS Quarterly Review*, March 2018, pp 29–45.

[15] See also IMF, *Global Financial Stability Report*, April 2018.

[16] These effects are implied by current capitalisation rates (rent-to-price ratios) (ACLI survey) and the estimates in J Duca, P Hendershott and D Ling, "How taxes and required returns drove commercial real estate valuations over the past four decades", *National Tax Journal*, vol 70, no 3, September 2017, pp 549–83.

[17] See C Borio, R McCauley and P McGuire, "FX swaps and forwards: missing global debt?", *BIS Quarterly Review*, September 2017, pp 37–54.

[18] One possible mechanism is that when the dollar weakens, the creditworthiness of currency-mismatched borrowers improves and global banks' balance sheet constraints are relaxed, thereby increasing the supply of cross-border lending. In turn, this ends up stimulating real investment (see S Avdjiev, V Bruno, C Koch and H S Shin, "The dollar exchange rate as a global risk factor: evidence from investment," *BIS Working Papers*, no 695, January 2018). This channel, also known as the risk-taking channel of the exchange rate, operates in the opposite direction from the textbook trade channel, which emphasises trade competitiveness resulting from currency movements. The relevance of the US dollar in influencing financial conditions globally has been documented, using the broad dollar index, in S Avdjiev, W Du, C Koch and H S Shin, "The dollar, bank leverage and the deviation from covered interest parity", *BIS Working Papers*, no 592, July 2017; S Avdjiev, C Koch and H S Shin, "Exchange rates and the transmission of global liquidity", unpublished mimeo, March 2018; and also, using bilateral exchange rates, in V Bruno and H S Shin, "Cross-border banking and global liquidity", *Review of Economic Studies*, vol 82, no 2, April 2015; V Bruno and H S Shin, "Capital flows and the risk-taking channel of monetary policy", *Journal of Monetary Economics*, vol 71, April 2015; and B Hofmann, I Shim and H S Shin, "Sovereign yields and the risk-taking channel of currency appreciation", *BIS Working Papers*, no 538, May 2017.

[19] There is some evidence that expectations have become somewhat de-anchored in the aftermath of the GFC in some countries, especially in the euro area (eg T Lyziak and M Paloviita, "Anchoring of inflation expectations in the euro area: recent evidence based on survey data", *European Journal of Political Economy*, vol 46, 2017; F Natoli and L Sigalotti, "Tail co-movement in inflation expectations as an indicator of anchoring", *International Journal of Central Banking*, January 2018); and more generally when inflation is significantly below target or when interest rates are close to the zero lower bound (eg R Banerjee and A Mehrotra, "Deflation expectations", *BIS Working Papers*, no 699, February 2018). Other studies, however, find no evidence of de-anchoring in most countries (eg O Blanchard, "The US Phillips curve: back to the '60s?", *Peterson Institute for International Economics Policy Briefs*, no PB 16-1, January 2016). De-anchoring of expectations also creates the risk of a persistent overshoot should inflation pick up.

[20] Shale oil production is more responsive to prices than that from other sources, as costs are much lower, wells can be opened and shut down much more rapidly, and the investment cycle is much shorter and less uncertain. Despite representing a small fraction of total oil production (6% in 2017), shale oil has accounted for over 60% of its cumulative increase since 2010.

[21] See eg M Obstfeld, "Trilemmas and trade-offs: living with financial globalisation", *BIS Working Papers*, no 480, January 2015; B Hofmann and E Takáts, "International monetary spillovers", *BIS Quarterly Review*, September 2105, pp 105–18; and E Kharroubi and F Zampolli, "Monetary independence in a financially integrated world: what do measures of interest rate co-movement tell us?", *BIS Papers*, no 88, October 2016, pp 193–205.

[22] For instance, the share of assets intermediated by other financial intermediaries (OFIs) has steadily increased, reaching about 30% of total financial system assets in 2016, mainly through collective investment vehicles and securitisation-based intermediation, which account for about 80% of the FSB's narrow measure of shadow banking.

[23] Sentiment-driven swings in investment along with fluctuations in credit and financial conditions are timeless features of business cycles and can explain why economic activity may turn even in the absence of strong inflationary pressures (see eg V Zarnowitz, "Theory and history behind business cycles: are the 1990s the onset of a golden age?", *Journal of Economic Perspectives*, vol 13, no 2, 1999).

[24] For example, IMF, *World Economic Outlook: Adjusting to lower commodity prices*, October 2015, considers a scenario in which a greater than anticipated slowing of potential output growth in EMEs is combined with smaller capital flows to EMEs and tighter financial conditions. After one year, growth is 0.8 percentage points lower than baseline in the BRICS and 0.4 points lower in advanced economies. Similarly, P Ollivaud, E Rusticelli and C Schwellnus, "Would a growth slowdown in emerging markets spill over to high-income countries? A quantitative assessment", *OECD Economics Department Working Papers*, no 1110, 2014, consider a scenario in which EMEs experience a 2 percentage point decline in domestic demand growth combined with a 10% fall in equity prices and a 20% currency depreciation (current account deficit countries). The same scenario also involves a 50 basis point increase in the equity risk premium in OECD economies, reflecting a negative confidence spillover due to tighter financial conditions in EMEs. As a result, growth declines by 1 percentage point in Japan and ⅔ percentage point in the United States and Germany, close to the average for OECD countries. These estimates may, however, understate the true effects, especially at times of heightened financial market volatility. Existing structural and empirical models may not fully capture the (time-varying and non-linear) power of financial factors.

[25] In addition, over time, the continuation of the expansion, especially if supported by low interest rates and growing financial imbalances, may also be accompanied by worsening imbalances in the real sector (see also Box I.A). Of particular note is the risk of sectoral resource misallocations: see eg C Borio, E Kharroubi, C Upper and F Zampolli, "Labour reallocation and productivity dynamics: financial causes, real consequences", *BIS Working Papers*, no 534, January 2016.

[26] See C Borio, M Lombardi and F Zampolli, "Fiscal sustainability and the financial cycle", in L Ódor (ed), *Rethinking fiscal policy after the crisis*, Cambridge University Press, 2017, pp 384–413.

[27] Empirical studies have documented the potential negative impact of public debt on future average growth, albeit not conclusively (for an overview, see eg "Is high public debt a drag on growth?", in BIS, *83rd Annual Report*, June 2013), and the amplifying effects of high public debt following a financial crisis (see eg O Jorda, M Schularick and A Taylor, "Sovereigns versus banks: credit, crises, and consequences", *Journal of the European Economic Association*, vol 14, no 1, February 2016).

II. Monetary policy: a narrow normalisation path

After the long period of ample and unconventional monetary accommodation that helped economies recover from the Great Financial Crisis (GFC), the incipient policy normalisation in the major advanced economies stands out in important respects. It involves normalising both policy rates and balance sheets; it is highly asynchronous, with the Federal Reserve raising policy rates while the ECB and the Bank of Japan continue with large-scale asset purchases and negative rates; and it takes place against a macro-financial landscape still marked by the preceding era of historically low interest rates. As a result, central banks face tough challenges ahead.

As an example of the special challenges confronting central banks, domestic and global financial conditions have not tightened for most of the period since the United States started to normalise its monetary policy. While conditions would probably have been even easier had the authorities not acted, the development nonetheless raises questions about policy transmission. Several factors may have been at work. The improved economic outlook and short-term fiscal stimulus may have boosted asset prices. Continued asset purchases by other major central banks may have partly offset the effects of US policy normalisation. And the gradual and predictable nature of this normalisation may itself have played a role. Only well into the second quarter of 2018 were there signs that a significant change could be in the offing, especially for emerging market economies (EMEs).

This highlights the delicate balance central banks must strike. On the one hand, moving too slowly could give rise to overheating and financial stability risks. On the other hand, moving too fast could trigger disruptive market reactions and harm the economic recovery, not least as global debt levels relative to GDP have continued to increase and financial market valuations appear stretched. The task is further complicated by uncertainties about the strength of transmission, the macroeconomic backdrop, the level of "equilibrium" interest rates, the impact of adjustments in central bank balance sheets and, above all, the limited room for manoeuvre to address any future economic downturn.

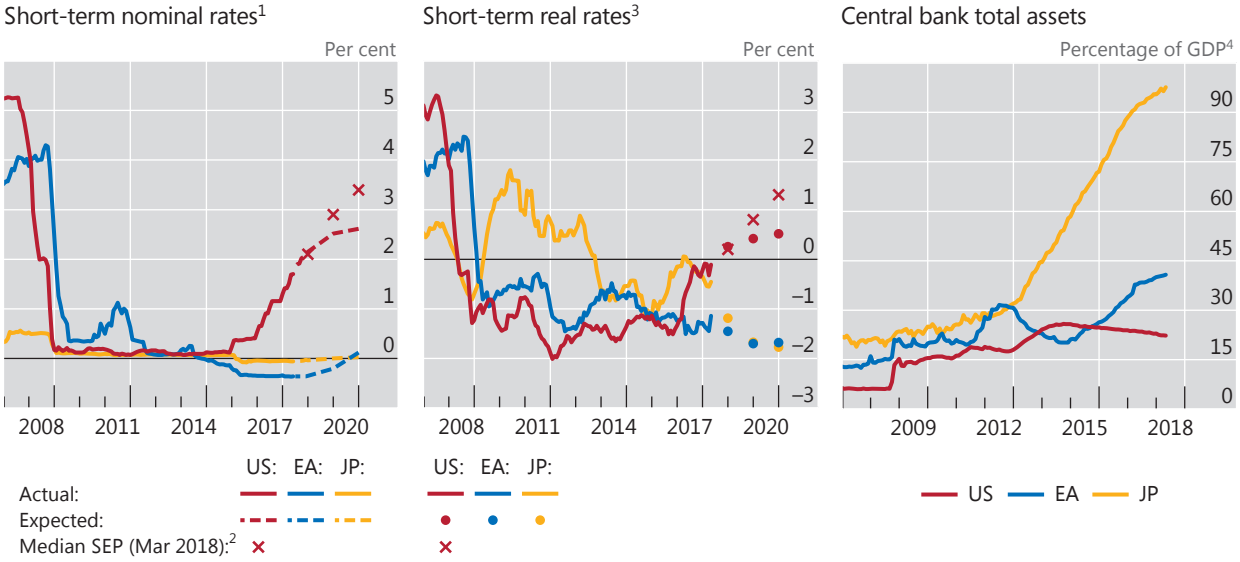
After taking stock of the global monetary policy landscape, this chapter homes in on the experience of the central bank that is furthest along the normalisation path – the Federal Reserve. It compares the current US policy tightening with previous ones, documenting its special character. The chapter closes with a discussion of the key policy challenges faced by central banks.

Monetary policy normalisation: where do we stand?

Monetary policy normalisation in the major advanced economies made uneven progress in the period under review, reflecting different states of recovery from the GFC. In the United States, policy rate normalisation gathered pace with three additional hikes of the federal funds target range, yielding an increase in the effective federal funds rate of about 80 basis points between June 2017 and May 2018 to 1.7% (Graph II.1, left-hand panel). Despite this, as of April 2018 the rate was still negative in inflation-adjusted (real) terms (centre panel). At the time of writing, the Federal Open Market Committee (FOMC) expected that economic conditions would warrant further gradual increases, so that the rate would be likely to remain below its expected longer-run level for some time. The expected pace of policy rate

An asynchronous policy normalisation

Graph II.1



[1] For actual: effective federal funds rate (US); EONIA (EA); one-month OIS rate (JP); monthly averages. For expected: OIS forward rates. As of 25 May 2018. [2] Summary of Economic Projections (SEP) of the US Federal Reserve Board members and US Federal Reserve Bank presidents. [3] Nominal rate less core inflation. For core inflation: price index for personal consumption expenditures excluding food and energy (US); HICP all items excluding food and energy (EA); CPI all items excluding fresh food and energy (JP). For expected core inflation: SEP of the US Federal Reserve Board members and US Federal Reserve Bank presidents, March 2018 (US); ECB staff macroeconomic projections for the euro area, March 2018 (EA); Bank of Japan, Outlook for Economic Activity and Prices (CPI excluding fresh food), April 2018 (JP). For Japan, core inflation is adjusted for the consumption tax hike, and fiscal year forecasts are linearly interpolated to obtain calendar year figures. [4] For the last period, latest available GDP.

Sources: Bloomberg; national data; BIS calculations.

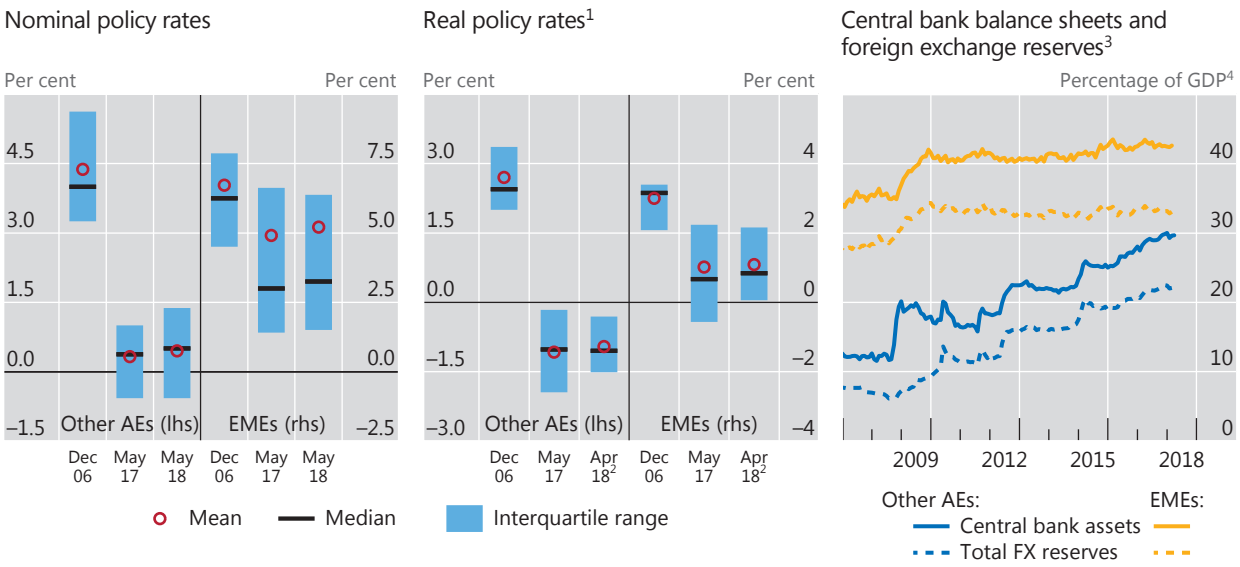
normalisation quickened in the second half of 2017 against the backdrop of strengthening labour market conditions, but remained very gradual. As of late May 2018, forward curves implied a federal funds rate at 2.6% by end-2020, while the FOMC participants' March projections were somewhat higher, at 3.4% (median projection). Thus, the real federal funds rate was expected to rise gradually to only 0.5–1.3% by 2020. In October 2017, the Federal Reserve also began to unwind its asset holdings by capping reinvestments. Thus, its balance sheet also shrank in absolute terms, after having declined relative to GDP since 2014 (right-hand panel).

By contrast, central banks in the euro area and Japan continued their large-scale asset purchases and their negative rate policies. The ECB took a further step towards normalisation by halving its monthly net asset purchases to €30 billion from January, but reiterated its commitment to keep rates at prevailing levels well past the end of the purchases, which would proceed at least until end-September this year. The Bank of Japan continued its Quantitative and Qualitative Easing with Yield Curve Control programme. The two major components of the programme are yield curve control, consisting of a negative short-term policy interest rate and a near 0% target for 10-year Japanese government bond yields, and a commitment to overshoot the 2% inflation target. In April this year, the Bank of Japan clarified that monetary policy would not be tied to a specific time frame for meeting the inflation target.

As of late May 2018, euro area and Japanese short-term interest rates were expected to rise only gradually, if at all, in the years ahead. In the euro area, market-implied short-term rates rose above zero only from 2020; in Japan, there is little sign of a meaningful increase any time soon (Graph II.1, left-hand panel). Thus, in real terms, money market rates were negative in both economies during the past

Low policy rates and large central bank balance sheets worldwide

Graph II.2



[1] Nominal policy rate less core inflation; if not available, headline inflation. [2] Or latest available. [3] Simple averages across economies. [4] For the last period, latest available GDP.

Sources: IMF; *International Financial Statistics*; CEIC; Datastream; national data; BIS policy rate statistics; BIS calculations.

year and, at the time of writing, were not expected to enter positive territory in the foreseeable future (centre panel). At the same time, the ECB's and the Bank of Japan's balance sheets expanded further, albeit at a slowing pace. By April 2018, assets at the ECB and the Bank of Japan stood at more than 40% and close to 100% of GDP, respectively (right-hand panel). Reflecting the mix of negative interest rate policies and large-scale asset purchases, respectively about 40% and more than 50% of euro area and Japanese government bonds traded at negative yields in late May 2018.

In most other advanced economies, policy rates changed little during the year, remaining well below pre-crisis levels (Graph II.2, left-hand panel). Most held their policy rates constant and maintained an accommodative policy stance as inflation remained low, including Australia, New Zealand and Norway; in the case of Denmark, Sweden and Switzerland, rates were kept negative. On the other hand, Canada raised its policy rate by 75 basis points from mid-2017, while the United Kingdom increased its base rate in November 2017 back to its pre-Brexit vote level. In real terms, policy rates in the other advanced economies remained negative across the board (centre panel). Central banks' balance sheets in those economies changed little and stood at 30% of GDP on average in April 2018 (right-hand panel).

In EMEs, policy rates also barely changed on balance in the period under review (Graph II.2, left-hand panel). The People's Bank of China continued to signal a neutral monetary policy stance and kept its key lending and deposit rates unchanged. The Reserve Bank of India too aimed at a neutral stance of monetary policy, with a 25 basis point cut in policy rates in August last year and subsequently unchanged rates through May 2018. In some cases, subdued inflation has led to more significant rate cuts as central banks extended policy accommodation (Brazil and South Africa) or sped up a transition to a neutral policy stance (Russia). Mexico tightened its policy rate to curb inflation risk as its currency depreciated, petrol prices were liberalised, and uncertainty rose about its trade relations with

the United States. In real terms, EME policy rates stayed on average slightly above zero (centre panel). Central bank balance sheets remained stable vis-à-vis GDP, standing on average above 40% in April 2018 and reflecting mainly large FX reserve holdings.

Starting in April 2018, some countries came under pressure as their currencies depreciated and capital flows reversed. While largely triggered by idiosyncratic developments, this also reflected a broader change in investor sentiment, linked to an appreciating US dollar and rising US interest rates (Chapter I). In particular, Argentina hiked its main interest rate by a total of 12.75 percentage points in April and May, to 40%. Also in May, Turkey raised its late liquidity window rate by 3 percentage points, to 16.5%, to stem outflows. Both countries stepped up foreign exchange intervention, and Argentina applied for an IMF programme. Indonesia raised interest rates twice in May, totalling 50 basis points and reversing the rate cuts of the third quarter of 2017, to stabilise the exchange rate.

The current backdrop for monetary policy normalisation is unprecedented in a number of important respects. Historically, interest rates in advanced economies, real and nominal, have never stayed this low for this long and central bank balance sheets have never swelled as large in peacetime. The long spell of multi-pronged policy accommodation may have left lasting marks on the macro-financial landscape, making policy effects harder to assess. Meanwhile, a broad-based economic recovery, with several countries close to or even beyond standard measures of full employment, coincides with subdued inflation in many jurisdictions (Chapter I). And debt levels in relation to GDP stand near historical highs.

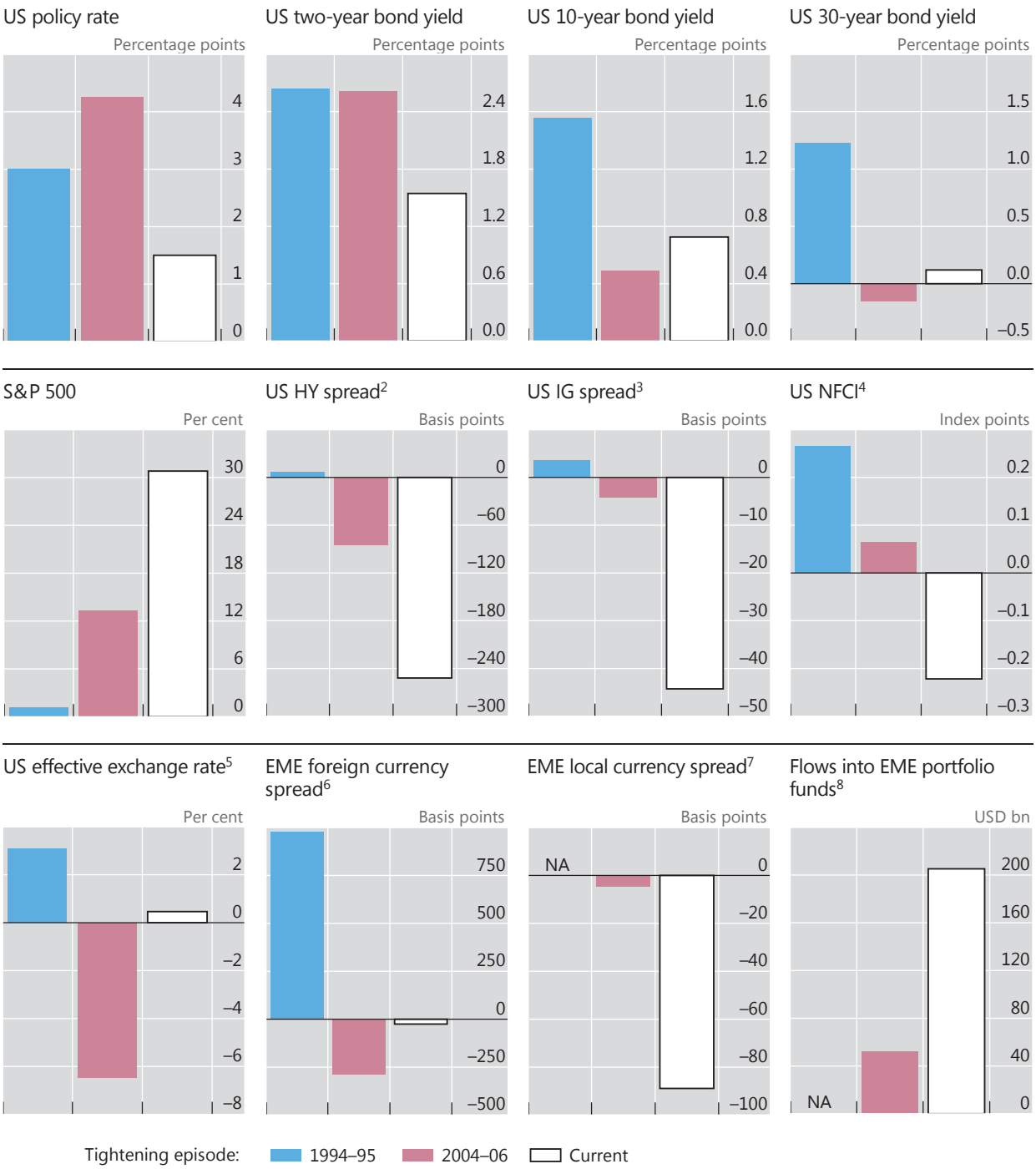
Monetary and financial conditions: imperfect transmission?

One notable development that may be partly linked to this unprecedented picture concerns the relationship between monetary policy and financial conditions. A tightening of monetary policy would normally coincide with a tightening of financial conditions. Short- and long-term capital market rates would be expected to rise, risk spreads to widen, asset price increases to at least slow down and the domestic currency to appreciate whenever interest rate differentials widened. A tightening in major economies would further be expected to be propagated globally, working through investor portfolio decisions and changes in risk-taking. Insofar as financial conditions are a key transmission channel for monetary policy, any weak link raises questions about the effectiveness of policy measures. And these conditions may also complicate policy by raising the risk of undesirable market disruptions further down the road if they induce or reflect higher risk-taking (Chapter I).

In fact, until at least the first quarter of 2018, no tightening of financial conditions accompanied the normalisation of US monetary policy; it was only well into the second quarter that any appreciable tightening was seen, particularly in EMEs (see also Chapter I). From December 2015, when the United States started tightening, until late May of this year, two-year US Treasury yields rose in line with higher policy rates, by more than 150 basis points (Graph II.3). But the yield on the 10-year Treasury note increased by only around 70 basis points, while very long-term yields traded sideways. Importantly, the S&P 500 surged by over 30%, and corporate credit spreads narrowed, in the high-yield segment by more than 250 basis points. The Federal Reserve Bank of Chicago's National Financial Conditions Index (NFCI) trended down to a 24-year trough last year before rebounding slightly this year, in line with several other financial condition gauges. The dollar appreciated slightly, but this reflected mainly a reversal from late April that undid its previous depreciation. This reversal

A tightening paradox?

Changes during US monetary policy tightening episodes[1] Graph II.3



[1] Tightening episodes are February 1994–February 1995, June 2004–June 2006 and the current tightening episode (starting from December 2015). The reference periods are, respectively, the months preceding the first rate hike. End-of-month data. As of 25 May 2018. [2] High-yield (HY) option-adjusted spread. [3] Investment grade (IG) option-adjusted spread. [4] Federal Reserve Bank of Chicago's National Financial Conditions Index; lower values indicate looser financial conditions. [5] Federal Reserve broad nominal effective exchange rate index; higher values indicate a stronger US dollar. [6] JPMorgan EMBI+ stripped spread, EMBI stripped spread before December 1997. [7] Spread of JPMorgan GBI-EM Broad Diversified composite index over US 10-year sovereign yields. [8] Total net bond and equity flows to EMEs.

Sources: Barclays; Bloomberg; Datastream; EPFR; JPMorgan Chase; national data; BIS policy rate statistics; BIS calculations.

went hand in hand with a significant tightening in EME financial conditions (Chapter I). That said, by late May, EME local currency bond spreads were still 90 basis points below their end-November 2015 levels, and cumulative net flows into EME portfolio funds over this period amounted to more than $200 billion.

Qualitatively, the current tightening cycle has some similarities with its counterpart in the mid-2000s. At that time, policy rate hikes of more than 400 basis points coincided with only marginal increases (or even declines) in long-term government bond yields – Federal Reserve Chairman Alan Greenspan's famous "conundrum". Stock markets also rose and US credit spreads narrowed, albeit by less than during the current tightening. The NFCI did at least register a small increase back then. Also, the US dollar fell by more than 6%, while EME spreads narrowed and portfolio flows rose.

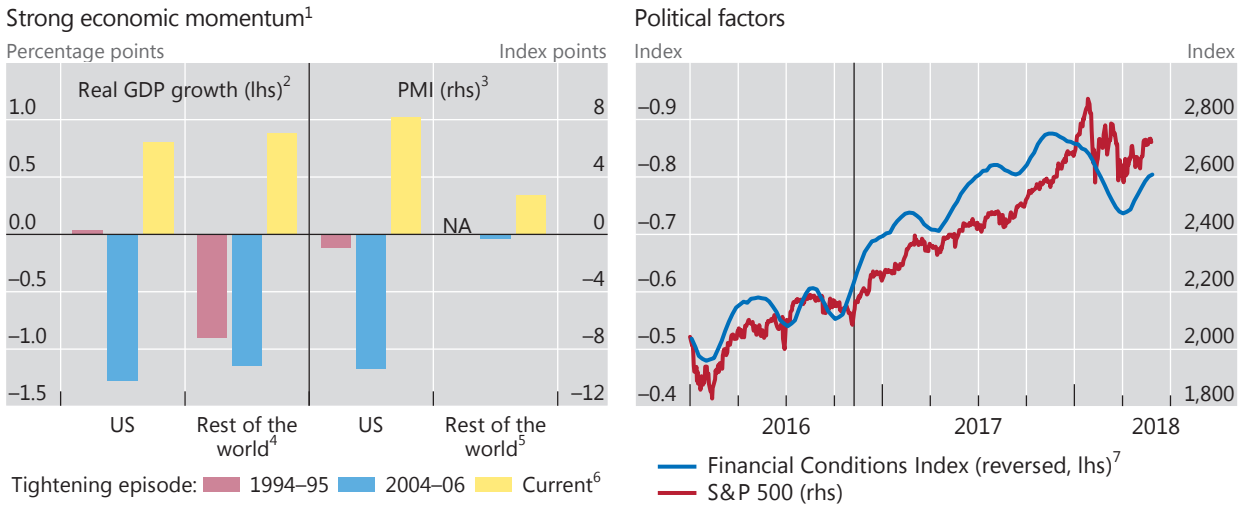
These two episodes contrast markedly with the tightening of 1994–95, when the Fed's actions triggered sharply higher long-term yields, somewhat wider US credit spreads and a tightening of overall US financial conditions, as captured by the NFCI index. Back then, the dollar appreciated, and EME spreads widened significantly on the back of large EME currency depreciations.

There are several possible reasons for monetary policy's limited impact on financial conditions. These include factors unrelated to the policy itself, large and growing central bank balance sheets outside the United States, and possibly the gradual and predictable nature of the normalisation. Consider each in turn.

The improved macroeconomic backdrop and outlook, potentially further boosted in the near term by the prospect of fiscal expansion, could have counteracted the effects of monetary policy tightening. Both in the United States and globally, the growth outlook has strengthened considerably over the past year, while inflation has remained subdued. In particular, during the current tightening cycle, economic momentum, reflected in the change in real GDP growth and in business sentiment, increased both in the United States and globally, while it tended

Factors offsetting monetary tightening

Graph II.4



The vertical line in the right-hand panel indicates 8 November 2016 (US presidential election).

[1] Changes in the respective variables during US tightening episodes. [2] Based on quarterly data. [3] Manufacturing sector (if not available, whole economy). [4] Simple averages across 10 AEs and 16 EMEs based on data availability. [5] Simple averages across nine AEs and 11 EMEs based on data availability. [6] For real GDP growth: up to Q1 2018 for the US; Q4 2017 for the rest of the world. For PMI: up to April 2018. [7] Federal Reserve Bank of Chicago's National Financial Conditions Index; lower values indicate looser financial conditions.

Sources: Datastream; IHS Markit; national data; BIS calculations.

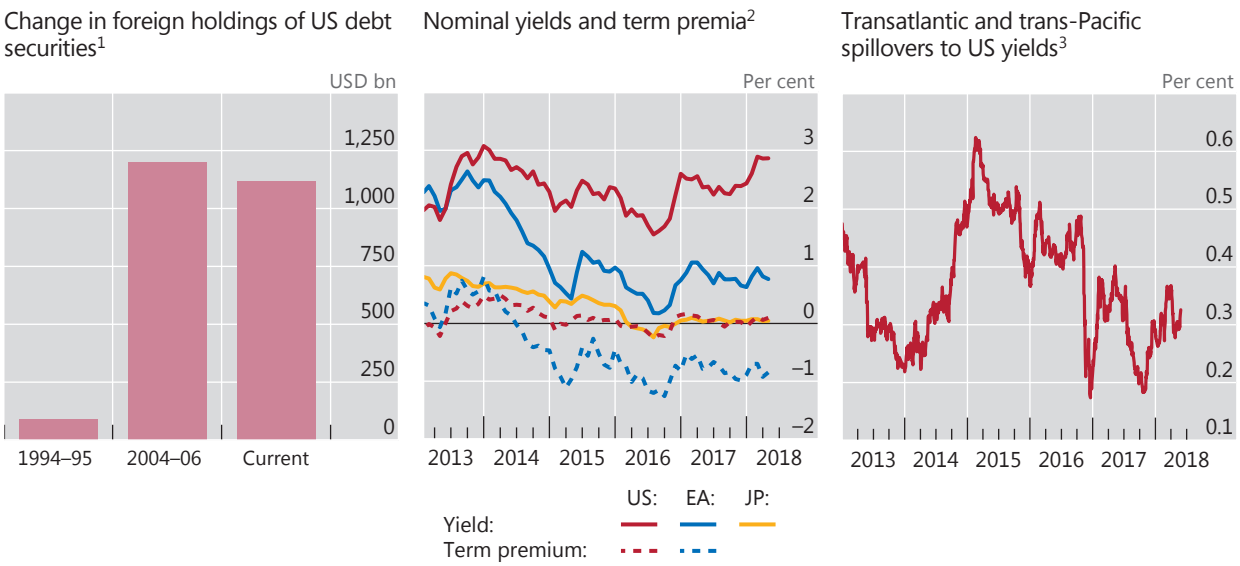
to slow during previous tightening episodes (Graph II.4, left-hand panel). Stronger growth has probably translated into lower perceived default risk and higher expected dividends, at least in the near term. This could have reduced credit spreads and boosted asset prices. In addition, political factors could have boosted financial market sentiment. Specifically, the outcome of the US presidential election in November 2016 may have buoyed expectations for business- and growth-friendly policies, thereby raising projected corporate profits and hence asset prices. Indeed, the election ushered in a steep increase in stock prices and an easing of broader financial conditions (right-hand panel).

The large-scale asset purchase programmes of the major central banks outside the United States may have offset the impact of the Fed's monetary policy normalisation. While the reduction in the Fed's balance sheet would be expected to raise the US term premium, continued large-scale asset purchases in Europe and Japan may have spilled over across borders and compressed it, as investors turned to higher-yielding US securities. Indeed, foreign holdings of US debt securities have increased as significantly during the current tightening as they did during the 2004 conundrum episode (Graph II.5, left-hand panel). By contrast, in 1994, foreign holdings barely rose.

The co-movements of US, euro area and Japanese bond yields, and of their term premia, support this notion (centre panel). Indeed, time variation in transatlantic and trans-Pacific interest rate spillovers can be linked to major changes in monetary policy (right-hand panel). Between 2014 and 2016, when the ECB and the Bank of Japan, respectively, launched and expanded their asset purchase programmes and introduced negative policy rates, movements in German and Japanese government bond yields explained about 40% of those in Treasury yields. Spillovers weakened in late 2016 but have risen again since late 2017.

Central bank asset purchases weigh on long-term interest rates

Graph II.5



[1] Changes during US tightening episodes. [2] Based on 10-year government zero coupon bond yields; see P Hördahl and O Tristani, "Inflation risk premia in the euro area and the United States", *International Journal of Central Banking*, vol 10, September 2014. Euro area is represented by France. [3] Spillovers from German and Japanese 10-year government bond yields to US 10-year Treasury yield. Estimated following F Diebold and K Yilmaz, "Measuring financial asset return and volatility spillovers, with application to global equity markets", *Economic Journal*, vol 119, no 534, January 2009. Contributions are calculated from the forecast error variance matrix inferred from generalised identification of shocks.

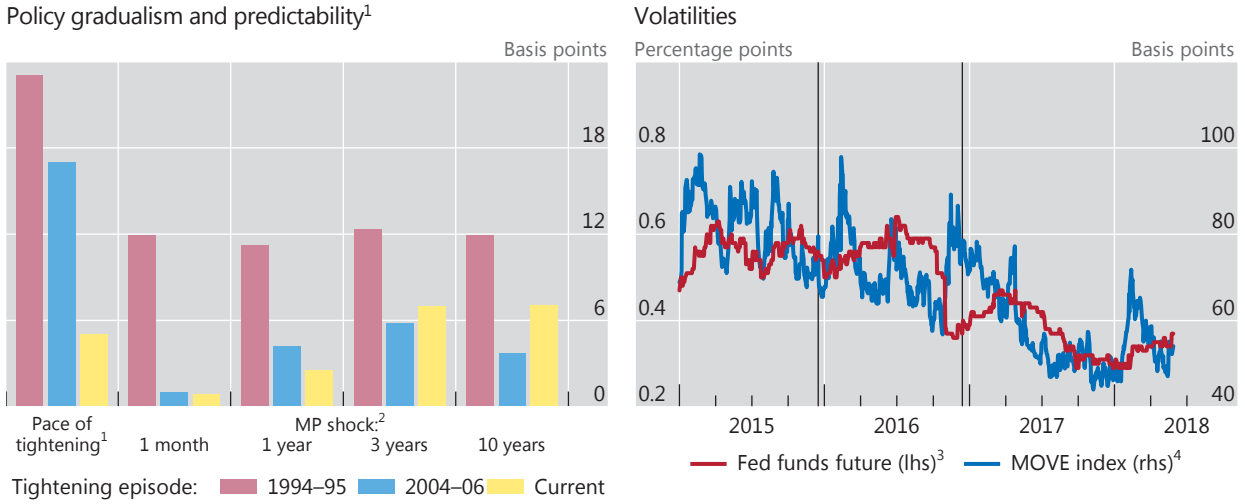
Sources: Federal Reserve Financial Accounts of the United States; Bloomberg; Datastream; national data; BIS calculations.

Finally, the gradualism and predictability of the tightening may also have played a role. Gradualism is especially called for when there is high uncertainty about the economic context and monetary transmission, as currently.[1] In such a situation, this can help avoid undesirable financial and economic responses. Yet a high degree of gradualism and predictability may also dilute the impact of policy tightening. More gradual hiking paths correspond to a flatter trajectory of expected future short rates while a high degree of predictability implies low uncertainty about that trajectory, reducing risk premia. Through these effects, gradualism and predictability could induce search-for-yield and risk-taking behaviour, further compressing risk premia and boosting asset prices.[2] Moreover, market participants could interpret gradualism and predictability as signalling that central banks wish to prevent sharp market moves, thereby providing implicit insurance for risky position-taking.[3]

Since December 2015, the Federal Reserve has been normalising its monetary policy very gradually and predictably. The average monthly pace of policy rate increases was just 5 basis points as of late May 2018, compared with a respective 20-plus and 15-plus basis points during the tightenings of the mid-1990s and mid-2000s (Graph II.6, left-hand panel). At the same time, the surprise element of policy rate changes was generally small. Short-term market interest rates changed on decision days by less than 2 basis points on average, similar to the impact of rate hikes in 2004, but much less than in 1994 when surprises tended to exceed 10 basis points. The surprise in medium- and long-term Treasury yields was somewhat higher than in the 2000s, possibly because of greater reliance on forward guidance and the additional effect coming from balance sheet normalisation, but still only around one half of that during the mid-1990s (left-hand panel). Similarly, the reduction in the Federal Reserve's asset holdings has followed a preannounced schedule with moderate reinvestment caps. Consistently with this overall picture, the volatility of policy rate futures and implied bond market volatility have eased since the beginning of policy rate normalisation (right-hand panel).

The current tightening has been highly gradual and predictable

Graph II.6



The vertical lines in the right-hand panel indicate 16 December 2015 (first rate hike) and 14 December 2016 (second rate hike).

[1] Average monthly changes in the US policy rate. [2] Average absolute changes in key interest rates on FOMC meeting dates. For one-month and one-year maturities, based on OIS and Libor rates; for three-year and 10-year maturities, based on US Treasury yields. [3] Annualised standard deviation of the daily price change in 12th generic futures contracts over the 90 most recent trading days. [4] Merrill Lynch Option Volatility Estimate.

Sources: Bloomberg; Datastream; BIS calculations.

Policy challenges

The weak effect of monetary policy tightening on financial conditions is just one example of the challenges central banks face in the normalisation process. Given the unprecedented starting conditions and the large array of instruments in use, there is considerable uncertainty surrounding the transmission mechanism and policy benchmarks.

Take the impact of interest rate changes. On the one hand, there is evidence that the link between short rates and long rates has weakened over yearly horizons since the early 2000s.[4] This suggests that monetary policy may have to act more strongly to achieve a given effect. On the other hand, there is also evidence that long-term interest rates have become more sensitive to monetary policy surprises at higher frequencies (daily and intradaily) over the same period.[5] This points to the risk of a snapback in long-term rates should policy be tightened more than expected.

Similar questions concern the impact of balance sheet normalisation on long-term rates. Estimates are very imprecise and vary widely. For example, a Federal Reserve study found that the announced balance sheet run-off plan would increase the 10-year Treasury term premium by around 15 basis points in the year 2018, but with a statistical uncertainty range around the level of the term premium of as much as 70 basis points.[6]

Questions also relate to the end-point for interest rates – sometimes referred to as the natural or equilibrium rate. This is conventionally defined as the real interest rate consistent with output at potential and inflation at target. Most estimates point to a notable decline in the natural rate over the past few decades, with a further drop post-crisis, but the ranges are very wide (Graph II.7). This decline has been linked to real developments that reduce investment and raise saving, such as demographic shifts and slowing potential growth. At the same time, while this notion draws strength from studies that focus on the past three decades, some recent work based on longer historical data finds less support for this hypothesis, including by pointing to a role for monetary policy (Box II.A).

Against this backdrop, central banks must strike a delicate balance in determining the timing and pace of any normalisation.

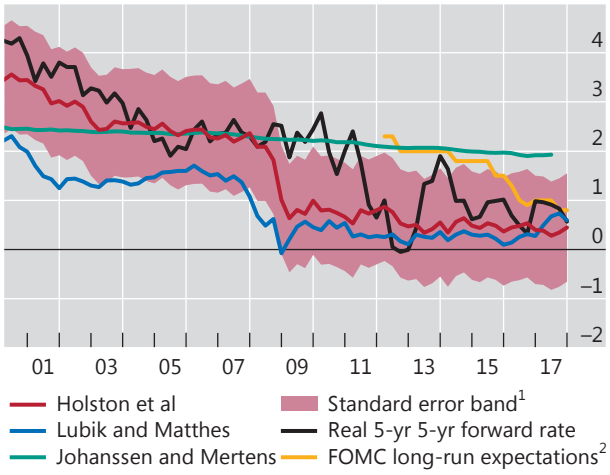
On the one hand, there is a risk of moving too early and too rapidly. The upswing may prove fragile, given the uncertainty over how financial markets and the economy might respond after the long period of ultra-low rates. Too fast an increase in interest rates may trigger an abrupt repricing in financial markets if it prompts an outsize revision in the expected level of risk-free interest rates or a decompression in risk premia. Such a snapback could be amplified by market dynamics (Chapter III) and possibly have adverse macroeconomic consequences (Chapter I and below). It could compromise the economic recovery or spill across borders in the case of international funding currencies, with broader repercussions. A particular concern is that the macroeconomic impact of tighter monetary policy could turn out to be larger than in the past, since debt has continued to rise globally as interest rates have sagged (Graph II.8, left-hand panel). There is evidence that the impact of monetary policy on the economy is significantly larger when debt is high, reflecting in part a much higher short-term impact on debt service ratios (right-hand panel).[7]

Other considerations too would support a very patient strategy. By testing how far the expansion can be accommodated, central banks may partly reverse some of the crisis-induced loss in production potential.[8] This could entice discouraged workers back into the labour force and boost investment and productivity. Such a strategy would also allow central banks to test the true extent of slack in the economy, premised on the view that inflation reliably signals excess capacity. Indeed, it is common practice to adjust measures of full employment and potential output according to the behaviour

The natural interest rate is measured with considerable uncertainty

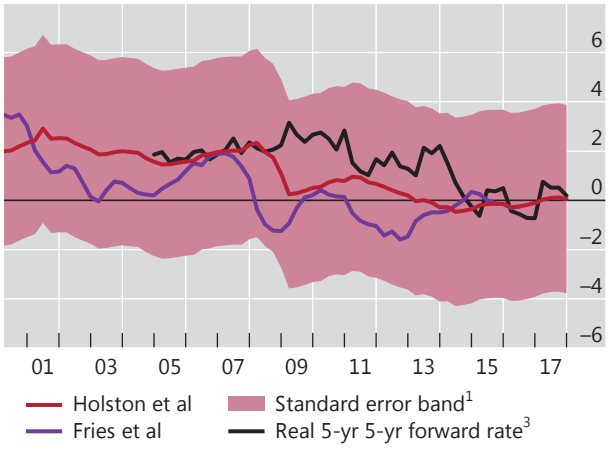
In per cent — Graph II.7

US natural rate measures



Holston et al; Lubik and Matthes; Johanssen and Mertens; Standard error band[1]; Real 5-yr 5-yr forward rate; FOMC long-run expectations[2]

Euro area natural rate measures



Holston et al; Fries et al; Standard error band[1]; Real 5-yr 5-yr forward rate[3]

[1] One standard error bands around natural rate estimates of Holston et al (2016), based on sample averages. [2] Longer-run median projection from the SEP for the federal funds rate less 2% inflation target. [3] Based on French government bond yields, supplemented by German government bond yields to interpolate missing data.

Sources: S Fries, J Mésonnier, S Mouabbi and J Renne, "National natural rates of interest and the single monetary policy in the euro area", Bank of France, *Working Papers*, no 611, October 2017; K Holston, T Laubach and J Williams, "Measuring the natural rate of interest: international trends and determinants", Federal Reserve Bank of San Francisco, *Working Papers*, November 2016; B Johannsen and E Mertens, "A time series model of interest rates with the effective lower bound", *BIS Working Papers*, no 715, April 2018; T Lubik and C Matthes, "Calculating the natural rate of interest: a comparison of two alternative approaches", Federal Reserve Bank of Richmond, *Economic Brief*, October 2015; Bloomberg; national data; BIS calculations.

of inflation, raising them if inflation fails to increase. Moreover, as long as inflation is not very responsive to demand and expectations remain well anchored – a flattening of the Phillips curve – the risk of a significant overshoot would be low, allowing the central bank to remain patient. Indeed, concerns with a de-anchoring of expectations and the associated loss of credibility have been a key motive for central banks' efforts to push inflation towards target and prevent deflation.

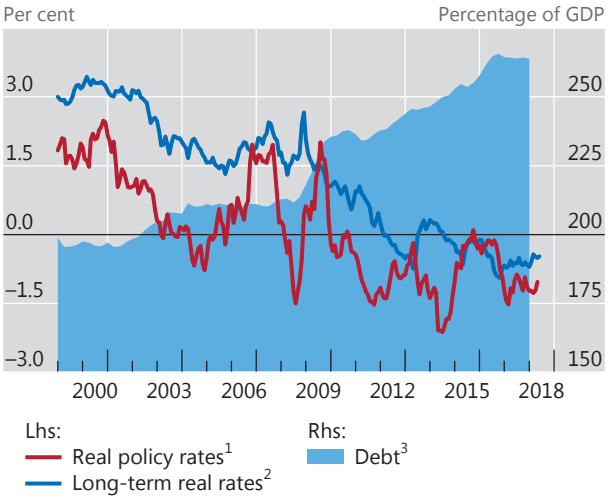
On the other hand, running a high-pressure economy raises risks too. The possibility of a stronger than expected rise in inflation cannot be ruled out (Chapter I). And given the hypersensitivity of overstretched financial markets, any disproportionate reaction could potentially damage the economy. The sharp stock market correction in response to slightly higher than expected wage increases in the United States underlines this risk. In fact, postponing and/or slowing down normalisation could further encourage risk-taking, paradoxically amplifying the likelihood of such a market response. Moreover, one might conjecture that a central bank risks a larger loss of credibility from overshooting the inflation target than from undershooting it. After all, inflation targeting was adopted to fight high inflation, and political economy pressures generally tend to push for an easing bias.

Even if inflation does not loom, risk would not disappear. Since the mid-1980s, unsustainable economic expansions appear to have manifested themselves mainly in the shape of unsustainable increases in debt and asset prices (Chapter I).[9] Thus, even in the absence of any near-term market disruptions, keeping interest rates too low for too long could raise financial and macroeconomic risks further down the road. In particular, there are reasons to believe that the downward trend in real rates and the upward trend in debt over the past two decades are related and even

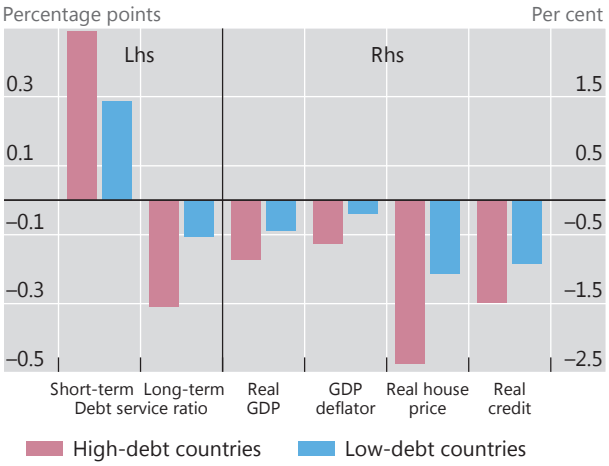
Higher debt raises vulnerabilities

Graph II.8

Interest rates sank as debt soared



Peak impacts of 100 basis point policy rate increase4



[1] Nominal rate less headline consumer price inflation. Simple average of DE, JP and US. [2] Simple average of index-linked 10-year government bond yields of FR, JP and US. [3] Total credit to non-financial sectors. Weighted average of the G7 economies plus China based on GDP and PPP exchange rates. [4] Peak impacts from impulse responses to a 100 bp shock to the policy rate based on mean group panel VAR estimations using quarterly data for 18 AEs and EMEs. For details, see B Hofmann and G Peersman, "Is there a debt service channel of monetary transmission?", *BIS Quarterly Review*, December 2017.

Sources: Bloomberg; Datastream; national data; BIS calculations.

mutually reinforcing. True, lower equilibrium interest rates may have increased the sustainable level of debt. But, by reducing the cost of credit, they also actively encourage debt accumulation. In turn, high debt levels make it harder to raise interest rates, as asset markets and the economy become more interest rate-sensitive – a kind of "debt trap" (Graph II.8, right-hand panel).[10]

A further complication in calibrating normalisation relates to the need to build policy buffers for the next downturn. Indeed, the room for policy manoeuvre is much narrower than it was before the crisis: policy rates are substantially lower and balance sheets much larger. While some central banks have shown that interest rates can be lowered below zero, this is probably possible only to a limited extent. And while central banks have field-tested unconventional tools in the wake of the crisis, their side effects set limits on how far they can be used. Hence, all else equal, if room for manoeuvre is valuable, it would make sense to adjust the normalisation trajectory to expand it. How far this is the case depends on the perceived likelihood of a downturn occurring before normalisation is complete, on the perceived impact of low rates on debt accumulation and on the perceived costs of raising rates.

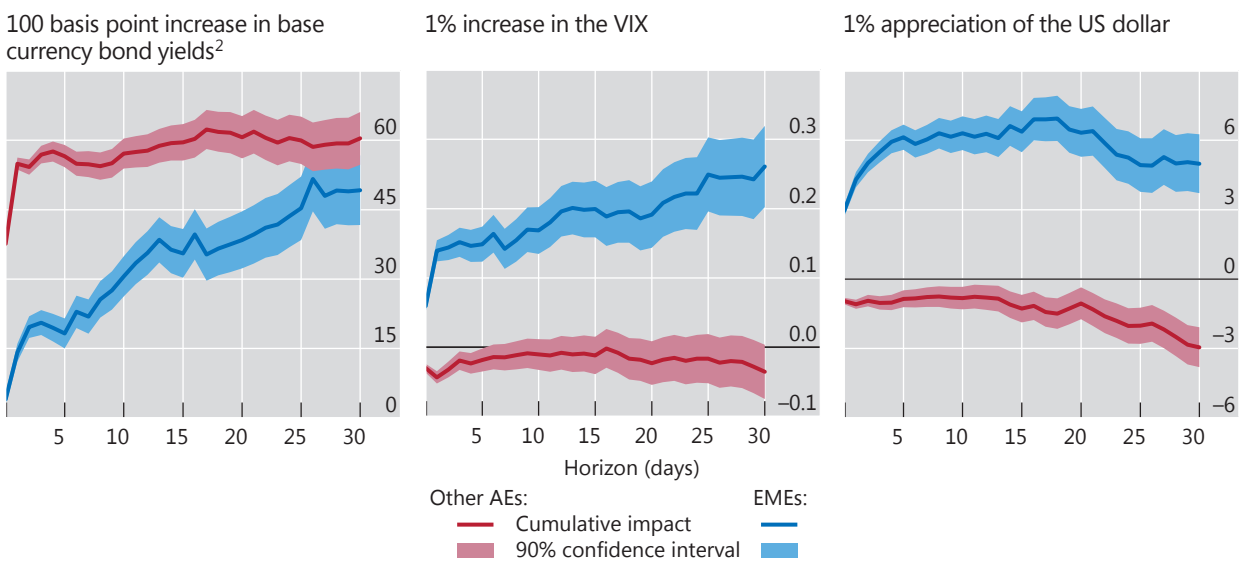
The policy normalisation of major central banks will also affect EMEs and other advanced economies through spillovers. Specifically, as a result of global investor arbitrage, there is a strong positive link between government bond yields in the core advanced economies and those in EMEs and other advanced economies (Graph II.9, left-hand panel). An increase in the VIX, a gauge of investor risk appetite, precedes a significant increase in EME yields and a slight decrease in yields in other advanced economies, probably reflecting safe haven flows (centre panel). More importantly, US dollar appreciation, working through foreign currency borrowing and global investor balance sheets, coincides with portfolio outflows from EMEs, pushing up bond yields there. Together with lower bond yields in the other advanced economies, this probably again reflects a flight to safety (right-hand panel).[11]

All this amplifies changes in financial conditions globally. During phases in which interest rates remain low in the main international funding currencies, especially the US dollar, EMEs in particular tend to benefit from easy financial conditions. These effects then play out in reverse once interest rates rise. A reversal could occur, for instance, if bond yields snapped back in core advanced economies, and especially if this went hand in hand with a rise in stock market volatility and a US dollar appreciation, as EME borrowers sought to hedge their positions and capital inflows turned into outflows. A clear case in point is the change in financial conditions experienced by EMEs since the US dollar started appreciating in the first quarter of 2018.

Such spillovers have posed a major challenge for central banks in EMEs and other advanced economies in the past, and will continue to do so in the future. On the one hand, a further prolongation of easy global financial conditions would worsen the policy trade-offs for economies that face concerns about appreciating currencies and the build-up of domestic financial imbalances. In small open advanced economies that do not rely on foreign currency borrowing and where inflation is already below target, any easing of domestic monetary policy to prevent excessive domestic currency appreciation would tend to encourage the further build-up of financial imbalances. For instance, in Switzerland interest rates have been negative and inflation very subdued for quite some time while a boom in the mortgage market has been raising concerns among the authorities. In EMEs that rely heavily on foreign currency debt, the room for policy manoeuvre is even narrower. This is because financial conditions in that debt segment depend directly on the monetary policy of the country issuing the currency of denomination. In addition, if inflation is above target or the build-up of domestic financial imbalances is a concern, tightening monetary policy is less effective. The tightening promotes a

Global spillovers

Impulse response of five-year sovereign yields, in basis points[1] Graph II.9



[1] Cumulative impact on five-year sovereign yields estimated by fixed effects panel local projections using daily data. The set of control variables includes the lagged dependent variable and the change in domestic three-month money market rates. [2] For CH, CZ, DK, HU, NO, PL and SE, the base currency is the euro; for AU, BR, CA, CL, CN, CO, GB, HK, ID, IL, IN, KR, MX, MY, NZ, PH, RU, SG, TH, TR and ZA, the US dollar.

Sources: ECB; Datastream; BIS calculations.

currency appreciation which, by reducing the foreign currency debt burden, can further ease domestic financial conditions. Borrowers are induced to borrow more and lenders to lend more, given the borrowers' apparent gain in creditworthiness.

To address these trade-offs, the authorities can usefully broaden the set of instruments deployed – an increasingly common strategy. Macroprudential measures can address emerging vulnerabilities in a targeted manner. While extremely useful, the evidence indicates that such measures are more effective in strengthening the resilience of the financial system than in preventing the build-up of financial imbalances themselves (Chapter IV). Similarly, FX intervention can offset some of the undesirable appreciation of the currency while building up a buffer that could be drawn down when conditions go into reverse.

When conditions do go into reverse, policy trade-offs become especially difficult, particularly in EMEs. Even if such a reversal is needed to limit the further build-up of financial imbalances, it could expose financial vulnerabilities in some countries, especially if it plays out in an abrupt and disorderly fashion. This could lead to powerful contractionary pressures alongside currency depreciation and hence, at least in the short run, to higher inflation. Scope for easing monetary conditions would be severely constrained; in fact, policy has often had to be tightened to prevent an uncontrolled depreciation. While FX reserves can be drawn down, experience indicates that their deployability may be smaller than their size may suggest, as markets can become nervous once the buffer shrinks. And the evidence suggests that macroprudential tools are more effective in building up buffers than in cushioning financial busts (Chapter IV).

Global spillovers can also have implications for the core countries at their origin. The collective size of the countries exposed to the spillovers suggests that what happens there could also have significant financial and macroeconomic effects in the economies that originated the spillovers. At a minimum, such spillbacks argue for enlightened self-interest in the core economies, consistent with domestic mandates.[12] This is an additional policy dimension that complicates the calibration of the normalisation and which deserves close attention.

To conclude, the normalisation path is a narrow one. Treading it will require a lot of judgment to evaluate trade-offs as well as a dose of pragmatism in adjusting to changing conditions. It will also call for flexibility in pursuing inflation objectives. In particular, since unsustainable expansions may manifest themselves in growing financial imbalances rather than rising inflation, and since accumulated debt may greatly constrain future room for manoeuvre, debt and asset price dynamics require close monitoring and should be factored into policy decisions. The same applies to the need to regain policy room for manoeuvre, which has narrowed significantly since the GFC. Given the starting conditions, this journey is bound to be bumpy. Financial market ructions will no doubt occur, in the manner of withdrawal symptoms. But as long as financial market disturbances remain contained, central banks should have no reason to adjust the normalisation pace. Volatility as such is not a problem. In fact, to the extent that it inhibits unbridled risk-taking, it is healthy and part of the solution. The challenge will be to normalise with a steady hand, without overreacting to any transient bouts of volatility.

Box II.A

The decline in natural real interest rates: what do we know?

The global decline in real interest rates in recent decades is often attributed to a lower level of natural real interest rates, defined as the level that equates desired real saving to investment at full employment.① Several factors may have lowered investment and raised saving over the past few decades, pushing down natural (or equilibrium) real interest rates. On the investment side, the most prominent candidates are lower productivity and potential growth, which may reduce the marginal returns to capital and hence investment. The decline in the relative price of capital (eg computers), which lowers the required investment outlay, is another potential factor. On the saving side, demographic developments have been highlighted as prompting increased saving, in particular a rising share of the working age population and increased life expectancy. As life-cycle theory posits, a lower dependency ratio results in increased saving as the working population tends to save more than retirees. Similarly, greater longevity prompts increased saving for a longer expected retirement. Greater income inequality also tends to increase aggregate saving as higher-income households have a higher propensity to save. Lastly, greater demand for safe assets and higher risk aversion could lead to lower real risk-free interest rates. Possible reasons include the limited global supply of safe securities, which has not kept pace with the increased saving demand, including from EMEs, and greater concerns about macroeconomic tail risks more generally.②

The pattern seen over the last few decades lends some support to the relevance of these saving-investment factors. Even a cursory look at the data suggests that saving-investment factors and the real interest rate share some common trends. For example, the drop in real rates over the last 30 years has coincided with a decline in dependency ratios and in productivity growth. In addition, life expectancy has moved up, inequality has increased, and the relative price of capital has fallen, as the hypothesis would postulate. Pairwise correlation between real interest rates and these variables is therefore high and consistent with theory over this period (Graph II.A, left-hand panel). Recent research also shows that structural models can explain much of the observed decline in real rates. For example, studies that emphasise demographics typically use overlapping-generation models to capture the joint dynamics between the dependency ratio, life expectancy and population growth. These studies find that demographics may have lowered real interest rates by between 1 and several percentage points over the past few decades. Rachel and Smith (2017) use pre-existing elasticity estimates and find that potential growth, demographics, the risk premium and the relative price of capital are the most important factors, together explaining a 3 percentage point fall in real interest rates since the 1980s.③

Another supporting piece of evidence is the fact that inflation has not increased despite the downward trend in real interest rates. Assuming a stable Phillips curve, a sustained gap between the real interest rate and its natural counterpart should exert pressure on aggregate demand, ultimately influencing the inflation dynamics. Relatively stable inflation suggests that real interest rates have merely tracked the natural rates downwards. Indeed, most "filtered" estimates of the natural rate have relied on the Phillips curve for identification, with most pointing to its steady decline over the last 30 years (Graph II.7).

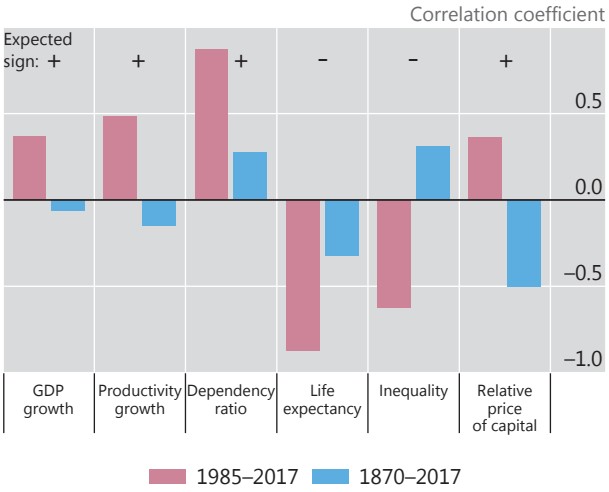
While the consensus is that the natural interest rate may have recently declined, there are also reasons to be more circumspect, at least in practical policymaking. The filtering-based estimates are associated with a notoriously large degree of statistical uncertainty, not least because the empirical link between inflation and economic slack has not always been tight (Graph II.7). Additional challenges arise when allowing for possible non-linearity of the Phillips curve and structural change in the inflation process. Meanwhile, the structural approach, which focuses on articulating few specific mechanisms at a time, by construction leaves little room for empirically evaluating different hypotheses. This in turn makes it harder to assess the outlook for the natural rate, as the future evolution for saving-investment factors may diverge. Ongoing population ageing could finally reverse the demographic effects and potential growth could trend higher, while inequality and the shortage of safe assets may be more persistent forces.

There is also a risk that too much emphasis has been placed on the experience over the last 30 years. The correlation between real interest rates and saving-investment factors either switches sign or becomes substantially weaker once one extends the sample to cover longer periods (Graph II.A, left-hand panel). Formal empirical studies using long data series corroborate this observation. Hamilton et al (2015) find that GDP growth, a key determinant of the natural rate in macro models, bears little relationship to real interest rates, while Lunsford and West (2017) consider a comprehensive set of factors in the United States, and find only one demographic variable to be correlated with real rates.④ Borio et al (2017) study a large set of factors for 19 advanced economies since the late 19th century, and allow these factors to jointly determine real interest rates across various specifications.⑤ They find that none of the saving-investment factors can consistently explain real interest rate movements. The finding survives various robustness tests and extensions, including a control for the risk premium.⑥

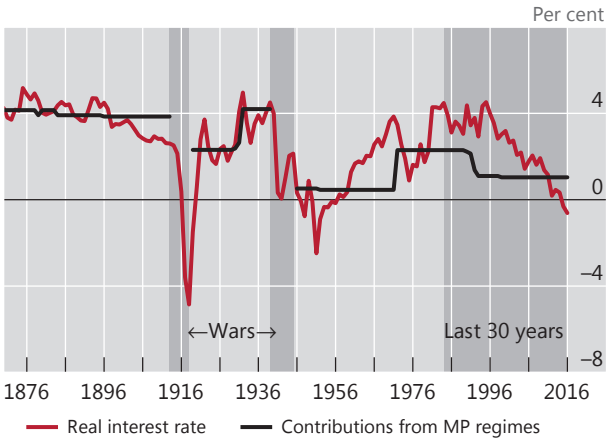
Monetary and non-monetary determinants of the real interest rate

Graph II.A

Correlation between real interest rates and saving-investment factors[1]



Real interest rate and monetary policy regimes[2]



[1] Correlation between cross-country median of real long-term interest rate and saving-investment factors. Cross-country median is based on 19 AEs. From 1991 onwards, the dependency ratio includes EMEs. [2] Real interest rate and contributions from monetary policy regimes are cross-country medians. Contributions from policy regimes for each country are computed using that country's policy regimes and saving-investment factors as inputs, with coefficients estimated from a panel regression. Effects of policy regimes are captured via country- and time-specific dummies, where seven different regimes are identified. War periods are ignored throughout.

Source: C Borio, P Disyatat, M Juselius and P Rungcharoenkitkul, "Why so low for so long? A long-term view of real interest rates", *BIS Working Papers*, no 685, December 2017.

An alternative hypothesis is that monetary factors may have more persistent effects on real interest rates than usually assumed. There are several possible channels. Inflation expectations may be pinned down more successfully under certain policy regimes (eg over the last 30 years and during the gold standard), so that changes in the nominal interest rate are persistently transmitted to the real rate. There is earlier evidence that breaks in mean real interest rates coincide with those in inflation, suggesting a systematic role for monetary policy (Rapach and Wohar (2005)).⑦ Also, financial boom-bust cycles may in part be driven by monetary policy, leaving a long-lasting imprint on the real economy, including on real interest rates. Indeed, Borio et al (2017) find that shifts in monetary policy regimes matter for the levels of real interest rates, even after accounting for the influence of saving-investment variables. The right-hand-panel of Graph II.A shows the estimated impact of changes in monetary policy regimes on real interest rates. For example, the shift from post-Bretton Woods in the 1980s to the current policy regime of inflation targeting is associated with a 1.3 percentage point reduction in the real interest rate. Trends in real rates also appear to be affected by such regime changes. The persistent effect of monetary policy regimes on real rates raises deep questions about the real-only saving-investment framework, further highlighting the practical limitations of the natural interest rate in policymaking.

① Equivalently, in a canonical macro model, it is defined as the level of the real interest rate that is neither expansionary nor contractionary for output. A distinction is sometimes made between short- and long-run natural interest rates. The short-run natural rate is influenced by transitory shocks, such as potential growth or productivity shocks; the long-run natural rate prevails once their effects wane. This rate is smoother, but may still vary over time owing to permanent shocks and structural breaks in economic relationships. ② For a detailed literature review and the references mentioned in this box, see Borio et al (2017) (for full reference, see source line of Graph II.A). ③ L Rachel and T Smith, "Are low real interest rates here to stay?", *International Journal of Central Banking*, vol 13, issue 3, September 2017, pp 1–42. ④ J Hamilton, E Harris, J Hatzius and K West, "The equilibrium real funds rate: past, present and future", *IMF Economic Review*, vol 64, issue 4, 2016, pp 660–707; K Lunsford and K West, "Some evidence on secular drivers of US safe real rates", Federal Reserve Bank of Cleveland, *Working Papers*, 17-23, 2017. ⑤ For full reference, see source line of Graph II.A. ⑥ Borio et al (2017) use higher moments of GDP growth and inflation as proxies for macroeconomic risk. ⑦ D Rapach and M Wohar, "Regime changes in international real interest rates: are they a monetary phenomenon?", *Journal of Money, Credit and Banking*, vol 37, issue 5, 2005 pp 887–906.

Endnotes

[1] Gradualism can be described as a policy approach where the central bank "tends to adjust interest rates incrementally, in a series of small or moderate steps in the same direction" (B Bernanke, "Gradualism", remarks at an economics luncheon co-sponsored by the Federal Reserve Bank of San Francisco and the University of Washington, Seattle, 20 May 2004). One rationale for gradualism is that a more cautious policy approach is called for when there is high uncertainty about how the economy responds to changes in the monetary policy stance; see W Brainard, "Uncertainty and the effectiveness of policy", *American Economic Review*, vol 57, 1967, pp 411–25; and B Sack, "Does the Fed act gradually? A VAR analysis", *Journal of Monetary Economics*, 2000, pp 229–56. Another rationale is that a commitment to act gradually could give the central bank more leverage over long-term interest rates; see M Woodford, "Optimal interest-rate smoothing", *Review of Economic Studies*, vol 70, 2003, pp 861–86.

[2] See C Borio and H Zhu, "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *Journal of Financial Stability*, December 2012, for a comprehensive discussion of the link between monetary policy and the perception and pricing of risk, ie the risk-taking channel of monetary policy. See T Adrian and H S Shin, "Financial intermediaries, financial stability and monetary policy", in *Maintaining stability in a changing financial system*, proceedings of the Federal Reserve Bank of Kansas City Jackson Hole Economic Symposium, August 2008, for the argument on predictability and gradualism being an enabling factor in the build-up of leverage before the GFC.

[3] The consequence could be a "whisper equilibrium", where the central bank whispers more and more in order not to upset markets while market participants lean in to hear better and better. As markets react more, central banks' efforts to avoid stirring up the market are partially undone and the signalling value of financial market prices is impaired. See J Stein, "Challenges for monetary policy communication", speech at the Money Marketeers of New York University, 6 May 2014; and H S Shin, "Can central banks talk too much", speech at the ECB conference on *Communications challenges for policy effectiveness, accountability and reputation*, 14 November 2017, for more detailed discussions of the whisper equilibrium.

[4] See S Hanson, D Lucca and J Wright, "Interest rate conundrums in the twenty-first century", Federal Reserve Bank of New York, *Staff Reports*, no 810, March 2017.

[5] See Hanson et al (2017), op cit.

[6] See B Bonis, J Ihrig and M Wei, "Projected evolution of the SOMA Portfolio and the 10-year Treasury term premium effect", Board of Governors of the Federal Reserve System, *FEDS Notes*, September 2017.

[7] For a more detailed discussion and empirical analysis of the debt service channel of monetary transmission, see B Hofmann and G Peersman, "Is there a debt service channel of monetary transmission?", *BIS Quarterly Review*, December 2017, pp 23–37, and the references therein.

[8] There is evidence for demand-driven recessions inducing long-lasting effects on output via hysteresis effects; see O Blanchard, E Cerutti and L Summers, "Inflation and activity – two explorations and their monetary policy implications", *IMF Working Papers*, WP/15/230, 2015; and R Martin, T Munyan and B Wilson, "Potential output and recessions: are we fooling ourselves?", Board of Governors of the Federal Reserve System, *International Finance Discussion Papers*, no 1145, 2015. The argument for running a high-pressure economy is premised on such a hysteresis effect working in reverse.

[9] The concept of finance-neutral output gaps is one way of incorporating information about financial imbalances in gauging economic slack. These measures have been shown to outperform traditional output gap measures as real-time indicators of output sustainability, including in the run-up to the GFC. See BIS, *86th Annual Report*, June 2016; and C Borio, P Disyatat and M Juselius, "Rethinking potential output: embedding information about the financial cycle", *Oxford Economic Papers*, vol 69, no 3, 2017, pp 655–77.

[10] The debt trap refers to a situation in which the debt accumulation that coincides with accommodative monetary policy makes it progressively harder to raise rates. For a more detailed discussion of the notion of a debt trap and empirical evidence to that effect, see C Borio and P Disyatat, "Low interest rates and secular stagnation: is debt a missing link?", *VOX*, June 2014; and M Juselius, C Borio, P Disyatat and M Drehmann, "Monetary policy, the financial cycle, and ultra-low interest rates", *International Journal of Central Banking*, vol 13, no 3, 2017, pp 55–90.

[11] For an overview of the mechanisms operating through banking flows and capital market financing, respectively, see V Bruno and H S Shin, "Global dollar credit and carry trades: a firm-level analysis", *BIS Working Papers*, no 510, August 2015; and B Hofmann, I Shim and H S Shin, "Sovereign yields and the risk-taking channel of currency appreciation", *BIS Working Papers*, no 538, January 2016, revised May 2017. See also BIS, *85th Annual Report*, June 2015, Chapter V, for a discussion of global spillover effects.

[12] See BIS (2015), op cit, for a discussion of the policy implications of global spillover effects.

III. The financial sector: post-crisis adjustment and pressure points

The Basel III reforms are finalised, completing a key part of the regulatory overhaul in the wake of the Great Financial Crisis (GFC). Given the favourable near-term economic outlook (Chapter I) and the prevailing easy financial conditions even as monetary policies are gradually tightened (Chapter II), the window of opportunity is wide open – for most banks – to finalise their adjustment to the post-crisis environment. Substantial progress has already been made, with most banks meeting the more stringent capital requirements and new liquidity standards. Yet compressed equity valuations indicate that banks' efforts to fully reap the benefits of the reforms and ensure sustainable profitability are not yet complete. Meanwhile, non-bank intermediaries have been gaining ground, pointing to important structural trends in financial markets that bear on market dynamics, particularly under stress. This calls for prompt and consistent implementation of all Basel III standards, along with tight regulation and supervision of both banks and non-banks, to guard against risks that may have built up during past years of unusually low interest rates and compressed volatility.

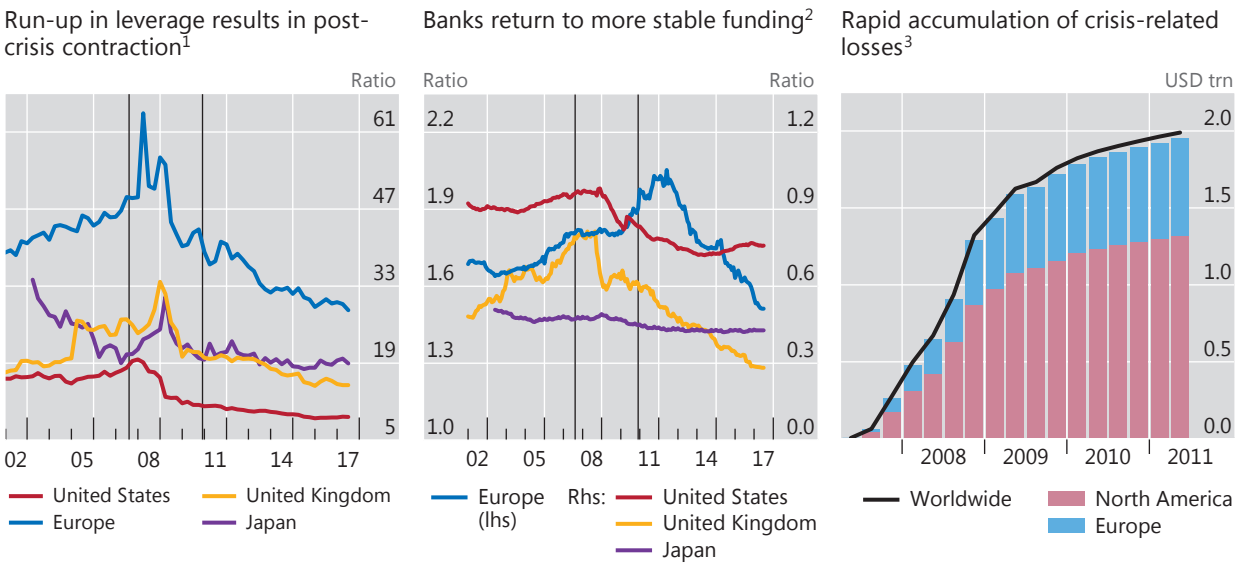
This chapter starts with a review of the rationale and key elements of the Basel III reforms, including the final package agreed in December 2017. It then discusses Basel III implementation and banks' adjustment to the post-crisis environment, highlighting areas that warrant attention. The last section examines changing bank/non-bank interactions and their impact on market dynamics under stress.

Basel III: key elements of the completed framework

The GFC laid bare the vulnerabilities of the international banking system. Major banks entered the crisis with excessive, mismeasured levels of leverage and insufficiently stable funding sources. Crisis-related losses accumulated rapidly, contagiously spreading across markets and countries, and forcing public sector intervention. What started as strains in US subprime mortgage markets turned into a full-blown financial crisis (Graph III.1).

Ten years on, the post-crisis reforms of the regulatory framework for internationally active banks – Basel III – have been completed.[1] In addressing the previous framework's weaknesses, the reforms have taken a two-stage approach (Table III.1). Stage 1, beginning in 2010, focused primarily on raising the size and quality of banks' capital buffers, while enhancing the robustness of the existing risk-weighted capital requirements (RWRs) through new capital and liquidity constraints. Stage 2 focused on the comparability and reliability of the internal model-based parts of the RWR framework, which allow banks to calculate their own risk weights. Most of the Basel III elements will be fully implemented as of 2022. Other reforms, such as minimum requirements for global systemically important banks' (G-SIBs') total loss-absorbing capacity, enhanced bank resolution regimes and the central clearing of all standardised derivatives contracts, are being implemented in parallel.[2]

Unsustainable risk-taking required decisive post-crisis adjustments by banks Graph III.1



The vertical lines in the left-hand and centre panels indicate August 2007 (interbank market turmoil in the early stages of the Great Financial Crisis) and December 2010 (the beginning of stage 1 Basel III reforms).

[1] Total assets divided by total equity; asset-weighted averages. Based on a sample of major internationally active banks. [2] Loans made by the banking sector to the private sector divided by banks' customer deposits; deposit-weighted averages. [3] Banks' cumulated losses and writedowns from Q2 2007 to Q2 2011 (series discontinued in Q2 2011).

Sources: IMF, *International Financial Statistics*; Bloomberg; S&P Capital IQ; national data; BIS calculations.

Stage 1 reforms: raising bank capital and liquidity buffers

A key concern behind the Basel III stage 1 reforms was insufficient loss-absorbing capital buffers (Graph III.1, left-hand panel). The Basel I standards had established minimum capital requirements through ratios that weighted assets by their riskiness – risk-weighted assets (RWAs): the higher the measured riskiness, the higher the weight. Then, under Basel II, in order to improve this risk sensitivity, banks had been given the option – subject to supervisory approval – to set the risk weights themselves through their own internal risk models, such as the internal ratings-based (IRB) approach for credit risk. Alternatively, they could apply the simpler risk weights set by supervisors – under the so-called standardised approaches (SAs).

In response to the crisis, the stage 1 reforms substantially tightened the definition and quality of bank capital as well as the required minimum capital ratio. Banks now had to comply with a minimum ratio of 4.5% of RWAs, defined in terms of a stricter Common Equity Tier 1 (CET1) capital definition, and a 6% Tier 1 capital ratio. They also had to maintain an additional CET1 capital conservation buffer of 2.5%. The resulting 7%–8.5% minimum ratio compares with what was effectively a 4% baseline under Basel II, based on a much weaker capital definition that included various instruments with limited loss-absorbing capacity.[3] In addition, the computation of RWAs was broadened, based on revised frameworks for securitisations and trading book positions (Table III.1).

These enhanced RWRs were complemented with four new requirements covering risks inadequately addressed in the pre-crisis standards. The resulting "multiple metrics" setup is intended to increase the framework's robustness by guarding more explicitly against the inherent uncertainties of risk management and measurement.[4] First, a simple minimum leverage ratio seeks to contain build-ups of

Basel III phase-in arrangements: key standards[1] Table III.1

Standard	Adoption year	Requirement	Phase-in from year	Full implementation year
Stage 1: Capital and liquidity				
Capital definition	2010	CET1; deductions	2013	2022
Minimum CET1 ratio	2010	4.5%	2013	2015
Capital conservation buffer	2010	2.5%	2016	2019
Countercyclical buffer	2010	0–2.5%	2016	2019
G-SIB capital surcharge	2010	0–3.5%	2016	2019
Leverage ratio (LR)	2010	3%	2015 (disclosure)	2018
Securitisation framework	*2014*	*Revised framework*		*2018*
Market risk framework	*2016*	*Revised framework*		*2022*
Liquidity Coverage Ratio	2010	100%	2015	2019
Net Stable Funding Ratio	2010	100%		2018
Stage 2: Tackling RWA variability				
Output floor	2017	72.5%	2022	2027
LR revisions/G-SIB surcharge	2017	50% scaling factor		2022
Credit risk framework	2017	Revised framework		2022
Operational risk framework	2017	Revised framework		2022

[1] The Basel framework distinguishes three pillars: (i) minimum capital requirements, (ii) supervisory review and (iii) market discipline, based on standardised disclosures. Complementary reforms, such as enhanced bank resolution regimes, are implemented in parallel.

Sources: BCBS; BIS.

excessive leverage in the banking sector, providing a backstop to the RWRs and a degree of protection against model risk, under both the SAs and internal models. Second, a countercyclical capital buffer and G-SIB capital surcharges address macroprudential considerations (Chapter IV). Finally, two liquidity standards (ie the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio) incentivise greater reliance on more stable funding sources (Graph III.1, centre panel) and limit maturity transformation risks.[5]

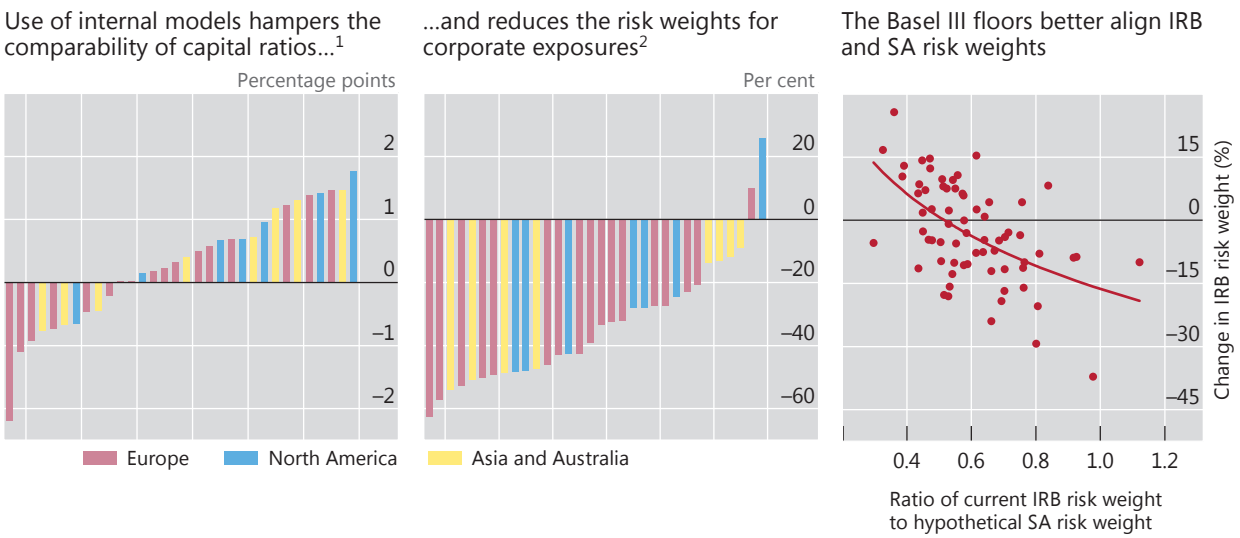
Stage 2 reforms: completing the framework

The recently finalised stage 2 of the Basel III reforms completes the framework by focusing mainly on enhancing the consistency and comparability of banks' RWAs (Table III.1). In the past, differences in the design and choice of parameters across banks' internal models had resulted in large differences in risk weights and corresponding capital requirements ("RWA variability"), providing ample leeway for banks to raise their leverage (Graph III.1, left-hand panel). From a prudential perspective, RWA variability is welcome if it reflects legitimate differences in underlying risks or their measurement.[6] However, there is evidence that it has also reflected unwarranted factors, such as "gaming" (ie choosing model assumptions to reduce measured risks).[7]

Such unwarranted RWA variability can be material. Assuming a benchmark capital ratio of 10%, a study by the Basel Committee on Banking Supervision (BCBS) found that two banks with identical banking book assets might report capital ratios differing by up to 4 percentage points (Graph III.2, left-hand panel).[8] Moreover, in

Basel III floors – addressing unwarranted RWA variability

Graph III.2



[1] Change from 10% benchmark capital ratio if banks' own model-implied (IRB) risk weights were adjusted to the median risk weight reported by all banks. Based on risk assessments by 32 major financial institutions of an identical (hypothetical) portfolio of sovereign, bank and corporate exposures; grossed up to overall RWA level, holding all other RWA components stable. [2] Percentage difference from standardised approach (SA) risk weights. Positive (negative) values indicate average IRB risk weights based on banks' own probability-of-default and loss-given-default estimates that are higher (lower) than SA risk weights for an identical exposure.

Sources: BCBS, "Analysis of risk-weighted assets for credit risk in the banking book", *Regulatory Consistency Assessment Programme (RCAP)*, July 2013; BCBS, *Basel III monitoring report,* December 2017; BIS calculations.

many cases, internally modelled risk weights were substantially lower than those under the SAs – for corporate exposures, by up to more than 60% (Graph III.2, centre panel). The observed wedge and capital relief are difficult to justify.

Stage 2 sought to address this unwarranted RWA variability through a range of measures, complementing the leverage ratio introduced with the stage 1 reforms.[9] Key among them are constraints on banks' internal modelling practices, known as "input and output floors". These constraints are especially important where model risk is high, eg when data are scarce or modelling techniques untested or not robust (ie for operational risk and various low-default credit portfolios).[10]

Input floors introduce a measure of conservatism in model parameter choice. They do so by either disallowing the use of internal models for particular exposures or setting minima for model parameters (such as the probability of default (PD)). Input floors address specific sources of RWA variability in a targeted manner. Yet, by design, they have to be set at low levels to avoid penalising some activities (ie by imposing minimum PDs that may be too high for certain low-risk exposures). As such, they do not constrain "aggressively" estimated RWAs for riskier exposures.

The output floor provides an additional degree of protection, by ensuring that a bank's RWA cannot fall below 72.5% of the RWA amount that would result from applying the SA to the same portfolio. In contrast to input floors, the output floor can thus provide a degree of protection against unwarranted RWA variability across the entire risk spectrum. And, unlike the leverage ratio, it limits the capital relief banks can obtain by opting for internal models rather than the SAs.

Recent BCBS data illustrate the effect of the new constraints on RWA variability. Average risk weights tend to change most for the banks that reported risk weights furthest below those implied by the SA (Graph III.2, right-hand panel). Thus, assuming that any differences in the two approaches reflect primarily unwarranted RWA variability, the output floor closes at least part of the gap.

Banks' adjustment: the long path to sustainability

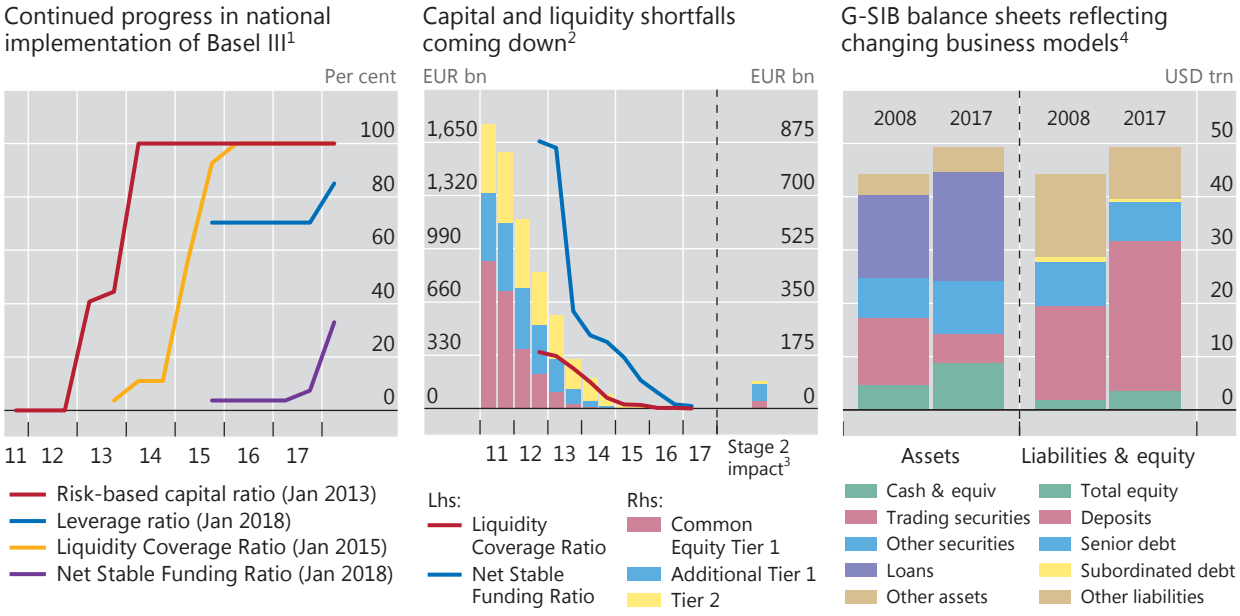
Reaping Basel III's financial stability benefits requires timely and consistent implementation of the new standards, backed by sustainable bank profitability. Supervisory metrics suggest that banks have already completed most of the adjustment to the standards ahead of schedule. Some market-based measures, however, cast doubt on the extent to which banks have managed to transition to viable new business models. Several levers are available to manage this transition. The public sector can provide additional support by removing legal or structural impediments to banks' own adjustment efforts.

Implementation and bank business models

The Basel III standards are being phased in over extended timelines to help banks adjust (Table III.1 above). By now, legal implementation is generally well advanced, with core stage 1 components, such as the new RWRs and the LCR, operational across all BCBS member – and many other – jurisdictions (Graph III.3, left-hand panel). National implementation of other elements, such as the leverage ratio, is progressing, and the stage 2 additions are due to follow mostly by 1 January 2022. Yet experience suggests that agreed implementation schedules may be difficult to maintain and that progress may slow. Therefore, progress monitoring is important – for example, via the BCBS's Regulatory Consistency Assessment Programme (RCAP).

Regardless of national implementation, most banks have already adjusted their balance sheets ahead of time to meet the new standards (Graph III.3, centre panel). One reason is market expectations. The fully loaded (ie completely phased-in)

Implementation of new requirements and banks' adjustments are progressing — Graph III.3



[1] Percentage of BCBS member jurisdictions in which each standard is in force; agreed implementation dates in parentheses. [2] The height of each bar shows the aggregated capital shortfall considering requirements for each tier (ie CET1, Additional Tier 1 and Tier 2) of capital for the major internationally active banks monitored by the BCBS (BCBS (2018)). [3] Estimates based on end-2015 bank balance sheet information (BCBS (2017), Table 3). [4] Total values; based on a balanced sample of 28 G-SIBs. Cash & equiv = cash and cash equivalents.

Sources: BCBS; BCBS, *Basel III monitoring report*, December 2017 and March 2018; SNL; BIS calculations.

requirements have become the investor benchmark; and banks with regulatory shortfalls risk facing market valuation pressures. Another, related reason is increased supervisory use of stress testing and corresponding disclosures, which often include fully loaded regulatory metrics.[11] Thus, looking ahead, one should expect banks to front-load their adjustments also to the latest stage 2 revisions. The amounts involved are small. Resulting CET1 capital shortfalls among the larger, BCBS-monitored internationally active banks are estimated at €27.9 billion (based on end-2015 balance sheet information), less than 1% of these banks' combined CET1 capital. And the estimate probably overstates the true shortfall, as it does not account for banks' business model or portfolio adjustments in response to the regulations.

Indeed, the impact of the reforms is already evident. Trends in aggregate G-SIB balance sheets, for example, tally quite closely with the reform's objectives (Graph III.3, right-hand panel): more and higher-quality capital; less reliance on short-term wholesale funding; bigger high-quality liquid asset (HQLA) buffers; and a shift away from business lines such as proprietary trading, apparent from the shedding of trading assets. This reflects a broader shift towards more retail-oriented business models, with relatively stable funding and income sources.[12]

Bank resilience: moving ahead

With bank balance sheet adjustment to the new regulatory standards mostly completed, a key question concerns the degree to which tighter regulation translates into increased bank resilience – Basel III's ultimate objective.

One way to measure progress is to assess the impact of changes in different capitalisation metrics on indicators of bank distress.[13] For example, simple logistic regressions – run on data covering 77 banks – provide estimates of the combined marginal predictive power of two key Basel III metrics (Tier 1 capital/RWAs and the leverage ratio) for a credit rating downgrade to "distress level" (Graph III.4, left-hand panel). Subject to the usual caveats, this analysis suggests that the likelihood of a bank facing distress within a two-year period decreases as the Tier 1 capital ratio increases (ie shifts along the horizontal axis). And importantly, for a given Tier 1 capital ratio, higher leverage ratio requirements tend to further reduce the distress probability (eg shifts from the yellow to the red line). This highlights the complementarity of the two ratios and supports the framework's multiple metrics setup (see above).

In the aggregate, higher capital and resilience have been achieved with little sign of an adverse impact on bank lending.[14] Bank lending to the private non-financial sector as a share of GDP has remained stable in many jurisdictions – meeting or exceeding pre-crisis averages.[15] That said, there are at least two areas where more action is needed to further increase resilience.

The first area concerns the link between resilience and regulatory reporting requirements, which can raise the risk of regulatory arbitrage. One such example relates to banks' "window-dressing" around regulatory reporting dates. The incentive arises in part because of differences in how authorities implement the leverage ratio across jurisdictions. Some, such as in the United States, require the ratio to be fulfilled on the basis of period averages, while others, such as in the euro area, do so on the basis of quarter-end values.

There is evidence that banks without averaging requirements markedly contract their balance sheets at quarter-ends relative to those subject to averaging (Box III.A). This can influence market functioning and monetary policy implementation, for instance by hindering access for those market participants that need to transact at quarter-ends. And it reduces the prudential usefulness of the leverage ratio, which may end up being met only four times a year.

Box III.A

Banks' window-dressing: the case of repo markets

Window-dressing refers to the practice of adjusting balance sheets around regular reporting dates, such as year- or quarter-ends. Window-dressing can reflect attempts to optimise a firm's profit and loss for taxation purposes. For banks, however, it may also reflect responses to regulatory requirements, especially if combined with end-period reporting. One example is the Basel III leverage ratio. This ratio is reported based on quarter-end figures in some jurisdictions, but is calculated based on daily averages during the quarter in others. The former case can provide strong incentives to compress exposures around regulatory reporting dates – particularly at year-ends, when incentives are reinforced by other factors (eg taxation).

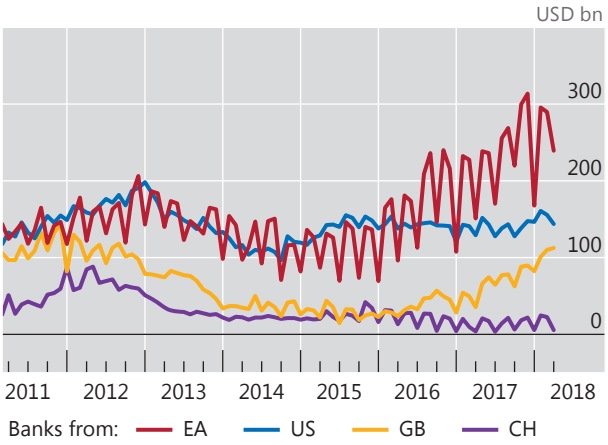
Banks can most easily unwind positions around key reporting dates if markets are both short-term and liquid. Repo markets generally meet these criteria. As a form of collateralised borrowing, repos allow banks to obtain short-term funding against some of their assets – a balance sheet-expanding operation. The cash received can then be onlent via reverse repos, and the corresponding collateral may be used for further borrowing. At quarter-ends, banks can reverse the increase in their balance sheet by closing part of their reverse repo contracts and using the cash thus obtained to repay repos. This compression raises their reported leverage ratio.

The data indicate that window-dressing in repo markets is material. Data from US money market mutual funds (MMMFs) point to pronounced cyclical patterns in banks' US dollar repo borrowing, especially for jurisdictions with leverage ratio reporting based on quarter-end figures (Graph III.A, left-hand panel). Since early 2015, with the beginning of Basel III leverage ratio disclosure, the amplitude of swings in euro area banks' repo volumes has been rising – with total contractions by major banks up from about $35 billion to more than $145 billion at year-ends.① While similar patterns are apparent for Swiss banks (which rely on quarter-end figures), they are less pronounced for UK and US banks (which use averages). Banks' temporary withdrawal from repo markets is also apparent from MMMFs' increased quarter-end presence in the Federal Reserve's reverse repo (RRP) operations, which allows them to place excess cash (right-hand panel, black line). Despite the implicit floor provided by the rates on the RRP (yellow line), there are signs of volatility spikes in key repo rates around quarter-ends (blue line). Such spikes may complicate monetary policy implementation and affect repo market functioning in ways that can generate spillovers to other major funding markets, especially if stress events coincide with regulatory reporting dates.②

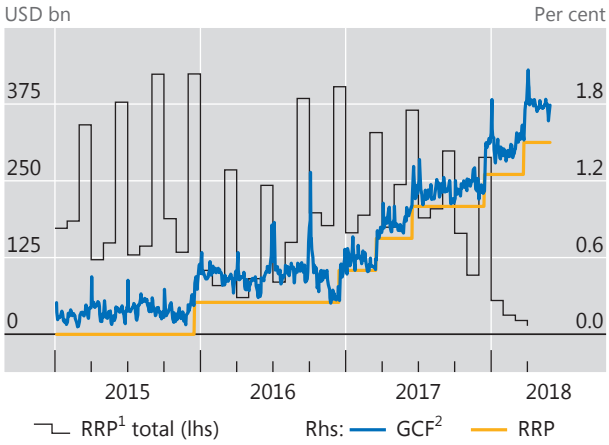
Banks' window-dressing through the lens of US repo markets

Graph III.A

Global banks' repo borrowing from US MMFs



Repo rates and MMF placements at the Federal Reserve



[1] Reverse repo. [2] DTCC General Collateral Financing (GCF) Repo Index (Treasury weighted average).

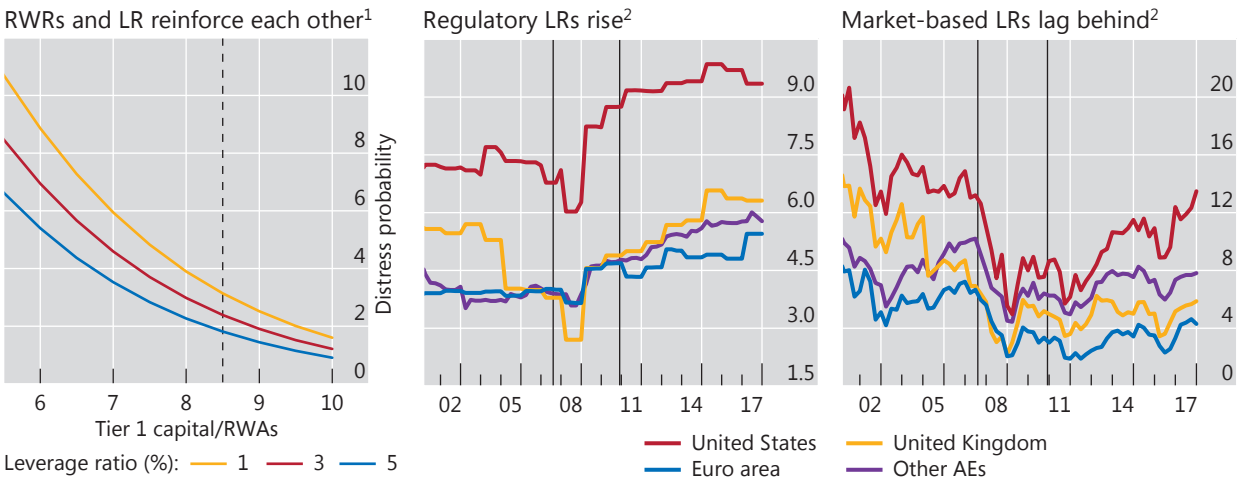
Sources: Federal Reserve Bank of St Louis (FRED); Office of Financial Research; Crane Data; DTCC; BIS calculations.

① The end-2017 contraction is equivalent to about 1.4% of the sample banks' total leverage ratio exposure measure. ② See CGFS, "Repo market functioning", *CGFS Papers,* no 59, April 2017; and I Aldasoro, T Ehlers and E Eren, "Business models and dollar funding of global banks", *BIS Working Papers,* no 708, March 2018.

Regulatory vs market-based metrics – resilience is up, but by how much?

In per cent

Graph III.4



The dashed vertical line in the left-hand panel indicates the 8.5% Tier 1/RWA minimum capital requirement. The vertical lines in the centre and right-hand panels indicate August 2007 (interbank market turmoil in the early stages of the Great Financial Crisis) and December 2010 (the beginning of stage 1 Basel III reforms).

[1] Estimated probability of distress within two years for a given level of risk-weighted Tier 1 capital (horizontal axis) at three different LRs. Estimates based on a logistic regression of a distress indicator denoting a bank's individual rating dropping below D within the next two years on the variables indicated in each panel and a control variable for total assets as well as a dummy variable to flag observations in the post-2007 period. The sample is an unbalanced panel of annual observations for 77 banks over the period 1995–2013. The vertical axis measures the estimated probability of distress for different values of the explanatory variable. [2] Asset-weighted averages of simplified regulatory LRs, based on the ratio of common equity to total assets (centre panel), and market value-based LRs (right-hand panel) by economy; based on 73 banks and not adjusted for national accounting differences.

Sources: I Fender and U Lewrick, "Calibrating the leverage ratio", *BIS Quarterly Review*, December 2015; Bankscope; Datastream; Moody's; national data; BIS calculations.

Prudential authorities can help reduce or prevent these types of effect in various ways. Options include aligning national implementation on the basis of period averages, stepping up supervisory responses, and requiring banks to disclose both metrics to enhance market discipline.

The second area concerns the outlook for bank profitability. Bank profitability is critical for resilience, as it affects the speed with which banks can recover from losses. Despite the progress made in terms of balance sheet and business model adjustments, market valuations for many banks point to continued investor scepticism about profitability prospects. Average bank price-to-book ratios (PBRs) hovered around a level of two times book value right before the GFC – admittedly, a level inconsistent with the risks revealed by the GFC (see regulatory discussion above). They then plummeted to values below one in 2008–09, and recovered only recently, while generally remaining lower than pre-crisis, especially for European banks.

Thus, once adjusted for depressed PBRs, conventional resilience measures look less solid.[16] One example is market-based leverage ratios, which have improved by less than their book value counterparts (compare the right-hand and centre panels, Graph III.4). Bank credit default swap (CDS) spreads and stand-alone credit ratings (which seek to abstract from official support, known to have been cut) tell a similar story (Graph III.5, left-hand and centre panels).[17] Even though pre-crisis levels are unlikely to be an appropriate benchmark, this suggests that reduced bank profitability has at least partly offset the stabilising effect of reduced leverage and maturity transformation. At the same time, there are signs that banks may have

The widening of Libor-OIS spreads

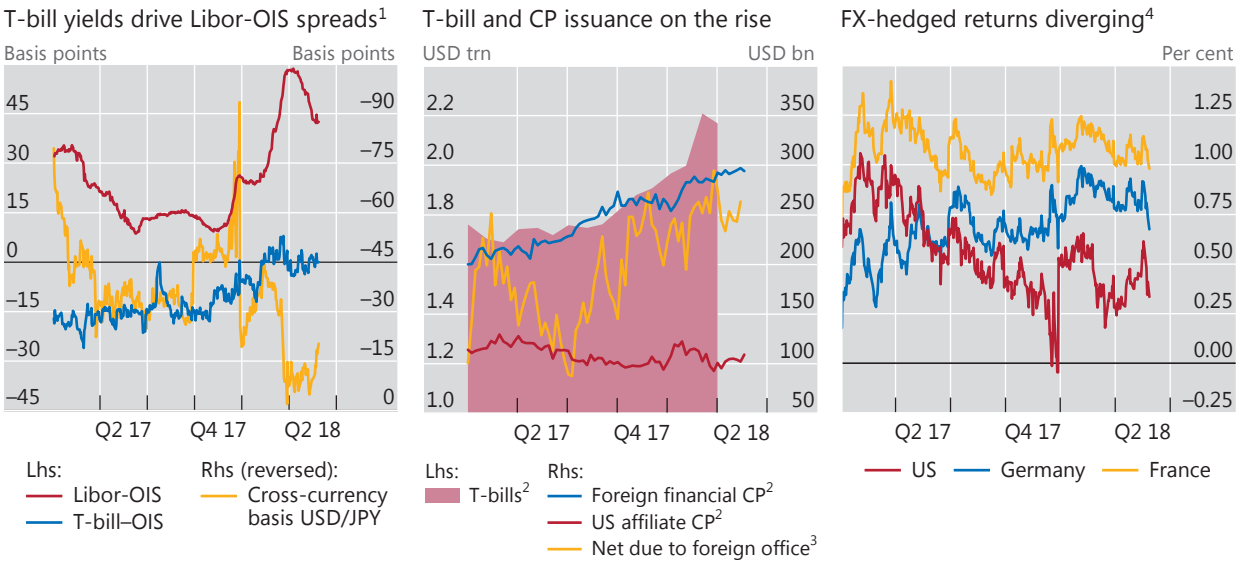
Spreads between short-term US dollar Libor and overnight indexed swap rates (Libor-OIS), a common indicator of funding stress, widened substantially in early 2018 (Graph III.B, left-hand panel). Yet, unlike during previous episodes, the surge did not reflect rising bank riskiness, as gauged from credit default swap spreads. Nor did it coincide with signs of stress in US dollar funding markets, as indicated by cross-currency basis spreads. What might explain it?

Two likely drivers are increased issuance of short-term US Treasury securities (T-bills) and repatriation flows due to the 2017 US tax reform. T-bill issuance jumped by more than $300 billion in Q1 2018 (centre panel). As a result, short-term yields increased, with the associated rise in the T-bill–OIS spread accounting for up to 40% of the change in Libor-OIS (left-hand panel). Tax reform is likely to explain part of the remainder, with US corporates repatriating some of the foreign profits previously held abroad. As part of these was invested in non-US bank commercial paper (CP), such flows tend to lower the supply of offshore US dollar funding for banks. This comes on top of reduced supply from money market mutual funds (MMMFs), which has not returned to pre-October 2016 US MMMF reform levels. Bank funding costs thus rose amid strong CP issuance in early 2018 (centre panel), adding to the rise in Libor-OIS.

The tightening of the cross-currency swap basis (left-hand panel) contrasts with previous episodes of Libor-OIS widening. One explanation put forward is that the US base erosion and anti-abuse tax raised foreign bank US affiliates' funding costs. Those affiliates would have to issue more debt of their own while cutting back on inter-office funding. This would lower demand for FX hedging, contributing to a tighter basis. Yet, contrary to this explanation, US affiliates' issuance declined, whereas net inter-office positions rose as Libor-OIS widened (centre panel). An alternative explanation of tight cross-currency spreads relates to portfolio rebalancing decisions.① FX-hedged returns on long-term US bonds declined relative to those on euro area sovereign debt, amid expectations of rising US interest rates (right-hand panel). Non-US investors may thus have reduced their dollar securities holdings and, as a result, their demand for FX hedging. Indeed, according to official data, Japanese investors cut their US bond holdings by about $50 billion while investing $30 billion in German and French sovereign bonds in early 2018.

Deciphering the recent surge in Libor-OIS spreads

Graph III.B



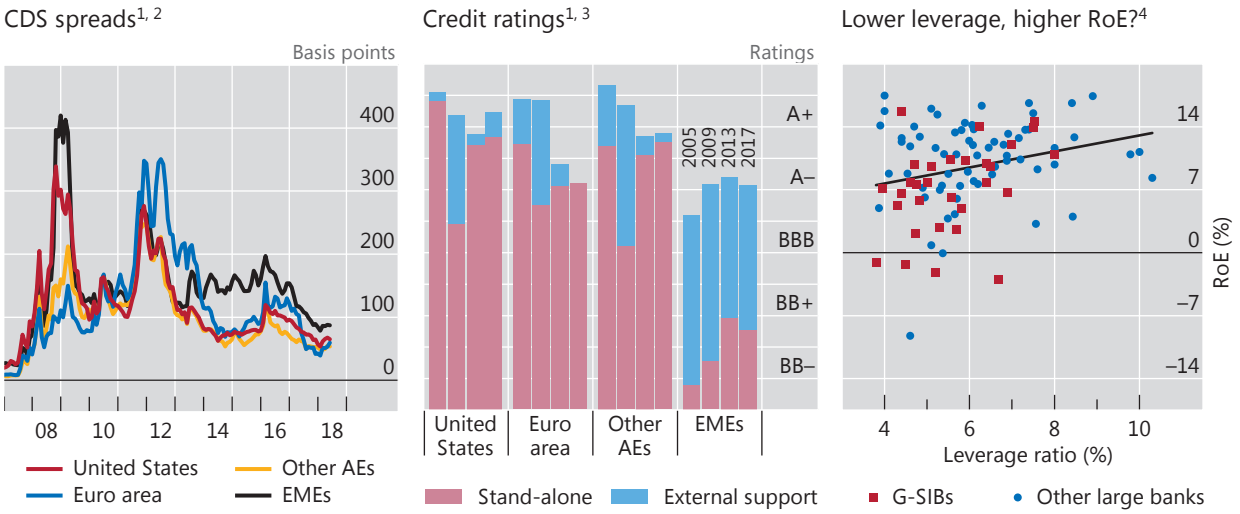
[1] Based on three-month tenors. [2] Outstanding amounts of T-bills and US commercial paper (CP) of foreign financials and US financials with foreign bank parent. [3] US financials' net liabilities vis-à-vis their related foreign offices. [4] Spread between the return on 10-year sovereign bonds, swapped into Japanese yen (adjusting for three-month rolling hedging cost), and the return on 10-year Japanese government bonds.

Sources: Federal Reserve Bank of St Louis (FRED); US Department of the Treasury; Bloomberg; Datastream; BIS calculations.

① See BIS, *87th Annual Report*, June 2017, Chapter II.

Bank credit risk and return-on-equity – further room for improvement

Graph III.5



[1] Asset-weighted averages. Based on a sample of about 50 large banks. [2] Five-year on-the-run credit default swap (CDS) spreads; monthly averages of daily data. [3] Based on Fitch ratings; end-of-year data. [4] Based on a sample of about 100 large banks. Leverage ratio and return-on-equity (RoE) at end-2017.

Sources: Fitch Solutions; IHS Markit; SNL; BIS calculations.

become less susceptible to adverse funding shocks. One example is the surge in Libor-OIS spreads in early 2018, which drove up bank funding costs, but left bank CDS spreads broadly unaffected (Box III.B and Graph III.5, left-hand panel).

Banks could seek to raise profitability and valuations in time-tested ways, such as cutting costs and repairing balance sheets by eliminating non-performing loans. Bank valuations are not generally out of line with what is predicted by simple valuation models that assign importance to those variables (Box III.C). In addition, there is evidence that a stronger capital base can help too. Even though lower leverage mechanically reduces banks' return-on-equity (RoE), better-capitalised institutions tend to exhibit a similar or even higher RoE than their more leveraged peers (Graph III.5, right-hand panel).[18]

Looking ahead, a key challenge is that these adjustments have to take place at a time of rapid technological change in the financial sector (various types of "fintech" innovation). On the one hand, many of these innovations allow banks to better exploit scale economies and – ultimately – reduce costs. One example is the use of distributed ledger technology to improve back office functions (Chapter V). On the other hand, client expectations are changing – and with them the nature of bank competitors. Clients, in particular those on the retail side, increasingly ask for a "seamless customer experience". While this may help segment the customer base and support price discrimination, the corresponding shift to multipurpose internet platforms invites new competitors. Here, so-called "big tech" players – dominant technology firms from the online sales or messaging sector – loom large. These already have the necessary IT infrastructure, analytical skills, financial resources and established client base to erode banks' market share.[19]

Further public sector initiatives could act as a catalyst for banks to make the necessary adjustments. These include efforts to tighten banks' provisioning policies (eg via asset quality reviews) and to tackle impediments to the reduction of overcapacity and banking sector consolidation.[20] The arrival of big tech competitors, in turn, may require cooperation among regulators from different fields (data protection agencies, competition authorities and others) and jurisdictions to preserve

Factors driving bank equity valuations

Low price-to-book ratios (PBRs), defined as the market value of a bank's equity to its accounting – or book – value, have been a persistent sign of post-crisis challenges in the banking sector. Having hovered at around two times book value, on average, in the run-up to the Great Financial Crisis (GFC), they plummeted to values below unity by 2009 and recovered only recently – while remaining below pre-crisis levels (Graph III.C, left-hand panel). As a measure of the market premium (or discount) applied to a bank's book value, PBRs are a key indicator of banks' expected underlying profitability. Hence, there is a strong interest in understanding what drives these market premia.

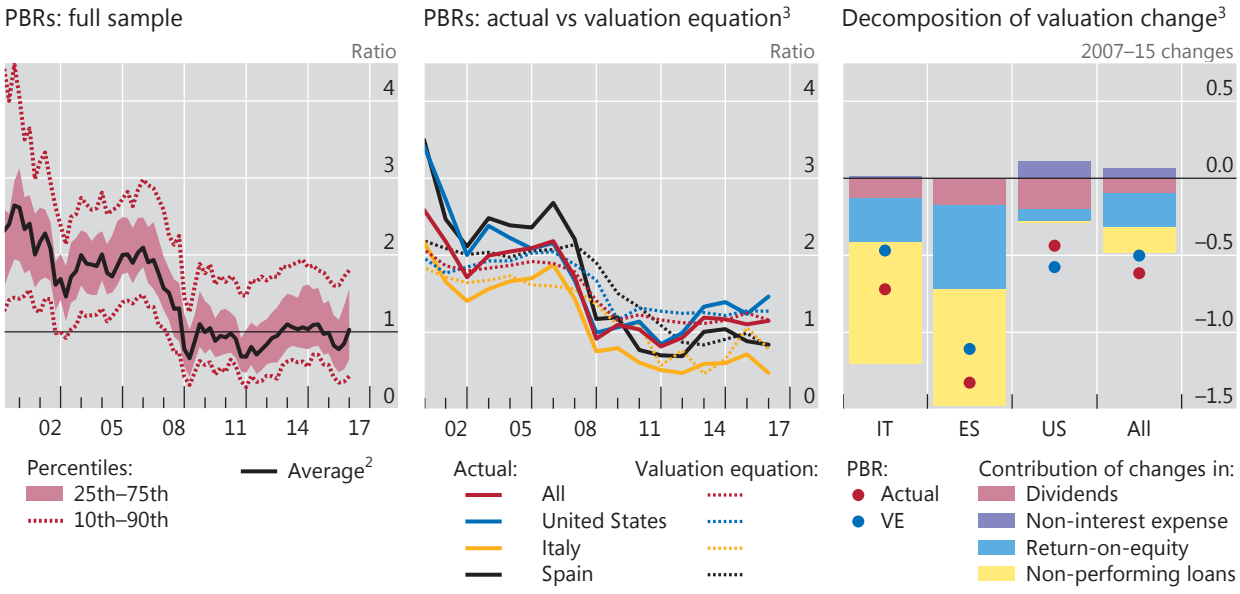
Recent BIS research① sheds some light on this question by estimating a valuation equation (VE) for a sample of 72 banks from 14 jurisdictions using annual data over the 2000–16 period. The panel regression includes five (sets of) explanatory variables known to affect PBRs, both directly and indirectly: (i) loans (including non-performing loans (NPLs)), (ii) deposits, (iii) expenses, (iv) other bank-specific factors (for instance, leverage or dividend payments) and (v) return-on-equity (RoE; a proxy of investors' return expectations).

The estimated VE tracks the evolution of bank PBRs closely across both time and countries (centre panel). PBRs are generally in line with VE-implied valuations, suggesting that investors' valuation benchmarks do not seem to have changed materially post-crisis. Despite the relatively large number of explanatory variables, just four key drivers explain around three quarters of the VE-implied change in bank PBRs between 2007 and 2015, with NPLs and RoE the most important ones (right-hand panel).

These findings suggest that banks are well placed to enhance their market value by focusing on a few key profitability drivers under direct management control, such as proactively addressing NPLs and other legacy assets, tight control of non-interest expenses, and reducing overcapacity in the sector.

Price-to-book ratios (PBRs) are closely approximated by the valuation equation[1]

Graph III.C



[1] The sample covers 72 banks in advanced economies; end-of-quarter data. [2] Asset-weighted average. [3] Based on valuation equations (VE) in Bogdanova et al (2018).

Sources: Bogdanova et al (2018); Datastream; Fitch Solutions; BIS calculations.

① For details, see B Bogdanova, I Fender and E Takáts, "The ABCs of bank PBRs", *BIS Quarterly Review*, March 2018. This analysis takes that of C Calomiris and D Nissim, "Crisis-related shifts in the market valuation of banking activities", *Journal of Financial Intermediation*, vol 23, no 3, 2014, pp 400–35, and extends it to an international setting.

a level playing field ("same risk, same regulation"), without unduly constraining technological innovation.[21] One such example is aligning constraints on the accumulation, use and sharing of client data for both banks and non-banks. The favourable macroeconomic environment (Chapter I), rising term spreads and reduced legacy problems (eg crisis-related litigation costs) provide further support. Banks that fail to seize this opportunity may see their resilience tested before their adjustment to the post-crisis environment is fully complete (see also the discussion on snapback risk below).

Bank/non-bank interactions: new pressure points?

The adjustment of banks' business models under way raises a number of questions at the current juncture. One such question concerns the system-level impact of the rising share of non-bank intermediaries in financial markets. Their interaction with banks and other parts of the financial system is changing the dynamics of markets in response to shocks. A key example relates to the process of monetary policy normalisation in major advanced economies and how increases in longer-term interest rates, including the possibility of rapid snapback (Chapter I), could propagate through the financial system.

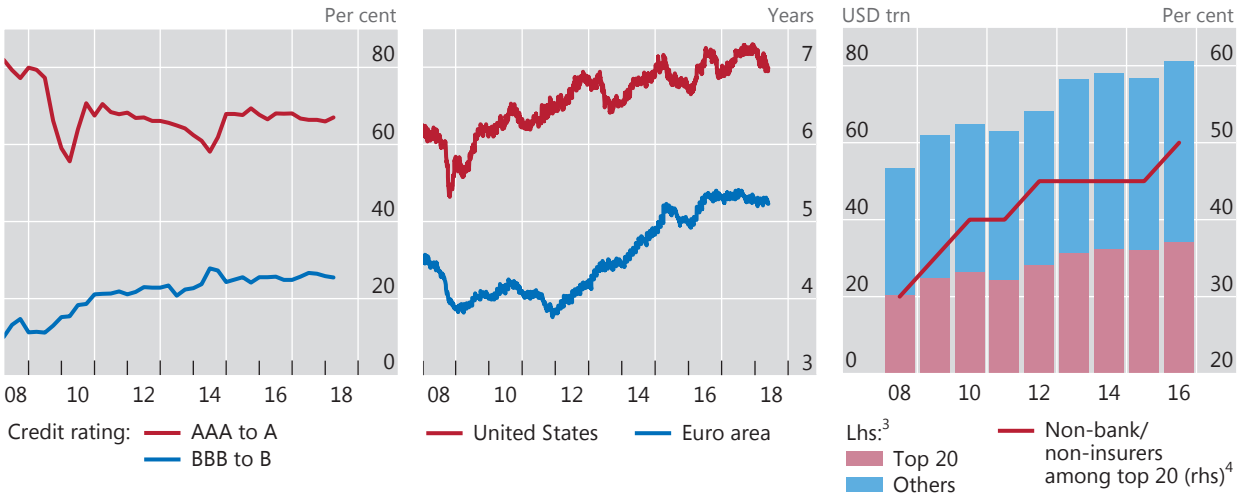
Institutional asset managers: bigger footprint, changing dynamics

Non-bank institutional asset managers, ranging from investment management companies to pension funds and insurers, have grown strongly over the past decade. Their total assets are estimated at nearly $160 trillion, exceeding those of banks worldwide.[22] Several drivers have contributed to this growth. They include an increasing demand for long-term investments, such as on the part of pension funds, and search for yield in an environment of unusually low interest rates, which has boosted the growth of open-end mutual funds and exchange-traded funds (ETFs).

Past years of exceptionally low interest rates have raised a variety of challenges for those institutional asset managers that are major fixed income investors.[23] These firms benefited initially from the decline in interest rates, which generated valuation gains on their bond holdings. Yet persistently low rates and compressed term premia reduced the yields on new investments, driving down future returns. Pension funds and insurance companies faced additional pressures owing to the rising mark-to-market value of their long-term liabilities. This provided strong incentives for institutional asset managers to extend the duration of their portfolio or to invest in riskier assets – a trend borne out in the available data (Graph III.6, left-hand and centre panels). Taken together, these factors suggest that sensitivity to snapback in both interest rates and volatilities has increased.

Various structural features of the asset management industry may contribute to magnifying this vulnerability. One is a high concentration of assets under management, which can result in a clustering of risks within a limited number of large asset management companies (Graph III.6, right-hand panel). True, investment activity is typically spread out over a large number of separately managed funds within these firms, mitigating the risk of concerted trading activity. But there is evidence that fund families exhibit correlated return and investor flow patterns.[24] In addition, reliance on common service providers (eg for IT infrastructures, risk management and pricing tools, or custody services) suggests common exposures to operational risks. And, rising investor demand for lower-cost passive asset management products may have increased the risk of crowded trades in leading market indices.[25]

Exposure to valuation losses and concentration in asset management are rising Graph III.6



[1] Share of total bond holdings for an unbalanced sample of more than 1,600 US mutual and exchange-traded bond funds. [2] Effective duration of investment grade (IG) corporate bond indices; US Corporate Master Index for the United States and EMU Corporate Index for the euro area. [3] Assets under management. [4] Percentage share of non-bank/non-insurers among the top 20 asset managers.

Sources: Datastream; ICE BofAML Indices; Lipper; Willis Towers Watson; BIS calculations.

Snapback and interlinkages

Institutional asset managers and banks are interlinked in a variety of ways, opening up both direct and indirect channels for the propagation of snapback risks and similar shocks. Open-end funds are especially relevant in this context. Not only are they exposed to valuation losses, like any other rate-sensitive investor, but they also face investor redemption risk (Box III.D). Funds' credit lines and deposits at banks thus represent a key direct link. In a snapback scenario, with widespread investor redemptions triggering a run-down of funds' cash balances, depository banks could be exposed to large deposit withdrawals by fund managers and rising credit exposures to funds. Granted, direct bank exposures to such risks are perhaps less of a challenge than indirect ones, given the supervisory attention that interest rate risks have received in recent years.[26] Even so, there is a need for banks to monitor and manage these risks particularly carefully.

Additional pressure points could magnify these effects. For one, large-scale redemptions could force open-end funds to sell relatively illiquid assets at short notice and, hence, at large discounts, further depressing valuations. Indeed, funds that promise daily redemptions – ie those offering deposit-like instruments – have increased their footprint. In the United States, for example, they now hold more than 16% of corporate debt according to financial accounts data – up from less than 7% in 2005. This is bound to have changed market dynamics.

Funds' liquidity management thus plays an important role in assessing the broader market impact of investor redemptions. Funds that invest in relatively illiquid assets, such as corporate bonds or some emerging market economy (EME) debt, need to strike a difficult balance between selling illiquid assets at potentially large discounts and running down their cash buffers, which may leave them vulnerable to future outflows. In addition, investors may be tempted to redeem their shares to front-run others, anticipating the liquidation cost-induced dilution of fund portfolios.

When yields "snap back" – funds' exposures and amplification effects

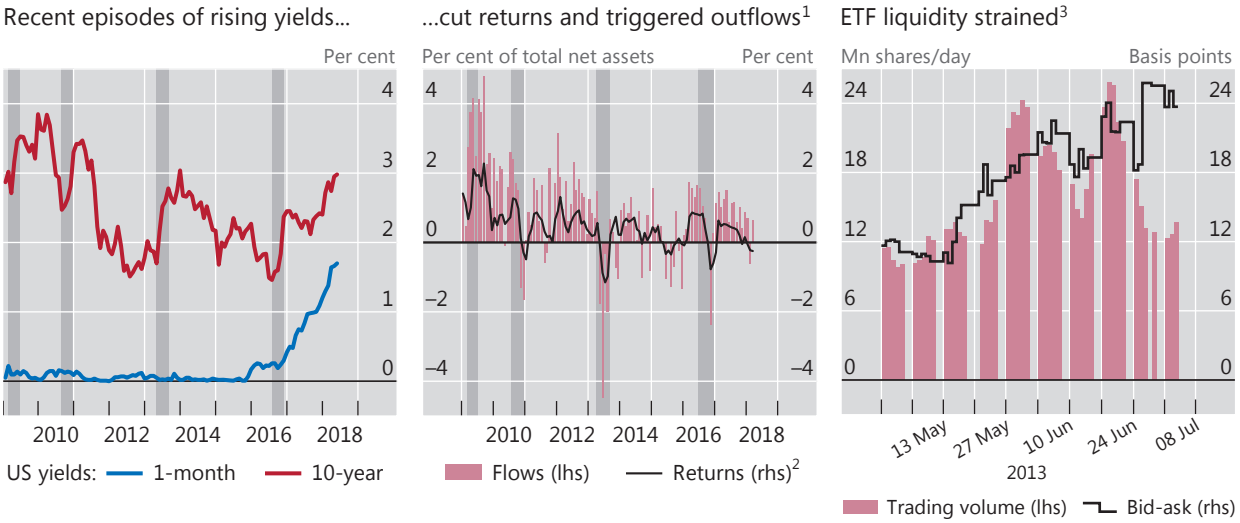
Interest rate risk is inherent in the regular activities of bond market investors and therefore actively managed. Even so, past episodes of snapbacks in long-term rates are useful reminders of the potential vulnerabilities of some segments of the fund industry. Historically, interest rate shocks have been linked to monetary policy decisions. As such, they coincided with rising short-term rates and flattening yield curves. More recently, however, long-term rates have occasionally snapped back without notable changes in short-term rates (Graph III.D, left-hand panel). Drivers of market dynamics may thus have changed, possibly giving rise to more abrupt market adjustments than in the past.

Open-end bond funds and exchange-traded funds (ETFs), key buyers of corporate bonds and other fixed income instruments in recent years, are particularly exposed to episodes of rapidly rising rates. This reflects both the induced valuation losses and the redemption pressures caused by declining fund returns (centre panel). Such redemptions may force sales at large discounts, exacerbating the downward pressure on fund returns and triggering further redemptions. Likewise, ETF investors may find it difficult to sell their shares in secondary markets, with bid-ask spreads often widening as fund returns deteriorate (right-hand panel).

Several factors may amplify such dynamics. For one, credit spreads are already quite compressed. Bond investors are thus unlikely to benefit from any offsetting effect of tighter spreads during snapbacks. In addition, portfolio duration has increased for many funds, amplifying the valuation impact of rate changes. Persistently low market volatility, notwithstanding recent increases, may have further sustained fixed income positions at low yields, increasing the scope for abrupt sell-offs. Finally, funds may amplify market adjustments by shedding assets in excess of redemptions to increase cash buffers – especially if other liquidity management tools (eg swing pricing) fail to discourage investors from redeeming.①

Fund flows and performance during recent episodes of rising long-term yields

Graph III.D



The shaded areas in the left-hand and centre panels indicate episodes during which 10-year US Treasury yields increased by at least 80 basis points before falling again.

[1] Active US open-end mutual bond funds. [2] Three-month rolling average of nominal fund returns; weighted by funds' total net assets. [3] Five-day rolling averages of volume-weighted bid-ask spreads and daily volume of the 10 largest bond ETFs by total assets during the US taper tantrum.

Sources: Bloomberg; Lipper; national data; BIS calculations.

① See S Morris, I Shim and H S Shin, "Redemption risk and cash hoarding by asset managers", *Journal of Monetary Economics*, 89, 2017, pp 88–91; and U Lewrick and J Schanz, "Is the price right? Swing pricing and investor redemptions", *BIS Working Papers*, no 664, October 2017.

Other institutional investors, for instance insurance companies and pension funds, could further intensify such market reactions. One issue is increasingly similar portfolio holdings in an environment of low rates (see above), making concerted selling more likely. Another is the use of dynamic hedging strategies, which implies that these investors would respond to any rise in long-term yields by selling long-term bonds in order to contain duration mismatches, adding to the risk of abrupt interest rate adjustments.[27]

Indirect, market-based interlinkages represent an additional channel of shock propagation. Any initial, snapback-induced position adjustment by mutual funds or other rate-sensitive investors is likely to be exacerbated by deteriorating market liquidity conditions, which would tend to spill over into other markets (eg via collateral valuations).

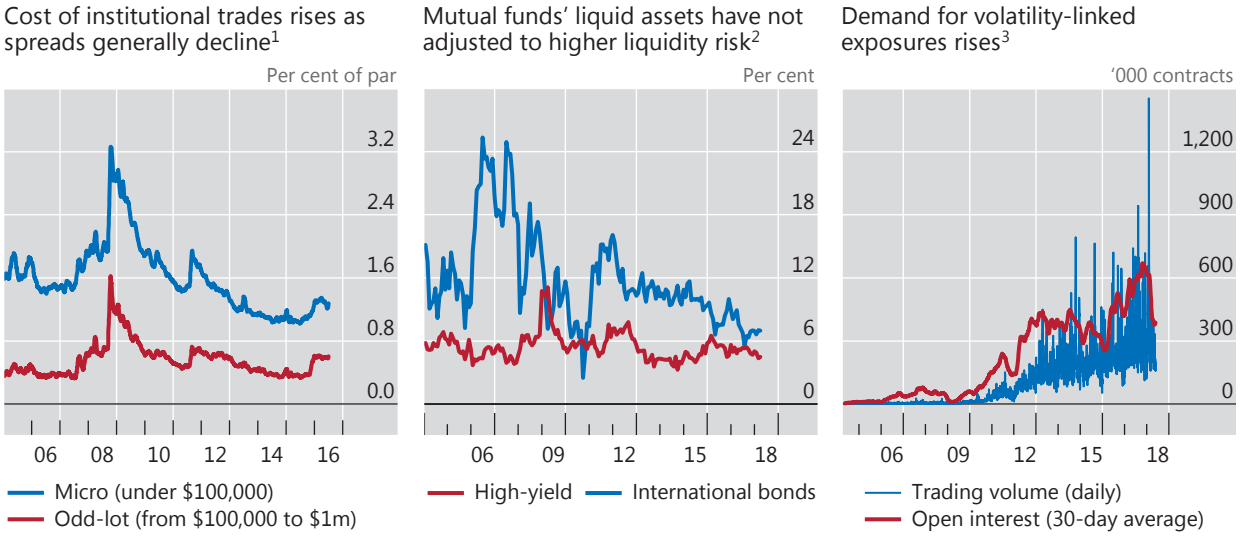
A key point is that structural changes in the provision of immediacy services may not be visible in standard measures of market liquidity, masking the risks associated with holding assets that may turn out to be illiquid in some scenarios. For example, many banks and other market-makers have cut back the amount of risk capital they allocate to trading activities.[28] To some extent, the reduction in market-making has been compensated by increased agency-based trading, in which the intermediary matches offsetting client orders with limited commitment of own balance sheet capacity. One implication of this trend is that the execution of large orders, particularly during stressed market conditions, has become more difficult (Graph III.7, left-hand panel). The associated risks have shifted from market-makers to investors, especially in the less liquid segments of the fixed income markets, such as EME debt or corporate bonds. On top of that, low yields and increasing competition have discouraged funds from raising low-yielding liquidity buffers, affecting their ability to manage redemption risks (Graph III.7, centre panel).

Alternative liquidity providers, such as proprietary trading firms (PTFs), have increased their market share in some fixed income markets. Their activities, however, have typically been limited to the most liquid segments, for example those for major advanced economy sovereign bonds. In addition, many PTFs trade with limited commitment of risk capital and lack the balance sheet capacity to maintain large inventories – as is generally necessary for market-making in infrequently traded assets, such as corporate bonds. This suggests that, while increasing competition is likely to further reduce the transaction costs of relatively liquid assets, funds invested in relatively illiquid ones remain exposed to high liquidity risks.

Developments in the ETF sector illustrate how these different factors can interact during abrupt interest rate moves and volatility spikes. ETFs are index-tracking investment funds. Yet, in contrast to traditional open-end mutual funds, their shares trade on secondary markets, and their creation and redemption are exclusively settled between designated financial intermediaries ("authorised participants", APs) and the ETF sponsor, usually an asset management company.[29] While ETFs are thus not directly exposed to investor redemption risk, other pressure points may arise.

One concerns APs' capacity to support secondary market liquidity in a snapback scenario. Under normal market conditions, APs arbitrage any difference in the ETF share price and that of the securities in the underlying index. But large selling pressure from ETF investors could overwhelm the APs' capacity to fund such arbitrage. Corporate bond ETFs provide one such example. While APs can redeem the shares they acquire from investors with the ETF sponsor in exchange for the underlying bonds, APs may hesitate to build up large bond inventories at a time of high risk and strained market liquidity in the underlying bond markets. This would drive a wedge between ETF prices and those of the underlying securities, which could in turn trigger further position adjustments and cross-market spillovers.

Hidden liquidity risks not covered by additional buffers? Graph III.7



[1] Bid-ask spreads for US corporate bonds as estimated in Adrian et al (2017); by trade size. [2] Liquid asset holdings as a percentage of funds' total net assets; by fund category. [3] CBOE S&P 500 Volatility Index (VIX) futures.

Sources: T Adrian, M Fleming, O Schachar and E Vogt, "Market liquidity after the financial crisis", *Annual Review of Financial Economics*, vol 9, 2017, pp 43–83; Federal Reserve Bank of New York; CBOE Global Markets; ICI; BIS calculations.

Concentration risk could amplify such tensions, since major APs also provide immediacy services in other markets and to other investors (eg for open-end funds).

Another issue concerns the procyclical trading activity in new ETF structures. The past few years have seen a growing demand for financial instruments that allow volatility trading – among others, ETFs (Graph III.7, right-hand panel). These products are designed to maintain a target exposure to a given volatility index, ie buying when the index rises and selling when it declines in a rather mechanical way. As a result, bouts of volatility prompt procyclical trading, reinforcing the initial volatility shock. Indeed, recent episodes of volatility spikes in equity markets have uncovered such dynamic feedback effects, highlighting the need for effective market backstops and prudent management of volatility risk.[30]

Implications for prudential policy

Structural changes in the asset management industry suggest that shock propagation can work through new, market-based channels that may amplify price movements relative to pre-crisis. Thus, even though banks and other intermediaries have become more resilient, snapback and similar shocks could lay bare new vulnerabilities. This has implications for prudential policy, adding to those in other policy areas (Chapters I and II).

For the banking sector, changes in market dynamics generate new exposures that may be insufficiently covered by current risk management practices. This underlines the need for tight supervision. In addition to guidance clarifying supervisory expectations regarding the management of interest rate risk, stress tests represent a key tool. In this context, adverse scenarios may need to be adapted to better reflect snapback-related exposures of banks' clients and counterparties and any associated knock-on effects.

Furthermore, supervisory attention may need to shift more in the direction of non-bank players and how these would perform in snapback and other stress

scenarios. One key issue is investment funds' liquidity management, which is their first line of defence in response to redemption pressures. Various tools are available to improve the management of these risks. These include additional liquidity buffers to mitigate fire sale risks as well as efforts to further develop investment funds' liquidity stress testing capacity (Chapter IV).[31] More work may be needed, however, to assess the effectiveness of these measures in different redemption scenarios in order to inform regulatory calibration decisions.

Endnotes

[1] See BCBS, *Governors and Heads of Supervision finalise Basel III reforms*, press release, 7 December 2017; and *Basel III: finalising post-crisis reforms*, December 2017.

[2] Under the new total loss-absorbing capacity (TLAC) standard, as of 1 January 2022 all G-SIBs will be required to have eligible TLAC instruments equal to a minimum of at least 18% of their risk-weighted assets (RWAs), not including any applicable regulatory capital buffers. TLAC will also need to be equivalent to at least 6.75% of the Basel III leverage ratio exposure measure. For details, see FSB, *Summary of findings from the TLAC impact assessment studies*, November 2015.

[3] Only half of the 8% Basel II minimum requirement was defined in terms of Tier 1 capital instruments, which included a range of hybrid structures and intangibles. See S Cecchetti, "The jury is in", *CEPR Policy Insights*, no 76, December 2014.

[4] For a motivation of this multiple metrics setup in a general equilibrium context, see F Boissay and F Collard, "Macroeconomics of bank capital and liquidity regulations", *BIS Working Papers*, no 596, December 2016.

[5] In addition, through revised guidance principles, the framework stresses the importance of prudent corporate governance (eg by promoting effective control functions).

[6] For details, see BIS, *83rd Annual Report*, June 2013, Box V.B.

[7] See M Behn, R Haselmann and V Vig, "The limits of model-based regulation", *ECB Working Papers*, no 1928, July 2016, for estimates of the extent of such gaming. Similar evidence based on more recent data is provided in F Niepmann and V Stebunovs, "Modeling your stress away", mimeo, 2018.

[8] See BCBS, "Analysis of risk-weighted assets for credit risk in the banking book", *Regulatory Consistency Assessment Programme (RCAP)*, July 2013, for details.

[9] See BCBS, *Basel III leverage ratio framework and disclosure requirements*, January 2014; and M Brei and L Gambacorta, "Are bank capital ratios pro-cyclical? New evidence and perspectives", *Economic Policy*, vol 31, no 86, 2016, pp 357–403.

[10] The scarcity (or outright lack) of reliable data can prevent supervisors from validating model outputs with sufficient confidence. This suggests that the use of internally modelled approaches may have to be withdrawn or restricted. Under Basel III, operational risk and various low-default credit portfolios now fall into this category. Exposures to large and mid-sized corporates, for example, are migrated away from the advanced IRB (which allows for modelling of loss-given-default (LGD)) to the foundation IRB or SA (which do not).

[11] See eg European Banking Authority, *2016 EU-wide stress test: results*, July 2016.

[12] See BIS, *87th Annual Report*, June 2017, Chapter V. For more analysis, see R Roengpitya, N Tarashev, K Tsatsaronis and A Villegas, "Bank business models: popularity and performance", *BIS Working Papers*, no 682, December 2017; and CGFS, "Structural changes in banking after the crisis", *CGFS Papers*, no 60, January 2018.

[13] See I Fender and U Lewrick, "Calibrating the leverage ratio", *BIS Quarterly Review*, December 2015, pp 43–58.

[14] Discussions of the macroeconomic impact of higher bank capital often presume that higher bank capital increases funding costs, which then translates into higher lending spreads and less lending. Recent research suggests that the opposite may be true, in that higher bank capital goes hand in hand with higher lending. See eg L Gambacorta and H S Shin, "Why bank capital matters for monetary policy", *Journal of Financial Intermediation*, 2018 (forthcoming).

[15] In Q3 2017, bank lending-to-GDP ratios in the euro area and the United Kingdom (at around 90% in each case) as well as the United States (about 45%) remained broadly unchanged from the average levels in 2002–06. Major EMEs, such as Brazil, China and India, even saw rising ratios relative to pre-crisis levels. See BIS, *86th Annual Report*, June 2016, Chapter VI.

[16] For a discussion, see N Sarin and L Summers (2016), "Understanding bank risk through market measures", *Brookings Papers on Economic Activity*, Fall, 2016, pp 57–127.

[17] See C Borio, "The banking industry: struggling to move on", keynote speech, Fifth EBA Research Workshop, 28–29 November 2016.

[18] Econometric analysis suggests that, post-GFC, higher capitalisation levels relative to total assets coincide with higher bank valuations. Accordingly, investors appear to have shifted from viewing leverage as a mechanism primarily for increasing RoE to a greater focus on ways in which excessive leverage can threaten solvency. See B Bogdanova, I Fender and E Takáts (2018), "The ABCs of bank PBRs", *BIS Quarterly Review*, March 2018, pp 81–95; and C Calomiris and D Nissim, "Crisis-related shifts in the market valuation of banking activities", *Journal of Financial Intermediation*, vol 23, no 3, 2014, pp 400–35.

[19] In a recent survey by Bain & Company, more than half of all US respondents – and 74% of those aged 18–24 – indicated that they expect to buy a financial product from a technology firm in the next five years. See Bain & Company, "Banking's Amazon moment", *Bain Brief*, March 2018.

[20] See C Borio, B Vale and G von Peter, "Resolving the financial crisis: are we heeding the lessons from the Nordics?", *BIS Working Papers*, no 311, June 2010; and European Systemic Risk Board, "Is Europe overbanked?", *Reports of the Advisory Scientific Committee*, no 4, June 2014.

[21] See A Carstens, "A level playing field in banking", keynote address, Institute of International Finance Board of Directors dinner, 21 January 2018.

[22] See FSB, *Global shadow banking monitoring report 2017*, March 2018.

[23] For a discussion, see BIS, *86th Annual Report*, June 2016, Chapter VI.

[24] See eg E Elton, M Gruber and C Green, "The impact of mutual fund family membership on investor risk", *Journal of Financial and Quantitative Analysis*, vol 42, no 2, 2007, pp 257–78.

[25] For a discussion of risks related to passive asset management, see V Sushko and G Turner, "The implications of passive investing for securities markets", *BIS Quarterly Review*, March 2018, pp 113–31.

[26] For example, since early 2010, US bank and depository supervisors have had explicit inter-agency guidance in place to alert market participants to the importance of interest rate risk and remind them of supervisory expectations regarding sound risk management practices. Similar guidance has been issued in other jurisdictions.

[27] See D Domanski, H S Shin and V Sushko, "The hunt for duration: not waving but drowning?", *IMF Economic Review*, vol 65, no 1, 2017, pp 113–53, for a discussion of potential amplification effects arising from insurance companies.

[28] For a discussion, see CGFS, "Market-making and proprietary trading: industry trends, drivers and policy implications", *CGFS Papers*, no 52, November 2014; and "Fixed income market liquidity", *CGFS Papers*, no 55, January 2016.

[29] For a discussion of ETFs and the associated risks, see V Sushko and G Turner, "What risks do exchange-traded funds pose?", Bank of France, *Financial Stability Review*, April 2018, pp 133–44.

[30] See eg BIS, "Volatility is back", *BIS Quarterly Review*, March 2018, pp 1–15.

[31] FSB, *Policy recommendations to address structural vulnerabilities from asset management activities*, January 2017.

IV. Moving forward with macroprudential frameworks

The Great Financial Crisis (GFC) revealed the inadequacy of pre-crisis prudential requirements and the limitations of the then existing tools to preserve financial stability. In response, authorities around the world have strengthened financial regulation and supervision (Chapter III) and adopted a macroprudential orientation to financial stability. The new macroprudential frameworks focus on the stability of the financial system as a whole and how it affects the real economy, rather than just on the stability of individual institutions.[1] This is important because the GFC and previous crises have shown that vulnerabilities may build up across the system even though individual institutions may look stable on a standalone basis. Indeed, many systemic financial crises of recent decades, the GFC included, resulted from the financial system's procyclicality – its tendency to amplify financial expansions and contractions, often with serious macroeconomic costs.[2]

Experience indicates that substantial progress has been made, but more needs to be done. Macroprudential frameworks have been very useful as a complement to the other financial reforms put in place after the GFC. Macroprudential measures build buffers, discourage risky lending and strengthen the financial system's resilience. They can also slow credit growth but, as deployed so far, their restraining impact on financial booms has not always prevented the emergence of the familiar signs of financial imbalances. And, as with any medicine, they come with side effects. This suggests that these measures would be most effective if embedded in a broader macro-financial stability framework that includes other policies, notably monetary, fiscal and structural.

The chapter is organised as follows. The first section describes the key elements of macroprudential frameworks and the main implementation challenges. The second discusses how authorities have dealt or could deal with some of these challenges, such as risk identification, instrument choice, policy communication and governance. The third section reviews evidence on the impact of macroprudential measures. A final section explores the role of macroprudential measures in a broader macro-financial stability framework and coordination with other policies. Two boxes discuss, respectively, macroprudential approaches to capital market activities and the use of FX intervention to reduce systemic risk.

Macroprudential frameworks: elements and challenges

Although the term dates back to the 1970s, it languished for the most part in obscurity until the turn of this century, when BIS General Manager Andrew Crockett called for a "macroprudential" approach to financial stability.[3] In the same speech, he differentiated the macroprudential dimension of financial stability – the stability of the financial system – from the microprudential dimension – the stability of individual institutions. What distinguishes the two perspectives is less the specific instruments – they are often the same – than why they are used and how they are calibrated.

It took the GFC to expose the limitations of a microprudential perspective. After the crisis, as these limitations were recognised in policy circles, more and more countries adopted financial stability mandates and implemented macroprudential measures. As a result, the term "macroprudential" has entered the mainstream

vocabulary of central banks (Graph IV.1, left-hand panel) and also of other policymakers. In addition, the average number of macroprudential measures adopted post-crisis has significantly increased for both advanced economies (AEs) and emerging market economies (EMEs) (Graph IV.1, right-hand panel).[4] In particular, AEs have stepped up their use of macroprudential measures in recent years.

The FSB, IMF and BIS set out the key elements of a macroprudential framework in a series of notes prepared for the G20.[5] These identified three intermediate objectives: (i) to increase the financial system's resilience to aggregate shocks by building and releasing buffers; (ii) to constrain financial booms; and (iii) to reduce structural vulnerabilities in the financial system that arise from common exposures, interlinkages and the critical role of individual intermediaries. This chapter focuses mainly on the first two objectives, which refer to the "time" dimension of systemic risk. By pursuing these objectives, macroprudential measures can build resilience and moderate financial cycles.

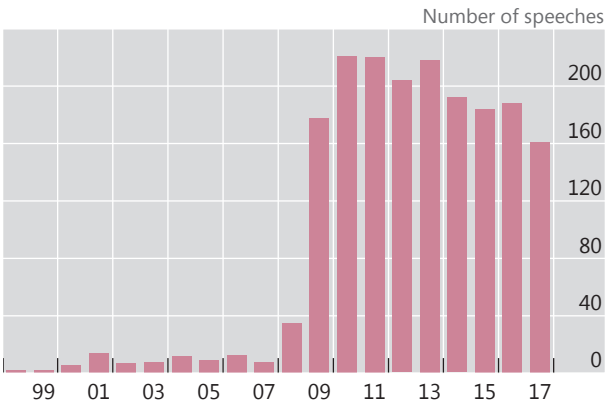
Adopting a macroprudential orientation to financial stability comes with a number of challenges. First, the ultimate objective – financial stability – is hard to define. For this reason, policymakers often resort to intermediate objectives, such as improving lending or risk management standards, strengthening banks' resilience and reducing fluctuations in credit.[6] Such intermediate objectives can help communicate macroprudential measures and improve the coordination between different policymakers responsible for financial stability. But even they may be too vague when it comes to assessing the impact of particular measures.

Second, macroprudential goals may conflict with other policy objectives. This is an issue because macroprudential authorities typically resort to instruments that may also be used for other purposes or from different perspectives. For instance, in a boom, bank supervisors may see no need to tighten regulatory requirements since individual institutions look solid when viewed in isolation, while macroprudential authorities might be more worried about procyclicality in the financial system and aggregate risk-taking and thus wish to tighten prudential instruments. Conversely, in a generalised downturn, macroprudential authorities may wish to release buffers to smooth the impact on the real economy, while bank

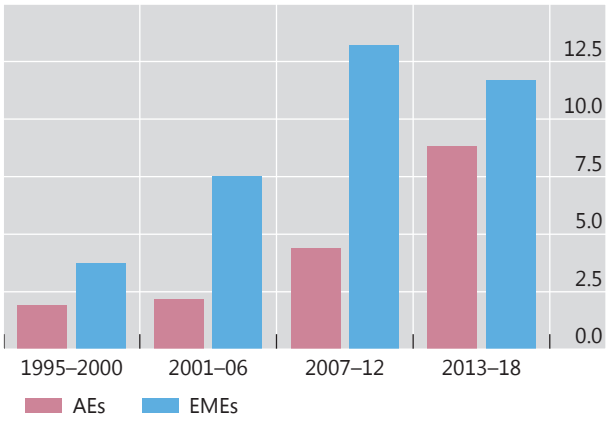
Macroprudential orientation moves to the mainstream

Graph IV.1

Central bank speeches mentioning "macroprudential"



Increasing use of macroprudential measures over time[1]



[1] The bars show the average number of macroprudential measures per year and per 10 economies in each group of economies.

Sources: BIS central bankers' speeches; BIS calculations based on macroprudential measures recorded in Table IV.1.

supervisors may prefer that institutions preserve as much capital as possible so as to better weather their losses. Tensions may also arise between macroprudential and monetary or fiscal authorities. Resolving them puts a premium on appropriate governance arrangements.

Third, it is typically difficult to identify financial vulnerabilities early enough and with sufficient certainty to take action. In some cases, it may be hard to disentangle the development of financial imbalances from welcome financial deepening and innovation. Vulnerabilities may also build up over many years, without leading to acute stress. The system may appear stable in the interim, especially since signs of low risk (eg compressed spreads) may in fact simply reflect high risk-taking. And, tightening measures when the financial system is already vulnerable could trigger the very instability one seeks to prevent.

Fourth, a bias towards inaction could result from the political economy costs of taking preventive measures, combined with difficulties in the timely identification of systemic risk. For one, policymakers are usually wary of sounding a false alarm, preferring to wait and see whether a development is actually harmful – even though prompt intervention is typically more effective. Further, the near-term costs of preventive actions are quite visible but their long-term benefits, while large,[7] are harder to discern, since policymakers and their policies rarely get any credit for a crisis that did not happen. Indeed, preventive measures may be quite unpopular, as they may hamper access to credit precisely when the general picture looks good. In this context, the temptation can be strong to argue that this time really is different, and that no action is needed.[8]

Finally, the impact of macroprudential measures can be hard to measure, given the plethora of potential instruments, their complex interactions and, frequently, the scantiness of evidence about their effectiveness. And this may be the case even when the objective is well defined. The way in which monetary policy and macroprudential measures may interact only adds to these challenges. In fact, despite recent progress, models that link the financial sector to the real economy tend to be highly stylised.[9] Thus, it could be argued that the calibration of macroprudential measures is more art than science.

When and how to act?

Ten years after the concept "macroprudential" entered the vocabulary of policymakers, there is a growing body of analytical research and practical experience on how some of these issues may be addressed. This section considers, in turn, the challenges in identifying risks, selecting and calibrating the instruments, communication and governance.

Identifying risks

Early warning indicators (EWIs) serve as a useful starting point for identifying systemic risks. Typically, they are calibrated on whether they would have been able to predict past crises. Many studies find that when credit and asset prices start deviating from long-run trends and breach certain critical thresholds, they can help to identify unsustainable booms with reasonable accuracy several years before a full-blown crisis actually develops.[10] Even so, such indicators can also sound a false alarm, not least because their critical thresholds are based on averages across a wide range of countries and over extended periods. As a result, they may not sufficiently take into account country-specific features or how financial systems evolve over time, including in response to changing regulation.

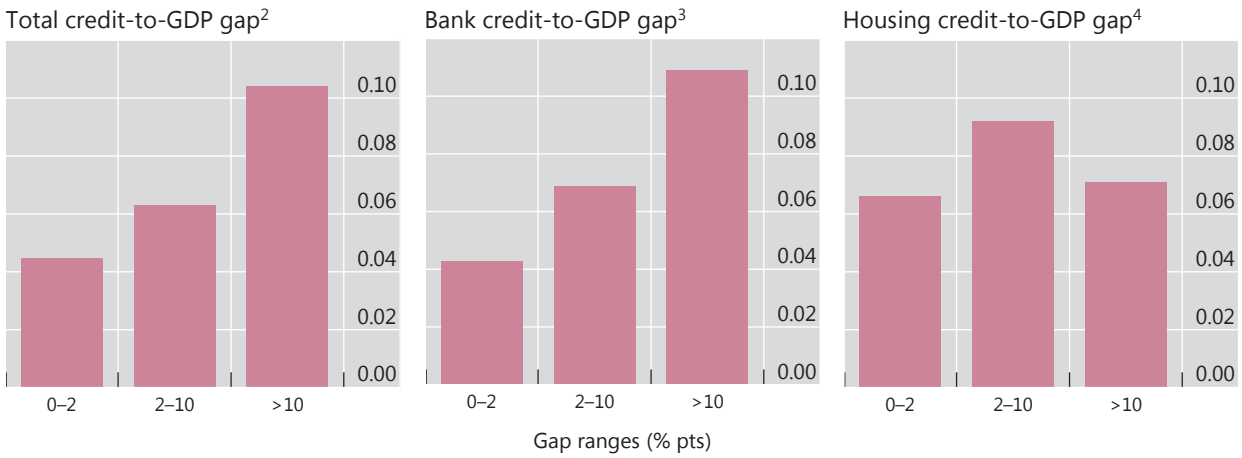
On balance, EWIs are a useful first step in identifying risks, but need to be complemented by more in-depth analysis. For instance, the distribution of exposures across borrowers may matter: even if the average borrower is solid, the failure of a critical mass of fragile ones could propagate through the system and cause a systemic event. Yet, on its own, analysis at the level of individual institutions will not suffice, since it cannot measure the impact of vulnerabilities on the financial system and the macroeconomy.[11]

A popular method for gauging financial system resilience is aggregate, or macro, stress testing. For example, major AE central banks use it, and all EME central banks responding to a recent BIS survey either used it or were planning to do so.[12] The tool helps assess resilience in response to hypothetical low-probability but high-impact macroeconomic and financial shocks. Stress tests have the advantage that they are forward-looking and can cover various scenarios. This makes them a valuable instrument for assessing specific systemic vulnerabilities – for instance, to assess the amount of capital required during an ongoing financial crisis. But it makes them less useful as a tool to identify risks when the range of scenarios is more open. Stress tests have other shortcomings too. They can help assess, say, the immediate impact of declines in house prices and increased mortgage defaults on bank balance sheets. But they are less good at capturing second-round effects arising from fire sales, lower market liquidity or the weaker spending and rising unemployment that follow such financial shocks.[13] Indeed, the stress tests carried out prior to the GFC gave little indication of any significant risks in the banking sector.[14]

Given the difficulties in identifying risks early and sufficiently surely, authorities often wait to see whether a development will have adverse consequences. This tendency may affect the timing of tightening actions during a credit boom. For example, the frequency of tightening actions increases as the credit gap crosses the 2 percentage point lower threshold in the Basel Committee guidelines on the calibration of the countercyclical capital buffer (CCyB) (Graph IV.2, all panels). As the total credit gap and general bank credit gap increase further above the

Tightening actions are used more frequently as credit booms build up[1]

Graph IV.2



[1] The values on the vertical axis are the number of economy-quarters with at least one tightening action taken by the economy divided by the total number of economy-quarters for which the gap is in the specified range. The respective credit-to-GDP gap is calculated by a one-sided Hodrick-Prescott filter with lambda 400,000. [2] Total credit refers to the total amount of credit to an economy's private non-financial sector extended by banks and non-banks in the form of loans and debt securities. [3] Bank credit refers to the amount of bank credit to the private non-financial sector. [4] Housing credit refers to the amount of housing loans extended by banks.

Sources: National data; BIS.

10 percentage point upper threshold in the guidelines, tightening actions tend to be used more frequently (left-hand and centre panels). By contrast, as the housing credit gap increases above the 10 percentage point threshold, tightening actions tend to be used slightly less frequently (right-hand panel). One possible reason is that national authorities can more easily identify financial imbalances building up in the housing market and thus more promptly deploy tightening actions before the gap exceeds the threshold.

Use of macroprudential measures by targeted credit, instrument type and region

Number of policy actions, 1995–2018 Table IV.1

	Region[1]						
Targeted credit Instrument type	Asia-Pacific [11]	Central and eastern Europe [14]	Latin America [6]	Middle East and Africa [4]	North America [2]	Western Europe [18]	All economies [55]
General credit	*31*	*156*	*68*	*5*	–	*56*	*316*
Countercyclical capital buffers	3	4	–	–	–	6	13
Limits on FX mismatch, position or liquidity	8	32	15	1	–	7	63
Capital inflow- or FX liability-based RR[2]	5	44	17	4	–	–	70
Credit growth- or asset-based marginal RR[2]	–	24	25	–	–	6	55
Others[3]	5	1	–	–	–	5	11
Housing/consumer/household credit	*168*	*125*	*24*	*13*	*13*	*114*	*457*
LTV[4] limits and loan prohibitions	76	37	9	4	7	35	168
DSTI, DTI[5] limits and other lending criteria	49	34	4	3	6	23	119
Risk weights	17	40	8	4	0	42	111
Loan loss provisioning rules	15	3	3	2	0	10	33
Others[6]	11	9	–	–	–	1	21
Corporate credit (including CRE loans)[7]	*18*	*19*	*2*	–	–	*24*	*63*
Credit to financial institutions[8]	*2*	*2*	*2*	–	–	*3*	*9*
Total[9]	*219 (1.00)*	*302 (1.02)*	*96 (0.88)*	*18 (0.29)*	*13 (0.31)*	*197 (0.49)*	*845 (0.75)*
Memo items: Total	*158 (0.72)*	*219 (0.74)*	*52 (0.48)*	*18 (0.29)*	–	*66 (0.17)*	*513 (0.46)*
General liability-based average RR[2]	115	159	50	17	–	34	375
Liquidity requirements[10]	43	60	2	1	–	32	138

Asia-Pacific = AU, CN, HK, ID, IN, KR, MY, NZ, PH, SG and TH; central and eastern Europe = BG, CZ, EE, HR, HU, LT, LV, PL, RO, RS, RU, SI, SK and TR; Latin America = AR, BR, CL, CO, MX and PE; Middle East and Africa = AE, IL, SA and ZA; North America = CA and US; western Europe = AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IS, IT, LU, NL, NO, PT and SE.

[1] The figures in square brackets indicate the number of economies in each region. [2] Reserve requirements. [3] Structural capital surcharges, other capital surcharges and loan loss provisioning rules on general credit. [4] Loan-to-value. [5] DSTI = debt service-to-income; DTI = debt-to-income. [6] Exposure limits on the housing sector and limits on FX loans to households. [7] Comprising LTV limits, DSTI limits, risk weights, loan loss provisioning rules and exposure limits. CRE = commercial real estate. [8] Comprising limits on interbank exposure, exposure limits on non-bank financial institutions and risk weights on exposure to financial institutions. [9] The figures in parentheses indicate the average number of actions per country per year for each region. [10] Liquidity Coverage Ratio, Net Stable Funding Ratio and liquid asset ratio.

Sources: Budnik and Kleibl (2018); Reinhardt and Sowerbutts (2016); Shim et al (2013); national data; BIS calculations.

Selecting and calibrating instruments

A broad array of tools can potentially be used to reduce systemic risk, although in some jurisdictions legal impediments or coordination issues may significantly restrict those that can actually be deployed. Essentially all prudential tools, such as restrictions on particular types of lending and capital or liquidity requirements, can be used from a macroprudential perspective as well as in the more traditional microprudential sense. In addition, monetary policy tools may also be used macroprudentially, for instance in the form of reserve requirements or even foreign exchange interventions.[15]

In practice, a wide range of tools has been deployed, primarily targeting various types of bank credit (Table IV.1). Authorities in both Asia-Pacific and central and eastern Europe have been the most active. Many economies have also introduced measures targeting commercial real estate mortgages and property developer loans. In particular, most EU member states have adjusted risk weights for loans collateralised with commercial property, while some EMEs have changed loan-to-value (LTV), debt service-to-income (DSTI) and exposure limits as well as loan loss provisioning rules on commercial real estate loans (Table IV.A1). Although the bulk of the measures focus on bank credit, authorities have reacted to the growing importance of market finance by also taking a macroprudential perspective on the capital market activities of asset managers and other institutional investors (Box IV.A).

The tools operate through different mechanisms. Some instruments refer to borrower characteristics, even though they are enforced on the lenders' side. Examples are caps on LTV, debt-to-income (DTI) and DSTI ratios. These increase the borrowers' resilience to house price or income fluctuations, in turn limiting the lenders' credit risk. By constraining effective credit demand, they may also put a brake on credit growth and, indirectly, on house prices too. Other tools work directly on the lender side. Examples are countercyclical capital requirements, provisioning rules and credit growth limits. Capital tools, in particular, increase banks' buffers to absorb losses, provided that they can actually be drawn down in case of stress. In addition, capital and provisioning requirements increase the cost of providing housing credit, which should slow credit growth.

The wide variety of potential tools lets authorities target specific exposures or activities.[16] For example, the Central Bank of Brazil imposed restrictions on auto loans that it deemed particularly risky, but not on other types of auto loan.[17] Such targeted actions can reduce the costs of intervention, but they also have drawbacks. First, they tend to have more immediate distributional consequences, which could result in greater political pressures. Second, they are more vulnerable to leakages – defined as the migration of the targeted activity outside the scope of the tool's application and enforcement.

Leakages can take many forms. At one end of the spectrum are evasive ploys that merely shift the targeted activity into a new guise, without changing the nature of its risks. For example, in Malaysia tighter LTV limits on mortgages to individuals led to a surge in home purchases by firms set up specifically to circumvent the restrictions.[18] Exposures may also migrate to lending institutions that are not subject to the specific measure – for instance, to shadow banks or foreign intermediaries. Some evidence suggests that macroprudential measures implemented on bank credit have led to an expansion in the credit provided by non-banks, and that measures targeting external bank borrowing have boosted offshore corporate bond issuance.[19] Such leakages may reduce the direct risk exposures of the domestic banking system but not the likelihood of corporate sector stress as such.

Partly in response to leakages, the authorities have in several cases progressively broadened the scope of the measures employed, for instance by expanding the set

Box IV.A

Macroprudential approaches to capital market activities

As current macroprudential measures focus mainly on banks, they may be less effective in dealing with risks arising from the market-based financing that has become more prevalent post-GFC. Similarly, financial innovation and the application of new technology to the financial industry may shift the nature of risk, requiring a new set of policy responses and an expanded arsenal of instruments (Chapter III). In this context, how can macroprudential approaches help address systemic risk arising from asset management funds and other institutional investors such as insurance companies and pension funds?

Correlated and procyclical trading by asset management funds could destabilise asset markets, resulting in large losses that could propagate through the financial system. Such effects are possible even if each market participant acts prudently on a standalone basis, given the interactions between market dynamics and the collective actions of individual market participants.① However, current regulation on the asset management fund industry is geared mainly towards microprudential and consumer protection objectives and thus fails to fully incorporate how actions by one player can affect the health of others via changes in asset prices, exchange rates and market liquidity. The macroprudential perspective should be extended to asset management funds to address these concerns.

Authorities have a number of options to address these risks. For example, minimum liquidity requirements for asset management funds may allow them to meet redemptions without selling relatively illiquid assets.② If so, such requirements could help increase the resilience of market liquidity. In January 2017, the US Securities and Exchange Commission (SEC) implemented new rules requiring open-end mutual funds and exchange-traded funds to establish liquidity risk management programmes.③ Among other measures, the rules require these funds to consider current market conditions and establish appropriate liquidity risk management policies and procedures in light of both normal and reasonably foreseeable stressed market conditions. Such requirements incorporate a macroprudential perspective in that they recognise that liquidity is adversely affected by market stress.

Liquidity stress tests for asset management funds have also been implemented by a few other national authorities. For example, in 2015 the Bank of Mexico assessed liquidity risk in domestic mutual funds. The French market supervisory authority has also published a guidance document on stress testing for asset management funds. But, in these exercises, the authorities took a mainly microprudential approach, by focusing on fund-level liquidity risks. By contrast, in February 2018 the European Systemic Risk Board published a recommendation on action to address systemic risks related to liquidity mismatches. In particular, it explicitly considered an amplification channel whereby mismatches between the liquidity of open-end investment funds' assets and their redemption profiles could lead to fire sales to meet redemption requests in times of market stress, potentially affecting other financial market participants holding the same or correlated assets.

To deal effectively with systemic risks stemming from asset management funds and other institutional investors, close cooperation among the various authorities involved is crucial – central banks, bank regulators, insurance regulators and securities regulators. Here, differences in perspectives can complicate matters. For instance, securities regulators with responsibility for asset managers put prime emphasis on investor protection, while central banks and bank regulators focus more on financial stability and hence are more inclined to apply macroprudential approaches.

National authorities are currently making the very first steps towards a macroprudential perspective on capital market activities, as compared with the progress already made in introducing macroprudential frameworks to the banking sector. The growing importance of asset managers and other institutional investors in both domestic and cross-border financial intermediation requires national authorities to monitor potential systemic risks from these activities at both the national and global levels and to consider how best to employ macroprudential approaches to deal with such risks.

① See Borio (2004) for further details of this interaction. ② FSB (2017) provides specific policy recommendations for dealing with liquidity risks in the asset management sector. ③ For details of the initial proposed rules, comments received and the final rules, see SEC (2016).

of activities targeted. In other cases, they have taken a relatively broad approach, applying a portfolio of measures with the aim of reducing possible channels for evasion.[20]

While a broad approach using many instruments may be more effective in targeting risks, it also has its drawbacks. It can easily become complex and difficult to communicate. In the extreme, it could result in the macroprudential authority

effectively taking on the role of credit allocation.[21] And it can complicate the calibration of individual instruments, by making it harder to assess their interaction and overall effect.

Macroprudential authorities have addressed the difficulties of calibrating instruments in a variety of ways. In some cases, central banks have relied on econometric estimates linking actions and outcomes. In others, they have used micro data to gauge the effects of specific measures on credit.[22] In the more common complex situations, they have resorted to stress tests,[23] calibrated models[24] or plain judgment.

A fairly common reaction to the uncertainty about how instruments work has been to start cautiously and then increase the intensity, scope and frequency of the measures until the effects become more apparent.[25] Such a gradual approach is consistent with the view that uncertainty calls for caution. But the heavy costs of a crisis could tip the scale towards more decisive action early on.[26]

Communication

As in many other policymaking areas, effective communication is critical for success. Communication can explain the objectives, strategy and policy process to the public, and thus build political support. In addition, it can help the authorities share their risk assessment with both the affected parties and the broader public, which can enhance effectiveness.[27]

For communication to achieve the desired effects, the message needs to be delivered effectively to the right audience. The primary audience largely determines the content, sophistication and channels used. Most central banks communicate financial stability risks in speeches, press conferences and their regular financial stability reviews. While such reviews are useful in communicating with specialists, they can easily prove opaque for the broader public, not least homeowners.[28] Thus, several authorities also use more targeted channels. For instance, the Reserve Bank of India issues short and simplified press releases for an audience with limited financial literacy. Establishing links with the media, such as through background briefings, is another common tool.

In one sense, communication might even be viewed as a macroprudential tool in its own right.[29] In theory, central bank warnings might head off adverse developments, obviating the need for any subsequent remedial action. In practice, examples of warnings that appear to have taken effect without subsequent concrete actions (or at least the threat thereof) are rather few. In Chile, warnings from the central bank in its Financial Stability Report between June and December 2012 appear to have affected bank lending practices, inducing a shift towards lower-LTV mortgages.[30]

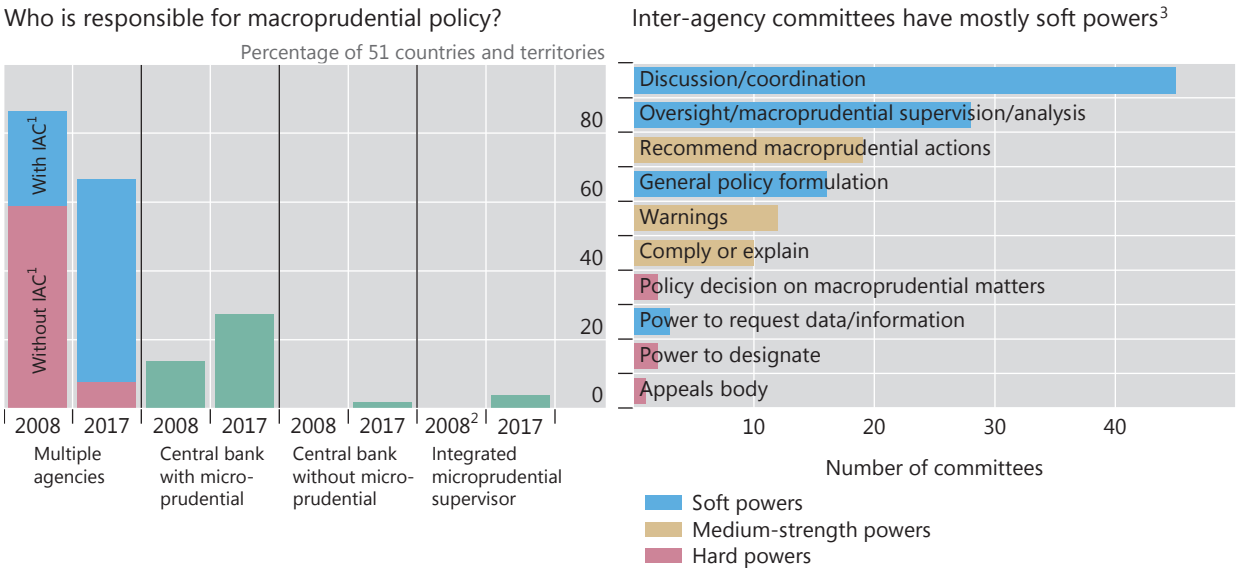
Governance

The multiple purposes of the instruments, the scope for strong political pressure and the mismatch between the mandate and tools put an onus on adequate governance arrangements. This involves several aspects: having a clear operational objective; providing incentives to act and tools commensurate with that objective; ensuring accountability and transparency;[31] and ensuring effective coordination across the policy areas that have a bearing on financial stability.[32]

The institutional arrangements governing macroprudential frameworks vary across countries. The most common is to allocate macroprudential functions to several bodies that coordinate through a committee (Graph IV.3, left-hand panel). The second most common one is to vest both macroprudential and microprudential

Macroprudential institutions and powers

Graph IV.3



[1] IAC = inter-agency committee. [2] Data not available. [3] One agency can have several attributes.

Source: BIS surveys.

responsibilities in the central bank. Far less frequently adopted are other possible arrangements, such as the sharing of responsibilities without a formal coordinating committee, or giving macroprudential responsibilities to an integrated microprudential supervisor.

The jury is still out on the effectiveness of these arrangements. In particular, many of them do not fully align financial stability responsibilities with decision-making powers over the necessary instruments. Notably, many of the inter-agency committees set up after the GFC lack hard decision-making powers (Graph IV.3, right-hand panel). Moreover, very few of the post-GFC financial stability mandates explicitly mention trade-offs between different policy objectives, let alone how to resolve them. In response to a BIS survey, only six out of 14 EME central banks that participated in inter-agency committees said that these had helped coordinate policies.[33] Several respondents stressed that decision-making powers remained with individual authorities, raising questions about the effectiveness of coordination. In some cases, the very inclusiveness of such committees can complicate decision-making.[34] In the United Kingdom, the tripartite system that comprised the Treasury, the central bank and the supervisory authority was abandoned, with most financial stability-related tasks and responsibilities shifting to the Bank of England.

Impact: the experience so far

Ultimately, macroprudential measures are effective if they ensure that the financial system is stable. But this benchmark is too general to be useful when assessing the effectiveness of individual tools. Narrower criteria focus on more specific objectives, such as curbing the growth of a particular form of credit or increasing the resilience of the financial system to the unwinding of financial booms or adverse shocks. Effectiveness can be measured by the change in the rate of credit growth or the increase in the banking system's capital or liquidity buffers.

Empirical evidence on the impact of macroprudential measures overall suggests that macroprudential measures have been generally successful in strengthening the financial system's resilience. By construction, capital and liquidity requirements increase the buffers available to, respectively, absorb future losses and bridge periods of illiquidity. That said, they can only do so if they can actually be drawn down when needed. By changing the relative price of different forms of credit, capital or reserve requirements on particular types of lending can also affect the composition of credit, reducing the riskiness of loan books.[35] All of this should result in a more resilient and thus stable financial system, as suggested by the small number of econometric studies that measure the impact of macroprudential measures on bank risk.[36]

There is also evidence that certain macroprudential measures have moderated financial booms. Panel regressions across a broad set of countries indicate that tighter LTV and DSTI limits may help curb housing credit growth (Graph IV.4, middle left-hand panel).[37] Tighter DSTI caps also appear to dampen house price growth (bottom left-hand panel). These results are largely in line with the empirical literature[38] and many central banks' own assessments.[39] Maximum LTV and DSTI ratios as well as limits on credit growth and foreign currency lending also appear to have moderating effects on bank leverage and asset growth.[40] Likewise, there is some evidence that FX position limits have a measurable impact on credit growth (top left-hand panel).[41] But other measures have less discernible effects or even work in the wrong direction.[42]

Interestingly, loosening LTV or DSTI requirements does not appear to have any effect on credit or house prices (Graph IV.4, right-hand panels). Again, such asymmetries are in line with the empirical literature. It appears that tightening measures can help discourage credit expansion but loosening does not encourage it much during financial downturns – much like pushing on a string. But looking at the impact of loosening measures on overall credit may not be the right criterion for success. A better one could be whether the measures help avoid unnecessary constraints on the supply of credit, not whether they prevent necessary deleveraging.[43]

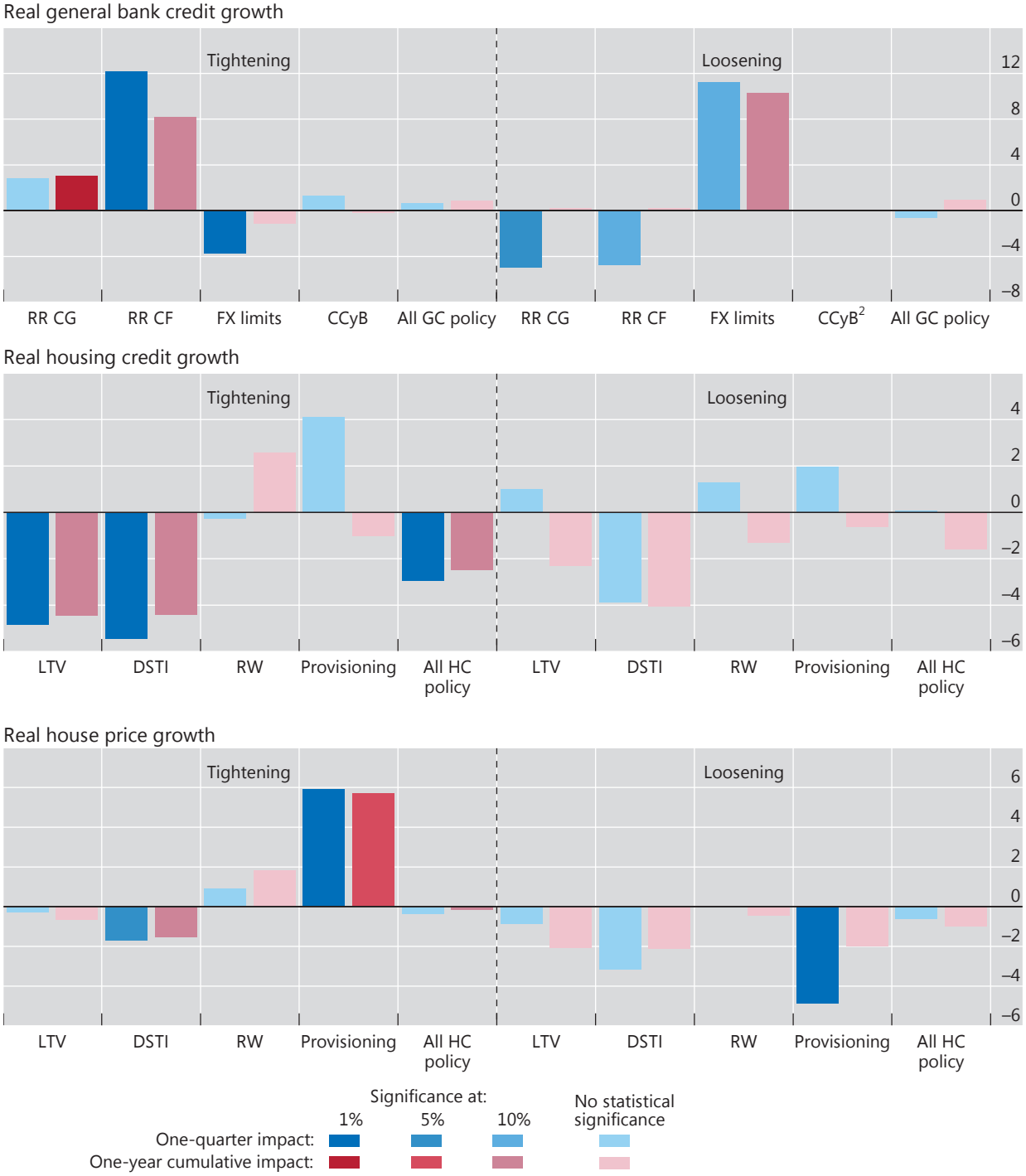
Still, easing by releasing buffers is not without its problems. The market may view a discretionary release of capital or liquidity buffers during a downturn as a signal of worse to come rather than as a tool to stabilise the financial system. Thus, to be effective in a bust, buffers may need to be sufficiently large to start with and to be released in a non-discretionary fashion.[44]

While some macroprudential measures appear to have helped slow credit growth, their restraining impact on financial booms has not always prevented the emergence of financial imbalances.[45] It remains an open issue whether this reflects inaction bias, leading to belated and overly timid action, a fear of side effects that limits the strength of the measures, evasion, or any intrinsic limitations of the instruments.

Although macroprudential measures tend to target specific activities or exposures, their effects are often much broader. For example, the activation of the CCyB on mortgages in Switzerland triggered a rise in corporate lending.[46] Such a spillover is largely unavoidable and differs from evasive ploys that leave risks essentially unchanged. More generally, the same panel regression analysis on direct effects also provides evidence of spillovers and leakages. In particular, housing, consumer and household credit growth significantly increased from the quarter following the implementation of measures tightening corporate credit including commercial real estate loans (Graph IV.5). In addition, policy actions tightening consumer credit appear to have boosted housing credit, and those tightening housing credit to have encouraged consumer credit, which is likely to indicate

Direct effects of macroprudential measures on bank credit and house prices[1]

In percentage points — Graph IV.4



All GC policy = all policy actions on general bank credit; All HC policy = all policy actions on housing credit; CCyB = countercyclical capital buffers; DSTI = maximum debt service-to-income ratios, maximum debt-to-income ratios and other lending criteria; FX limits = limits on FX mismatch or position; LTV = maximum loan-to-value ratios and loan prohibitions; Provisioning = loan loss provisioning rules on housing loans; RR CF = capital flow- or FX liability-based reserve requirements; RR CG = credit growth- or asset-based marginal reserve requirements; RW = risk weights on housing loans.

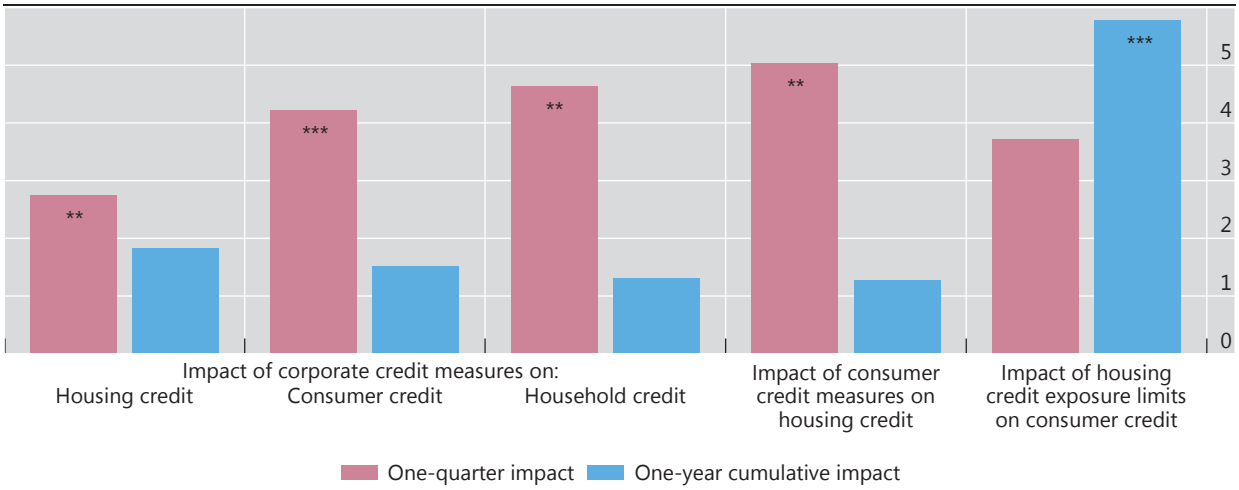
[1] The expected sign of the bars for tightening (loosening) actions is negative (positive). [2] Data not available.

Source: BIS calculations based on Kuttner and Shim (2016).

Effects of targeted macroprudential tightening measures on other types of credit

In percentage points

Graph IV.5



/* indicates statistical significance at the 5/1% level.

Source: BIS calculations based on Kuttner and Shim (2016).

leakages. Whether such behavioural responses should raise concerns will depend on their systemic risk impact.

Similar to monetary policy measures, macroprudential measures affect economic activity by changing the cost of borrowing or modifying households' or firms' access to finance. A relatively small number of studies find that tightening macroprudential measures tends to reduce output growth, but evidence of their effect on inflation is rather mixed.[47]

No analysis of policy impact would be complete without considering side effects. These can come in many guises. For instance, the measures may have undesired distributional effects, such as limiting access to finance for those who need it most and discouraging financial innovation. They may also distort credit allocation. Unfortunately, the evidence on these issues is so far limited.

In a financially integrated world, developments in one country may give rise to systemic risk in another. For example, low interest rates and unconventional monetary policy actions in the large AEs post-crisis have resulted in large capital flows to EMEs and small open AEs, fuelling domestic financial booms.[48] International spillovers may also result from macroprudential measures. For instance, recent studies find that bank regulation of multinational banks in their home country affects their lending standards elsewhere.[49]

Towards an integrated macro-financial stability framework

The adoption of a more macroprudential approach to financial regulation and supervision represents an important step forward, in both identifying and mitigating financial stability risks. It entails a major cultural shift in the concept of risk, by acknowledging the limitations of market prices as risk indicators as well as recognising the importance of self-reinforcing financial booms and busts ("financial cycles") and financial system-wide considerations. Moreover, the implementation of macroprudential frameworks has helped strengthen the financial system's resilience and moderate financial excesses.

At the same time, such frameworks are no panacea. The task of ensuring sustainable financial stability is clearly complex. Reliance on one set of tools alone, even when based on solid arrangements, is unlikely to be enough. For instance, while macroprudential measures can mitigate credit expansion, those employed so far, in some cases quite actively, have not necessarily prevented the familiar signs of financial imbalances from manifesting themselves. Given the economic and social costs of financial crises and the macroeconomic costs of financial cycles more generally, it would be imprudent to look exclusively to macroprudential frameworks to deliver the desired results.

All this suggests that macroprudential frameworks should be embedded in a more holistic, comprehensive and balanced macro-financial stability framework. Alongside more micro-oriented financial regulation and supervision, such a framework would also encompass monetary, fiscal and structural policies. The ultimate goal would be to have the various policies work alongside each other to ensure macroeconomic and financial stability while raising long-term sustainable growth. At a minimum, such a framework would also reduce the risk that different policies work at cross purposes.

Designing such a framework raises difficult analytical and practical issues. Some general observations are offered here.

An important element of a macro-financial stability framework is monetary policy. Interest rates directly affect both asset prices and borrowers' willingness and ability to take on leverage. In addition, and partly for the same reasons, they appear to affect economic agents' risk-taking.[50] As a result, monetary policy influences the financial cycle and systemic risk and, through these, macroeconomic fluctuations. This is the case whether or not it operates through interest rates, balance sheet policies or foreign exchange intervention (Box IV.B).[51] At the very least, therefore, monetary and macroprudential authorities need to take into account each other's actions when making decisions.

How far monetary policy should go in taking financial stability considerations into account is controversial. The answer depends on a range of factors, including the degree to which monetary policy affects risk-taking, debt and asset prices; the effectiveness of macroprudential actions; the particular nature of the risks; and the secondary effects of taking action.[52] For instance, macroprudential measures can advantageously target more granular risks, such as in the mortgage sector, while monetary policy has a more pervasive impact, thus limiting leakage and regulatory arbitrage.[53] Similarly, in more open economies, higher interest rates have the disadvantage of encouraging more capital inflows and exchange rate appreciation, which could offset at least in part their restraining influence on the build-up of financial imbalances. By contrast, macroprudential measures do not suffer from this limitation. Moreover, it is precisely in this context that foreign exchange intervention can contribute to the design of a more balanced policy response. It can do so by building up buffers for use when the tide turns and by dampening the expansionary impact of an exchange rate appreciation on capital inflows and the build-up of imbalances (Box IV.B and Chapter II).[54] That said, there is always some tension when operating macroprudential and monetary policy measures in opposite directions, as when interest rates are reduced to address inflation concerns while macroprudential measures are tightened to restrain the build-up of financial imbalances.

These are just some of the many considerations that need to be taken into account when evaluating the role of monetary policy and macroprudential measures in a macro-financial stability framework. They help explain the range of possible roles monetary policy can in principle play, from serving simply as a backstop for more targeted macroprudential measures to playing a much more prominent part. What is clear is that a more active role for monetary policy requires

a flexible interpretation of inflation objectives, so as to better reconcile near-term stabilisation objectives with longer-run financial and hence macroeconomic stability. This, in turn, calls for longer horizons than the widely adopted two-year ones. These refinements would provide necessary room for manoeuvre to address the slower-moving build-up of financial vulnerabilities linked to the financial cycle (Chapter I).[55]

Fiscal policy is another key element of a broader macro-financial stability framework.[56] Relatively tight fiscal policy may help restrain the build-up of imbalances during financial booms. More importantly, it will build buffers that can be drawn upon to dampen the real effects of financial downturns. For example, the loosening of fiscal policy was crucial in supporting output during the GFC. Sufficiently large fiscal buffers can also help prevent the sovereign itself being a source of financial instability, as has happened recently in several European economies. But running a sound fiscal policy during a financial boom is challenging for a number of reasons.[57] First, financial booms create revenues that will not be there when the boom stops. Second, financial booms also result in an overestimation of potential output and growth. It is therefore very important, when assessing structural deficits, to allow for the flattering effect of financial booms on public finances. Third, financial booms may create hidden contingent liabilities, including the fiscal costs of dealing with financial instability, or lower revenues and higher expenditures from an ensuing recession.

Often financial imbalances result at least in part from distortions in the tax system or the real sector. For example, the tax codes of most economies favour debt over equity, creating incentives for leverage.[58] Changing the tax code to reduce this bias could result in less vulnerable funding structures. In the case of housing booms, measures that expand the supply of land or encourage construction could have a more lasting impact on property prices and, indirectly, mortgage credit than higher interest rates or tighter macroprudential measures. Similarly, authorities may limit speculative activity in the shape of rapid turnover (or "flipping") in the housing market by raising transaction taxes or stamp duties, rather than through macroprudential or monetary policy measures.[59]

Putting together a comprehensive macro-financial stability framework naturally raises coordination issues. In some cases, it might be enough to merely take into account decisions in other policy spheres, just as monetary policymakers take the fiscal stance as given when deciding on interest rates. In other instances, the case for coordination is stronger. Coordination between the monetary authority and other authorities, such as macroprudential and fiscal, may also broaden political and social support.

Coordination may become even more difficult when it has to take place across borders. While the literature rightly cautions that not all forms of cross-border spillover call for policy intervention,[60] they sometimes do. For macroprudential measures, the case for international coordination is perhaps easiest to make in preventing cross-border arbitrage, ie "leakages". The Basel agreement on reciprocity in the implementation of the Basel III CCyB is one such example. Designed to overcome the problems associated with global banks bypassing national regulations on capital requirements, this agreement stipulates that when the CCyB is activated in any given country, all countries are expected to apply the same buffer on exposures to that country from banks in their jurisdiction.[61] But there may be other cases too. For example, when a country introduces prudential measures to reduce systemic risks related to FX borrowing, capital flows may be diverted to another country in the same region. In this case, coordination would mean that both countries tighten such prudential measures, ie that their actions complement each other.[62]

FX interventions in a macroprudential context

The frequency and size of capital flow surges and reversals in EMEs have increased over the past three decades. Such surges and reversals pose macro-financial stability risks by significantly raising the volatility of exchange rates and interest rates as well as the risk of financial crises. This raises the questions of how to respond, and how best to combine policies as part of a holistic macro-financial stability framework. This box considers what role foreign exchange intervention can play.

FX intervention can help underpin financial stability in two ways. First, intervening in response to capital inflows can help build international reserves that can be deployed when tides turn. Second, intervention may constrain the build-up of financial imbalances. All else equal, an appreciating exchange rate tends to improve the creditworthiness of domestic borrowers and thus open the door for more borrowing. This is most obvious if debt is denominated in foreign currency and assets are denominated in the domestic currency. In this case, an appreciation of the exchange rate reduces the value of this debt relative to domestic assets and income. But the effect may also be felt even in the absence of currency mismatches. An exchange rate appreciation tilts the relative value of domestic versus foreign assets that could serve as collateral, thus making international banks and institutional investors more willing to lend.①

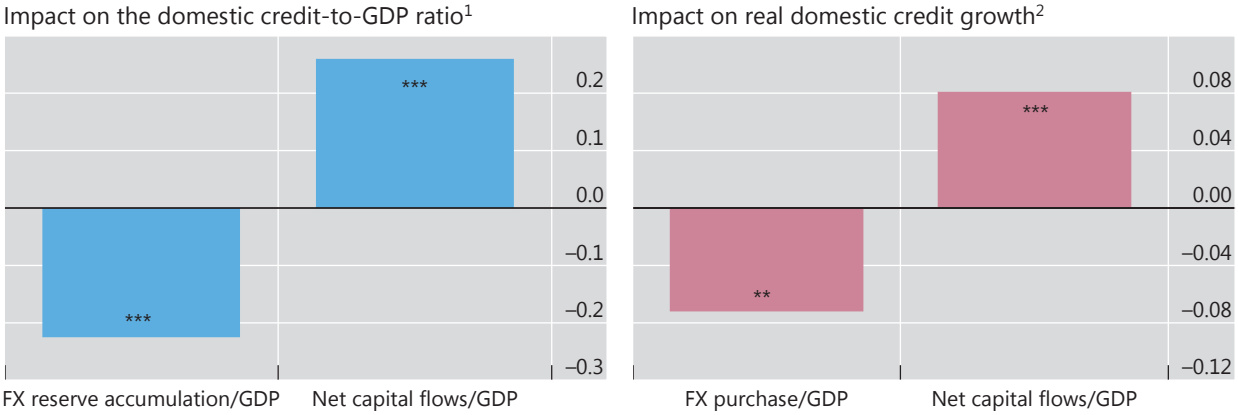
EMEs have frequently used FX intervention to mitigate the effects of external conditions on the domestic economy, especially those of exchange rate and capital flow volatility. Many cross-country studies on the effectiveness of sterilised FX intervention in EMEs find evidence that it has tempered exchange rate appreciation in response to gross inflows.② By doing so, intervention can also weaken the impact of foreign financial conditions on domestic credit and thus reduce systemic risk. Indeed, Graph IV.B shows that sterilised FX intervention tends to offset the impact of capital inflows on domestic credit growth.③

In contrast to restrictions on capital flows, FX intervention works directly on the source of shocks, ie the exchange rate, rather than directly discouraging inflows. However, FX intervention does not always work well. While it helps build buffers and neutralise the exchange rate channel, it does not offset the direct effect of inflows on debt. In general, intervention works better when the inflow is less persistent and less sensitive to return differentials.④ Therefore, FX intervention could be best regarded as a complement to other policies, such as interest rate policy and domestic macroprudential measures that EMEs can use to maintain macro-financial stability.

FX intervention to smooth a depreciation of the domestic currency in the face of capital outflows has to be communicated properly in order to be effective. In particular, national authorities should emphasise the macroprudential

Sterilised FX intervention and domestic credit growth

In percentage points — Graph IV.B



/* indicates statistical significance at the 5/1% level.

[1] This panel shows the coefficient of the variables on the horizontal axis from a BIS panel regression analysis for 20 EMEs from 2000 to 2017, where the dependent variable is the change in the ratio of domestic credit to GDP and the control variables are the lagged dependent variable, the US dollar exchange rate, the real domestic money market rate, country fixed effects and time fixed effects. [2] This panel shows the coefficient of the variables on the horizontal axis from a panel regression analysis for 45 EMEs from 2005 to 2013 reported in specification (7) in Table 9.2 of Ghosh et al (2017).

Sources: Ghosh et al (2017); BIS calculations.

objective of such actions, making sure that they are not interpreted as a lack of conviction on the part of the authorities to make other, more fundamental policy adjustments when they are required, as in the monetary or fiscal space.

① See Bruno and Shin (2015a,b). ② See Blanchard et al (2015) and Daude et al (2016). Fratzscher et al (2017) examine foreign exchange intervention based on daily data covering 33 AEs and EMEs from 1995 to 2011, and find that intervention works well in terms of smoothing the path of exchange rates, and stabilising the exchange rate in countries with narrow band regimes. ③ This is in line with recent studies using a variety of methodologies, For cross-country evidence, see Ghosh et al (2017). Hofmann et al (2018) look at the micro data of Colombia and find that sterilised FX interventions counter the procyclical effects of capital inflows on bank lending. Using Korean bank-level data, Yun (2018) finds that, facing reserve accumulation, primary dealer banks and foreign bank branches reduced lending more than non-primary dealer banks and domestic banks, respectively. ④ For details, see Ghosh et al (2017).

Endnotes

[1] In line with agreed terminology, this chapter defines macroprudential frameworks as those that use (primarily) prudential tools to target specifically systemic risk and thus mitigate the impact of systemic events on the macroeconomy. The operational objectives of existing macroprudential frameworks have been to strengthen the resilience of financial systems and dampen the financial booms and busts at the heart of much of the financial instability seen historically. For more details, see FSB-IMF-BIS (2011a,b, 2016).

[2] For an early in-depth analysis of the concept of procyclicality and its implications, see Borio et al (2001).

[3] See Crockett (2000). Clement (2010) traces the term "macroprudential" back to a submission of the Bank of England to the Cooke Committee, the precursor of the Basel Committee on Banking Supervision. Borio (2003) sought to clarify its contours more precisely.

[4] This graph is based on 845 macroprudential measures taken by 55 economies over 1995–2018.

[5] At their meeting in Seoul in November 2010, G20 leaders asked the FSB, the IMF and the BIS to undertake further work on macroprudential policy. See FSB-IMF-BIS (2011a,b, 2016) for summaries of this work.

[6] For examples, see Table 3 in CGFS (2016).

[7] See Fender and Lewrick (2016) for a recent review of estimates of the costs of financial distress.

[8] See Reinhart and Rogoff (2009).

[9] For an overview, see Claessens and Kose (2018).

[10] See Aldasoro et al (2018) for a recent contribution and further references. While credit gaps also have predictive power for EMEs, the case where credit grows exponentially over an extended period starting from a very low level may not be comparable with the deviation of credit in an advanced economy, which tends to behave more cyclically.

[11] Moreover, the complexity and interconnections that give rise to systemic risk are often the result of financial intermediation having grown large. See Shin (2017).

[12] See Anderson et al (2018) for details on the macroprudential stress tests conducted by major advanced economy central banks and international organisations; and Arslan and Upper (2017) for the BIS survey on practices in EMEs.

[13] Over time, testing methodologies have started to incorporate feedback effects through contagion between firms, or through the interaction between the economy's financial and real sectors. But these second-round effects tend to be mechanistic, failing to capture the behaviour of firms or banks.

[14] For a critical assessment of stress tests, see Borio et al (2014).

[15] Non-prudential instruments need to be specifically targeted at systemic risk and underpinned by governance arrangements that prevent any slippage in order to be considered macroprudential. See FSB-IMF-BIS (2011b).

[16] See CGFS (2010), especially Table 1, Crowe et al (2013) and Claessens (2015) for mappings from particular vulnerabilities to tools.

[17] The restrictions were applied to auto loans with long maturities and high loan-to-value ratios. See Costa de Moura and Martins Bandeira (2017) for more details.

[18] The central bank responded by introducing tighter loan-to-value caps on housing loans to firms too. See Central Bank of Malaysia (2017).

[19] See Cizel et al (2016) and Bruno et al (2017).

[20] A multi-instrument approach is also consistent with the theory of policymaking under uncertainty developed by Brainard (1967), which suggests that policymakers should use all available tools – but cautiously – to mitigate the effects of uncertainty.

[21] Indeed, some of the measures used for macroprudential purposes, for instance some credit restrictions, were originally introduced to allocate credit.

[22] See eg Allen et al (2017).

[23] For example, the Bank of England set the countercyclical capital buffer (CCyB) so that the sum of the 2.5% Basel III capital conservation buffer and the CCyB was equivalent to the average loss of 3.5% of banks' risk-weighted assets as revealed by the Bank's stress test. See Bank of England (2017).

[24] For example, the Bank of France uses dynamic stochastic general equilibrium models with several macro-financial variables to calibrate a rule that links the CCyB to macroeconomic developments.

[25] The country studies in *BIS Papers*, no 94, provide many examples.

[26] See Bahaj and Foulis (2017), who relax Brainard's (1967) assumptions that the costs of missing the target are symmetrical.

[27] See CGFS (2016) and Patel (2017).

[28] The inaccessibility is only partly due to the nature of the issues. Textual analysis finds that many central banks use overly complex language. See Patel (2017).

[29] CGFS (2016) provides extensive discussion of communication as an instrument, including many practical examples.

[30] See Alegría et al (2017). For counterexamples, see CGFS (2016).

[31] See Powell (2018) for discussions on the role of public transparency and accountability for both financial stability and monetary policy.

[32] See FSB-IMF-BIS (2011b).

[33] See Villar (2017).

[34] At one extreme, the European Systemic Risk Board (ESRB) has 78 member institutions and three observers, although the ESRB has formal procedures for conducting macroprudential policies.

[35] For examples, see Gambacorta and Murcia (2017) and the country studies in *BIS Papers*, no 94.

[36] See eg Aguirre and Repetto (2017), Altunbas et al (2018) and Gómez et al (2017).

[37] The analysis uses the sample of macroprudential measures described in Table IV.A1. In line with most other cross-country studies, it defines dummy variables for tightening (+1) and loosening (–1) actions. Recently, a small number of papers have attempted to capture the intensity of policy actions considering the size (and sometimes even the scope) of changes in regulatory ratios. See Glocker and Towbin (2015), Vandenbussche et al (2015) and Richter et al (2018). See Galati and Moessner (2017) for a recent review of the effectiveness of macroprudential measures.

[38] See eg Cerutti et al (2017), Gambacorta and Murcia (2017), Kuttner and Shim (2016) and Lim et al (2011). Many country-level studies also reach similar conclusions. For example, see Igan and Kang (2011) for Korea and Wong et al (2011) for Hong Kong SAR.

[39] See Arslan and Upper (2017).

[40] For example, Claessens et al (2013) use a sample of around 2,800 banks in 48 countries over the period 2000–10 and find that maximum LTV and DSTI ratios as well as limits on credit growth and foreign currency lending have reduced bank leverage and asset growth during booms. By contrast, they find that few policies have helped to stop declines in bank leverage and assets during downturns.

[41] Lim et al (2011) obtain similar results.

[42] In particular, the top left-hand panel of Graph IV.4 shows that policy actions which tighten capital flow- or FX liability-based reserve requirements or credit growth- or asset-based marginal reserve requirements significantly increased real general bank credit growth. Empirical studies on the impact of reserve requirements also show mixed results.

[43] See Takáts and Upper (2013).

[44] For the discussion on the appropriate criteria, see Borio (2014). Jiménez et al (2017) find that the ability of Spanish banks to keep lending during the GFC depended on how much capital they had put aside under the automatic dynamic provisioning programme.

[45] See Aldasoro et al (2018).

[46] See Auer and Ongena (2016).

[47] For country-specific studies, see Kelber and Monnet (2014), Aikman et al (2016) and Monnet (2014). For cross-country studies, see Sánchez and Röhn (2016), Boar et al (2017), Kim and Mehrotra (2018) and Richter et al (2018).

[48] See Agénor and Pereira da Silva (2018) for a review.

[49] See eg Buch and Goldberg (2017), Hoggarth et al (2013), Ongena et al (2013), Reinhardt and Sowerbutts (2015) and Tripathy (2017).

[50] This is the risk-taking channel of monetary policy first introduced by Borio and Zhu (2012). For further evidence, see Jiménez et al (2012). For a critique, see Svensson (2017).

[51] To illustrate the use of two monetary policy tools – the policy rate and sterilised FX intervention – under imperfect capital mobility to stabilise inflation, the output gap and the exchange rate, see Blanchard (2012).

[52] The strength of the risk-taking channel of monetary policy is controversial. This is important because models in which this channel is strong tend to indicate that monetary policy should include a financial stability objective, while models in which it is absent tend to suggest that it should not (Adrian and Liang (2018)). For an overview of the arguments of whether monetary policy should lean against the development of financial imbalances, see IMF (2015), Filardo and Rungcharoenkitkul (2016) and Adrian and Liang (2018) as well as references therein.

[53] As succinctly put by former US Federal Reserve Governor Jeremy Stein, "monetary policy gets into all the cracks" (Stein (2013)). See also Crockett (2000), Borio and Lowe (2002), Crowe et al (2013) and Blanchard et al (2013).

[54] Capital flow management (CFM) tools used for prudential purposes can complement FX intervention in dealing with capital flows and thus financial imbalances. Recent empirical studies generally show that CFM tools are sometimes effective in slowing down targeted flows but that the effects tend to be temporary and leakages abound. Such CFM tools are often used when other types of tool do not successfully moderate capital flows. Moreover, there is no consensus on which types of CFM tool are macroprudential and which are not.

[55] For instance, Drehmann et al (2012) document how the equity price crashes in 1987 and 2001, and the associated economic slowdowns or mild recessions, did not stop the expansion of the financial cycle, as credit growth and property price increases continued. When the financial cycle turned a few years later, it ushered in financial stress and a more severe recession – what the authors term the "unfinished recession" phenomenon. Presumably, the monetary policy easing in response to the equity crashes and economic slowdowns contributed to the financial cycle expansion at the time. See also eg Borio and White (2004) and Beau et al (2014). In turn, Juselius et al (2017), by estimating a model of the economy that embeds an articulated version of the financial cycle (Juselius and Drehmann (2015)), find that an augmented Taylor rule which also includes a financial cycle proxy could have improved both output and inflation performance over longer horizons since the 1990s.

[56] See Chapter V of BIS (2016).

[57] See eg Borio et al (2016).

[58] See Box V.C in BIS (2016).

[59] Crowe et al (2013) and Kuttner and Shim (2016) find that such measures tend to have a sizeable impact on both housing credit and house prices.

[60] Korinek (2017) sets out three conditions of which at least one needs to be violated to generate inefficiency and scope for cooperation: (i) policymakers act competitively in the international market; (ii) they have sufficient external policy instruments; and (iii) international markets are free of imperfections. If one of these conditions is violated, then international cooperation can improve welfare. For a discussion of the need for international cooperation on monetary policy, see BIS (2015).

[61] A special case is coordination in multilayered jurisdictions such as the European Union, where multilateral institutions such as the European Systemic Risk Board and the Single Supervisory Mechanism have some directive powers over national bodies.

[62] See Agénor and Pereira da Silva (2018) and Agénor et al (2017).

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Use of macroprudential measures by targeted credit, instrument type and region

Number of policy actions, 1995–2018 Table IV.A1

Targeted credit / Instrument type	Region[1]						
	Asia-Pacific [11]	Central and eastern Europe [14]	Latin America [6]	Middle East and Africa [4]	North America [2]	Western Europe [18]	All economies [55]
General credit	*31*	*156*	*68*	*5*	–	*56*	*316*
Countercyclical capital buffers	3	4	–	–	–	6	13
Non-cyclical (structural) systemic risk capital surcharges (D-SIB, O-SII, SRB)[2]	1	5	2	–	–	11	19
Other capital surcharges[3]	–	14	4	–	–	15	33
Loan loss provisioning rules (general, specific, dynamic, statistical, FX loans)	9	32	5	–	–	6	52
Limits on FX mismatch, position or liquidity	8	32	15	1	–	7	63
Capital inflow- or FX liability-based reserve requirements	5	44	17	4	–	–	70
Credit growth- or asset-based marginal reserve requirements	–	24	25	–	–	6	55
Credit growth limits[4]	5	1	–	–	–	5	11
Housing/consumer/household credit	*168*	*125*	*24*	*13*	*13*	*114*	*457*
Countercyclical capital buffers (housing credit)	–	–	–	–	–	2	2
LTV limits and loan prohibitions	76	37	9	4	7	35	168
DSTI, DTI limits and other lending criteria	49	34	4	3	6	23	119
Risk weights	17	40	8	4	0	42	111
Loan loss provisioning rules	15	3	3	2	0	10	33
Exposure limits	11	9	–	–	–	1	21
Limits on FX mismatch or FX loans	–	2	–	–	–	1	3
Corporate credit (including CRE loans)	*18*	*19*	*2*	–	–	*24*	*63*
LTV limits and loan prohibitions	2	3	–	–	–	4	9
DSTI, DTI limits and other lending criteria	3	2	–	–	–	–	5
Risk weights	2	12	–	–	–	18	32
Loan loss provisioning rules	5	1	1	–	–	–	7
Exposure limits	1	1	–	–	–	2	4
Limits on FX mismatch or FX loans	5	–	1	–	–	–	6
Credit to financial institutions[5]	*2*	*2*	*2*	–	–	*3*	*9*
Total	219	302	96	18	13	197	845
Memo items: Total	*158*	*219*	*52*	*18*	–	*66*	*513*
General liability-based average reserve requirements	115	159	50	17	–	34	375
Liquidity requirements (LCR, NSFR, liquid asset ratio, loan-to-deposit ratio)[6]	43	60	2	1	–	32	138

Asia-Pacific = AU, CN, HK, ID, IN, KR, MY, NZ, PH, SG and TH; central and eastern Europe = BG, CZ, EE, HR, HU, LT, LV, PL, RO, RS, RU, SI, SK and TR; Latin America = AR, BR, CL, CO, MX and PE; Middle East and Africa = AE, IL, SA and ZA; North America = CA and US; western Europe = AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IS, IT, LU, NL, NO, PT and SE.

[1] The figures in square brackets indicate the number of economies in each region. [2] D-SIB = domestic systemically important bank; O-SII = other systemically important institution; SRB = systemic risk buffer. [3] On trading activities, FX exposures and others. [4] Growth limit on general, housing or consumer credit. [5] Including limits on interbank exposure, exposure limits on non-bank financial institutions and risk weights on exposure to financial institutions. [6] LCR = Liquidity Coverage Ratio; NSFR = Net Stable Funding Ratio.

Sources: Budnik and Kleibl (2018); Reinhardt and Sowerbutts (2016); Shim et al (2013); national data; BIS calculations.

V. Cryptocurrencies: looking beyond the hype

Less than 10 years after their inception, cryptocurrencies[1] have emerged from obscurity to attract intense interest on the part of businesses and consumers, as well as central banks and other authorities. They garner attention because they promise to replace trust in long-standing institutions, such as commercial and central banks, with trust in a new, fully decentralised system founded on the blockchain and related distributed ledger technology (DLT).

This chapter evaluates whether cryptocurrencies could play any role as money: looking beyond the hype, what specific economic problems, if any, can current cryptocurrencies solve? The chapter first reviews the historical context. Many episodes of monetary instability and failed currencies illustrate that the institutional arrangements through which money is supplied matter a great deal. This review shows that the essence of good money has always been trust in the stability of its value. And for money to live up to its signature property – to act as a coordination device facilitating transactions – it needs to efficiently scale with the economy and be provided elastically to address fluctuating demand. These considerations call for specific institutional arrangements – hence the emergence of today's independent and accountable central banks.

The chapter then gives an introduction to cryptocurrencies and discusses the economic limitations inherent in the decentralised creation of trust which they entail. For the trust to be maintained, honest network participants need to control the vast majority of computing power, each and every user needs to verify the history of transactions and the supply of the cryptocurrency needs to be predetermined by its protocol. Trust can evaporate at any time because of the fragility of the decentralised consensus through which transactions are recorded. Not only does this call into question the finality of individual payments, it also means that a cryptocurrency can simply stop functioning, resulting in a complete loss of value. Moreover, even if trust can be maintained, cryptocurrency technology comes with poor efficiency and vast energy use. Cryptocurrencies cannot scale with transaction demand, are prone to congestion and greatly fluctuate in value. Overall, the decentralised technology of cryptocurrencies, however sophisticated, is a poor substitute for the solid institutional backing of money.

That said, the underlying technology could have promise in other applications, such as the simplification of administrative processes in the settlement of financial transactions. Still, this remains to be tested. As cryptocurrencies raise a host of issues, the chapter concludes with a discussion of policy responses, including regulation of private uses of the technology, the measures needed to prevent abuses of cryptocurrencies and the delicate questions raised by the issuance of digital currency by central banks.

Putting the rise of cryptocurrencies into perspective

A good way to examine whether a new technology can be a truly useful addition to the existing monetary landscape is to step back and review the fundamental roles of money in an economy and what history teaches us about failed attempts to create new private moneys. Then one can ask whether money based on this new technology can improve upon the current monetary landscape in any way.[2]

A brief history of money

Money plays a crucial role in facilitating economic exchange. Before its advent millennia ago, goods were primarily exchanged for the promise to return the favour in the future (ie trading of IOUs).[3] However, as societies grew larger and economic activity expanded, it became harder to keep a record of ever more complex IOUs, and default and settlement risks became concerns. Money and the institutions issuing it came into existence to address this growing complexity and the associated difficulty in maintaining trust.

Money has three fundamental and complementary roles. It is: (i) a unit of account – a yardstick that eases comparison of prices across the things we buy, as well as the value of promises we make; (ii) a medium of exchange: a seller accepts it as a means of payment, in the expectation that somebody else will do the same; and (iii) a store of value, enabling users to transfer purchasing power over time.[4]

To fulfil these functions, money needs to have the same value in different places and to keep a stable value over time: assessing whether to sell a certain good or service is much easier if one is certain that the received currency has a guaranteed value in terms of both current and future purchasing power. One way to achieve this is by pure commodity moneys with intrinsic value, such as salt or grain. But commodity money by itself does not effectively support exchange: it may not always be available, is costly to produce and cumbersome in exchange, and may be perishable.[5]

The expansion of economic activity required more convenient moneys that could respond to increasing demand, be efficiently used in trade and have a stable value. However, maintaining trust in the institutional arrangements through which money is supplied has been the biggest challenge. Around the world, in different settings and at different times, money started to rely on issuance by centralised authorities. From ancient times, the stamp of a sovereign certified a coin's value in transactions. Later, bills of exchange intermediated by banks developed as a way for merchants to limit the costs and risks of travelling with large quantities of coinage.[6]

However, historical experience also made clear an underlying trade-off, for currencies that are supplied flexibly can also be debased easily.[7] Sustained episodes of stable money are historically much more of an exception than the norm. In fact, trust has failed so frequently that history is a graveyard of currencies. Museums around the world devote entire sections to this graveyard – for example, room 68 of the British Museum displays stones, shells, tobacco, countless coins and pieces of paper, along with many other objects that lost their acceptability as exchange and found their way to this room. Some fell victim to the expansion of trade and economic activity, as they were rendered inconvenient with a larger scale of use. Some were discarded when the political order that supported them weakened or fell. And many others fell victim to the erosion of trust in the stability of their value.

History proves that money can be fragile whether it is supplied through private means, in a competitive manner, or by a sovereign, as a monopolist supplier. Bank-issued money is only as good as the assets that back it. Banks are meant to transform risks, and therefore, under certain extreme scenarios, confidence in privately issued money can vanish overnight. Government-backed arrangements, where assuring trust in the instrument is a centralised task, have not always worked well either. Far from it: a well known example of abuse is the competitive debasement of coins issued by German princes in the early 17th century, known as the Kipper- und Wipperzeit (clipping and culling times).[8] And there have been many others, up to the present-day cases of Venezuela and Zimbabwe. Avoiding abuse by the sovereign has thus been a key consideration in the design of monetary arrangements.

The quest for solid institutional underpinning for trust in money eventually culminated in the emergence of today's central banks. An early step was the establishment of chartered public banks in European city-states during the period 1400–1600. These emerged to improve trading by providing a high-quality, efficient means of payment and centralising a number of clearing and settlement operations. Such banks, set up in trading hubs such as Amsterdam, Barcelona, Genoa, Hamburg and Venice, were instrumental in stimulating international trade and economic activity more generally.[9] Over time, many of these chartered banks functioned in ways similar to current central banks. Formal central banks, as we know them today, also often emerged in direct response to poor experiences with decentralised money. For example, the failures of wildcat banking in the United States eventually led to the creation of the Federal Reserve System.

The current monetary and payment system

The tried, trusted and resilient way to provide confidence in money in modern times is the independent central bank. This means agreed goals: clear monetary policy and financial stability objectives; operational, instrument and administrative independence; and democratic accountability, so as to ensure broad-based political support and legitimacy. Independent central banks have largely achieved the goal of safeguarding society's economic and political interest in a stable currency.[10] With this setup, money can be accurately defined as an "indispensable social convention backed by an accountable institution within the state that enjoys public trust".[11]

In almost all modern-day economies, money is provided through a joint public-private venture between the central bank and private banks, with the central bank at the system's core. Electronic bank deposits are the main means of payment between ultimate users, while central bank reserves are the means of payment between banks. In this two-tiered system, trust is generated through independent and accountable central banks, which back reserves through their asset holdings and operational rules. In turn, trust in bank deposits is generated through a variety of means, including regulation, supervision and deposit insurance schemes, many ultimately emanating from the state.

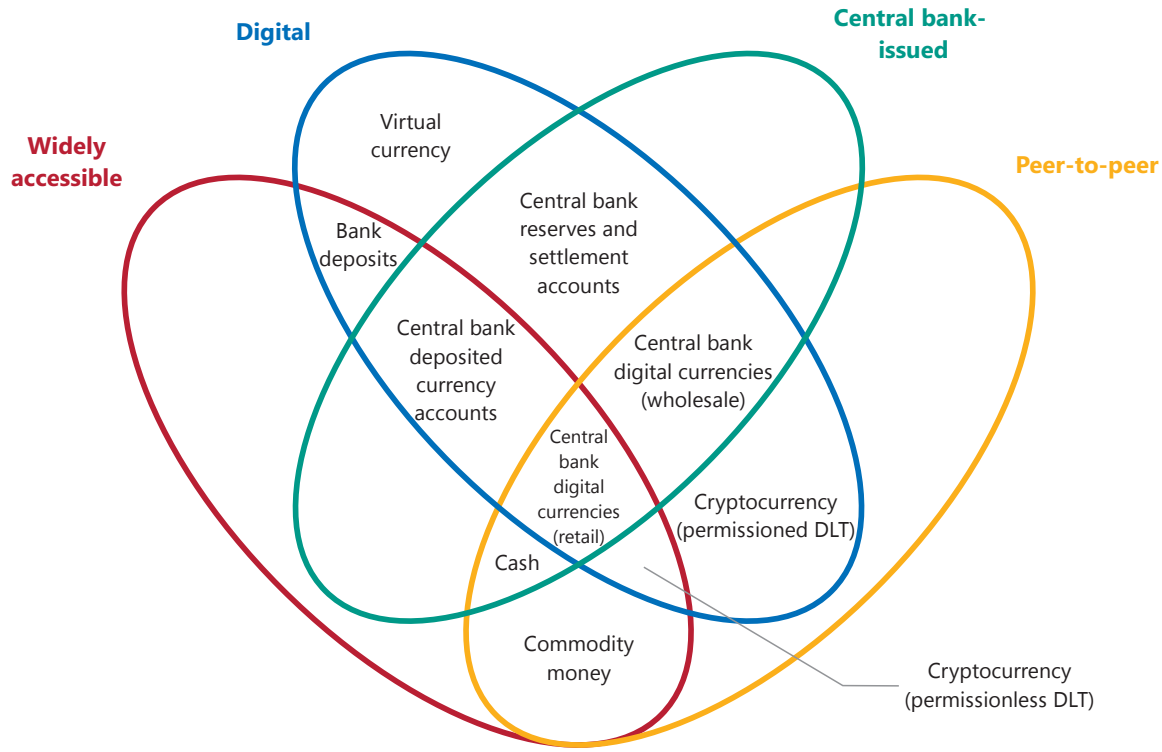
As part of fulfilling their mandate to maintain a stable unit of account and means of payment, central banks take an active role in supervising, overseeing and in some cases providing the payments infrastructure for their currency. The central bank's role includes ensuring that the payment system operates smoothly and seeing to it that the supply of reserves responds appropriately to shifting demand, including at intraday frequency, ie ensuring an elastic money supply.[12]

Thanks to the active involvement of central banks, today's diverse payment systems have achieved safety, cost-effectiveness, scalability and trust that a payment, once made, is final.

Payment systems are safe and cost-effective, handling high volumes and accommodating rapid growth with hardly any abuse and at low costs. An important contributor to safety and cost-effectiveness is scalability. In today's sophisticated economies, the volume of payments is huge, equal to many multiples of GDP. Despite these large volumes, expanding use of the instrument does not lead to a proportional increase in costs. This is important, since an essential feature of any successful money and payment system is how widely used it is by both buyers and sellers: the more others connect to a particular payment system, the greater one's own incentive to use it.

Users not only need to have trust in money itself, they also need to trust that a payment will take place promptly and smoothly. A desirable operational attribute is thus certainty of payment ("finality") and the related ability to contest transactions that may have been incorrectly executed. Finality requires that the system be largely

The money flower: a taxonomy of money Graph V.1



Source: Adapted from M Bech and R Garratt, "Central bank cryptocurrencies", *BIS Quarterly Review*, September 2017, pp 55–70.

free of fraud and operational risks, at the level of both individual transactions and the system as a whole. Strong oversight and central bank accountability both help to support finality and hence trust.

While most modern-day transactions occur through means ultimately supported by central banks, over time a wide range of public and private payment means has emerged. These can be best summarised by a taxonomy characterised as the "money flower" (Graph V.1).[13]

The money flower distinguishes four key properties of moneys: the issuer, the form, the degree of accessibility and the payment transfer mechanism. The issuer can be a central bank, a bank or nobody, as was the case when money took the form of a commodity. Its form can be physical, eg a metal coin or paper banknote, or digital. It can be widely accessible, like commercial bank deposits, or narrowly so, like central bank reserves. A last property regards the transfer mechanism, which can be either peer-to-peer, or through a central intermediary, as for deposits. Money is typically based on one of two basic technologies: so called "tokens" or accounts. Token-based money, for example banknotes or physical coins, can be exchanged in peer-to-peer settings, but such exchange relies critically on the payee's ability to verify the validity of the payment object – with cash, the worry is counterfeiting. By contrast, systems based on account money depend fundamentally on the ability to verify the identity of the account holder.

Cryptocurrencies: the elusive promise of decentralised trust

Do cryptocurrencies deliver what they promise? Or will they end up as short-lived curiosities? In order to answer these questions, it is necessary to define them more

precisely, to understand their supporting technology and to examine the associated economic limitations.

A new petal in the money flower?

Cryptocurrencies aspire to be a new form of currency and promise to maintain trust in the stability of their value through the use of technology. They consist of three elements. First, a set of rules (the "protocol"), computer code specifying how participants can transact. Second, a ledger storing the history of transactions. And third, a decentralised network of participants that update, store and read the ledger of transactions following the rules of the protocol. With these elements, advocates claim, a cryptocurrency is not subject to the potentially misguided incentives of banks and sovereigns.

In terms of the money flower taxonomy, cryptocurrencies combine three key features. First, they are digital, aspiring to be a convenient means of payment and relying on cryptography to prevent counterfeiting and fraudulent transactions. Second, although created privately, they are no one's liability, ie they cannot be redeemed, and their value derives only from the expectation that they will continue to be accepted by others. This makes them akin to a commodity money (although without any intrinsic value in use). And, last, they allow for digital peer-to-peer exchange.

Compared with other private digital moneys such as bank deposits, the distinguishing feature of cryptocurrencies is digital peer-to-peer exchange. Digital bank accounts have been around for decades. And privately issued "virtual currencies" – eg as used in massive multiplayer online games like World of Warcraft – predate cryptocurrencies by a decade. In contrast to these, cryptocurrency transfers can in principle take place in a decentralised setting without the need for a central counterparty to execute the exchange.

Distributed ledger technology in cryptocurrencies

The technological challenge in digital peer-to-peer exchange is the so-called "double-spending problem". Any digital form of money is easily replicable and can thus be fraudulently spent more than once. Digital information can be reproduced more easily than physical banknotes. For digital money, solving the double-spending problem requires, at a minimum, that someone keep a record of all transactions. Prior to cryptocurrencies, the only solution was to have a centralised agent do this and verify all transactions.

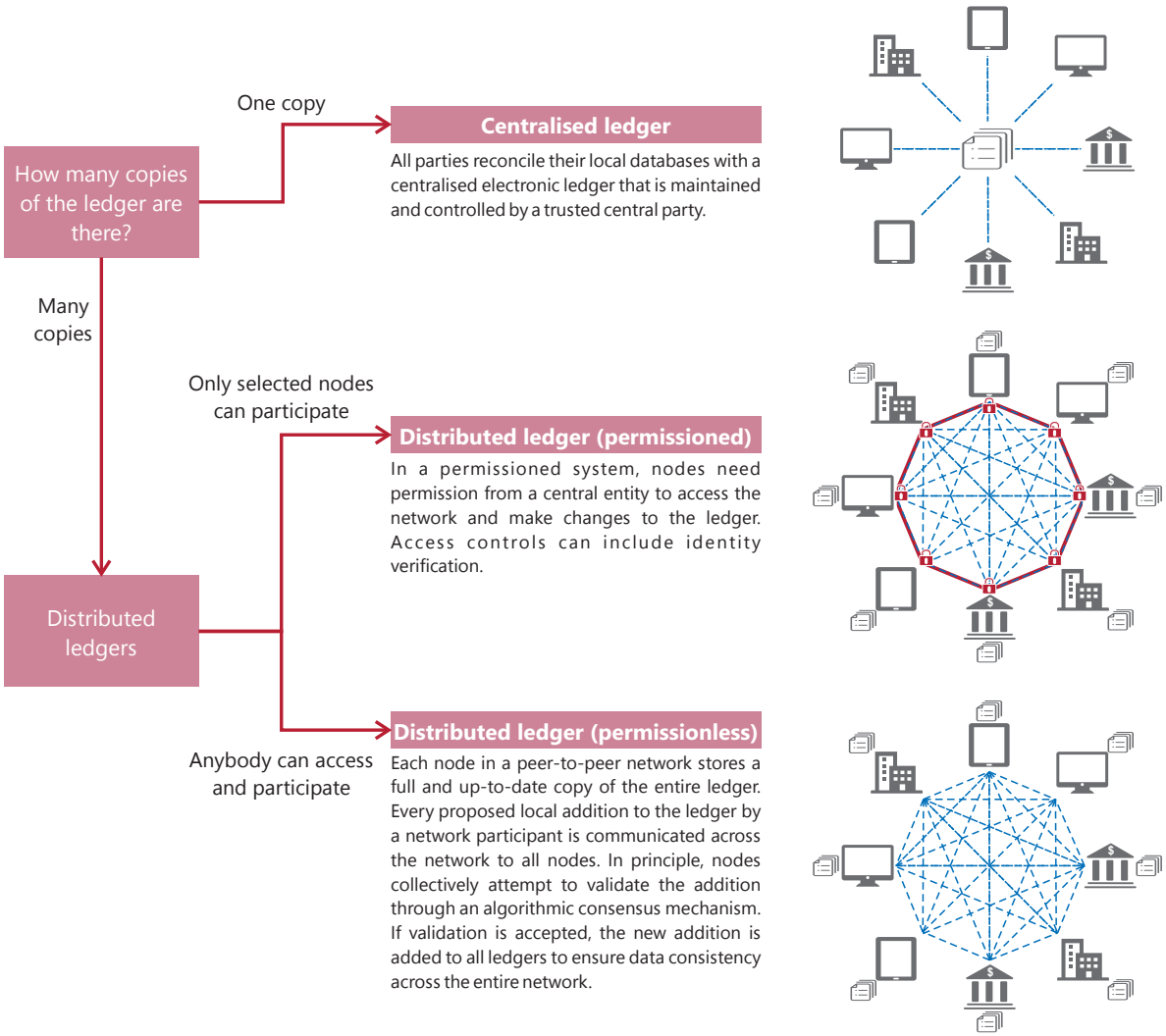
Cryptocurrencies overcome the double-spending problem via decentralised record-keeping through what is known as a distributed ledger. The ledger can be regarded as a file (think of a Microsoft Excel worksheet) that starts with an initial distribution of cryptocurrency and records the history of all subsequent transactions. An up-to-date copy of the entire ledger is stored by each user (this is what makes it "distributed"). With a distributed ledger, peer-to-peer exchange of digital money is feasible: each user can directly verify in their copy of the ledger whether a transfer took place and that there was no attempt to double-spend.[14]

While all cryptocurrencies rely on a distributed ledger, they differ in terms of how the ledger is updated. One can distinguish two broad classes, with substantial differences in their operational setup (Graph V.2).

One class is based on "permissioned" DLT. Such cryptocurrencies are similar to conventional payment mechanisms in that, to prevent abuse, the ledger can only be updated by trusted participants in the cryptocurrency – often termed "trusted nodes". These nodes are chosen by, and subject to oversight by, a central authority,

Centralised ledger and permissioned/permissionless decentralised ledgers

Graph V.2



		Private electronic money based on fiat system	Privately issued cryptocurrencies	
			Permissioned	Permissionless
1	Storage of balances/holdings	Ledger (accounts) stored centrally by banks and other financial institutions	Decentralised storage of ledger	
2	Verification to avoid double-spending	Identity-based concept	Peer-to-peer concept: distributed ledger can be checked to see whether a specific unit of a currency has already been spent	
3	Processing of transactions	Accounts updated by bank	Updating of ledger via trusted nodes	Updating of ledger via proof-of-work Rule to follow longest chain
4	Finality/settlement concept	Settlement ultimately via central bank	Settlement in cryptocurrency itself	Probabilistic concept of finality via rule to follow longest chain
5	Elasticity of supply	Central bank policy, eg regarding intraday credit	Protocol can be changed by trusted nodes	Protocol-determined
6	Trust-creating mechanisms	Reputation of banks and central banks, banking supervision, lender of last resort, legal tender laws, central bank independence and accountability, AML/CFT checks, cyber-security	Reputation of issuing firm and nodes Trusted nodes, some of which may be subject to regulation	Proof-of-work requires honest computing majority

Sources: Adapted from H Natarajan, S Krause and H Gradstein, "Distributed ledger technology (DLT) and blockchain", World Bank Group, *FinTech Note*, no 1, 2017; BIS.

eg the firm that developed the cryptocurrency. Thus, while cryptocurrencies based on permissioned systems differ from conventional money in terms of how transaction records are stored (decentralised versus centralised), they share with it the reliance on specific institutions as the ultimate source of trust.[15]

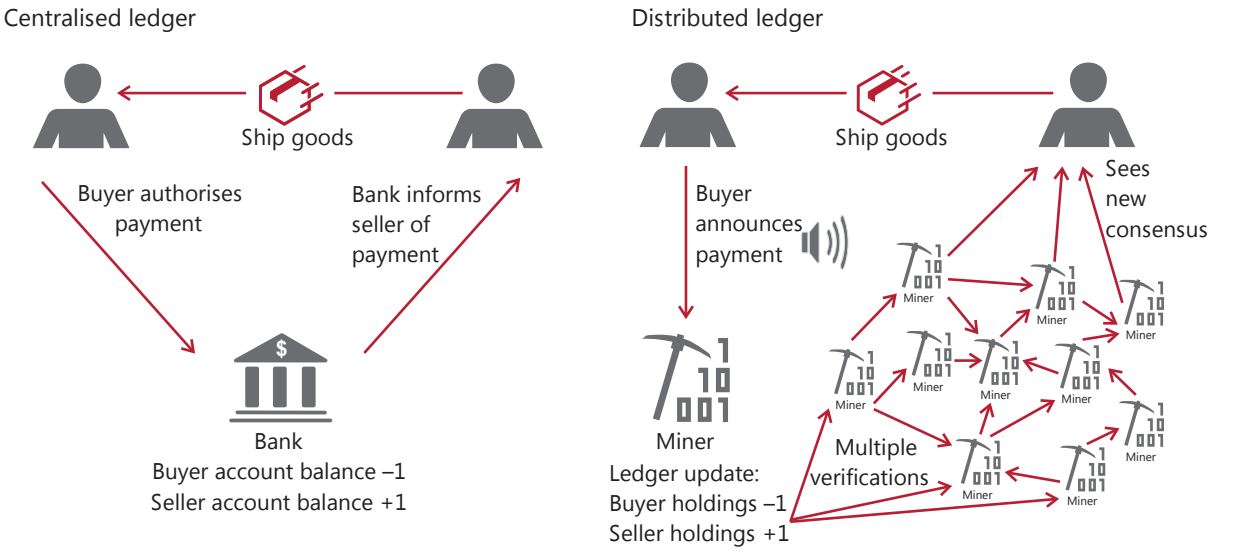
In a much more radical departure from the prevailing institution-based setup, a second class of cryptocurrencies promises to generate trust in a fully decentralised setting using "permissionless" DLT. The ledger recording transactions can only be changed by a consensus of the participants in the currency: while anybody can participate, nobody has a special key to change the ledger.

The concept of permissionless cryptocurrencies was laid out for the case of Bitcoin[16] in a white paper by an anonymous programmer (or group of programmers) under the pseudonym Satoshi Nakamoto, who proposed a currency based on a specific type of distributed ledger, the "blockchain". The blockchain is a distributed ledger that is updated in groups of transactions called blocks. Blocks are then chained sequentially via the use of cryptography to form the blockchain. This concept has been adapted to countless other cryptocurrencies.[17]

Blockchain-based permissionless cryptocurrencies have two groups of participants: "miners" who act as bookkeepers and "users" who want to transact in the cryptocurrency. At face value, the idea underlying these cryptocurrencies is simple: instead of a bank centrally recording transactions (Graph V.3, left-hand panel), the ledger is updated by a miner and the update is subsequently stored by all users and miners (right-hand panel).[18]

Valid transactions in a centralised ledger/bank account and in a permissionless cryptocurrency

Graph V.3



A buyer purchases a good from the seller, who initiates shipment upon perceived confirmation of the payment. If the payment takes place via bank accounts – ie via a centralised ledger (left-hand panel) – the buyer sends the payment instruction to their bank, which adjusts account balances debiting the amount paid from the buyer's account and crediting it to the seller's account. The bank then confirms payment to the seller. In contrast, if payment takes place via a permissionless cryptocurrency (right-hand panel), the buyer first publicly announces a payment instruction stating that the cryptocurrency holdings of the buyer are reduced by one, while those of the seller are increased by one. After a delay, a miner includes this payment information in a ledger update. The updated ledger is subsequently shared with other miners and users, each verifying that the newly added payment instruction is not a double-spend attempt and is authorised by the buyer. The seller then observes that the ledger including the payment instruction emerges as the one commonly used by the network of miners and users.

Source: Adapted from R Auer, "The mechanics of decentralised trust in Bitcoin and the blockchain", *BIS Working Papers*, forthcoming.

Underlying this setup, the key feature of these cryptocurrencies is the implementation of a set of rules (the protocol) that aim to align the incentives of all participants so as to create a reliable payment technology without a central trusted agent. The protocol determines the supply of the asset in order to counter debasement – for example, in the case of Bitcoin, it states that no more than 21 million bitcoins can exist. In addition, the protocol is designed to ensure that all participants follow the rules out of self-interest, ie that they yield a self-sustaining equilibrium. Three key aspects are the following.

First, the rules entail a cost to updating the ledger. In most cases, this cost comes about because updating requires a "proof-of-work". This is mathematical evidence that a certain amount of computational work has been done, in turn calling for costly equipment and electricity use. Since the proof-of-work process can be likened to digging up rare numbers via laborious computations, it is often referred to as mining.[19] In return for their efforts, miners receive fees from the users – and, if specified by the protocol, newly minted cryptocurrency.

Second, all miners and users of a cryptocurrency verify all ledger updates, which induces miners to include only valid transactions. Valid transactions need to be initiated by the owners of funds and must not be attempts to double-spend. If a ledger update includes an invalid transaction, it is rejected by the network and the miner's rewards are voided. The verification of all new ledger updates by the network of miners and users is thus essential to incentivise miners to add only valid transactions.[20]

Third, the protocol specifies rules to achieve a consensus on the order of updates to the ledger. This is generally done by creating incentives for individual miners to follow the computing majority of all other miners when they implement updates. Such coordination is needed, for example, to resolve cases where communication lags lead to different miners adding conflicting updates – ie updates that include different sets of transactions (Box V.A).

With these key ingredients, it is costly – though not impossible – for any individual to forge a cryptocurrency. To successfully double-spend, a counterfeiter would have to spend their cryptocurrency with a merchant and secretly produce a forged blockchain in which this transaction was not recorded. Upon receipt of the merchandise, the counterfeiter would then release the forged blockchain, ie reverse the payment. But this forged blockchain would only emerge as the commonly accepted chain if it were longer than the blockchain the rest of the network of miners had produced in the meantime. A successful double-spend attack thus requires a substantial share of the mining community's computing power. Conversely, in the words of the original Bitcoin white paper, a cryptocurrency can overcome the double-spending problem in a decentralised way only if "honest nodes control a majority of [computing] power".[21]

Assessing the economic limitations of permissionless cryptocurrencies

Cryptocurrencies such as Bitcoin promise to deliver not only a convenient payment means based on digital technology, but also a novel model of trust. Yet delivering on this promise hinges on a set of assumptions: that honest miners control the vast majority of computing power, that users verify the history of all transactions and that the supply of the currency is predetermined by a protocol. Understanding these assumptions is important, for they give rise to two basic questions regarding the usefulness of cryptocurrencies. First, does this cumbersome way of trying to achieve trust come at the expense of efficiency? Second, can trust truly and always be achieved?

As the first question implies, a key potential limitation in terms of efficiency is the enormous cost of generating decentralised trust. One would expect miners to compete to add new blocks to the ledger through the proof-of-work until their

anticipated profits fall to zero.[22] Individual facilities operated by miners can host computing power equivalent to that of millions of personal computers. At the time of writing, the total electricity use of bitcoin mining equalled that of mid-sized economies such as Switzerland, and other cryptocurrencies also use ample electricity (Graph V.4, left-hand panel). Put in the simplest terms, the quest for decentralised trust has quickly become an environmental disaster.[23]

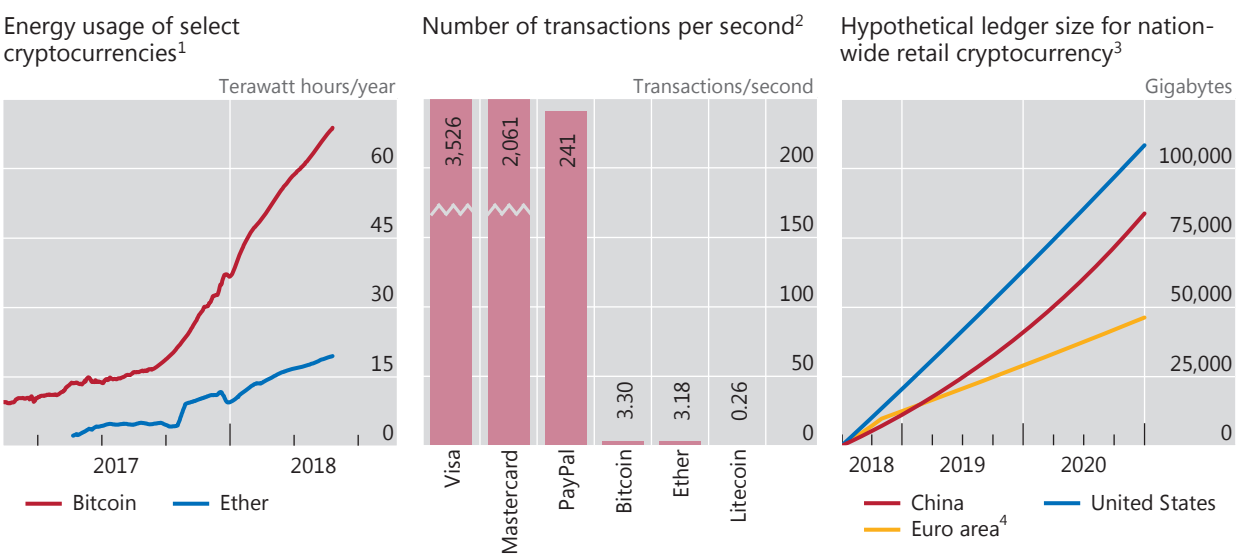
But the underlying economic problems go well beyond the energy issue. They relate to the signature property of money: to promote "network externalities" among users and thereby serve as a coordination device for economic activity. The shortcomings of cryptocurrencies in this respect lie in three areas: scalability, stability of value and trust in the finality of payments.

First, cryptocurrencies simply do not scale like sovereign moneys. At the most basic level, to live up to their promise of decentralised trust cryptocurrencies require each and every user to download and verify the history of all transactions ever made, including amount paid, payer, payee and other details. With every transaction adding a few hundred bytes, the ledger grows substantially over time. For example, at the time of writing, the Bitcoin blockchain was growing at around 50 GB per year and stood at roughly 170 GB. Thus, to keep the ledger's size and the time needed to verify all transactions (which increases with block size) manageable, cryptocurrencies have hard limits on the throughput of transactions (Graph V.4, centre panel).

A thought experiment illustrates the inadequacy of cryptocurrencies as an everyday means of payment (Graph V.4, right-hand panel). To process the number of digital retail transactions currently handled by selected national retail payment systems, even under optimistic assumptions, the size of the ledger would swell well beyond the storage capacity of a typical smartphone in a matter of days, beyond that of a typical personal computer in a matter of weeks and beyond that of servers in a matter of months. But the issue goes well beyond storage capacity, and extends

Energy consumption and scaling issues

Graph V.4



[1] Estimated. [2] 2017 data. [3] The displayed hypothetical size of the blockchain/ledger is calculated assuming that, starting from 1 July 2018, all non-cash retail transactions of either China, the United States or the euro area are processed via a cryptocurrency. Calculations are based on information on non-cash transaction numbers from CPMI (2017) and assume that each transaction adds 250 bytes to the ledger. [4] BE, FR, DE, IT and NL.

Sources: Committee on Payments and Market Infrastructures, *Statistics on payment, clearing and settlement systems in the CPMI countries*, December 2017; www.bitinfocharts.com; Digiconomist; Mastercard; PayPal; Visa; BIS calculations.

to processing capacity: only supercomputers could keep up with verification of the incoming transactions. The associated communication volumes could bring the internet to a halt, as millions of users exchanged files on the order of magnitude of a terabyte.

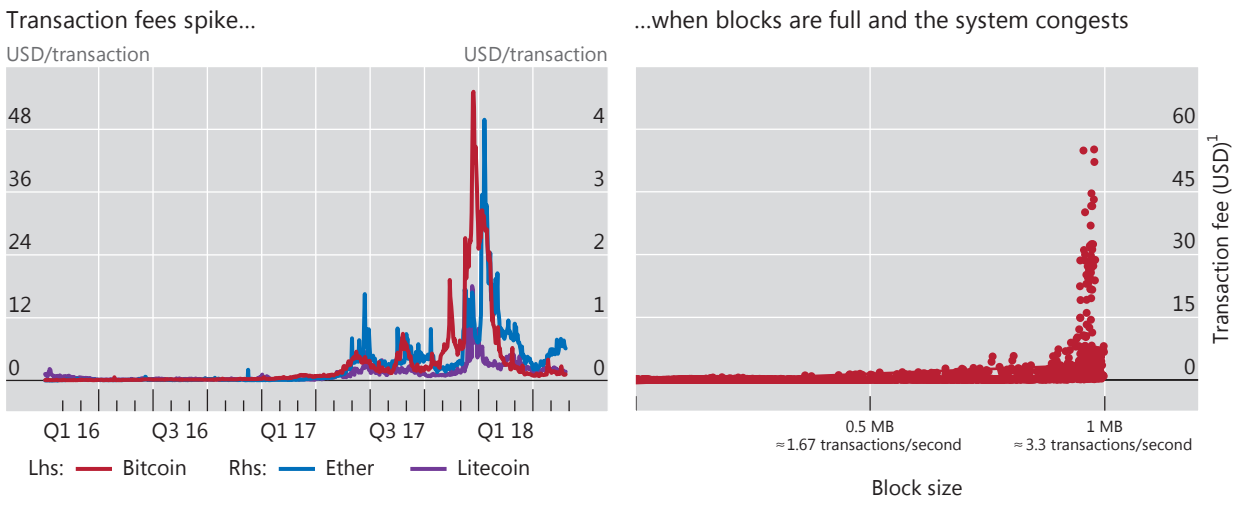
Another aspect of the scalability issue is that updating the ledger is subject to congestion. For example, in blockchain-based cryptocurrencies, in order to limit the number of transactions added to the ledger at any given point in time, new blocks can only be added at pre-specified intervals. Once the number of incoming transactions is such that newly added blocks are already at the maximum size permitted by the protocol, the system congests and many transactions go into a queue. With capacity capped, fees soar whenever transaction demand reaches the capacity limit (Graph V.5). And transactions have at times remained in a queue for several hours, interrupting the payment process. This limits cryptocurrencies' usefulness for day-to-day transactions such as paying for a coffee or a conference fee, not to mention for wholesale payments.[24] Thus, the more people use a cryptocurrency, the more cumbersome payments become. This negates an essential property of present-day money: the more people use it, the stronger the incentive to use it.[25]

The second key issue with cryptocurrencies is their unstable value. This arises from the absence of a central issuer with a mandate to guarantee the currency's stability. Well run central banks succeed in stabilising the domestic value of their sovereign currency by adjusting the supply of the means of payment in line with transaction demand. They do so at high frequency, in particular during times of market stress but also during normal times.

This contrasts with a cryptocurrency, where generating some confidence in its value requires that supply be predetermined by a protocol. This prevents it from being supplied elastically. Therefore, any fluctuation in demand translates into changes in valuation. This means that cryptocurrencies' valuations are extremely volatile (Graph V.6, left-hand panel). And the inherent instability is unlikely to be fully overcome by better protocols or financial engineering, as exemplified by the experience of the Dai cryptocurrency. While engineered to be fixed to the US dollar

Transaction fees over time and in relation to transaction throughput

Graph V.5



[1] Transaction fee paid to miners over the period 1 August 2010–25 May 2018; daily averages.

Sources: www.bitinfocharts.com; BIS calculations.

at a rate of one to one, it reached a low of $0.72 just a few weeks after its launch in late 2017. Other cryptocurrencies designed to have a stable value have also fluctuated substantially (centre panel).

This outcome is not coincidental. Keeping the supply of the means of payment in line with transaction demand requires a central authority, typically the central bank, which can expand or contract its balance sheet. The authority needs to be willing at times to trade against the market, even if this means taking risk onto its balance sheet and absorbing a loss. In a decentralised network of cryptocurrency users, there is no central agent with the obligation or the incentives to stabilise the value of the currency: whenever demand for the cryptocurrency decreases, so does its price.

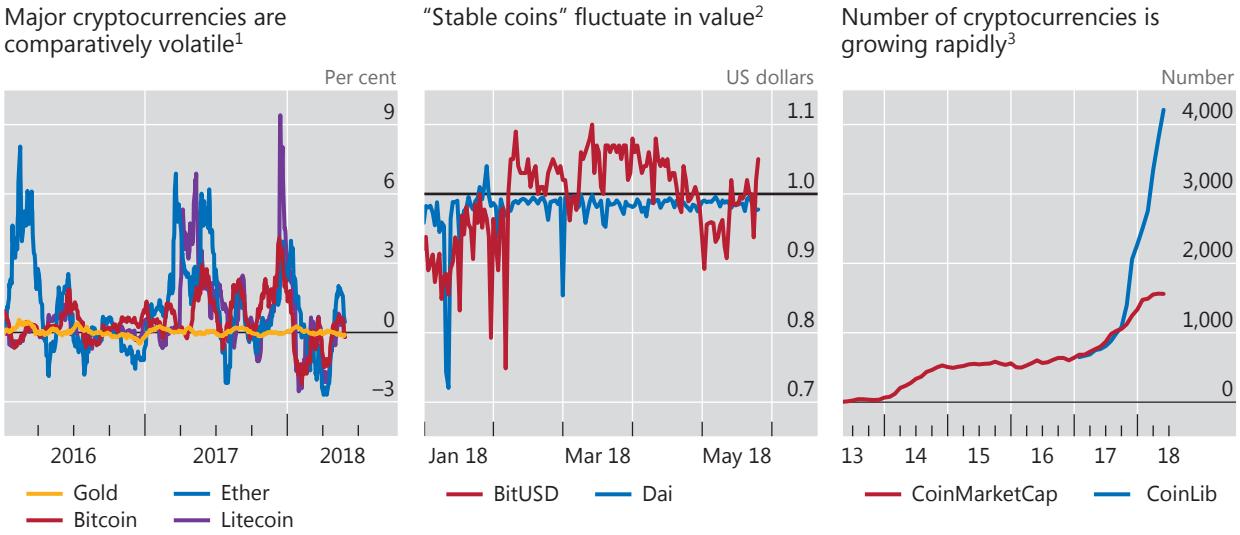
Further contributing to unstable valuations is the speed at which new cryptocurrencies – all tending to be very closely substitutable with one another – come into existence. At the time of writing, several thousand existed, though proliferation makes reliable estimates of the number of outstanding cryptocurrencies impossible (Graph V.6, right-hand panel). Recalling the private banking experiences of the past, the outcome of such liberal issuance of new moneys is rarely stability.

The third issue concerns the fragile foundation of the trust in cryptocurrencies. This relates to uncertainty about the finality of individual payments, as well as trust in the value of individual cryptocurrencies.

In mainstream payment systems, once an individual payment makes its way through the national payment system and ultimately through the central bank books, it cannot be revoked. In contrast, permissionless cryptocurrencies cannot guarantee the finality of individual payments. One reason is that although users can verify that a specific transaction is included in a ledger, unbeknownst to them there can be rival versions of the ledger. This can result in transaction rollbacks, for example when two miners update the ledger almost simultaneously. Since only one of the two updates can ultimately survive, the finality of payments made in each ledger version is probabilistic.

Volatility of select cryptocurrencies and number of cryptocurrencies

Graph V.6



[1] Thirty-day moving averages of daily returns. [2] Daily price minimum. [3] Based on monthly snapshots from two different providers. CoinMarketCap includes only cryptocurrencies with a minimum 24-hour trading volume of $100,000; CoinLib does not use a threshold.

Sources: www.bitinfocharts.com; www.coinlib.io; www.coinmarketcap.com; Datastream.

The lack of payment finality is exacerbated by the fact that cryptocurrencies can be manipulated by miners controlling substantial computing power, a real possibility given the concentration of mining for many cryptocurrencies (Graph V.7, left-hand panel). One cannot tell if a strategic attack is under way because an attacker would reveal the (forged) ledger only once they were sure of success. This implies that finality will always remain uncertain. For cryptocurrencies, each update of the ledger comes with an additional proof-of-work that an attacker would have to reproduce. Yet while the probability that a payment is final increases with the number of subsequent ledger updates, it never reaches 100%.[26]

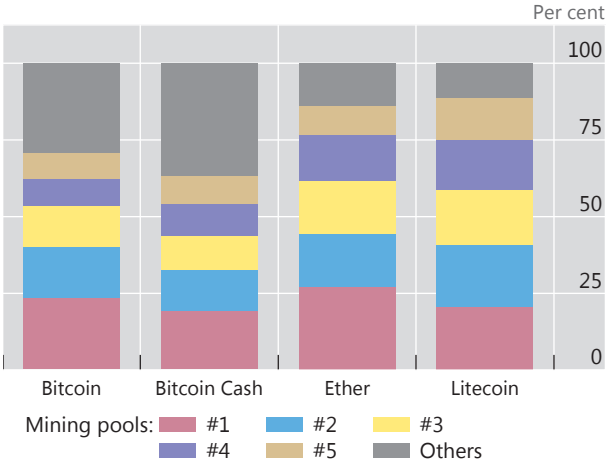
Not only is the trust in individual payments uncertain, but the underpinning of trust in each cryptocurrency is also fragile. This is due to "forking". This is a process whereby a subset of cryptocurrency holders coordinate on using a new version of the ledger and protocol, while others stick to the original one. In this way, a cryptocurrency can split into two subnetworks of users. While there are many recent examples, an episode on 11 March 2013 is noteworthy because – counter to the idea of achieving trust by decentralised means – it was undone by centralised coordination of the miners. On that day, an erroneous software update led to incompatibilities between one part of the Bitcoin network mining on the legacy protocol and another part mining using an updated one. For several hours, two separate blockchains grew; once news of this fork spread, the price of bitcoin tumbled by almost a third (Graph V.7, right-hand panel). The fork was ultimately rolled back by a coordinated effort whereby miners temporarily departed from protocol and ignored the longest chain. But many transactions were voided hours after users had believed them to be final. This episode shows just how easily cryptocurrencies can split, leading to significant valuation losses.

An even more worrying aspect underlying such episodes is that forking may only be symptomatic of a fundamental shortcoming: the fragility of the decentralised consensus involved in updating the ledger and, with it, of the underlying trust in the cryptocurrency. Theoretical analysis (Box V.A) suggests that coordination on how the ledger is updated could break down at any time, resulting in a complete loss of value.

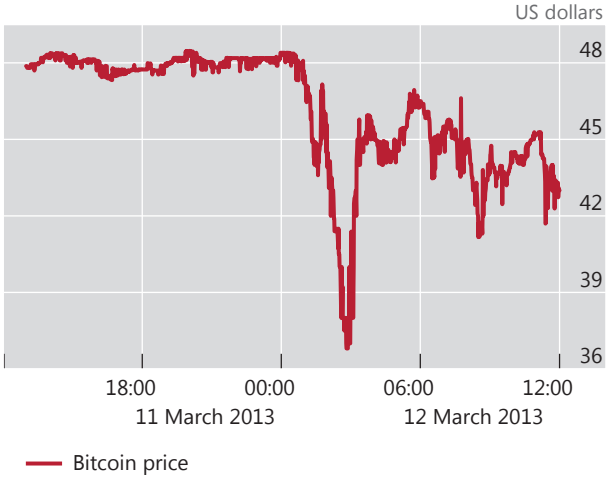
Mining concentration and bitcoin value during a temporary fork

Graph V.7

Mining is highly concentrated across all cryptocurrencies[1]



Value of bitcoin during a 2013 temporary fork[2]



[1] Data for the largest mining pools as of 28 May 2018. [2] Bitcoin price dynamics during Bitcoin fork on 11–12 March 2013.

Sources: www.btc.com; www.cash.coin.dance; CoinDesk; www.etherchain.org; www.litecoinpool.org.

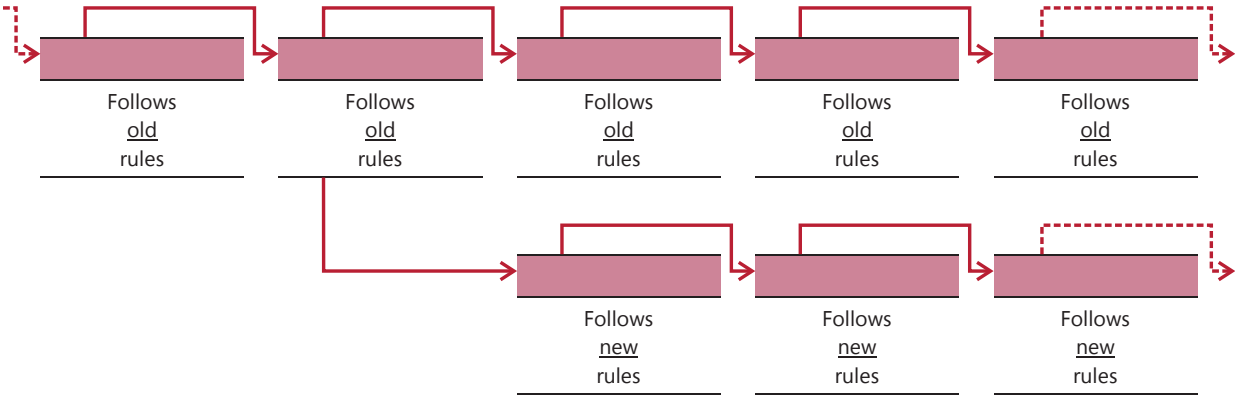
Box V.A

Forking and the instability of decentralised consensus in the blockchain

Forking has contributed to the explosive growth in the number of cryptocurrencies (Graph V.6, right-hand panel). For example, the month of January 2018 alone brought to the fore the Bitcoin ALL, Bitcoin Cash Plus, Bitcoin Smart, Bitcoin Interest, Quantum Bitcoin, BitcoinLite, Bitcoin Ore, Bitcoin Private, Bitcoin Atom and Bitcoin Pizza forks. There are many different ways in which such forks can arise, some permanent and others temporary. One example is termed a "hard fork" (Graph V.A). It arises if some of the miners of a cryptocurrency coordinate to change the protocol to a new set of rules that is incompatible with the old one. This change could involve many aspects of the protocol, such as the maximum permitted block size, the frequency at which blocks can be added to the blockchain or a change to the proof-of-work required to update the blockchain. The miners who upgrade to the new rules start from the old blockchain, but subsequently add blocks that are not recognised by the miners who have not upgraded. The latter continue to build on the existing blockchain following the old rules. In this way, two separate blockchains grow, each with its own transaction history.

Example of a hard fork

Graph V.A



Source: BIS.

Frequent episodes of forking may be symptomatic of an inherent problem with the way consensus is formed in a cryptocurrency's decentralised network of miners. The underlying economic issue is that this decentralised consensus is not unique. The rule to follow the longest chain incentivises miners to follow the computing majority, but it does not uniquely pin down the path of the majority itself. For example, if a miner believes that the very last update of the ledger will be ignored by the rest of the network of miners, it becomes optimal for the miner to also ignore this last update. And if the majority of miners coordinates on ignoring an update, this indeed becomes a new equilibrium. In this way, random equilibria can arise – and indeed frequently have arisen, as indicated by forking and by the existence of thousands of "orphaned" (Bitcoin) or "uncle" (Ethereum) blocks that have retroactively been voided. Additional concerns regarding the robustness of the decentralised updating of the blockchain relate to miners' incentives to strategically fork whenever the block added last by a different miner includes high transaction fees that can be diverted by voiding the block in question via a fork.①

① For an analysis of the uniqueness of the updating of the blockchain, see B Biais, C Bisière, M Bouvard and C Casamatta, "The blockchain folk theorem", *TSE Working Papers*, no 17–817, 2017. For an analysis of strategic motives to create a fork, see M Carlsten, H Kalodner, S M Weinberg and A Narayanan, "On the instability of Bitcoin without the block reward", *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security*.

Overall, decentralised cryptocurrencies suffer from a range of shortcomings. The main inefficiencies arise from the extreme degree of decentralisation: creating the required trust in such a setting wastes huge amounts of computing power, decentralised storage of a transaction ledger is inefficient and the decentralised

consensus is vulnerable. Some of these issues might be addressed by novel protocols and other advances.[27] But others seem inherently linked to the fragility and limited scalability of such decentralised systems. Ultimately, this points to the lack of an adequate institutional arrangement at the national level as the fundamental shortcoming.

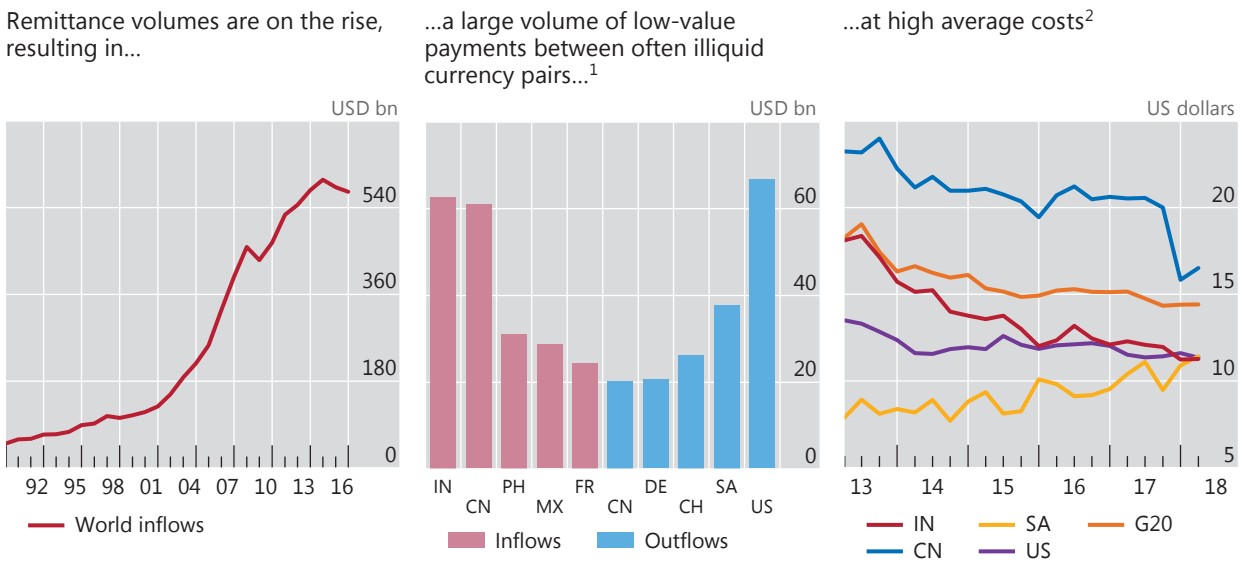
Beyond the bubble: making use of distributed ledger technology

While cryptocurrencies do not work as money, the underlying technology may have promise in other fields. A notable example is in low-volume cross-border payment services. More generally, compared with mainstream centralised technological solutions, DLT can be efficient in niche settings where the benefits of decentralised access exceed the higher operating cost of maintaining multiple copies of the ledger.

To be sure, such payment solutions are fundamentally different from cryptocurrencies. A recent non-profit example is the case of the World Food Programme's blockchain-based Building Blocks system, which handles payments for food aid serving Syrian refugees in Jordan. The unit of account and ultimate means of payment in Building Blocks is sovereign currency, so it is a "cryptopayment" system but not a cryptocurrency. It is also centrally controlled by the World Food Programme, and for good reason: an initial experiment based on the permissionless Ethereum protocol resulted in slow and costly transactions. The system was subsequently redesigned to run on a permissioned version of the Ethereum protocol. With this change, a reduction of transaction costs of about 98% relative to bank-based alternatives was achieved.[28]

Permissioned cryptopayment systems may also have promise with respect to small-value cross-border transfers, which are important for countries with a large share of their workforce living abroad. Global remittance flows total more than $540 billion annually (Graph V.8, left-hand and centre panels). Currently, forms of

Indicators of the volume and cost of remittances — Graph V.8



[1] Data for 2016. [2] Average total cost for sending $200 with all remittance service providers worldwide. For CN and IN, receiving country average total cost; for G20, SA and US, sending country average total cost.

Sources: World Bank, *Remittance Prices Worldwide*, remittanceprices.worldbank.org; World Bank; BIS calculations.

international payments involve multiple intermediaries, leading to high costs (right-hand panel). That said, while cryptopayment systems are one option to address these needs, other technologies are also being considered, and it is not clear which will emerge as the most efficient one.

More important use cases are likely to combine cryptopayments with sophisticated self-executing codes and data permission systems. Some decentralised cryptocurrency protocols such as Ethereum already allow for smart contracts that self-execute the payment flows for derivatives. At present, the efficacy of these products is limited by the low liquidity and intrinsic inefficiencies of permissionless cryptocurrencies. But the underlying technology can be adopted by registered exchanges in permissioned protocols that use sovereign money as backing, simplifying settlement execution. The added value of the technology will probably derive from the simplification of administrative processes related to complex financial transactions, such as trade finance (Box V.B). Crucially, however, none of the applications require the use or creation of a cryptocurrency.

Policy implications

The rise of cryptocurrencies and related technology brings to the fore a number of policy questions. Authorities are looking for ways to ensure the integrity of markets and payment systems, to protect consumers and investors, and to safeguard overall financial stability. An important challenge is to combat illicit usage of funds. At the same time, authorities want to preserve long-run incentives for innovation and, in particular, maintain the principle of "same risk, same regulation".[29] These are largely recurrent objectives, but cryptocurrencies raise new challenges and potentially call for new tools and approaches. A related question is whether central banks should issue their own central bank digital currency (CBDC).

Regulatory challenges posed by cryptocurrencies

A first key regulatory challenge is anti-money laundering (AML) and combating the financing of terrorism (CFT). The question is whether, and to what extent, the rise of cryptocurrencies has allowed some AML/CFT measures, such as know-your-customer standards, to be evaded. Because cryptocurrencies are anonymous, it is hard to quantify the extent to which they are being used to avoid capital controls or taxes, or to engage in illegal transactions more generally. But events such as Bitcoin's strong market reaction to the shutdown of Silk Road, a major marketplace for illegal drugs, suggest that a non-negligible fraction of the demand for cryptocurrencies derives from illicit activity (Graph V.9, left-hand panel).[30]

A second challenge encompasses securities rules and other regulations ensuring consumer and investor protection. One common problem is digital theft. Given the size and unwieldiness of distributed ledgers, as well as high transaction costs, most users access their cryptocurrency holdings via third parties such as "crypto wallet" providers or "crypto exchanges". Ironically – and much in contrast to the original promise of Bitcoin and other cryptocurrencies – many users who turned to cryptocurrencies out of distrust in banks and governments have thus wound up relying on unregulated intermediaries. Some of these (such as Mt Gox or Bitfinex) have proved to be fraudulent or have themselves fallen victim to hacking attacks.[31]

Fraud issues also plague initial coin offerings (ICOs). An ICO involves the auctioning of an initial set of cryptocurrency coins to the public, with the proceeds sometimes granting participation rights in a startup business venture. Despite

Box V.B

Distributed ledger technology in trade finance

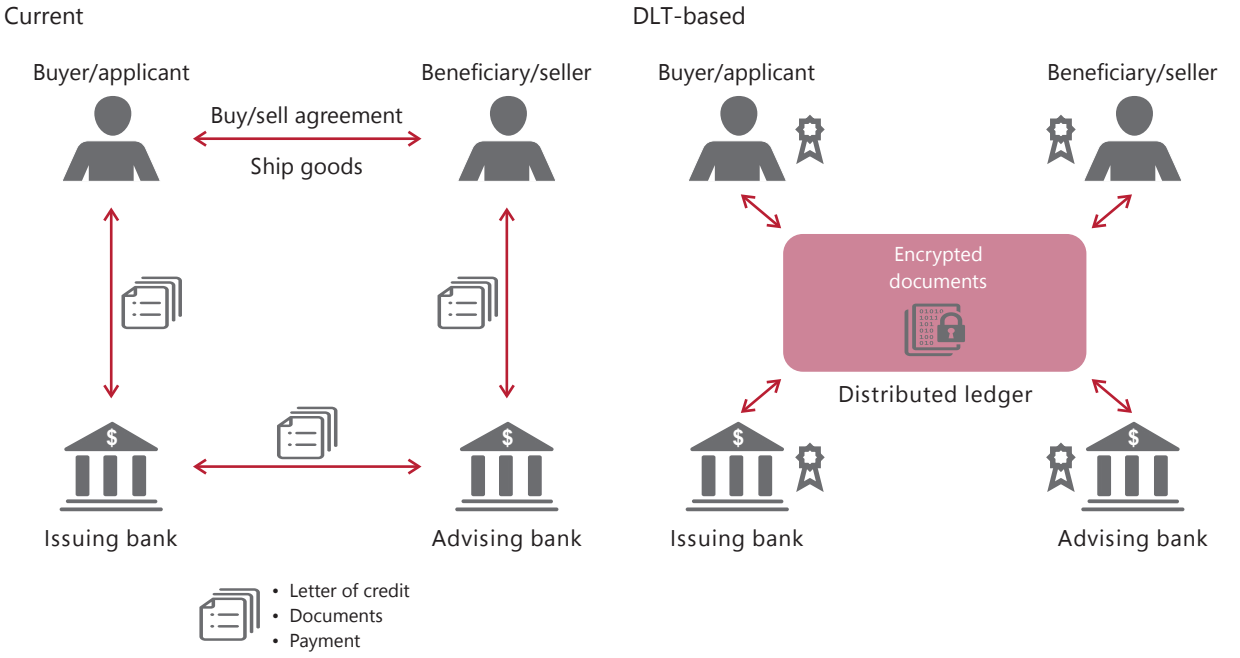
The World Trade Organization estimates that 80–90% of global trade relies on trade finance. When an exporter and an importer agree to trade, the exporter often prefers to be paid upfront due to the risk that the importer will not make a payment after receiving the goods. Conversely, the importer prefers to reduce their own risk by requiring documentation that the goods have been shipped before initiating payment.

Trade financing offered by banks and other financial institutions aims to bridge this gap. Most commonly, a bank in the importer's home country issues a letter of credit guaranteeing payment to the exporter upon receipt of documentation of the shipment, such as a bill of lading. In turn, a bank in the exporter's country might extend credit to the exporter against this pledge, and collect the payment from the importer's bank to complete the transaction.

In its current form (Graph V.B, left-hand panel), trade finance is cumbersome, complex and costly. It involves multiple document exchanges between the exporter, the importer, their respective banks, and agents making physical checks of shipped goods at each checkpoint, as well as customs agencies, public export credit agencies or freight insurers. The process often involves paper-based administration. DLT can simplify the execution of the underlying contracts (right-hand panel). For example, a smart contract might automatically release payment to the exporter upon the addition of a valid bill of lading to the ledger. And the better availability of information on which shipments have already been financed could also reduce the risk that exporters illegally obtain credit multiple times for the same shipment from different banks.

How trade finance on a distributed ledger works

Graph V.B



Source: Adapted from www.virtusapolaris.com.

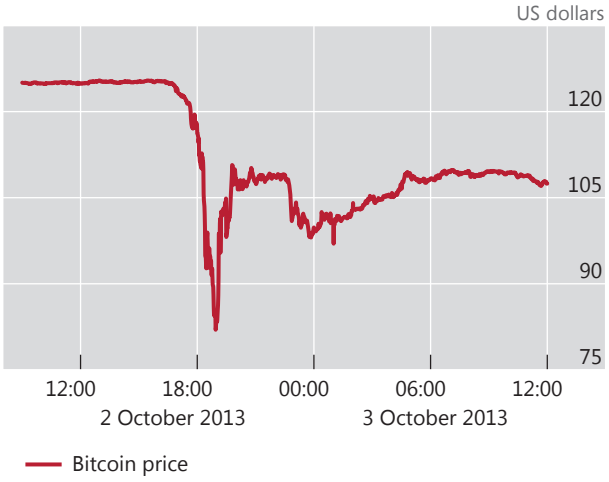
warnings by authorities, investors have flocked to ICOs even though they are often linked to opaque business projects for which minimal and unaudited information is supplied. Many of these projects have turned out to be fraudulent Ponzi schemes (Graph V.9, right-hand panel).

A third, longer-term challenge concerns the stability of the financial system. It remains to be seen whether widespread use of cryptocurrencies and related self-executing financial products will give rise to new financial vulnerabilities and systemic risks. Close monitoring of developments will be required. And, given their novel risk profiles, these technologies call for enhanced capabilities of regulators

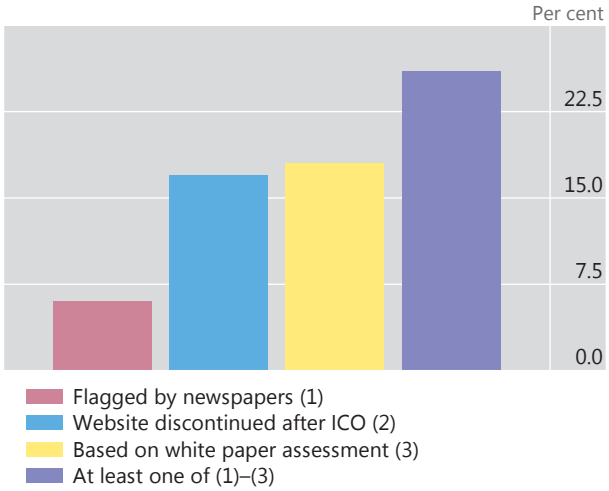
The shutdown of an illegal marketplace and the legitimacy of ICOs

Graph V.9

Cryptocurrency prices react strongly to shutdowns of illegal marketplaces[1]



A large share of initial coin offerings is thought to be fraudulent



[1] Bitcoin price during October 2013 Silk Road shutdown.

Sources: C Catalini, J Boslego and K Zhang, "Technological opportunity, bubbles and innovation: the dynamics of initial coin offerings", *MIT Working Papers*, forthcoming; CoinDesk.

and supervisory agencies. In some cases, such as the execution of large-value, high-volume payments, the regulatory perimeter may need to expand to include entities using new technologies, to avoid the build-up of systemic risks.

The need for strengthened or new regulations and monitoring of cryptocurrencies and related cryptoassets is widely recognised among regulators across the globe. In particular, a recent communiqué of the G20 Finance Ministers and Central Bank Governors highlights issues of consumer and investor protection, market integrity, tax evasion and AML/CFT, and calls for continuous monitoring by the international standard-setting bodies. It also calls for the Financial Action Task Force to advance global implementation of applicable standards.[32]

However, the design and effective implementation of strengthened standards are challenging. Legal and regulatory definitions do not always align with the new realities. The technologies are used for multiple economic activities, which in many cases are regulated by different oversight bodies. For example, ICOs are currently being used by technology firms to raise funds for projects entirely unrelated to cryptocurrencies. Other than semantics – auctioning coins instead of shares – such ICOs are no different from initial public offerings (IPOs) on established exchanges, so it would be natural for securities regulators to apply similar regulation and supervision policies to them. But some ICOs have also doubled as "utility tokens", which promise future access to software such as games. This feature does not constitute investment activity and instead calls for the application of consumer protection laws by the relevant bodies.[33]

Operationally, the main complicating factor is that permissionless cryptocurrencies do not fit easily into existing frameworks. In particular, they lack a legal entity or person that can be brought into the regulatory perimeter. Cryptocurrencies live in their own digital, nationless realm and can largely function in isolation from existing institutional environments or other infrastructure. Their legal domicile – to the extent they have one – might be offshore, or impossible to establish clearly. As a result, they can be regulated only indirectly.

How can authorities implement a regulatory approach? Three considerations are relevant.

First, the rise of cryptocurrencies and cryptoassets calls for a redrawing of regulatory boundaries. The boundaries need to fit a new reality in which the lines demarcating the responsibilities of different regulators within and across jurisdictions have become increasingly blurred.[34] Since cryptocurrencies are global in nature, only globally coordinated regulation has a chance to be effective.[35]

Second, the interoperability of cryptocurrencies with regulated financial entities could be addressed. Only regulated exchanges can provide the liquidity necessary for DLT-based financial products to be anything but niche markets, and settlement flows ultimately need to be converted into sovereign currency. The tax and capital treatment rules for regulated institutions wanting to deal in cryptocurrency-related assets could thus be adapted. Regulators could monitor whether and how banks deliver or receive cryptocurrencies as collateral.

Third, regulation can target institutions offering services specific to cryptocurrencies. For example, to ensure effective AML/CFT, regulation could focus on the point at which a cryptocurrency is exchanged into a sovereign currency. Other existing laws and regulations relating to payment services focus on safety, efficiency and legality of use. These principles could also be applied to cryptocurrency infrastructure providers, such as "crypto wallets".[36] To avoid leakages, the regulation would ideally be broadly similar and consistently implemented across jurisdictions.

Should central banks issue digital currencies?

A related medium-term policy question concerns the issuance of CBDCs, including who should have access to them. CBDCs would function much like cash: the central bank would issue a CBDC initially, but once issued it would circulate between banks, non-financial firms and consumers without further central bank involvement.[37] Such a CBDC might be exchanged between private sector participants bilaterally using distributed ledgers without requiring the central bank to keep track and adjust balances. It would be based on a permissioned distributed ledger (Graph V.2), with the central bank determining who acts as a trusted node.

While the distinction between a general purpose CBDC and existing digital central bank liabilities – reserve balances of commercial banks – may appear technical, it is actually fundamental in terms of its repercussions for the financial system. A general purpose CBDC – issued to consumers and firms – could profoundly affect three core central banking areas: payments, financial stability and monetary policy. A recent joint report by the Committee on Payments and Market Infrastructures and the Markets Committee highlights the underlying considerations.[38] It concludes that the strengths and weaknesses of a general purpose CDBC would depend on specific design features. The report further notes that, while no leading contenders have yet emerged, such an instrument would come with substantial financial vulnerabilities, while the benefits are less clear.

At the moment, central banks are closely monitoring the technologies while taking a cautious approach to implementation. Some are evaluating the pros and cons of issuing narrowly targeted CBDCs, restricted to wholesale transactions among financial institutions. These would not challenge the current two-tier system, but would instead be intended to enhance the operational efficiency of existing arrangements. So far, however, experiments with such wholesale CBDCs have not produced a strong case for immediate issuance (Box V.C).

Box V.C

Wholesale central bank digital currencies

In recent decades, central banks have harnessed digital technologies to improve the efficiency and soundness of payments and the broader financial system. Digital technology has enabled central banks to economise on liquidity provision to real-time gross settlement (RTGS) systems. Linking these systems through Continuous Linked Settlement (CLS), commercial banks around the world settle trillions of dollars of foreign exchange around the clock every day. CLS helps to remove Herstatt risk – the risk that a correspondent bank in a foreign exchange transaction runs into financial trouble before paying the equivalent foreign currency to the designated recipient – which had previously posed a significant financial stability risk. More recently, faster retail payments have spread across the world, and central banks are actively promoting and facilitating this trend.

As part of their broader ventures into new payment technology, central banks are also experimenting with wholesale CBDCs. These are token-based versions of traditional reserve and settlement accounts. The case for wholesale DLT-based CBDCs depends on the potential for these technologies to improve efficiency and reduce operational and settlement costs. The gains could be substantial, to the extent that many current central bank-operated wholesale payment systems rely on outdated and costly-to-maintain technologies.

There are two key challenges for the implementation of wholesale CBDCs. First, the limitations of permissionless DLT also apply to CBDCs, meaning that they need to be modelled on permissioned protocols. Second, the design choices for the convertibility of central bank reserves in and out of the distributed ledger need to be implemented carefully, so as to sustain intraday liquidity while minimising settlement risks.

A number of central banks, including the Bank of Canada (Project Jasper), the ECB, the Bank of Japan (Project Stella) and the Monetary Authority of Singapore (Project Ubin), have already run experiments operating DLT-based CBDC wholesale RTGS systems. In most cases, the central banks have chosen a digital depository receipt (DDR) approach, whereby the central bank issues digital tokens on a distributed ledger backed by and redeemable for central bank reserves held in a segregated account. The tokens can then be used to make interbank transfers on a distributed ledger.

Central banks are now publishing the results. In their initial stages, each of the experiments largely succeeded in replicating existing high-value payment systems. However, the results have not been clearly superior to existing infrastructures.①

① See M Bech and R Garratt, "Central bank cryptocurrencies", *BIS Quarterly Review*, September 2017, pp 55–70; and Committee on Payments and Market Infrastructures and Markets Committee, *Central bank digital currencies*, March 2018.

Endnotes

[1] Terminology on this topic is fluid and evolving, with related legal and regulatory ambiguities. The use of the term "cryptocurrencies" in this chapter is not meant to indicate any particular view of what the underlying protocol-based systems are; typically, they have some, but not all, of the characteristics of a sovereign currency and their legal treatment varies across jurisdictions. In some cases, the chapter refers to specific cryptocurrencies or cryptoassets as examples. These examples are not exhaustive and do not constitute any endorsement by the BIS or its shareholders of any cryptocurrency, firm, product or service.

[2] On this issue, see also Carstens (2018a,c).

[3] Graeber (2011) argues that money only became widespread with the invention of coinage, which appeared in China, India and Lydia almost simultaneously around 600–500 BCE. He further shows that, contrary to popular belief, prior to the use of money, exchange took place mostly through bilateral IOUs rather than barter.

[4] These functions of money have been studied extensively in the literature. A few key examples are the following: Kiyotaki and Wright (1989) show how money, when used as a medium of exchange, can improve on barter. Kocherlakota (1996) shows that when perfect record-keeping and commitment are not possible, money improves outcomes by serving as "memory". Samuelson (1958) shows in an overlapping generations model that money can improve efficiency when used as store of value. Doepke and Schneider (2017) show how using a common unit of account improves outcomes and why government money is the unit of account and the medium of exchange at the same time.

[5] Examples of items used as commodity money include shells in Africa, cocoa beans in the Aztec civilisation and wampum in North American colonies. Even in these cases, credit relationships no doubt coexisted with these arrangements. See eg Melitz (1974) for a more detailed discussion.

[6] On the evolution of letters of credit and the pivotal role they have played in the development of monetary systems in general, and the financing of trade in particular, see De Roover (1948, 1953). For a detailed analysis and history, see Kindleberger (1984) for a general treatment and Santarosa (2015) for the importance of the introduction of joint liability.

[7] Commodity-backed government money, such as the gold standard, was another attempt to strike a balance. While offering stability in normal times, its constraints have tended to limit the central bank's ability to elastically supply currencies at times of financial and economic strains. In extreme circumstances, these constraints have often simply been discarded, with a shift to inconvertibility. For example, under the gold standard, one could regard the function of convertibility into gold as constraining the sovereign's ability to overissue and debase the currency. The constraint was credible precisely because the commodity has a market value in non-monetary uses, ie other than as a means of payment. This prevented the sovereign from keeping the holders hostage to its monopoly powers. See Giannini (2011) for further discussion.

[8] For a recent treatment, including an analysis of incentives to debase the money, see Schnabel and Shin (2018).

[9] See Van Dillen (1964), Roberds and Velde (2014) and Bindseil (2018). For the link with central banking, see Ugolini (2017), Bindseil (2018) and Schnabel and Shin (2018).

[10] Moreover, central banks have generally had the flexibility to act as lenders of last resort. The recent Great Financial Crisis was yet another reminder of the both the fragility and the adaptability of the current monetary arrangements, even in the most advanced economies. While the crisis laid bare the shortcomings of the prevailing regulatory framework, the increased focus post-crisis on bank supervision and regulation highlights how institutional arrangements can evolve to maintain trust in money within the broad framework of the two-tiered system.

[11] See Carstens (2018a). Giannini (2011) also highlights the importance of institutional arrangements through which money is supplied: "The evolution of monetary institutions appears to be above all the fruit of a continuous dialogue between economic and political spheres, with each taking turns to create monetary innovations … and to safeguard the common interest against abuse stemming from partisan interests."

[12] Indeed, central banks these days oversee payment systems and provide large amounts of intraday credit to secure precisely this outcome, notably in wholesale payment systems. Depending on the specificities of the arrangements, this credit may also be extended overnight or at longer maturities. For a further description of the arrangements, operating procedures and other issues, see BIS (1994) and Borio (1997).

[13] See Bech and Garratt (2017) and CPMI-MC (2018) for a detailed discussion.

[14] Much like with banknotes and other physical tokens, each transaction is verified with reference to the payment object, ie the respective ledger entry. This differs from other forms of electronic money, where verification is based on the identity of the account holder. Cryptocurrencies are hence token-based digital money.

[15] Current or planned examples of cryptocurrencies employing a permissioned model with designated trusted nodes include the coin to be issued by the SAGA Foundation, Ripple and Utility Settlement Coin.

[16] We use "Bitcoin" to denote the protocol and network of users and miners of the cryptocurrency, and "bitcoin" to denote the unit of currency.

[17] Examples include Ethereum, Litecoin and Namecoin.

[18] Auer (2018) presents a detailed description of the technological elements of Bitcoin and other blockchain-based cryptocurrencies such as digital signatures, hashing and the cryptographic chaining of blocks. See also Berentsen and Schär (2018).

[19] Technically, this is implemented via the use of cryptographic hash functions (such as SHA-256 in Bitcoin). These have the property that results are unpredictable, and a specific result can thus only be generated by trial and error.

[20] For a permissionless cryptocurrency to function in an entirely trustless environment, all miners and users need to store an up-to-date copy of the entire ledger. However, in practice many users trust the information provided by others. Some users only verify summary information of the ledger via a process called simplified payment verification. And, much in contrast to the original idea underlying Bitcoin, an even larger number of users can only access their funds through a third-party website. In these cases, the third party alone is in control of its clients' cryptocurrency holdings.

[21] Nakamoto (2009), p 8.

[22] This is achieved by self-calibration of the proof-of-work, which increases the required level of mathematical difficulty up to the point where the combined computing power of all miners just suffices to update the ledger at the speed pre-set by the protocol.

[23] See Carstens (2018a).

[24] While congestion could be removed by allowing for bigger block sizes, this might actually be even more destructive. Block rewards aside, having some congestion is essential to induce users to pay for transactions, for if the system operates below its limit, all transactions will be processed and rational users will thus post almost no transaction fees. The miners would not receive any benefits for updating the transactions, and the equilibrium could break down. See in particular Hubermann et al (2017) and Easley et al (2017), as well as Abadi and Brunnermeier (2018).

[25] In technical terms, the interaction between the users is that of strategic substitutes, not strategic complements. Cryptocurrencies are hence a congestion, rather than a coordination, game.

[26] The probabilistic nature of finality could in particular create aggregate risks if cryptocurrencies were used in wholesale settings, where funds tend to be reinvested without delay. In fact, this would create an entirely new dimension of aggregate risk, as exposures would be linked to each other via the probability of non-finality of the entire transaction history.

[27] There is no shortage of proposed solutions, but most have yet to be proved in practice. On the one hand, future cryptocurrency protocols might do away with costly proof-of-work by replacing it with "proof-of-stake", the underlying idea of which is to achieve credibility by staking cryptocurrency holdings rather than doing costly computational work. Proposed solutions for the scaling problem include the Lightning Network, which essentially shifts small transactions off the main blockchain and into a separate pre-funded environment. There are also new cryptocurrencies, such as IOTA, that aim to replace the blockchain with a more complex ledger and verification structure.

[28] See Juskalian (2018).

[29] See Carstens (2018a,b).

[30] Government officials are also not immune from the lure of cryptocurrencies: two US government agents have been charged with theft of bitcoins confiscated during the closing of Silk Road.

[31] For example, most bitcoin payments made via smartphone are most likely made indirectly via third party, since the current blockchain size exceeds the storage capacity of most smartphones. Reuters (2017) and Moore and Christin (2013) list some of the cases in which such third parties have proved to be fraudulent or have fallen victim to hacking attacks. For an analysis of illicit uses of cryptocurrencies, see Fanusie and Robinson (2018) and Foley et al (2018).

[32] See G20 Finance Ministers and Central Bank Governors (2018).

[33] Clayton (2017), discussing the regulation of ICOs as opposed to IPOs from a US perspective, states that a "change in the structure of a securities offering does not change the fundamental point that when a security is being offered, our securities laws must be followed". FINMA (2018) sets out a regulatory framework in Switzerland that classifies ICOs according to the eventual use of the tokens issued: in payments, as assets or as utility tokens.

[34] Technically, all that is needed for protocol-based cryptocurrencies to operate is for at least one country to allow access. The authorities' difficulties in shutting down illegal download sites such as Napster or The Pirate Bay and download protocols such as BitTorrent underline the associated enforcement problems.

[35] Financial Action Task Force (2015) argues that treating similar products and services consistently according to their function and risk profile across jurisdictions is essential for enhancing the effectiveness of the international AML standards.

[36] One complication is that payments are regulated by a set of authorities and laws with very different goals, such as payment system oversight, prudential supervision, consumer protection and AML/CFT. For example, US-based institutions must adhere to, among others, the Bank Secrecy Act, the USA PATRIOT Act and Office of Foreign Assets Control regulations. Another complication has to do with the applicability of existing legislation to the new instruments. For instance, in the European Union the legal definition of electronic money includes the requirement that balances should represent a claim on the issuer. As cryptocurrencies do not represent any claim, they cannot be considered electronic money and are thus by default not covered by the respective legislation.

[37] There are many potential technical implementations of token-based CBDCs. They could be based on DLT, with similar characteristics to cryptocurrencies, with the difference being that the central bank rather than the protocol itself would be in control of the amount issued and would guarantee the token's value.

[38] CPMI-MC (2018).

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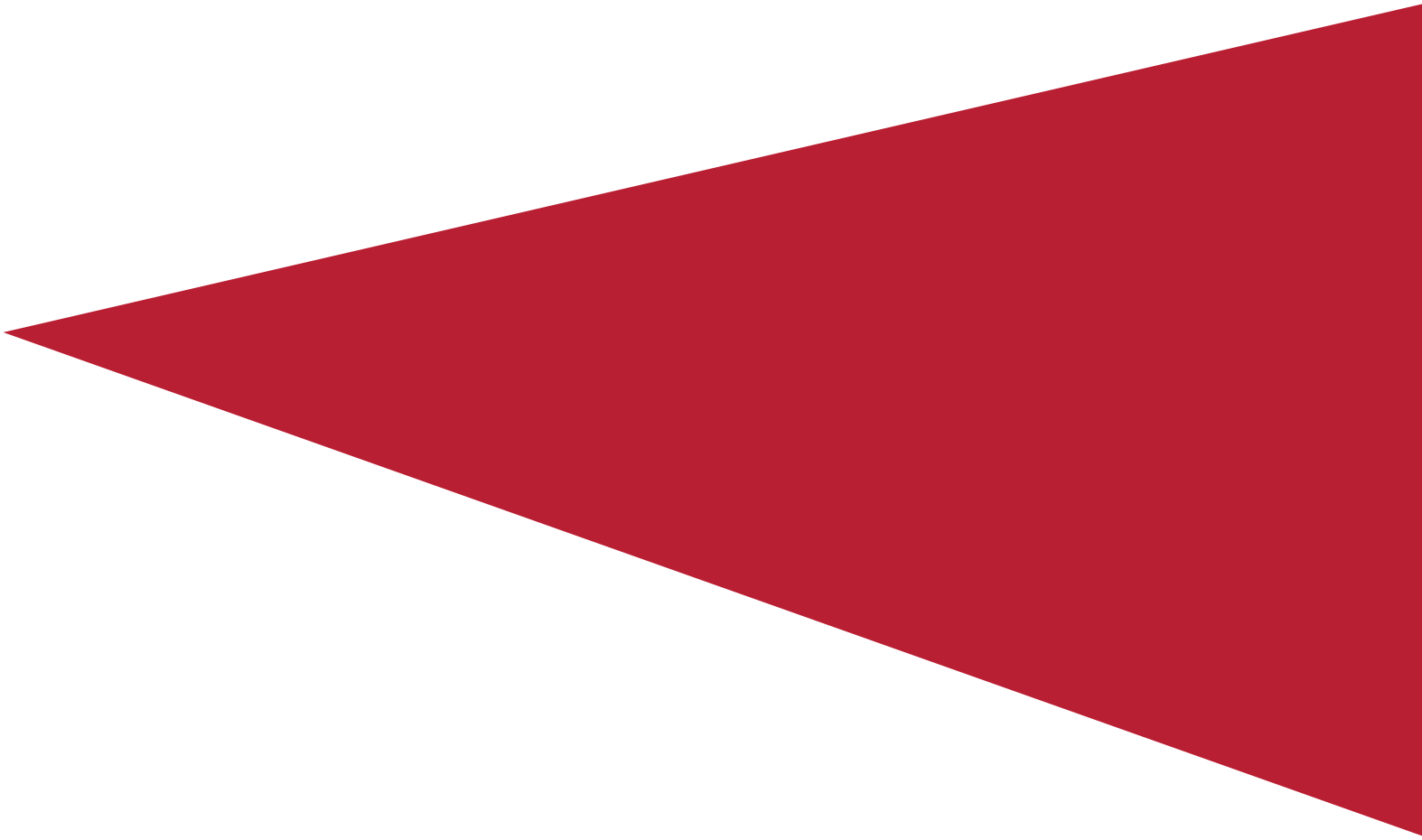

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