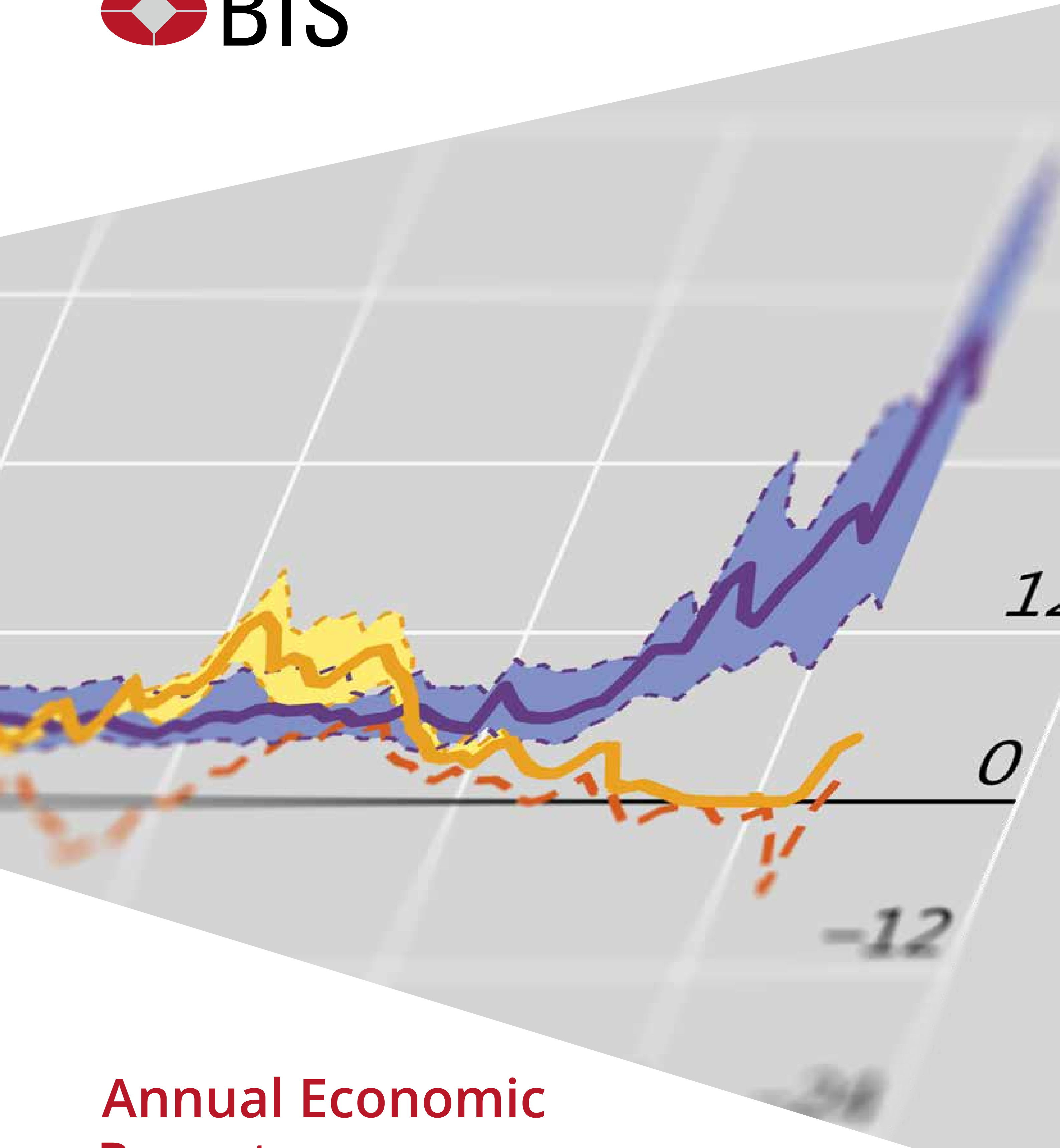

Annual Economic Report

June 2024

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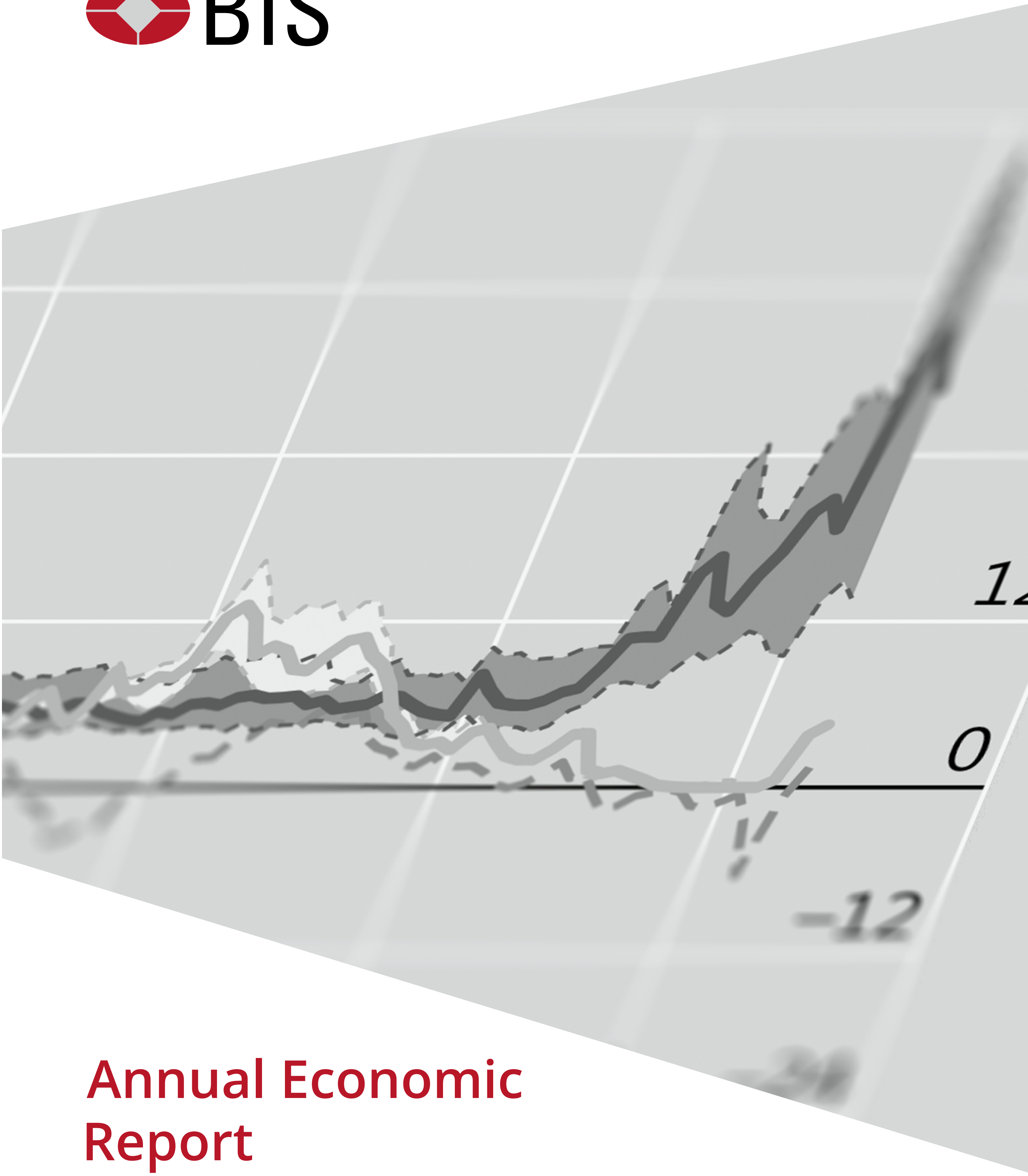

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A technical annex containing detailed explanations for the graphs and tables is included at the end of each chapter.

Conventions used in the Annual Economic Report

std dev	standard deviation
σ^2	variance
$	US dollar unless specified otherwise
’000	thousands
mn	million
bn	billion (thousand million)
trn	trillion (thousand billion)
% pts	percentage points
bp	basis points
lhs, rhs	left-hand scale, right-hand scale
pa	per annum
sa	seasonally adjusted
saar	seasonally adjusted annual rate
mom	month on month
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 terms “country” and “economy” used in this publication also cover territorial entities that are not states as understood by international law and practice but for which data are separately and independently maintained. The designations used and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the BIS concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its frontiers or boundaries. Names of countries or other territorial entities are used in a short form which is not necessarily their official name.

Country codes

AE	United Arab Emirates	GR	Greece	NO	Norway
AR	Argentina	HK	Hong Kong SAR	NZ	New Zealand
AT	Austria	HR	Croatia	PE	Peru
AU	Australia	HU	Hungary	PH	Philippines
BE	Belgium	ID	Indonesia	PL	Poland
BR	Brazil	IE	Ireland	PT	Portugal
CA	Canada	IL	Israel	RO	Romania
CH	Switzerland	IN	India	RU	Russia
CL	Chile	IT	Italy	SA	Saudi Arabia
CN	China	IS	Iceland	SE	Sweden
CO	Colombia	JP	Japan	SG	Singapore
CZ	Czechia	KR	Korea	SI	Slovenia
DE	Germany	KW	Kuwait	SK	Slovakia
DK	Denmark	LT	Lithuania	TH	Thailand
DZ	Algeria	LU	Luxembourg	TR	Türkiye
EA	euro area	LV	Latvia	TW	Chinese Taipei
EE	Estonia	MA	Morocco	US	United States
ES	Spain	MT	Malta	VN	Vietnam
FI	Finland	MX	Mexico	ZA	South Africa
FR	France	MY	Malaysia		
GB	United Kingdom	NL	Netherlands		

Currency codes

AED	UAE dirham	KRW	Korean won
ARS	Argentine peso	KWD	Kuwaiti dinar
AUD	Australian dollar	MAD	Moroccan dirham
BRL	Brazilian real	MXN	Mexican peso
CAD	Canadian dollar	MYR	Malaysian ringgit
CHF	Swiss franc	NOK	Norwegian krone
CLP	Chilean peso	NZD	New Zealand dollar
CNY (RMB)	Chinese yuan (renminbi)	PEN	Peruvian sol
COP	Colombian peso	PHP	Philippine peso
CZK	Czech koruna	PLN	Polish zloty
DKK	Danish krone	RON	Romanian leu
DZD	Algerian dinar	RUB	Russian rouble
EUR	euro	SAR	Saudi riyal
GBP	pound sterling	SEK	Swedish krona
HKD	Hong Kong dollar	SGD	Singapore dollar
HUF	Hungarian forint	THB	Thai baht
IDR	Indonesian rupiah	TRY	Turkish lira
ILS	new shekel	USD	US dollar
INR	Indian rupee	VND	Vietnamese dong
JPY	Japanese yen	ZAR	South African rand

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): Algeria, Argentina, Brazil, Chile, China, Colombia, Czechia, Hong Kong SAR, Hungary, India, Indonesia, Israel, Korea, Kuwait, Malaysia, Mexico, Morocco, Peru, the Philippines, Poland, Romania, Russia, Saudi Arabia, Singapore, South Africa, Thailand, Türkiye, the United Arab Emirates and Vietnam.

Global: all AEs and EMEs, as listed.

Depending on data availability, country groupings used in graphs and tables may not cover all the countries listed. The grouping is intended solely for analytical convenience and does not represent an assessment of the stage reached by a particular country in the development process.

So far, so good…

Introduction

So far, so good. The world economy appears to be finally leaving behind the legacy of the Covid-19 pandemic and the commodity price shock of the war in Ukraine. The worst fears did not materialise. On balance, globally, inflation is continuing to decline towards targets, economic activity and the financial system have proved remarkably resilient, and both professional forecasters and financial market participants see a smooth landing ahead. This was by no means a given a year ago. It is a great outcome.

Still, there is a "but". Challenges remain. The recent stickiness of inflation in some key jurisdictions reminds us that central banks' job is not yet done. Financial vulnerabilities have not gone away. Fragile fiscal positions cast a shadow as far as the eye can see. Subdued productivity growth clouds economic prospects. Beyond the near term, laying a more solid foundation for the future is as difficult as ever. It could not be otherwise: it is an arduous task that requires a long-term view, courage and perseverance.

As is customary, this year's Annual Economic Report (AER) takes the pulse of the global economy and explores policy challenges. It also devotes particular attention to two issues. Looking back, it reflects on the lessons learned so far from the conduct of monetary policy in the tumultuous first quarter of the 21st century. Looking forward, it examines the opportunities and risks associated with the rise of artificial intelligence (AI).

The year under review

In the year under review, the global economy made further progress in absorbing the huge and long-lasting dislocations caused by the pandemic and Russia's invasion of Ukraine.

Inflation has continued to decline from its peak in 2022. Both headline and core inflation kept moving down for much of the period under review. The rotation in the contribution to inflation from goods to services proceeded further, as commodity prices edged down while services price growth proved stickier. By the end of the period, inflation had come down substantially further: monetary policy had delivered (see below). At the same time, although it was more subdued in places, particularly in Asia, it was still hovering above central bank targets across much of the world. There were signs that the decline had become more hesitant in some key jurisdictions, notably the United States.

Economic activity held up surprisingly well, indicating that a "normalisation" in both demand and supply had helped disinflation. Employment remained unusually buoyant in relation to output, supporting demand further in the near term. Households again dipped into savings accumulated during the pandemic. The lingering effects of extraordinarily generous fiscal support, and in some cases additional fiscal expansion, boosted activity. Having borrowed at longer maturities and at fixed rates, households and firms were partly shielded from higher interest rates and the burden of debt.

The resilience of the financial system and financial market sentiment underpinned activity. There were no renewed serious banking strains à la March 2023. And while banks were rather cautious in granting credit, conditions in financial markets remained quite easy. Equity prices rose, with those in the technology sector reaching heady heights, and bond spreads remained quite narrow by historical standards. For much of the period, buoyant investor sentiment reflected eager expectations of an immediate and substantial easing of monetary policy that did not materialise.

Against this backdrop, the most intense and synchronised monetary policy tightening in decades gave way to a somewhat more differentiated picture, in line with the growing differences in domestic inflation outlooks. Central banks prepared the ground for easing, for example in the euro area and much of Asia, or made the first cuts, such as in some countries in Latin America, where policy had been tightened ahead of the rest, and in Asia. The People's Bank of China eased further in response to weak domestic conditions and given subdued inflation. In Japan, the central bank finally exited the negative interest rate policy era and abandoned yield curve control while retaining an accommodative stance.

This more differentiated picture has raised the prospect of larger interest rate differentials and pressures on currencies. In particular, following the latest monthly inflation readings in the United States, financial market participants expect greater divergence in policy rate trajectories, especially between the Federal Reserve and other central banks. This has reinforced a broad-based dollar appreciation, which has been especially marked vis-à-vis the yen. The appreciation has already elicited policy responses, including in some cases foreign exchange intervention or adjustments in the policy stance. And it has raised broader questions about the impact on capital flows and financial markets.

Pressure points and risks ahead

Looking ahead, the central scenario painted by professional forecasters and priced in financial markets is a smooth landing. Price stability is restored, economic growth picks up, central banks ease, and the financial system remains strain-free. Compared with past expectations, which were generally that a significant economic slowdown could be required to lower inflation, this is an impressive outcome. That said, risks persist. Some are more near-term, others further out. Some reflect an incomplete adjustment to the pandemic dislocations, others longer-standing weaknesses. To varying degrees, they all stem from the same root cause analysed in previous AERs: the pandemic hit a global economy that, while enjoying low inflation and growing briskly, had been relying for too long on an unsustainable debt-fuelled growth model. Hence worrying signs emerged, such as the historically high levels of private and public debt and the drastically reduced monetary and fiscal policy headroom.

Consider several pressure points pertaining to inflation, the macro-financial nexus and real economy factors, respectively. While somewhat arbitrary given the tight interconnections involved, this classification can help organise the discussion.

At the heart of the risks to inflation is the partial adjustment of two, closely related, relative prices thrown out of kilter by the pandemic. One is the price of services relative to that of (core) goods; the other is the price of labour (wages) relative to that of goods and services (the price level), ie real wages.

The pandemic-induced dislocations interrupted the secular increase in the price of services relative to that of goods. As demand rotated away from services to goods and clashed with inelastic supply, the price of goods rose by much more. And as demand subsequently rebounded strongly after having been first artificially suppressed by public health measures and then turbocharged by economic policies, its rotation back to services failed to re-establish the pre-pandemic relative price relationships even as services became the prime inflation driver. It is possible that the pandemic, and associated aggregate demand stimulus and supply disruptions, has permanently altered the trend relative price relationship between goods and services. However, it is not clear why this should be the case, to the extent that the trend reflected deep-seated structural forces. These include a growing relative demand for services as incomes rise, slower productivity growth in services than in goods and nominal wage increases that do not compensate for the productivity growth rate differential in the two sectors. If the relative price between goods and services did return to its previous trend, it would raise overall inflation significantly above pre-pandemic rates for some time, unless disinflation in goods proceeded sufficiently fast, with prices growing below those rates. It might be hard for goods prices to grow that slowly in a world in which globalisation tailwinds are waning.

The pandemic-induced dislocations also interrupted the secular increase in real wages, as the surprising inflation flare-up eroded purchasing power. Real wages have recovered somewhat since then, but generally languish considerably below the previous trend. The shortfall could add to wage pressures ahead, especially given continued tightness in labour markets and sluggish productivity growth (see below). To the extent that profit margins have benefited from surprise inflation, there should be room for adjustment. But having regained a taste for pricing power during the inflation phase, firms might be tempted to use it again.

The two relative price adjustments are closely linked because the services sector is more labour-intensive. This is one reason why services price increases tend to be stickier than those of goods. And it helps to explain why the pass-through from wages to prices is much higher in this sector.

These incomplete relative price adjustments could provide fertile ground for other sources of inflationary pressures. Any commodity price spikes linked to, say, geopolitical tensions or the withdrawal of price subsidies would be more likely to trigger second-round effects. And the likelihood is higher following the long phase of above-target inflation, which can encourage and entrench inflation psychology.

Macro-financial pressure points reflect the combination of higher interest rates and financial vulnerabilities in private sector balance sheets in the form of high debt and stretched valuations. The current configuration is rather unique. The previous globally synchronised and intense monetary policy tightening took place during the Great Inflation era of the 1970s, when a repressed financial system had not allowed widespread vulnerabilities to develop (see previous AERs).

The outcome, so far, has been surprisingly benign, but tougher tests may lie ahead. The significant banking strains in March 2023 stemmed in many cases from the materialisation of interest rate risk alone, as higher interest rates shook valuations without causing borrowers to default. The materialisation of credit risk is still to come; the only question is when and how intense it will be. The lag is typically quite long, and yet it can appear deceptively short as memories fade. There are indications that financial cycles have started to turn. Savings buffers are dwindling. Debts will have to be refinanced.

Within this broad picture, specific macro-financial pressure points abound. There are those we know about. Commercial real estate, historically a much more typical source of banking stress than residential real estate, has been on supervisors' radar screen for quite some time. The office segment, in particular, has fallen victim to the confluence of post-pandemic structural and cyclical forces. Similarly, the opaque risks in the burgeoning private credit markets have attracted considerable attention. And then there are certainly vulnerabilities we know far less about. They could catch markets by surprise and shake confidence and trust.

The intensity of any stress that could emerge will naturally depend on the condition of financial institutions. Banks are now much better capitalised than before the Great Financial Crisis, notably thanks to stronger prudential regulation. Their profits have also benefited from higher interest rates, which have buoyed net interest margins. That said, many are still facing longer-term profitability challenges and investor mistrust, as reflected in depressed price-to-book ratios. The more lightly regulated parts of the non-bank financial sector remain a source of concern as stress amplifiers, owing to hidden leverage and liquidity mismatches.

Two real economy pressure points stand out: fragile fiscal positions and subdued productivity growth.

As assessed in detail in last year's AER, fiscal trajectories represent one of the biggest threats to macroeconomic and financial stability in the medium to longer term. Pre-pandemic, the threat was masked by the long phase of exceptionally low interest rates, which had taken the debt service burden to historical lows despite historically high debt-to-GDP ratios. Since then, further broad-based fiscal support has darkened the picture. In some cases, fiscal policy is still adding stimulus to the economy, acting at cross-purposes with monetary policy. Absent consolidation measures, debt ratios are set to climb over time, even in a scenario in which interest rates remain below the growth rate of the economy. And demands on fiscal authorities have been increasing, as the financing needs of the green transition and geopolitical considerations have come on top of the looming burden of ageing populations.

Post-pandemic, productivity growth – the key to longer-term prosperity – has been generally lacklustre compared with previous trends, although the United States is one exception. The lingering impact of the pandemic makes it especially hard to parse the influence of cyclical and structural forces. But gradually slowing productivity growth was a concern even before Covid-19 struck. The wave of technological advances under way, notably AI, could significantly improve the picture. Still, it would be unwise to simply assume it will. Should slow productivity growth continue, it would make the economic and political environment more challenging. It would add to inflationary pressures, reduce the headroom for both monetary and fiscal policy, and, more generally, widen the gap between society's expectations and policymakers' capacity to meet them, making any adjustments much harder.

Policy challenges

The overarching policy challenge is to complete the job of returning to price stability while at the same time keeping a firm eye on the longer term, thereby laying the foundations for sustainable and balanced growth. This has implications for both policy settings and frameworks in the monetary, prudential, fiscal and structural domains.

Near-term policy settings

The priority for monetary policy is to firmly re-establish price stability. In doing so, the lessons learned from the conduct of policy in the tumultuous years since the turn of the century can be helpful in guiding decisions (see below). This means travelling the last mile of the disinflation with a steady hand, being especially alert to the risk of further significant upward surprises and not hesitating to tighten again if inflation proves to be more stubborn and unresponsive than anticipated. It also means safeguarding the room for policy manoeuvre that central banks have finally regained – the only silver lining of the inflation flare-up. For instance, it would be imprudent to cut interest rates significantly based on the view that the "neutral" or "natural" interest rate (r-star) remains as low as it was perceived to be before inflation took hold. We simply know too little about where such a rate might be and what its determinants are. Rather, it would be safer to be guided by actual inflation and to take this opportunity to wean the economy off the low-for-long state that can generate longer-term risks for financial, macroeconomic and, hence, price stability.

The prospects of greater divergence in the outlook for interest rates and concomitant pressures on exchange rates and capital flows could raise additional challenges for adjustments in monetary policy settings. Emerging market economies, in particular, are in a better position to address them than in the past, thanks to the build-up of foreign currency reserve buffers and stronger policy frameworks generally. As experience in recent years indicates, this should provide greater room for manoeuvre in the calibration of monetary policy, supported, where appropriate, by judicious use of foreign exchange (FX) intervention.

The priority for prudential policy is to strengthen further the resilience of the financial system. There is still a window of opportunity to build up defences for the credit losses that will inevitably materialise at some point. In particular, on the macroprudential side, it would be important to avoid a premature loosening, calibrating the measures with respect to financial cycle conditions. On the microprudential side, tight supervision can temper risk-taking and help ensure adequate provisioning and realistic asset valuations. Should financial stress emerge, supervisors would need to act in concert with monetary and fiscal authorities to manage the strains in an orderly way while allowing monetary policy to focus on re-establishing price stability.

The priority for fiscal policy is to consolidate with clear-eyed and firm resolve. This would relieve pressure on inflation, even if in the near term any removal of lingering energy and food subsidies would raise prices – a foreseen side effect. More importantly, it would pave the way for the arduous long-term task of ensuring the sustainability of public finances.

Longer-term policy frameworks

Monetary policy frameworks have faced a series of extraordinary tests since the Great Financial Crisis shattered the deceptive tranquillity of the so-called Great Moderation. And central banks have delivered: they have contained the damage of financial crises; they avoided major shortfalls of inflation from target all the way to the pandemic; and they have put in place a solid basis for a return to price stability following the post-pandemic inflation surge. The years ahead may be no less challenging. Unless fiscal positions are brought under control, the threats to financial and macroeconomic stability will grow. The risk of global fragmentation, the reality of climate change and demographic trends could make the supply of goods and services less elastic and the world more inflation-prone. At the same time, a return of persistent disinflationary pressures cannot be ruled out either, especially if the current wave of technological advances bears fruit.

Against this backdrop, Chapter II's in-depth analysis of the conduct of monetary policy over this long historical phase points to a number of lessons that could inform refinements to existing frameworks. Some of these lessons confirm previous widely held beliefs; others temper previous expectations. Together, they help us to better understand monetary policy's strengths and limitations. Five lessons stand out.

First, forceful monetary tightening can prevent inflation from transitioning to a high-inflation regime. Arguably, central banks underestimated the extent to which the exceptional and prolonged further easing at the time of the pandemic would contribute to the flare-up in inflation, and could have responded more promptly once inflation surged. But their subsequent vigorous and determined response has so far succeeded in preventing a shift to a high-inflation regime.

Second, forceful action can stabilise the financial system at times of stress and prevent the economy from falling into a tailspin, thereby eliminating a major source of deflationary pressures. On such occasions, the deployment of the central bank balance sheet does the heavy lifting, as the central bank is called upon to perform as lender and, increasingly, market-maker of last resort. That said, whenever the solvency of borrowers, financial or non-financial, is threatened, this requires government backstops. And those interventions, if repeated, can distort risk-taking incentives in the longer term. Hence the importance of strengthening regulation and supervision further.

Third, exceptionally strong and prolonged monetary easing has limitations. It exhibits diminishing returns, it cannot by itself fine-tune inflation in a low-inflation regime, and it can generate unwelcome side effects over the long term. These include weakening financial intermediation and inducing resource misallocations, encouraging excessive risk-taking and the build-up of vulnerabilities, and raising economic and political economy challenges for central banks as their balance sheets balloon. These limitations were not fully appreciated at the time the measures were first introduced.

Fourth, communication has become more complicated. The multiplicity of instruments makes it difficult to aggregate their effect and to understand which of them are intended to influence the stance, and when. The failure to anticipate the surge in inflation has threatened credibility. More generally, there is a growing "expectations gap" between what central banks are expected to deliver and what they can actually deliver.

Finally, the experience of emerging market economies, in particular, has illustrated how the deployment of complementary tools can help to improve the near-term trade-offs that monetary policy faces between price and financial stability. If used judiciously, FX intervention – a form of balance sheet policy, but in foreign currency – allows the build-up of FX buffers that strengthens resilience and can help to address disruptive swings in global financial conditions and exchange rates. Macroprudential measures, which central banks either control or help set, have been a welcome addition to the toolkit to address financial booms and busts.

These lessons highlight the importance of four features that could inform refinements to frameworks: robustness, realism in ambition, safety margins and nimbleness. Together, they can reduce the risk that monetary policy, just as fiscal policy, is relied upon excessively to drive growth – the "growth illusion" analysed in detail in last year's AER. And they are designed to ensure that monetary policy focuses on maintaining inflation within the region of price stability while safeguarding financial stability. Consider the implications of these considerations for the definition of the inflation objective, for acceptable deviations from targets, for the deployment of the tools, and for the institutional arrangements that support policy, including the role of communication in that context.

The operational definition of price stability would need to help hardwire a low-inflation regime while allowing for deviations consistent with central banks' ability to control inflation. Ideally, the objective would be low enough so that inflation would not materially influence economic agents' behaviour. Adjusting current targets upwards, quite apart from the risk of undermining central banks' hard-earned credibility, would not be consistent with this goal and would risk squandering the self-equilibrating properties that inflation exhibits in such a low-inflation regime.

When inflation evolves in a low-inflation regime, there is room for greater tolerance than in the past for moderate, even if persistent, shortfalls of inflation from narrowly defined targets. The additional room would take advantage of the self-equilibrating properties of inflation and reduce the side effects of keeping interest rates very low for extended periods. This would allow central banks to better take into account the threats to financial, macroeconomic and price stability that develop over longer horizons and would reduce the risk of losing precious safety margins. At the same time, the self-reinforcing nature of transitions from low- to high-inflation regimes underscores the importance of reacting strongly when inflation rises sharply above levels consistent with price stability and threatens to become entrenched. It is one thing to avoid fine-tuning, leveraging the self-stabilising properties of the low-inflation regime; it is quite another to put the system's self-equilibrating properties to the test.

The desirability of operating with safety margins to reduce the vulnerability of the economy puts a premium on the prudent deployment of instruments. This means implementing policies that include as an explicit consideration retaining policy room for manoeuvre over successive business and financial cycles. It means putting a premium on exit strategies from extreme policy settings designed to stabilise the economy and on keeping balance sheets as small and riskless as possible, subject to effectively fulfilling mandates. And it means avoiding overreliance on approaches that may unduly hinder flexibility, such as certain forms of forward guidance, critical dependencies on unobservable and highly model-specific concepts, or frameworks designed for seemingly invariant economic environments.

Good monetary policy often requires taking actions that may involve costs in the short run to reap benefits in the longer run. This calls for appropriate supporting communication strategies and institutional arrangements. As regards communication, the toughest and growing challenge is to narrow the "expectations gap" – a major source of pressure on the central bank to test the limits of sustainable economic expansions and to pursue mutually inconsistent and overly ambitious objectives. Failing to do so can ultimately undermine the central bank's legitimacy and society's trust. As regards institutional arrangements, there is a need to shield the central bank from political economy pressures, be they linked to inflation or the build-up of financial imbalances. Safeguards for central bank independence are essential. They may become even more important in the years ahead.

Monetary policy frameworks, however, are only one element of the broader policy setup. Indeed, the trade-offs monetary policy faces can become unmanageable, and sustainable macroeconomic and financial stability remain beyond reach, unless other policies also play a key role in a coherent whole – what the BIS has termed a holistic macro-financial stability framework.

In the years ahead, further efforts will be needed to strengthen prudential frameworks. In the near term, it is essential to complete the international banking reforms, known as Basel III, in a full, timely and consistent manner. In the longer term, as discussed in more detail in last year's AER, it will be important to adjust regulatory and supervisory arrangements in the light of the evolving financial landscape and the lessons drawn from episodes of financial stress, both recent ones and inevitable future ones. An area that requires urgent action is the non-bank financial intermediation sector. Despite many post-Great Financial Crisis initiatives, a systemic stability-oriented ("macroprudential") regulatory framework has proved beyond reach. Making substantial progress may well require more incisive steps, not least to include financial stability as an explicit objective in the mandate of securities regulators.

Fiscal policy frameworks, too, require strengthening. It is imperative that sufficient institutional safeguards be put in place to ensure that fiscal positions are sustainable and that, just like monetary policy, fiscal policy can operate with adequate safety margins. The types of remedy are well known. They all involve constraints that can be embedded in legislation and enforced in a variety of ways, with different degrees of stringency. Ultimately, though, no remedy is workable without the political will to adopt it. And implementing the necessary policy adjustments has arguably become harder since the Great Financial Crisis, as expectations of government support have grown.

The same political will is needed to revive the flagging effort to reinvigorate the supply potential of the global economy. Only structural policies can deliver the productivity improvements needed to enable higher sustainable growth. Recognising this point, in turn, calls for a broad change of mindset to dispel the deeply rooted "growth illusion" at the heart of the debt-fuelled growth model that the world has de facto relied on for too long. The analysis and proposals in this report are intended to promote such a change.

The AI wave

Among the structural developments of relevance to central banks, AI figures high on the list. AI has taken the world by storm and has set off a gold rush across the economy, with an unprecedented pace of adoption and investment in the technology.

The technology underpinning AI has been in development for decades, but AI has come of age with the ready availability of unstructured data and the computing power that can process it. Machine learning excels at imposing mathematical structure on unstructured data, such as text or images, to allow enormous computing power to process the information. The result is the uncanny versatility of the latest AI applications. They can perform tasks that they were not specifically trained to perform, or need only minimal training to do so; they are "zero-shot learners" or "few-shot learners". Large language models (LLMs) are trained on the totality of the text and non-text data on the internet, drawing on connections in the data to tackle a wide range of tasks. Such versatility distinguishes the latest AI models from past expert systems that were good for only narrowly defined domains. For these reasons, AI will have a profound impact on daily lives.

AI impinges on the job of central banks in two important ways.

First, it bears on central banks' core activities as stewards of the economy. The versatility of AI models will have far-reaching implications for the economy. In the labour market, AI could displace some workers but could complement the skills of others and introduce altogether new tasks that boost economic activity, innovation and growth. Central banks' mandates around monetary and financial stability would be profoundly affected by AI. The impact on inflation will depend on how the balance of supply and demand effects plays out, but widespread adoption of AI could enhance firms' ability to adjust prices quickly in response to changing circumstances, affecting inflation dynamics. Financial markets will also be affected, with implications for market dynamics and financial fragility. These issues are rightly of great concern to central banks.

AI also affects central banks as users of the technology. The ability to impose mathematical structure on unstructured data makes AI ideally suited to identify patterns that are otherwise obscured. This ability "to find a needle in the haystack" could offer breakthroughs in nowcasting economic activity and in the monitoring of financial systems for the build-up of risks. The "zero-shot" or "few-shot" nature of LLMs also means that they can perform tasks other than simply analysing textual information. LLMs excel at detecting patterns. Just as LLMs are trained by guessing the next word in a sentence using a vast database of textual information, macroeconomic forecasting models can use the same techniques to forecast the next numerical observation from a sea of structured and unstructured data. Many central banks already support their economic analysis with nowcasting models, producing real-time assessments of the economy. Financial market applications by central banks mirror AI tools already in use by private sector institutions in their data analytics, risk management and fraud detection, but AI's potential impact could be of even greater importance for central banks given their influence on the economy.

All this said, AI also introduces new challenges.

One such challenge is new sources of cyber risk that exploit weaknesses in LLMs to make the model behave in unintended ways, or to reveal sensitive information. By the same token, however, AI can be harnessed to strengthen cyber security by uncovering anomalies, trends or correlations that might not be obvious to the naked eye.

Most importantly, the new era of AI highlights the importance of data governance. While the underlying mathematics of the latest AI models follow basic principles that would be familiar to earlier generations of computer scientists, their capabilities derive from the combination of vast troves of data and massive computing power that is up to the task of unlocking the insights. The centrality of data demands a rethink of central banks' traditional roles as the compilers, users and disseminators of data.

Our conventional approach to data favours using existing structured data sets organised around traditional statistical classifications. However, the age of AI will rely increasingly on unstructured data drawn from all walks of life, collected by autonomous AI agents. Data availability and data governance are key enabling factors for central banks' use of AI. Both will require investment in technology and in human capital. Above all, the challenges of the age of AI necessitate close cooperation among central banks. Central banks need to come together to foster a "community practice" to share knowledge, data, best practices and AI tools.

I. Laying a robust macro-financial foundation for the future

Key takeaways

- Following the most synchronised and intense monetary policy tightening in a generation, inflation has declined substantially with little collateral damage so far. The financial system has been largely strain-free since March 2023, and market pricing suggests a smooth landing.
- That said, a number of pressure points could throw the global economy off track. Inflationary pressures may prove more stubborn than anticipated, growth may stall and long-standing fiscal and macro-financial vulnerabilities may lead to stress.
- Monetary policy will need to finish the job on disinflation. Fiscal policy will need to consolidate. Prudential policy will need to remain vigilant and continue efforts to enhance resilience. Structural policy will need to set the basis for sustainable growth and prepare the economy for the challenges ahead.

The global economy appears to be poised for a smooth landing. The sudden post-pandemic burst of inflation was met with the most synchronised and intense monetary policy tightening in a generation. So far, the efforts have borne fruit, defying last year's concerns of looming recessions and very sticky inflation. The financial system has proved resilient. The baseline going forward is a gradual convergence of growth rates to their medium-term trends as inflation approaches central bank targets.

Still, old risks have not gone away while new ones have come into sight. A number of pressure points could compromise the benign baseline scenario. Inflationary dynamics could re-emerge, spurred by ongoing adjustments of relative prices. Geopolitical events and commodity price increases could complicate the last mile of disinflation. Varying exposure to inflationary pressures could deepen the divergences across jurisdictions, bringing about disorderly adjustment in exchange rates and capital flows. Fiscal policies could boost demand at an inopportune time, while debt sustainability concerns could strain the financial system. Depleted buffers and the cumulative effects of past monetary policy tightening could reach tipping points and prompt a sharp squeeze in private demand. Seemingly dormant, macro-financial imbalances could unwind in a costly way.

In this challenging landscape, policies will need to finish the job of guiding the economy back to price stability and set the foundation for durable growth. In doing so, macroeconomic policies will need to keep a firm eye on the longer-term consequences of near-term decisions. Monetary policy will need to stay alert to a re-emergence of inflationary pressures and preserve the regained room for manoeuvre. Fiscal consolidation remains essential to support disinflation and restore debt sustainability. Prudential policy needs to remain vigilant and continue the efforts to strengthen the resilience of the financial system. Structural reform efforts, which have flagged for too long, need to be revived to support higher sustainable growth and a better income distribution. Enhancing growth and resilience through reforms that foster competition, flexibility and innovation will improve economic well-being and ensure the capacity for effective macro-stabilisation policy responses, when the need arises.

This chapter reviews economic and financial conditions over the past year. It then discusses the key pressure points and lays out scenarios for how they might threaten a smooth landing. Finally, it elaborates on the near- and long-term policy challenges.

The year in retrospect

On course for a smooth landing

The global economy proved resilient over the past year. Growth surprised to the upside across several major advanced economies (AEs), including the United States and Japan, as well as large emerging market economies (EMEs), such as India, Mexico and Brazil (Graph 1). At 3.2% for 2023, global growth exceeded expectations as of mid-2023, slowing only moderately from 3.5% in 2022. Fears of a global recession proved unfounded. Growth this year is expected to hold up at 3.0%. To date, the smooth-landing trajectory appears intact.

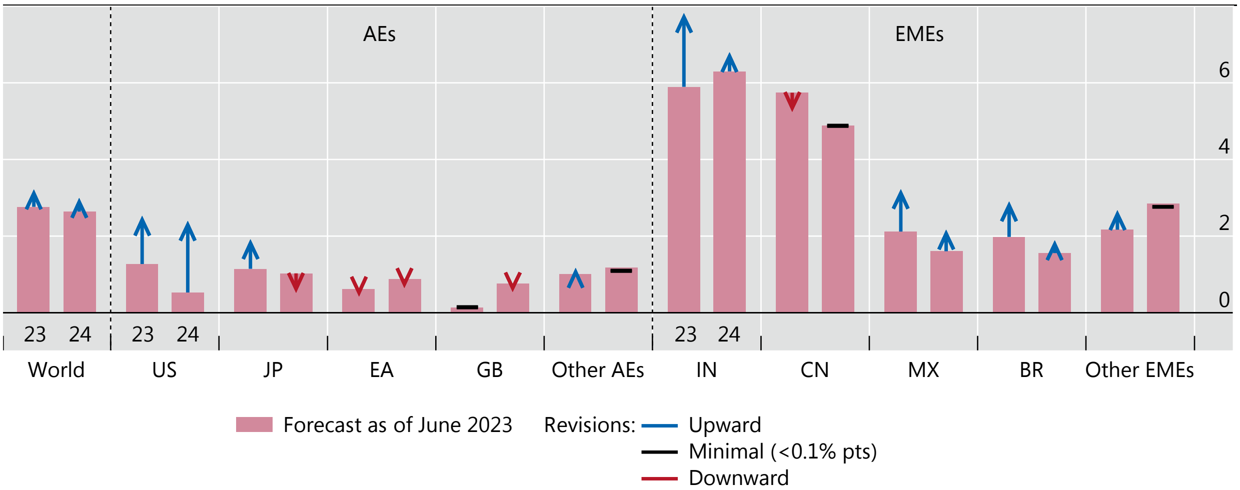
Two factors help explain this surprising resilience.

First, the labour market remained unusually buoyant in relation to output. Unemployment rates stayed close to pre-pandemic levels, edging up only slowly despite sharp monetary policy tightening. Based on historical relationships, the labour market was generally stronger than would have been predicted by output growth (Graph 2.A). Labour market tightness reflected the continued cyclical uplift from the services-led recovery, which is more labour intensive, and pandemic-related behavioural shifts.[1] This, in turn, lent support to household income (purple bars in Graph 2.B) and domestic demand, contributing to more resilient activity.

Second, the transmission of monetary policy to the real economy proved smooth and non-disruptive. One reason was the measured pass-through of monetary policy to financial conditions. Buoyant market sentiment kept risk spreads compressed and the financial system remained largely strain-free (see below). Importantly, the pass-through

Evolution of realised and forecasted output growth[1]

In per cent | Graph 1

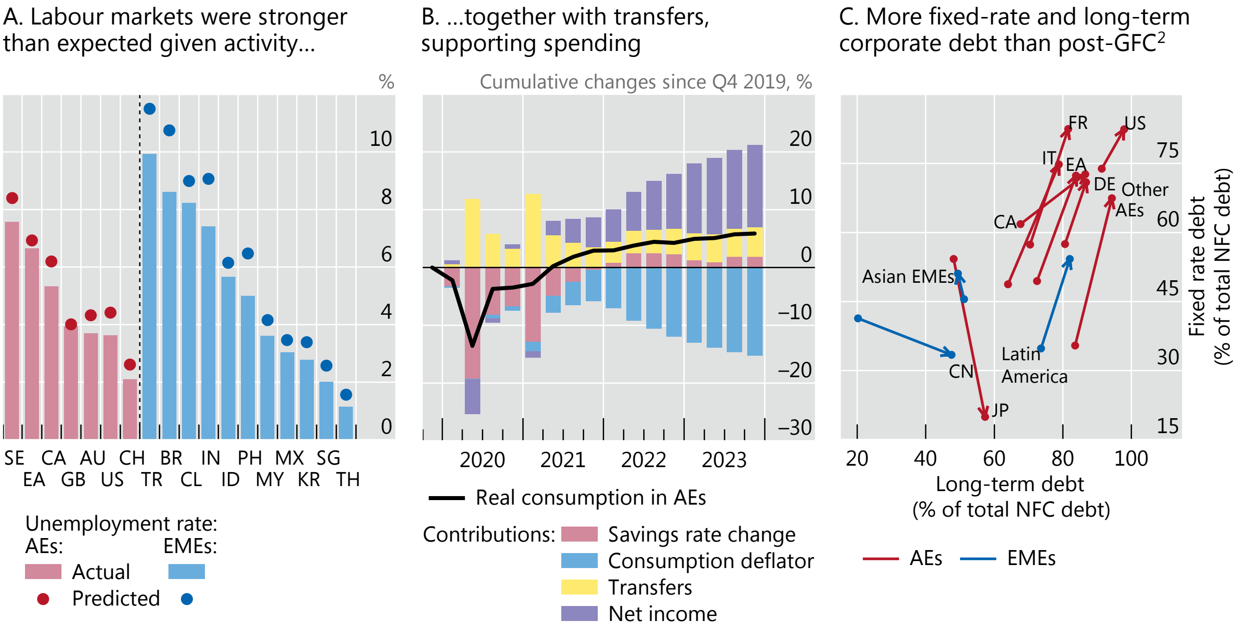


[1] For 2023, the starting point of the arrow shows the forecasted GDP growth for 2023 in June 2023, and the end point shows the realised GDP growth in 2023. For 2024, the starting point of the arrow shows the forecasted GDP growth for 2024 in June 2023, and the end point shows the latest forecast (as of May 2024) for GDP growth for 2024.

Sources: IMF; Consensus Economics; BIS.

Several factors sustained economic resilience[1]

Graph 2



[1] See technical annex for details. [2] NFC = non-financial corporation. The start (end) of an arrow represents 2010 (2023).

Sources: OECD; LSEG Datastream; S&P Capital IQ; national data; BIS.

from tighter financial conditions to real activity was dampened by robust household and corporate balance sheets. While private debt levels are high, the prominence of fixed-rate loans and the lengthening of loan maturities delayed the impact of higher rates on borrowers (Graph 2.C). More generally, large cash cushions allowed investment to remain robust, while excess savings from the Covid-19 era and the lingering effects of fiscal support, including energy subsidies (yellow bars in Graph 2.B), played a part in sheltering consumption.

EMEs were resilient, contrary to some earlier tightening cycles, reaping the benefits of stronger policy frameworks and domestic financial systems. Since the early 2000s, the shift towards inflation targeting and greater exchange rate flexibility, supported by larger reserves, had enhanced central bank credibility, helping to anchor inflation expectations and to reduce the pass-through of changes in the exchange rate to inflation (Chapter II). Stronger prudential regulation and supervision had strengthened the banking system's resilience. Fiscal policy frameworks had also improved somewhat, and many EMEs benefited from a greater market tolerance for government indebtedness, hence the broad stability of sovereign credit ratings despite much higher debt levels for many countries. A substantial reduction in currency mismatch in borrowers' balance sheets and the development of domestic-currency bond markets reduced the sensitivity of EME bond spreads to global financial conditions.[2]

Not all jurisdictions around the world proved equally resilient, however, and differences in growth became more apparent as the year progressed. Growth was remarkably strong in the United States, supported by substantial fiscal spending. Latin American economies, most notably Brazil and Mexico, performed well, also benefiting from proximity to the United States. By contrast, the euro area, the United Kingdom and several small open AEs registered barely positive growth. Economic activity was also typically weaker in central Europe and emerging Asia. Subdued global trade amid a continued manufacturing slump played a role, given some of these economies' reliance on exports. The greater impact of rising energy prices, especially in Europe, and smaller fiscal support also played a part. In China, domestic real estate woes continued to beset the economy and weigh on consumer confidence, prompting further policy support for the sector. Activity was held up by strong investment in manufacturing and infrastructure as well as by exports.

Sustained disinflation opened the door to a monetary policy pivot

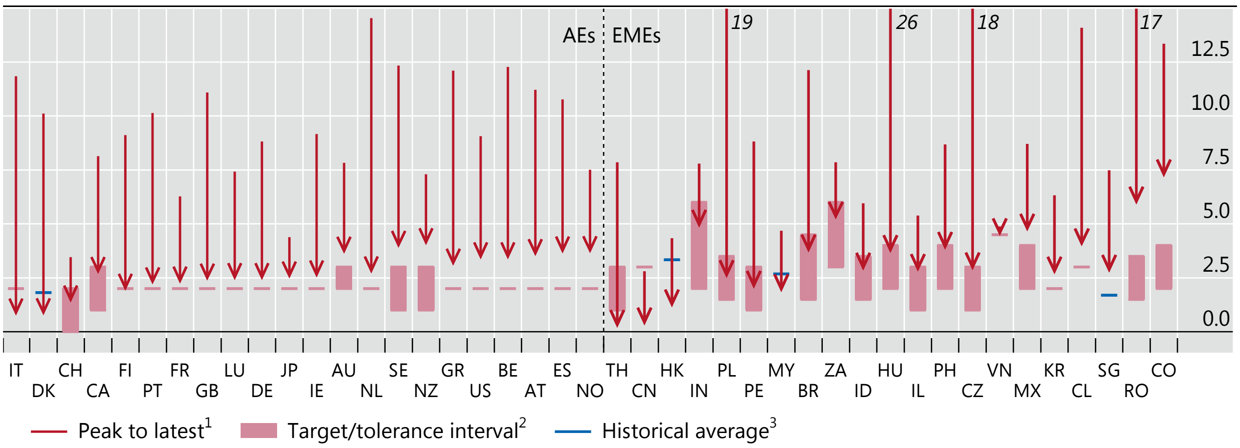
Global inflation continued to recede from the peak it reached in 2022. Inflation was back to around central bank targets across a range of countries, including several euro area economies (Graph 3). In the United States, the disinflation journey largely followed the forecasted path, notwithstanding the upside surprises in early 2024, and inflation remained a little above target. Most EMEs also saw inflation decline, with a few exceptions, such as Argentina and Türkiye. In both Latin America and Asia, disinflation was broad-based, with Thailand and China even seeing falling prices at one point. China's export drive may have acted as a global disinflationary force for importing countries (Box A).

The decline in inflation was common for both core and headline, but headline decreased more, especially in AEs. Headline inflation dropped below 3% in AEs and below 4% in EMEs (Graph 4.A). This was in large part due to commodity prices retreating from 2022 peaks, despite elevated geopolitical tensions (red line in Graph 4.B). By early 2024, contributions to inflation from food and energy had largely disappeared in AEs and had dropped significantly in EMEs (yellow bars in Graph 4.A).

Among core inflation components, moderation in price growth was more pronounced in (core) goods than in services. Benign supply chain conditions (blue line in Graph 4.B) and a continued rotation of spending from goods back to services (Graph 4.C) supported these patterns. The main inflation driver in AEs became services price growth, a more persistent component historically. Similarly, in EMEs, contributions to inflation from services doubled since 2021 and remained large, while contributions from food, energy and other goods shrank.

Inflation receded towards central bank targets

Year on year, in per cent | Graph 3



[1] Headline CPI used for cross-country comparability and may not correspond to the central banks' preferred measure. Peak since 2021. Countries are sorted by distance of the latest value of headline inflation relative to the target (midpoint for those with an interval). [2] Inflation targets are official point targets, target bands, tolerance ranges or unofficial objectives announced by authorities. [3] Monthly headline inflation average for 1990–2019.

Sources: LSEG Datastream; national data; BIS.

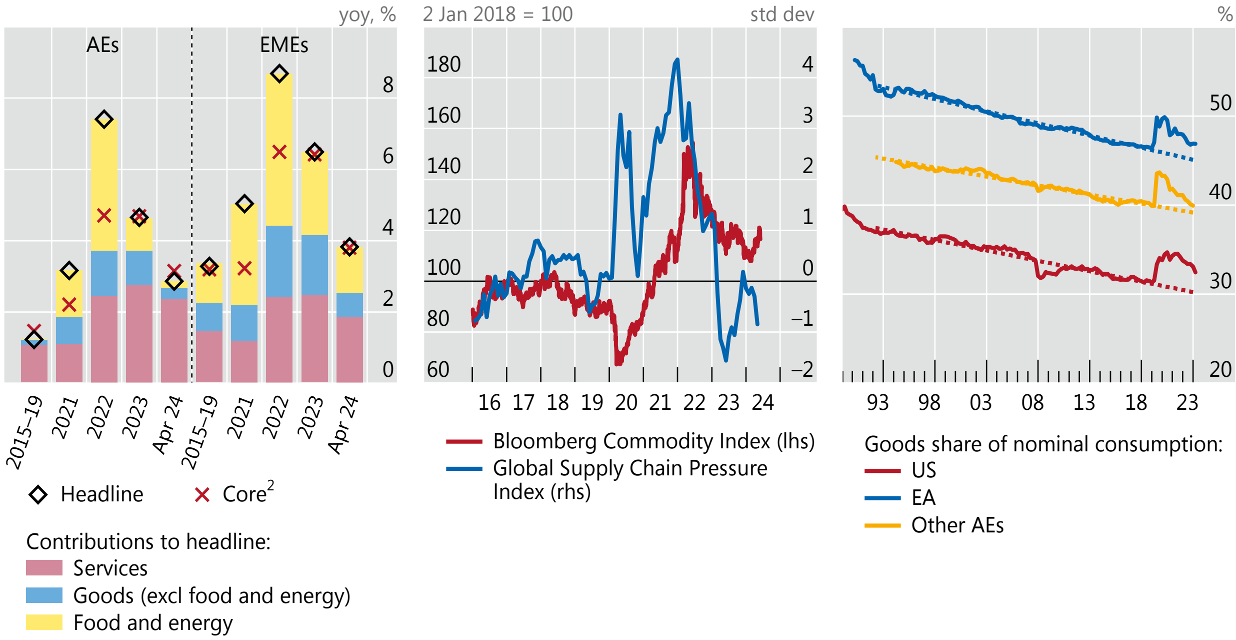
Inflation abated as commodities retreated and spending rotation reversed

Graph 4

A. Both headline and core inflation declined[1]

B. Commodity prices and supply disruptions down from 2022 highs

C. Spending started to rotate back to services[1, 3]



[1] See technical annex for details. [2] Core inflation does not add up to the sum of services (red bar) and goods (blue bar) because the sum shows the contributions to headline inflation. [3] Dashed lines correspond to trend based on 1993–2019 data.

Sources: OECD; LSEG Datastream; Macrobond; national data; BIS.

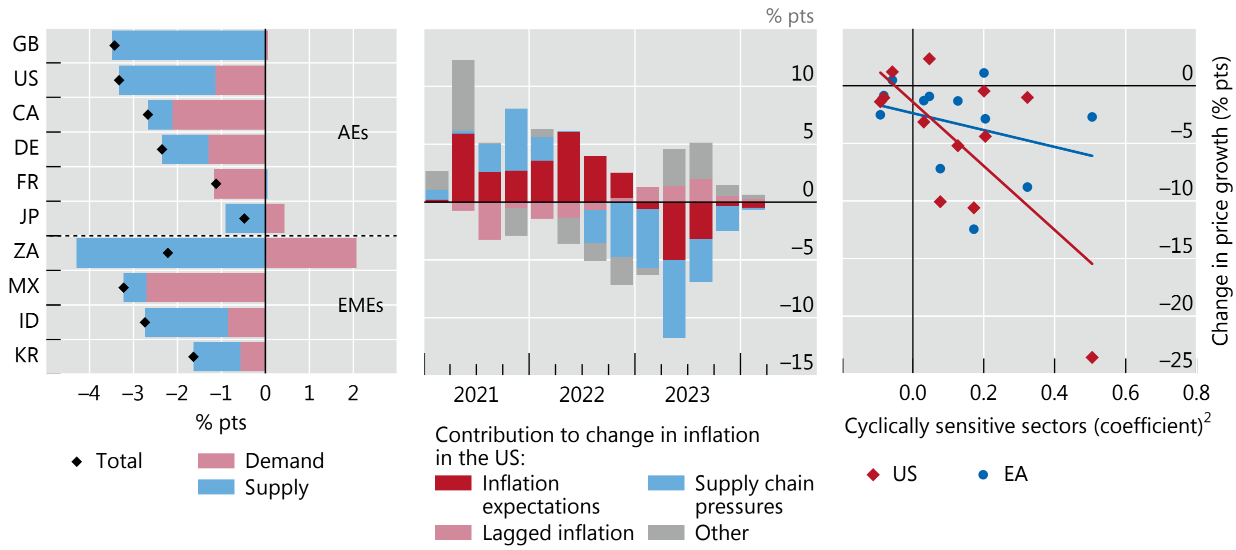
Both supply and demand contributed to disinflation[1]

Graph 5

A. Supply and demand contributed to the decline in inflation from peak

B. Anchored inflation expectations contributed to disinflation

C. Inflation dropped more for cyclically sensitive sectors



[1] See technical annex for details. [2] The sectors in order of highest to lowest cyclical sensitivity are: transport, housing and utilities, restaurants and hotels, education, food and non-alcoholic beverages, clothing and footwear, furniture, miscellaneous, recreation and culture, health, alcoholic beverages and tobacco, and communications.

Sources: Firat and Hao (2023); Federal Reserve Bank of Cleveland; Federal Reserve Bank of New York; Federal Reserve Bank of St Louis; OECD; Bloomberg; LSEG Datastream; BIS.

Box A

China as a disinflationary force

Declining prices in China have been delivering a disinflationary impulse to prices elsewhere. Through falling prices for its exports, as well as the impact of weaker domestic demand on commodity prices, developments in China are estimated to have reduced the annual rate of import price increases in other major economies by around 5 percentage points over 2023, on average. It can take time for such downward pressures to be fully reflected in consumer prices given that many of China's exports are intermediate goods (such as steel) or capital goods (such as machinery).[1] While these direct effects are the focus of this box, indirect effects are also likely to be arising from China's role as the marginal producer of many products, which would lead competitors from other countries to also reduce prices.

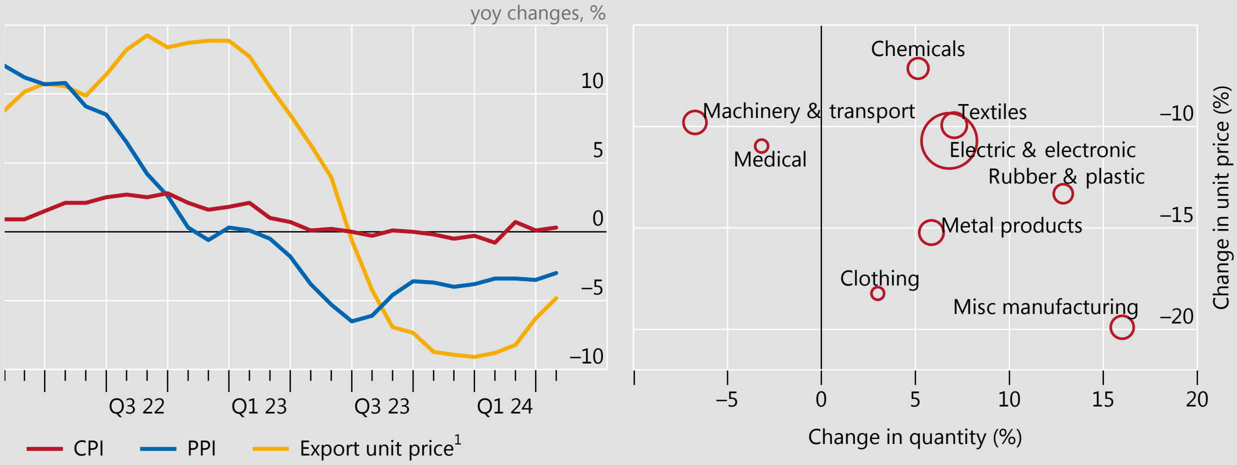
In China, headline consumer price index (CPI) inflation has been close to zero since April 2023 (Graph A1.A, red line). While declining food prices are part of the explanation, core inflation has also been weak: the level of core CPI was around the same in early 2024 as two years before. Producer prices have fallen by even more (Graph A1.A, blue line), although declines in producer prices are much more common than in consumer prices.

China's prices have weakened

Graph A1

A. China price indices

B. Changes in export prices and quantities by sector[2]



[1] Three-month moving average. [2] The changes are between H1 2023 and H2 2023; the size of the circle reflects the relative magnitude of total exports of the sector.

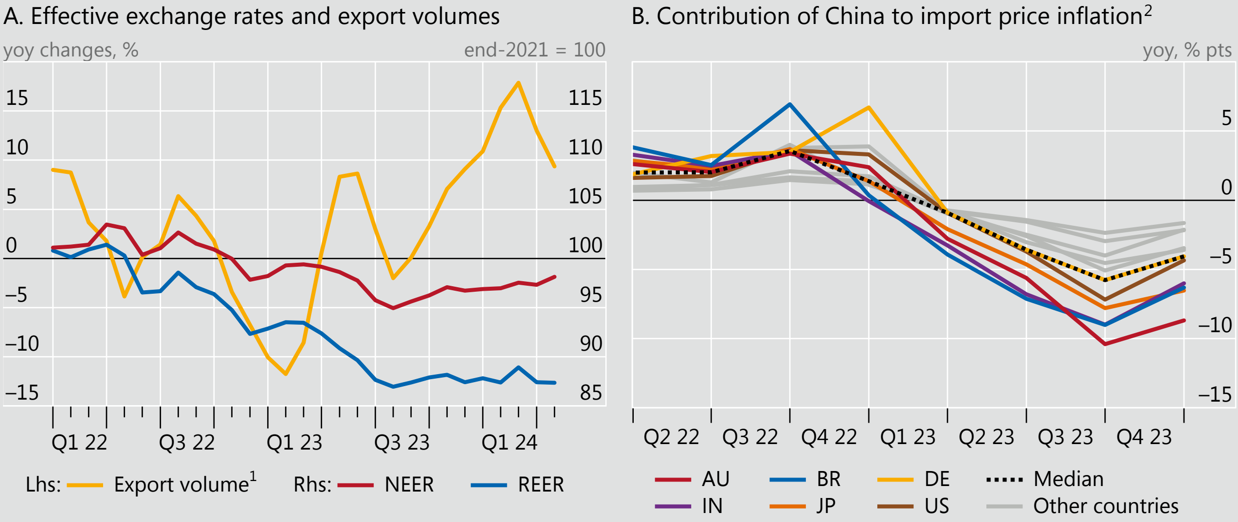
Sources: CEIC; Macrobond; BIS.

China's export prices have also fallen sharply (Graph A1.A, yellow line). Nearly all exporting sectors had seen price drops in 2023, with the steepest ones in labour-intensive sectors such as clothing and miscellaneous manufacturing (Graph A1.B). Not surprisingly, Chinese export volumes have grown significantly (Graph A2.A, yellow line). For iron and steel products, the export volume increased by 9.4% in the year to February 2024 while prices fell 15.7%, and for the automobile sector, the volume increased by 27.7% while prices fell 4.4%.

The depreciation of the Chinese yuan against many other currencies further boosted China's competitiveness, amplifying the impact of China's domestic disinflation on export volumes. Between early 2022 and early 2024, the nominal effective exchange rate fell by about 6% (Graph A2.A, red line). The combination of falling prices and a depreciating currency caused the yuan's real value to depreciate by 13% over the same period (Graph A2.A, blue line).

Declining prices in China have increasingly translated into lower import prices in other countries. Estimates based on four-quarter changes in export prices within the network of bilateral product-level trading relationships among 12 major countries indicate that, during 2022, China's exports added around 2 percentage points to the increase in import prices in its trading partners.[2] In contrast, by the third quarter of 2023 their median estimated effect was a 5.8 percentage point reduction, which moderated to 4.1 percentage points the following quarter (Graph A2.B). Looking at individual countries, the effect was stronger where Chinese exports made up a larger share, such as in Australia, Brazil and India.

China's disinflation is translating into lower import prices in other countries | Graph A2



NEER = broad nominal effective exchange rate; REER = broad real effective exchange rate.

[1] Three-month moving average. [2] Estimated effect of China on the year-on-year inflation rate of imported goods, following the approach in Amiti et al (2024). The sample consists of AU, BR, CA, CN, DE, ES, GB, IN, IT, JP, MX and US.

Sources: United Nations Comtrade; Macrobond; BIS.

While the effects on CPI are likely to build over time, elasticity estimates from other studies suggest that a 5.8 percentage point decrease in import prices would eventually translate into a 1.5 percentage point lower CPI inflation rate, on average, albeit with significant variation across countries.[3]

[1] Di Sano et al (2023) suggest that the effect of China's lower prices on euro area inflation is relatively limited, decreasing headline inflation by around 0.4 percentage points in the year to June 2023. However, given that 43% of Chinese exports to the European Union are intermediate goods, the impact takes some time to feed through supply chains to inflation. [2] This follows the approach in Amiti et al (2024), which provides an estimate of the contribution of each source country to import price inflation in each destination country at each point in time. [3] Goldberg and Campa (2010) assess the sensitivity of the CPI to import prices across 21 countries based on input-output tables for around the year 2000. The sensitivity varies from 0.07 for the United States to 0.56 for Ireland, with an average of 0.26. This implies that, on average, a 1% increase in import prices at the border is associated with a 0.26 percentage point rise in the CPI across these countries.

Both supply and demand factors played a role in the disinflation process. Distinguishing their respective contributions is difficult, but results from a range of stylised exercises can help shed some light.

One exercise, which distinguishes supply and demand based on the relationship between price and quantity changes, points to cross-country differences.[3] This analysis suggests that more than half of the decline in inflation from its peak reflects increased supply in the United Kingdom, the United States, South Africa, Indonesia and Korea (Graph 5.A). By contrast, weaker demand appears to have accounted for more of the inflation decline in Canada, France and Mexico.

A complementary simple regression exercise provides further insights by breaking down US inflation into the contribution of a wider range of factors (Graph 5.B). According to these estimates, the resolution of supply chain pressures explains a significant portion of the inflation decline since late 2022 (blue bars), confirming the importance of supply factors. Monetary policy has also played a key role (see Box B for further discussion). One important channel is by anchoring inflation expectations, following their upward drift during the inflation flare-up (red bars). Expectations of low and stable future inflation influence current spending as well as the price- and wage-setting decisions of firms and households; anchored expectations therefore limit second-round effects and in turn contribute to the actual decline in inflation in future. Another channel is by restraining demand. Indeed, sectors that are more sensitive to the output gap, such as transportation and food, experienced larger drops in price growth (Graph 5.C). Not captured in these estimates, the globally synchronised tightening has also had an impact by cooling commodity price increases.[4]

After a notable period of synchronisation, divergence eventually emerged in monetary policy stances across countries. With notable progress towards meeting their inflation targets, some central banks reduced policy rates and others signalled easing ahead. Most central banks in Latin America cut rates, after being among the first to tighten. Among AEs, the Swiss National Bank was the first to cut and was followed by Sveriges Riksbank, while the ECB and the Bank of Canada both lowered their policy rates in June. The Federal Reserve kept policy rates constant, reiterating the need for greater confidence in inflation converging to target before considering an easing.

Changes in policy rates in Asia were more moderate and varied, partly reflecting lower inflation in the region and greater use of other stabilisation instruments, such as foreign exchange intervention. The People's Bank of China eased monetary policy further in response to weak domestic conditions. The Bank of Japan increased the policy rate for the first time since 2007 in response to accumulated evidence that inflation could finally rise to the 2% target on a durable basis. Bank Indonesia raised rates, while several Asian EMEs intervened in foreign exchange markets to mitigate pressure on their currencies linked to interest rate differentials with AEs.

The financial system positioned for a smooth landing

Against this benign macroeconomic backdrop, exuberant financial markets anticipated a smooth landing, in part helped by a lack of major incidents like those in March 2023.

The prospects of lower policy rates and resilient growth, alongside improving earnings, propelled equity markets across most AEs and EMEs (Graphs 6.A and 6.B). The rally was particularly strong in technology stocks, which benefited from optimism related to artificial intelligence (AI). Valuation ratios of AI stocks reached lofty heights, above historical norms (Graph 6.C). China was a notable exception to this general picture, as stocks there slumped at the beginning of 2024 before partly recovering.

Credit markets also reflected the general risk-on sentiment. Credit spreads of investment grade and high-yield bonds continued their downward trajectory from mid-2022. They started the review period above historical norms but finished it deeply below (Graph 7.A). Despite such narrow spreads, corporate bond issuance remained subdued in both the euro area and the United States.

The optimism in financial markets contrasted with more cautious central bank communication. While taking cues from incoming data and policy announcements, market participants anticipated more monetary easing ahead than central banks did for much of the period, especially in the United States. Accordingly, they paid less attention to inflation surprises than the Federal Reserve (Graph 7.B). Still, the perception gap narrowed over time (Graph 7.C), and markets converged to central bank assessments by the second quarter of 2024 amid renewed inflation concerns.

On balance, global financial conditions tightened during the review period, despite the risk-on mood. They tightened sharply in the third quarter of 2023 and loosened through end-2023, finishing the review period tighter than where they started and tighter than historical averages (Graph 8.A). Conditions danced to the tune of evolving perceptions of the degree of monetary easing ahead. Uncertainty about the future path of interest rates was high, to the point that bond volatility hovered well above equity volatility – a rare occurrence. The gap between the two volatilities

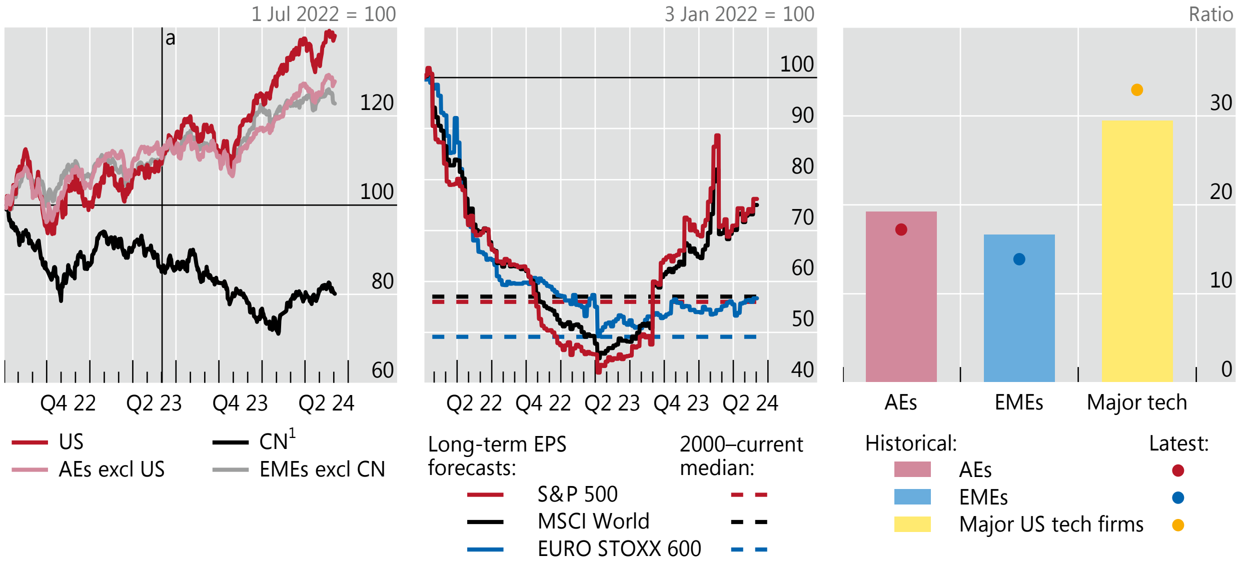
Equity markets rallied as earnings improved

Graph 6

A. Global stock markets rallied, with the exception of China...

B. ...as expected earnings improved[2]

C. Price-to-earnings ratios for major tech firms remained above norms[3]



[a] Start of period under review (1 June 2023).

[1] Shanghai Shenzhen CSI 300 equity index. [2] EPS = earnings per share. Current shows latest figures as of 31 May 2024. [3] See technical annex for details.

Sources: IMF; Bloomberg; LSEG Datastream; LSEG Workspace; BIS.

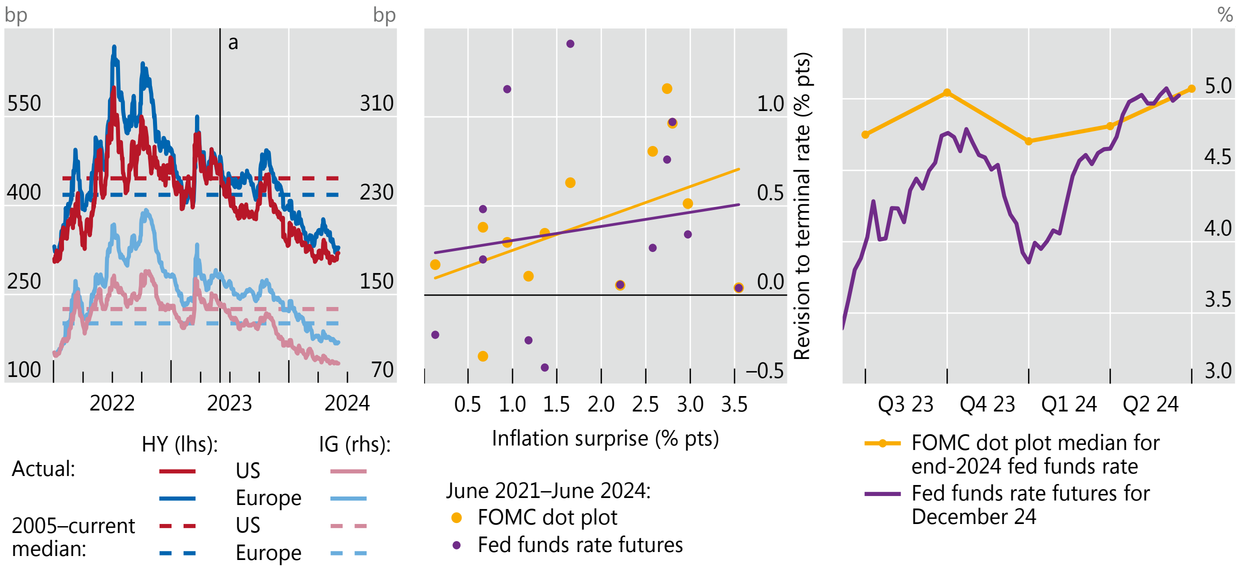
Spreads narrowed, market expectations converged to central bank assessments[1]

Graph 7

A. Corporate spreads narrowed[2]

B. Inflation surprises influenced terminal-rate expectations

C. Market expectations converged to that of the central bank



[a] Start of period under review (1 June 2023).

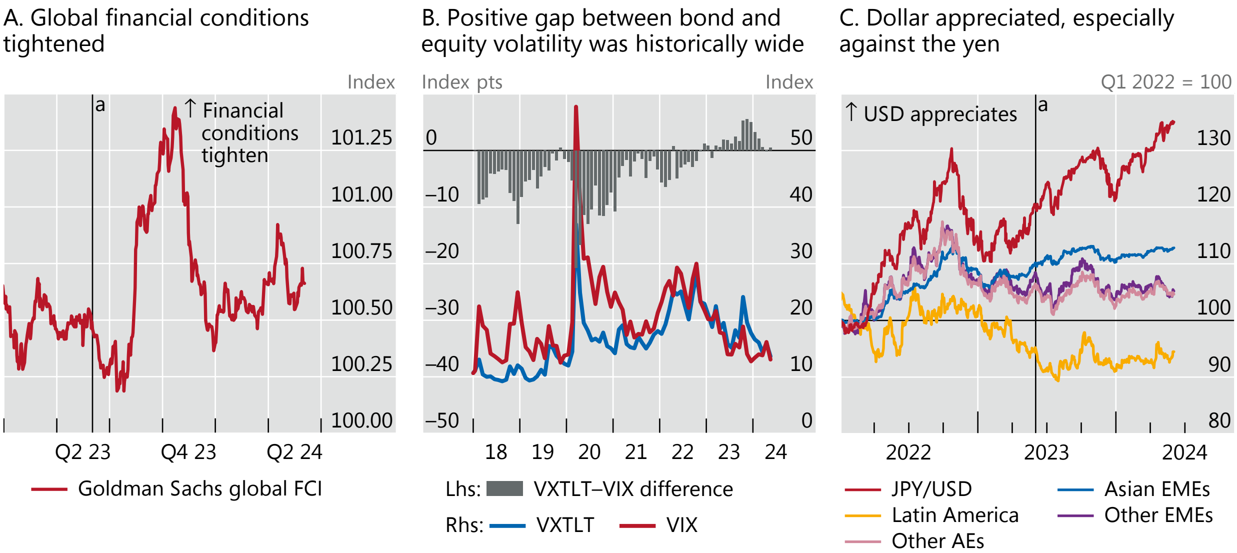
[1] See technical annex for details. [2] HY = high-yield; IG = investment grade.

Sources: Board of Governors of the Federal Reserve System; Bloomberg; ICE Data Indices; BIS.

was positive for most of 2023 and 2024 – and the widest in 20 years – unlike in previous years (Graph 8.B). In contrast to past risk-on episodes, the dollar appreciated (Graph 8.C). Notably, the Japanese yen dropped to record lows against the dollar, on account of interest rate differentials.

In contrast to the exuberance in financial markets, bank lending remained cautious. Banks reported tighter lending standards (Graph 9.A) and weaker demand

Risk-on phase contrasted with high bond volatility and a stronger dollar[1] Graph 8

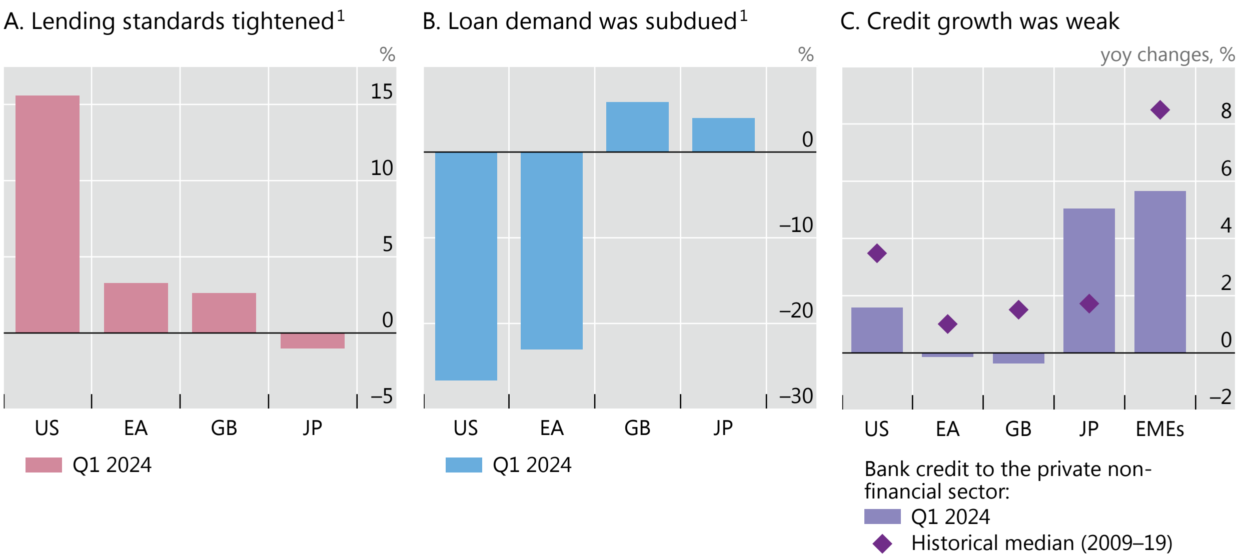


[a] Start of period under review (1 June 2023).

[1] See technical annex for details.

Sources: Bloomberg; Goldman Sachs Global Investment Research; LSEG Datastream; BIS.

Lending standards were tight, loan demand and credit growth were weak Graph 9



[1] See technical annex for details.

Sources: LSEG Datastream; national data; BIS.

Box B

The role of monetary policy in the recent inflation episode

Inflation has declined considerably following the strongest surge seen in decades. The effects of the robust post-pandemic rebound in aggregate demand, further boosted by fiscal and monetary policies, have faded, while those of the rotation in demand are still under way. Supply chain disruptions and war-induced commodity price shocks have ebbed. But monetary policy has also played an important role. This box examines the impact of monetary policy through the initial burst and subsequent decline of inflation.

At the onset of the inflation spike, the stance of monetary policy was extraordinarily accommodative. Indeed, in response to the pandemic, central banks globally cut policy interest rates to historical lows, and some stepped up asset purchases. This came on top of the unusually long period of extraordinarily easy policy that had followed the Great Financial Crisis, given the persistent shortfall of inflation from point targets. While inflation flared up in early 2021, major central banks began to lift rates only one year later, partly due to uncertainty about its persistence after the long period of very subdued price increases (Graph B1.A). With the benefit of hindsight, the exceptional degree of accommodation put in place to support the economy probably contributed to the surprisingly strong rebound in economic activity, increasing the risk of second-round price adjustments.

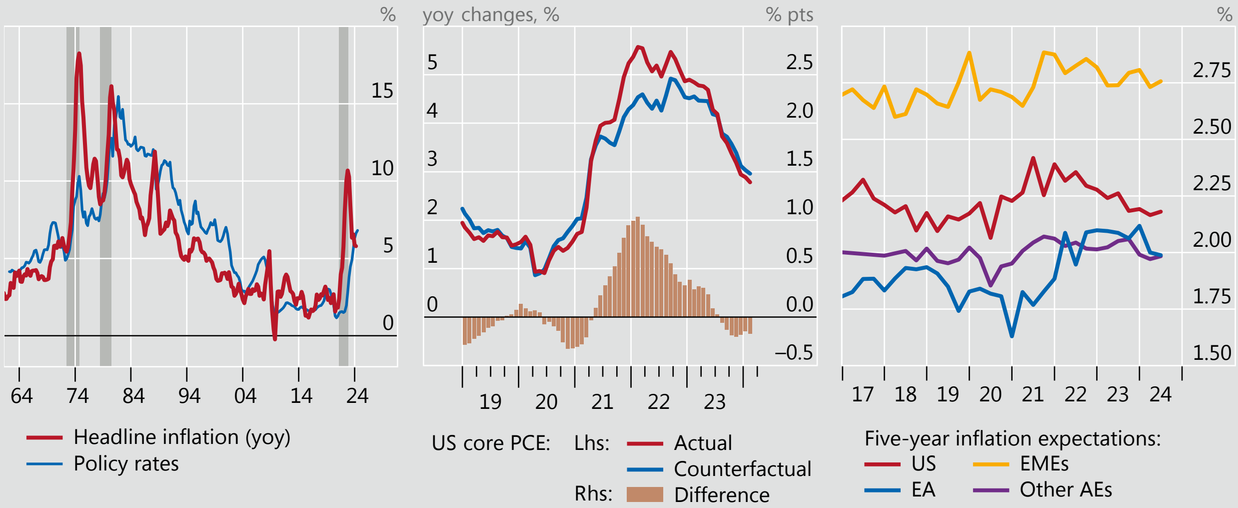
Monetary policy and inflation

Graph B1

A. Inflation bursts prompted a delayed but sharp policy tightening[1]

B. Monetary policy contributed to latest inflation surge and retreat[2]

C. Decisive policy actions anchored medium-term inflation expectations[3]



[1] GDP-PPP weighted averages for 10 AEs (AU, CA, DK, EA, GB, JP, NO, NZ, SE and US) and 10 EMEs (CL, CO, IN, KR, MX, MY, PH, TH, TR and ZA). Shaded areas represent persistent inflation periods. [2] Simulation based on a Bayesian vector autoregression (BVAR) model of core personal consumption expenditures (PCE) inflation, output gap, financial condition index and monetary policy stance index (an optimally weighted average of policy rate and balance sheet size). Blue line is the counterfactual inflation outcome assuming zero monetary policy shocks, identified through sign restrictions. Methodology based on Mojon et al (forthcoming). [3] Median across countries within regions. Other AEs = AU, CA, CH, DK, GB, JP, NO, NZ and SE.

Sources: Mojon et al (forthcoming); Congressional Budget Office; Federal Reserve Bank of Chicago; Federal Reserve Bank of St Louis; Consensus Economics; national data; BIS.

As the full extent of inflationary pressures became apparent, monetary policy responded forcefully to rein in inflation. Central banks raised policy rates to two-decade highs, keeping them there even as inflation began to come off the peak. Central banks also clearly signalled their willingness and determination to act as needed to return inflation to target. These decisive policy actions illustrated central banks' commitment to price stability and helped to restrain demand, a key force that had pushed inflation higher.

To quantify the role of monetary policy, one approach is to appeal to historical relationships and ask what has been different this time. Focusing on the United States, the exercise uses a time series model to capture the joint evolution of inflation, monetary policy and other key macroeconomic variables, and identifies the effects of monetary policy as those consistent with theory. The exercise then compares the actual outcomes with one where monetary policy would have reacted more promptly to the inflation burst, in line with the past reaction function. The comparison suggests that the initial slow response of monetary policy to inflation did contribute to price pressures. Had monetary policy kept pace with macroeconomic developments, in line with past patterns, and tightened earlier, core personal consumption expenditure (PCE) inflation would have been around 1 percentage point lower than the actual peak of 5.6% in early 2022 (Graph B1.B). The analysis also indicates that this effect was temporary, as the subsequent swift policy tightening brought the monetary stance in line with past behaviour. Higher interest rates associated with this catch-up in turn contributed importantly to the disinflation observed since mid-2023.

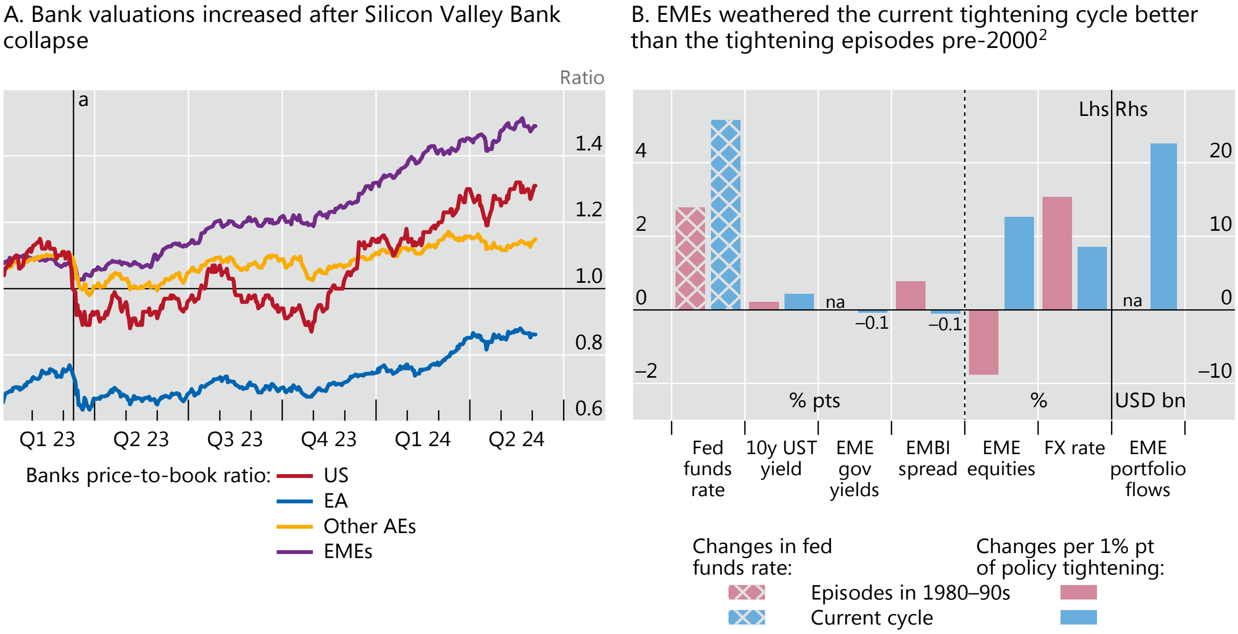
The preceding analysis, subject to the usual caveats of any statistical model, does not directly capture a key role played by monetary policy: anchoring economic agents' expectations to a low-inflation regime. In a low-inflation environment, such anchoring is relatively trivial because households and businesses pay little attention to inflation. But as inflation rises, it can quickly draw public focus. A strong monetary policy response becomes crucial in pre-empting a transition to a high-inflation regime. Without it, the central bank's commitment to price stability could be called into question, resulting in a much higher and more persistent inflation surge (see Chapter II).

Indicators of inflation expectations confirm this role. Central banks' forceful policy tightening appears to have kept them in check. Although medium-term inflation expectations ticked up in some cases early on, they eventually settled within the pre-pandemic range (Graph B1.C).

for credit across major AEs (Graph 9.B). Credit growth was generally subdued in major AEs, except Japan, as well as in EMEs (Graph 9.C).

The financial system remained resilient despite the challenges posed by the higher interest rate environment. Some signs of strain did emerge. US regional banks were in the spotlight again, following losses in New York Community Bancorp. And Chinese banks remained under pressure as the problems in the real estate sector continued. That said, the strains were localised and were nothing like those seen in March 2023 among regional banks in the United States or in Europe, where a global systemically important bank, Credit Suisse, had gone under. And any incipient stress was absorbed in an orderly manner. Bank valuations recovered (Graph 10.A), and

Banks remained resilient and EMEs weathered the tightening cycle well[1] Graph 10



[a] Silicon Valley Bank (SVB) announced capital raising (9 March 2023).

[1] See technical annex for details. [2] Changes relative to the month prior to the first policy rate hike, scaled by the corresponding increase in the policy rate (except for the policy rate itself). na = not available.

Sources: Federal Reserve Bank of St Louis; Bloomberg; EPFR; JPMorgan Chase; LSEG Datastream; national data; BIS.

capital ratios remained stable or improved. Despite one of the most synchronised and fastest tightening cycles in AEs, financial markets in EMEs managed to weather the change very smoothly compared with past episodes (Graph 10.B).

Pressure points

A smooth landing is the central scenario, but several pressure points remain. Four stand out: the underlying inflation trajectory, the macro-financial backdrop, fiscal positions and productivity growth. These pressure points, and their interactions, could compromise the expected benign outcome.

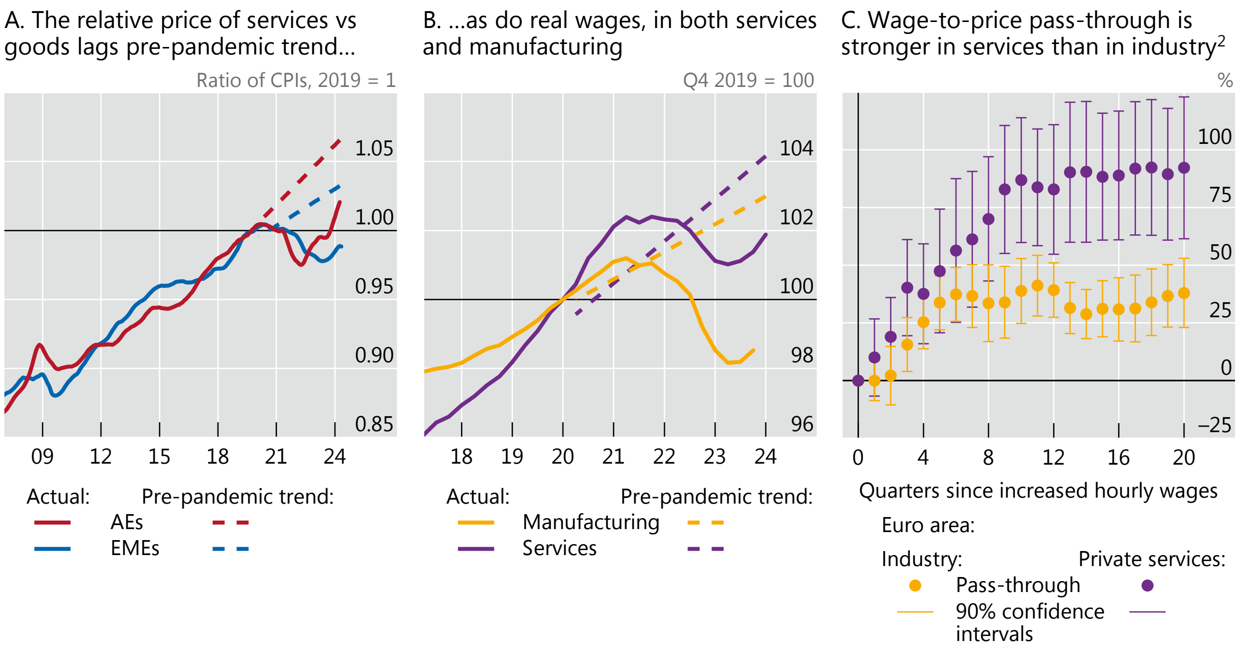
Inflation pressure points

Despite encouraging progress to date, two key and closely related relative price adjustments could stretch out the path towards inflation targets.

The first relative price adjustment is that of core goods versus services. The powerful pandemic-induced sectoral shifts in demand interrupted the decades-long entrenched trend of services prices outpacing core goods prices (Graph 11.A).[5] The initial plunge in the relative price of services vis-à-vis core goods has partly unwound following the resolution of supply disruptions and the fall in commodity prices. Indeed, most of the recent disinflation has been driven by goods prices; services inflation has proven more stubborn, and its contribution to overall inflation has increased.

Despite the recent unwinding, the relative price of services vis-à-vis goods remains below the pre-pandemic trend in most economies, and a further adjustment is likely. The price of services vis-à-vis core goods in EMEs is still well below its 2019

Two key relative price adjustments are still incomplete[1] Graph 11



[1] See technical annex for details. [2] Cumulated response at different horizons (in quarters) of producers' price indices in the industrial and services sectors to a 1 percentage point increase in hourly wages.

Sources: Amatyakul, Igan and Lombardi (2024); Ampudia et al (2024); Eurostat; OECD; LSEG Datastream; national data; BIS.

pre-pandemic ratio, while it has just recently crossed it in AEs. In both cases, the relative price remains below the previous trend. Unless the pandemic-induced disruptions have permanently altered preferences or productivity patterns, the upward trend in the relative price would re-establish itself. If lower core goods price growth does not compensate for the shortfall, the upward pressure on inflation could be sizeable (see scenario 1 below).

There are signs that are consistent with this risk. Demand for services has been growing more strongly than that for goods in many economies – an indication that consumers are reverting to pre-pandemic preferences. Input – most notably labour – cost pressures also remain more pronounced for services. Admittedly, core goods price growth could slow further, including owing to developments in China (Box A). That said, goods price increases could gather pace at some point, given the indications of greater fragmentation in the global economy.

The second relative price adjustment is that of labour versus consumer goods and services, ie real wages. As inflation surged, real wages plummeted across most jurisdictions, and have yet to recover despite robust labour markets (Graph 11.B). The catch-up may take time and be less than complete if workers' bargaining power remains as limited as it was before the pandemic.[6] Even so, there is a risk that sustained robust conditions in labour markets lead to persistent wage demands in excess of growth in productivity. And since terms of trade effects have largely dissipated, there is no obvious reason why real wages should not catch up. These pressures could remain in the pipeline even after inflation subsides, especially in jurisdictions where wage bargaining is more centralised and staggered. If the purchasing power lost in the recent inflation burst were recouped in the coming years, there could be significant upward pressure on inflation (see scenario 1 below).

The risks are related because services are more labour-intensive than goods. This is one reason why price growth in the services sector generally tends to be more persistent. It also helps to explain why the pass-through from wages to prices tends to be higher in that sector. For example, estimates based on the euro area suggest that the pass-through is twice as large in the private services sector than in industrial sectors. Moreover, the lags are significant, about two to three years (Graph 11.C).[7]

In addition to the incomplete adjustment of relative prices, other pressure points are noteworthy.

Rather mechanically, the withdrawal or expiration of support measures could unleash new short-term price increases. In particular, fuel subsidies are still substantially above pre-pandemic levels, highlighting the significant role of fiscal policy in containing living costs. Lifting the subsidies is essential, both from a fiscal sustainability point of view and to avoid medium-term inflationary pressures. But, as was clear from the outset, dismantling them will have short-term costs in terms of inflation and make the disinflation journey bumpier.

In addition, further disruptive supply side shocks cannot be ruled out, particularly in the current geopolitical environment. Tensions could flare up and have a significant impact on commodity prices in particular. After a long period of inflation well above target, further shocks would be more likely to threaten a shift to a high-inflation regime, as behaviour adjusts to the recent more inflationary experience.

Macro-financial pressure points

Although the financial system has been resilient so far, macro-financial imbalances could unwind and cause headwinds due to historically high levels of debt and debt service costs. As the impact of pandemic-era loan assistance programmes fades, some households and businesses might find themselves in a precarious position. The cumulative effects of policy tightening could then carry momentum.

Indeed, particularly in AEs, there are signs that the financial cycle has peaked, as credit indicators and real property prices start returning to their longer-term trends (Graph 12.A). Typically, this is a harbinger of credit losses ahead and weaker economic activity.[8] Historically, financial stress tends to show up within two to three years following the first rate hike, as loan impairment ratios rise and economic activity weakens (Graph 12.B, yellow and blue lines, respectively).[9] The current cycle is still in very early stages of the post-peak phase (red and purple lines). This historical comparison suggests that it is typical for stress to emerge only with a lag. The risk is higher the longer interest rates stay up, putting pressure on borrowers that need to refinance their debts, especially once the pandemic support that kept defaults artificially low fades.

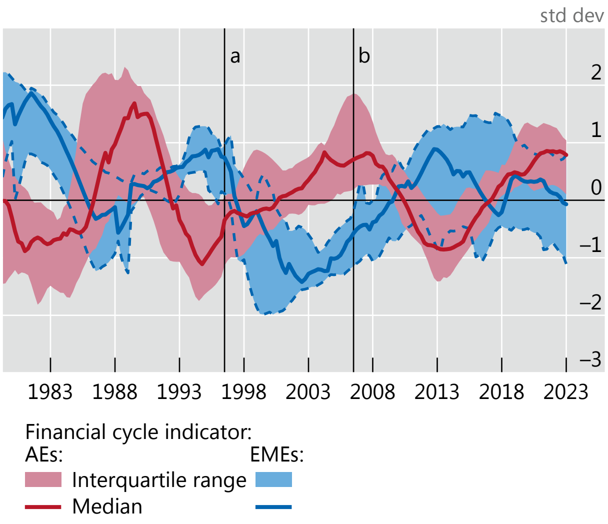
Within this broad picture, several pressure points merit particular attention.

First, deteriorating balance sheets in the non-financial sector and dwindling savings buffers could cause domestic demand to falter. Even for those households benefiting from large fiscal support, excess savings have run out or diminished substantially (Graph 13.A).[10] As maturity walls are hit (Graphs 13.B and 13.C), the need to roll over debt at higher interest rates could further dent the financial buffers of households and firms. The cumulative effects of past monetary tightening could generate a materially stronger contractionary effect on domestic demand than seen in the last few years.

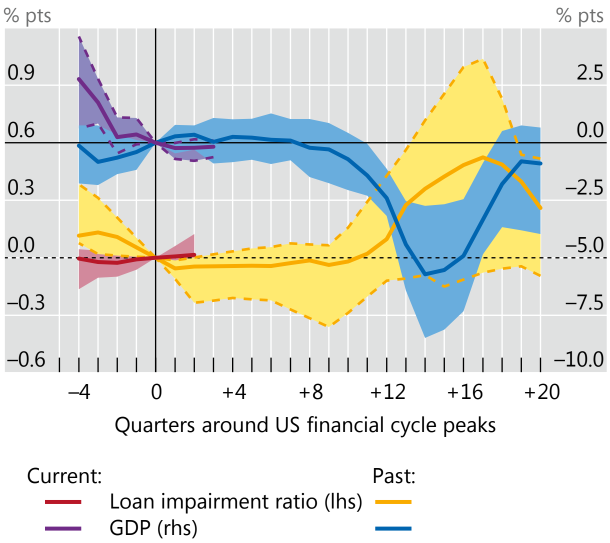
Second, and more specifically, commercial real estate (CRE) is facing both cyclical and structural headwinds (Box C). CRE bankruptcies could impact banks' lending capacity and overall financial health. Signs of possible future stress in the sector appeared initially in 2023, with losses on US CRE exposures crystallising in the books of a few US regional banks and banks elsewhere. Major banks have also reportedly started increasing provisions in anticipation of future losses. So far, the banking system has proved resilient, but vulnerabilities could become evident if exposures to CRE are underreported and if prices drop more than expected.

The financial cycle is peaking[1] — Graph 12

A. Credit and property price indicators are returning to their longer-term trends…



B. …pointing to possible stress ahead[2]



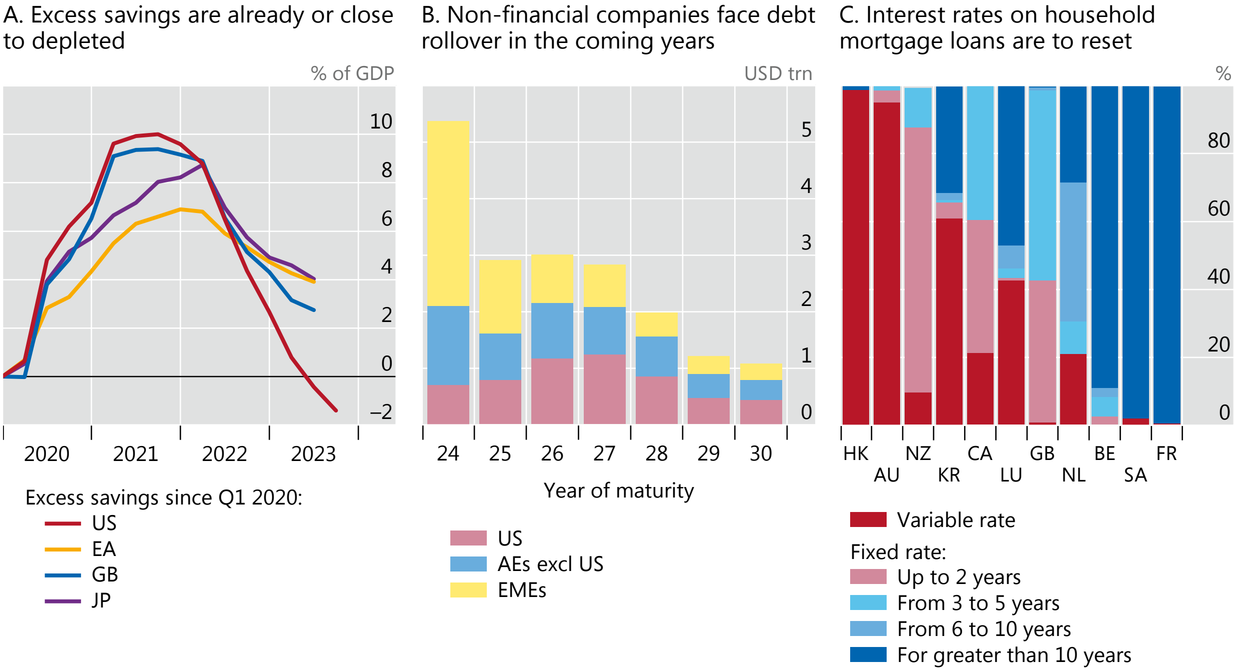
[a] Start of the Asian financial crisis (Q3 1997). [b] Start of the Great Financial Crisis (Q3 2007).

[1] See technical annex for details. [2] Lines show medians and shaded areas show interquartile ranges across countries.

Sources: Fitch; national data; BIS.

Private sector's financial buffers are diminishing[1]

Graph 13



[1] See technical annex for details.

Sources: De Soyres et al (2023); CGFS (2023); Board of Governors of the Federal Reserve System; S&P Capital IQ; national data; BIS.

The macro-financial impact of a large CRE correction could be significant. In the 1990s, when CRE prices fell by over 40% in real terms, credit and GDP growth dropped by 12 and 4 percentage points, respectively (Graph 14.A). An econometric estimate of macro-financial responses to CRE price shocks suggests a sharp fall in CRE prices this time could have a similarly material impact on credit and GDP growth (Graph 14.B). While naturally uncertain, these estimates highlight the possible repercussions of a CRE bust. And the impact could be amplified by credit losses or a broader drop in other asset prices. Indeed, the risk of such a drop looms large for the residential segment of real estate markets, where house price valuations continue to be very stretched relative to in the past (Graph 14.C).

Third, nonbank financial intermediation merits close monitoring. In particular, private credit and equity markets have grown exponentially in the post-Great Financial Crisis (GFC) years of cheap financing (Box D).[11] This has increased their vulnerability to higher interest rates. Despite the recent drop in credit spreads, the gap between those in the riskiest and those in other loan segments has increased (Graph 15.A), highlighting pockets of vulnerability. Opaque valuations and infrequent updates of these valuations might create a lagged reaction of private markets to a potential correction in public markets. A correction in private equity and credit could spark broader financial stress via at least three channels. First, investors might liquidate assets elsewhere, potentially transmitting the shock to other market segments. Insurance companies could be quite vulnerable given their increased exposure to private credit (Box E). Second, firms that tap the market could find themselves squeezed, generating spillovers on their clients and the economy. Third, banks remain exposed to the sector, either directly or indirectly, not least as ultimate providers of liquidity.

Finally, a slowdown in the Chinese economy and troubles in its financial sector, particularly related to real estate, could spill over globally. The falling equity market

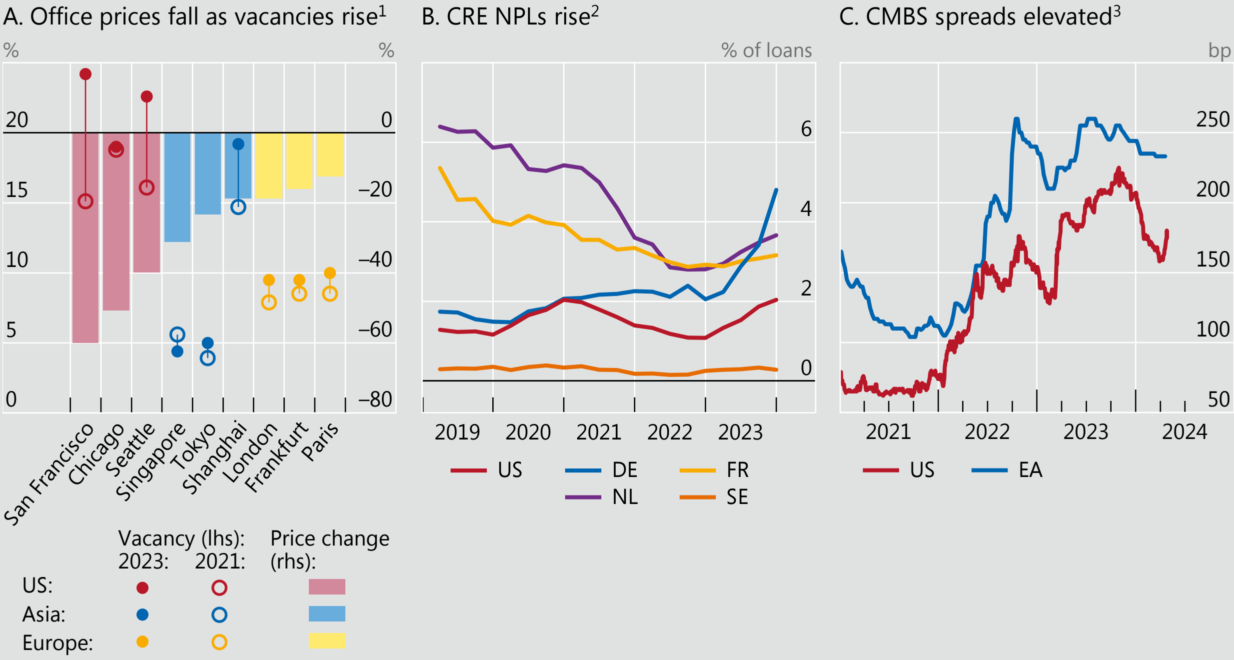
Box C

Commercial real estate risks in the spotlight

Commercial real estate (CRE) markets are smaller than residential real estate (RRE) markets, yet they present a greater risk to financial stability. Historically, it was losses on CRE, rather than RRE, that often caused financial crises.[1] The Covid-19 pandemic generated a structural shift in the demand for CRE, particularly office space. Compounded by a rising interest rate environment, this put downward pressure on prices in the sector, reducing valuations and creating losses for lenders. Such losses have already started generating stress at some banks and other financial intermediaries. These losses are poised to weigh on profits and may cause further strains – a risk recognised by authorities in a number of countries.[2]

Commercial real estate (CRE) prices are falling, risk is rising

Graph C1



[1] Top three cities in each area with largest price drop between Q4 2021 and Q1 2024. 2021 vacancy rate approximated by Q1 2022 value for Asia. [2] NPL = non-performing loans. [3] Commercial mortgage-backed securities (CMBS) spreads refer to the difference in yield between CMBS and a benchmark interest rate. For US, it is the five-year on-the-run AAA CMBS spread over the Secured Overnight Financing Rate (SOFR). For EA, it is the five-year euro CMBS spread over Euribor.

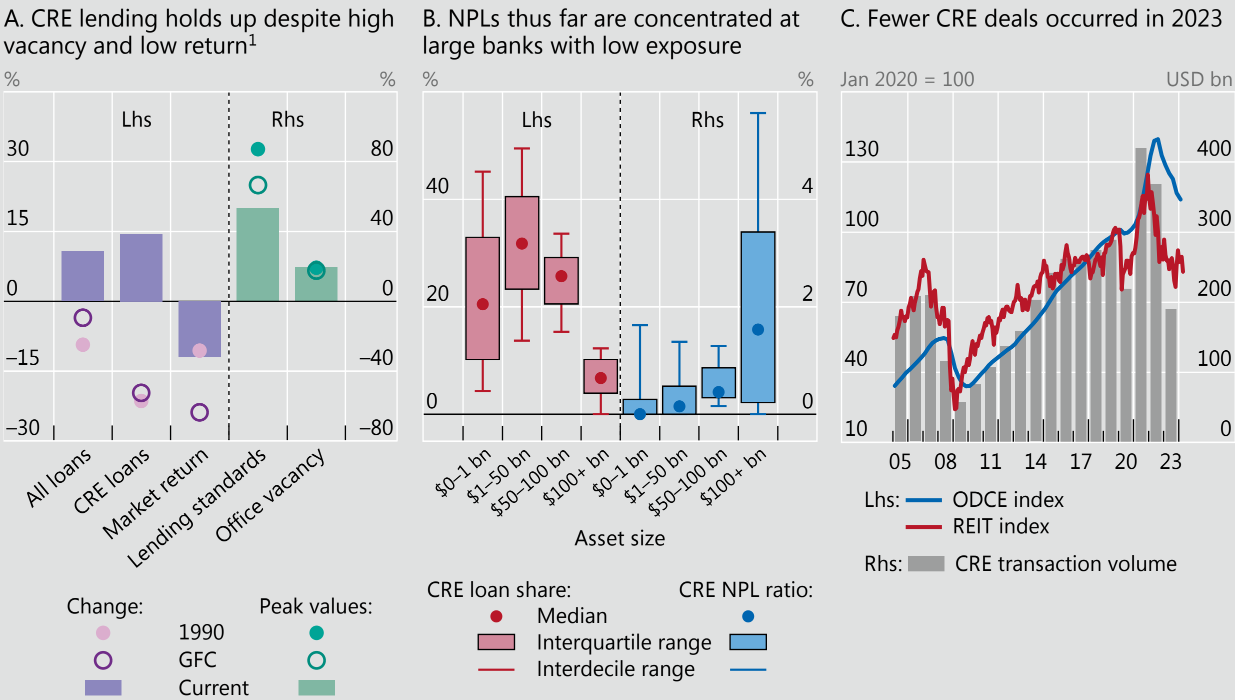
Sources: European Banking Authority; BankRegData; Bloomberg; CommercialEdge; JPMorgan Chase; Knight Frank; Macrobond; Statista; BIS.

The post-pandemic shift in the CRE landscape has affected property values worldwide. Vacancy rates in office CRE have risen in many large cities in the past two years, especially in the United States and China (Graph C1.A). Higher vacancy rates depress rent revenues and put downward pressure on property prices. CRE prices have declined in many countries, particularly in the office sector, with the largest drops in US cities.

Declining CRE prices have increased the risk of default and losses at financial intermediaries. Banks' non-performing CRE loans rose starting in 2022 (Graph C1.B). CRE makes up about 18% of bank loans in the United States, 12% in Germany and 10% in the Netherlands – countries where non-performing loans (NPLs) have risen sharply. While banks are typically the key lenders, non-bank financial institutions (NBFIs) have been playing a growing role and have seen risks materialise for example in commercial mortgage-backed securities (CMBS) (Graph C1.C).

In the United States, the impact on the financial system has not yet led to actual stress, as in past episodes. Vacancy rates are at an all-time high, bank lending standards have tightened, and thus far the decline in market returns for CRE investors has already exceeded that of the 1990 CRE stress (Graph C2.A). Despite this, however, credit to the CRE sector continues to expand, even at a faster pace than overall bank credit (same panel). This may stem in part from the distribution of CRE exposure and losses. While direct exposure to the CRE sector as a whole in the US banking system is largest at small and mid-sized banks, NPLs have thus far risen mainly among the largest banks, which account for most lending to the office sector in large cities (Graph C2.B).[3] Further, large banks have indirect exposure to CRE though the NBFIs they lend to, but also hold more capital and have more diversified business lines and income sources, and so are in a better position to absorb the losses.

Commercial real estate (CRE) in the United States | Graph C2



NPL = non-performing loans; ODCE = open end diversified core equity real estate fund; REIT = real estate investment trust.

[1] CRE loans consist of loans secured by real estate for construction, multi-family and non-farm non-residential. Market return is the National Council of Real Estate Investment Fiduciaries (NCREIF) total return index. Lending standards are the net percentage of banks reporting that they are tightening lending standards for CRE loans. Peak to trough periods for loans are Q3 1989–Q2 1993, Q4 2008–Q3 2012 and Q4 2021–Q4 2023 (there was no peak or trough in the current episode); and for market return, Q3 1990–Q4 1992, Q2 2008–Q4 2009 and Q3 2022–Q1 2024. Peaks for lending standards are Q1 1991, Q4 2008 and Q2 2023. Peaks for vacancy rates are 1991, 2010 and 2023.

Sources: Federal Deposit Insurance Corporation; Federal Reserve Bank of St Louis; Altus Group; BankRegData; Bloomberg; LSEG Datastream; BIS.

Even so, stress could materialise. While NPLs remain relatively low for now, provisioning for CRE loans has not kept pace with the rise in NPLs in some banks.[4] Furthermore, turnover of CRE properties was low in 2023, and so the true market value of many CRE assets is difficult to determine (Graph C2.C). The sustained CRE lending may reflect to some extent an "extend and pretend" strategy, as banks avoid crystallising losses in the near term in the hope of a reprieve from lower interest rates in the future. The recent divergence in prices between real estate investment trusts (REITs, traded on exchanges) and open end diversified core equity (ODCE) funds (only periodically appraised) suggests latent CRE losses throughout the financial system. This divergence not only points to artificially high valuations and unrecognised losses but also amplifies redemption pressures and increases the risk of a disorderly adjustment. Losses take time to materialise, and those that have been recognised were substantial in some cases, with price declines upwards of 40%.

While regulators have already identified many outlier banks, further vigilance is needed. Past CRE boom-bust cycles often preceded banking crises, such as in the case of Finland (1990), Japan (1991) and Thailand (1997), just to mention some of the more recent ones.[5] And even if system-wide indicators look fine, lenders of different sizes are poised to suffer losses in their CRE portfolios. History has repeatedly shown that stress in a few banks in a seemingly isolated market segment can have systemic repercussions.

[1] Zhu (2002) [2] For example, Federal Reserve, *Financial Stability Report*, October 2023; Deutsche Bundesbank, *Financial Stability Review 2023*. [3] Glancy and Wang (2023). [4] S Gandel, "Bad property debt exceeds reserves at largest US banks", *Financial Times*, 20 Feb 2024. [5] Hilbers et al (2001).

and capital outflow pressures were reflected in various indicators, including a widening cross-currency basis (Graph 15.B), which sent some warning signs about the state of the economy. And while policy support has provided an important backstop, it has

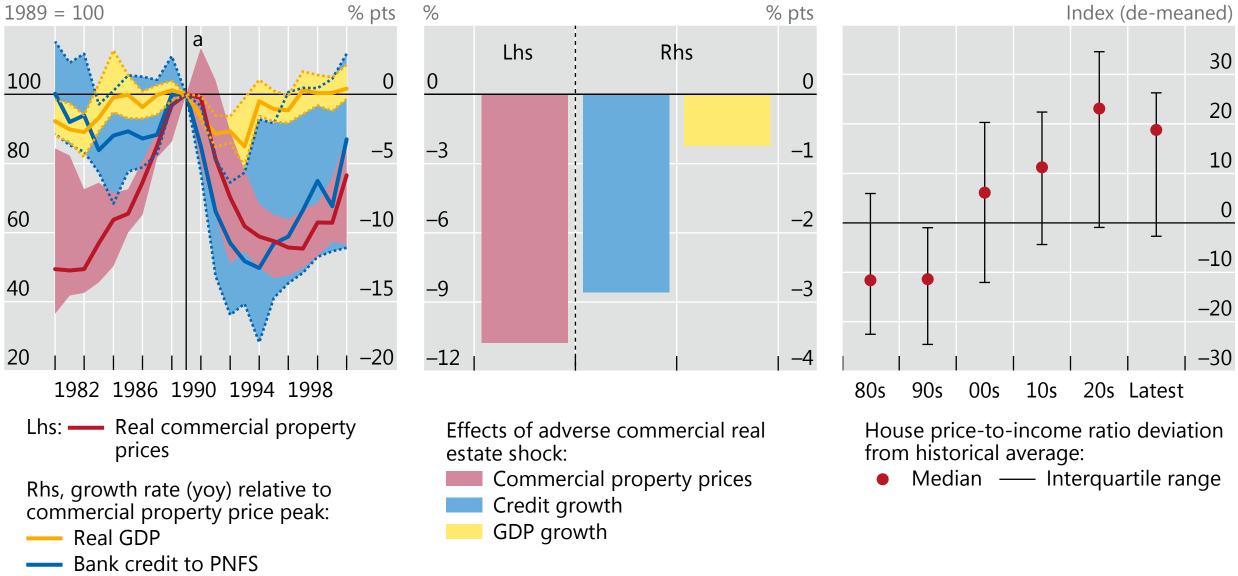
Sharp declines in real estate prices pose risk to outlook[1]

Graph 14

A. The commercial real estate price bust in the 1990s was costly[2]

B. A repeat today would disrupt the benign growth outlook

C. Stretched residential property valuations could add to risk



[a] Commercial property price peak (1989).

[1] See technical annex for details. [2] PNFS = private non-financial sector. Lines show medians and shaded areas show interquartile ranges across countries.

Sources: Borio et al (1994); Zhu (2002); OECD; Bloomberg; national data; BIS

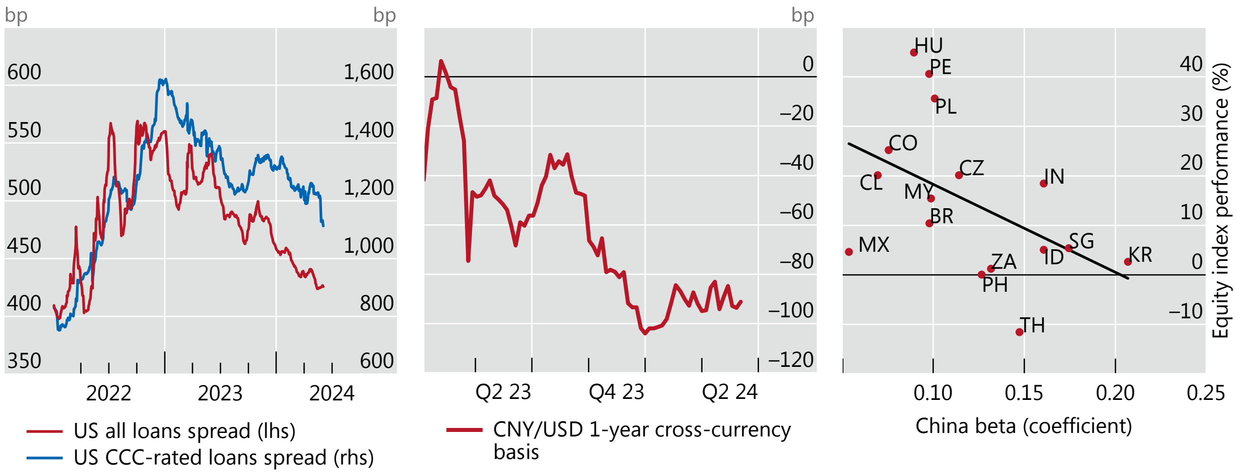
Chinese FX swap markets and riskiest loan segments point to stress[1]

Graph 15

A. Loan spreads dropped, but those on riskiest loans declined less

B. Cross-currency basis for the CNY widened

C. Markets more exposed to China decreased more



[1] See technical annex for details.

Sources: Bloomberg; PitchBook Data Inc; BIS.

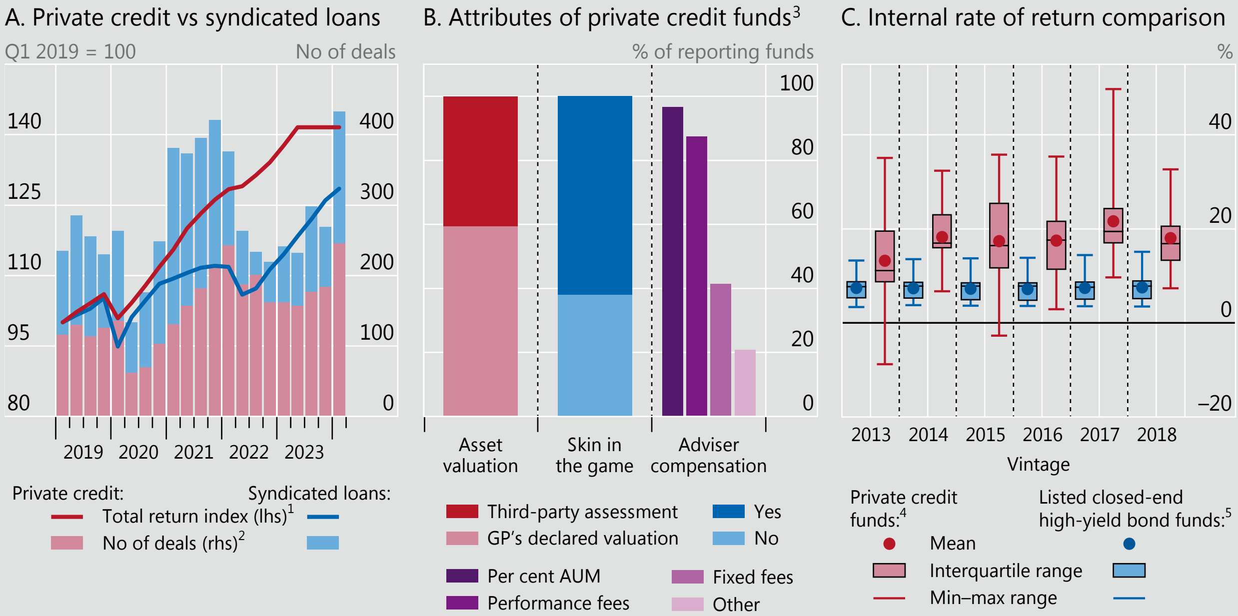
Box D

The challenge of private credit

Within the fast-growing ecosystem of private markets, the expansion of private credit has recently garnered significant attention. Private credit is predominantly intermediated through specialised closed-end funds and mostly takes the form of direct lending, outside commercial banks or securities markets. Assets under management (AUM) of private credit funds tripled over the past decade, rising by 50% in the post-pandemic period to an estimated $2.1 trillion. Close to 80% of private credit assets are in the United States, where their stock is comparable to the outstanding amounts of leveraged loans or high-yield bonds.[1] The restrained lending by banks during the recent tightening cycle and the temporary drop in syndicated leveraged loan issuance created the opportunity for private credit funds to make further inroads into areas traditionally dominated by banks (Graph D1.A, bars). This box discusses select drivers of rapid growth of private credit, issues surrounding the risk-return assessment in this asset class and broad implications for financial stability.

Private credit: features and comparisons with competing assets

Graph D1



[1] Private credit returns proxied with the Cliffwater Direct Lending Index (CDLI) and syndicated leveraged loans returns proxied with the Morningstar LSTA Leveraged Loan Index. [2] US deals only. [3] Based on the most recently available SEC filings of Form Uniform Application for Investment Adviser Registration (ADV) by private credit fund advisers, including business developed companies (9% of assets covered). GP = general partner. AUM = assets under management. [4] Distribution of internal rates of return as of Q4 2023, starting at five-year vintage, a typical horizon at which cash distributions to investors begin exceeding capital drawdowns. [5] Based on a sample of US and European high-yield closed-end bond funds, calculated based on income earned each quarter as a percentage of initial investment.

Sources: Bloomberg; Refinitiv Lipper; PitchBook Data Inc; US Securities and Exchange Commission (SEC); BIS.

Both credit demand and supply contributed to the rapid growth of private credit over the past decade. On the demand side, unrated firms, including highly indebted companies or small and medium-sized enterprises, which may struggle or be reluctant to borrow from banks or to issue debt in public markets, have been able to borrow from private credit funds. Typically, lending terms are highly tailored to borrowers' needs. Spreads are wider in private credit, reflecting in part the higher intrinsic credit risk of borrowers and the bespoke lending terms. In return, borrowers are not subject to the compliance costs imposed by securities regulation or banks' lending standards.

On the supply side, high rates of return and portfolio diversification motives have made private credit an attractive asset class for long-term investors, particularly during the search-for-yield period in the low-for-long environment. Total returns on private credit assets outpaced those on comparable asset classes, such as syndicated leveraged loans (Graph D1.A, lines). In terms of portfolio diversification, private credit is attractive because it gives exposure to a set of risks with, presumably, low correlations to public markets, and because the underlying volatility is smoothed, since there is no real-time market pricing and the assets are valued infrequently. Private credit fund managers thus raise capital from sophisticated long-term investors with minimal needs for immediate liquidity – mainly pension funds, insurance companies, endowment funds, sovereign wealth funds and family offices.[2]

Market intelligence suggests that private lenders proactively manage credit risk. They conduct wide-ranging due diligence to gain an understanding of borrowers' business and cash flow profiles, with the associated costs passed on to the lending rates or as fees to investors. Further, private lenders protect themselves through senior secured loans with an extensive use of financial covenants. Where possible, outright defaults are avoided because lenders prefer to extend or restructure loans through cash flow-saving provisions.

Still, due to the opaqueness of the sector, it is difficult to fully understand and assess the risks involved and how they relate to measured returns.[3] For example, the calculation of internal rates of return (IRRs) at any given time depends crucially on the valuation of the remaining assets in the fund portfolio, especially for recent vintages that are still far from completing their life cycle. While such valuation is straightforward in the case of tradable assets, in private credit it is often left to models developed by the fund managers themselves. Based on data for funds reporting to the US Securities and Exchange Commission, third-party valuations were conducted by only 40% of the reporting funds (Graph D1.B, dark red bar).

With these caveats in mind, recent academic evidence suggests that higher returns on private credit are entirely due to compensation for fees and for higher risks.[4] Almost all funds charge management fees as a percentage of AUM (Graph D1.B, dark purple bar), typically 1.5–2%, and close to 90% of funds charge an additional performance fee, typically 15–20% of net profits. If so, the pricing of credit risk could explain why, even net of fees, the mean IRR of private credit funds is significantly higher than that of listed closed-end fund alternatives (Graph D1.C). That said, the credit risk could still be underestimated. A market estimate suggests that more than a third of borrowers from private credit funds saw their interest coverage ratio (ie net income to interest expense) fall below 1.5 in 2023, which could strain their debt servicing ability. And, in April 2024, Moody's put three major private credit funds on negative outlook due to concerns about the credit quality of their underlying loans.

Difficulties in evaluating credit risk stems, in part, from the high dispersion in fund manager performance. For any of the reported vintages,[5] the dispersion of private credit funds' IRRs is much wider than that of comparable actively managed closed-end funds (Graph D1.C, min–max and interquartile range). Since most of these private credit fund managers have yet to be tested in a credit cycle downturn, the risks behind manager selection may be underestimated, especially at times of breakneck market expansion.

Another concern revolves around incentives. The close links of private credit with private equity raise questions about the incentive structures and the existence of proper internal corporate controls. For instance, in the United States 78% of private credit deal volume goes to private equity sponsored firms.[6] Private credit funds have also issued loans to private equity funds collateralised with the funds' underlying portfolio of companies. These so-called net asset value loans can have a variety of purposes, such as for bridge financing. However, they are also being used to accelerate distributions to private equity investors. While fund managers often invest their own capital in the vehicle ("skin in the game"), signalling the compatibility of managers' incentives with investors' interests, as many as 40% of the funds do not feature skin in the game (Graph D1.B. light blue bar). This suggests scope for incentive misalignment in a substantial segment of the sector.

Risks to financial stability from private credit warrant close monitoring. Mitigating factors include the still small size, low share in investors' portfolios, low liquidity risks and low fund-level leverage. However, the direct and indirect interconnections with other parts of the financial system, especially banks, could amplify future shocks. Private credit is connected to the banking sector at least through: (i) contingent credit lines that banks provide; (ii) joint ventures, in which some banks originate and distribute the underlying portfolio asset while retaining skin in the game; and (iii) interest rate hedging, where banks serve as counterparties to firms seeking to hedge their floating-rate liabilities to private credit funds.

[1] See Aramonte (2020), Aramonte and Avalos (2021), Cai and Haque (2024) and IMF (2024c) for further detail on the private credit market. [2] Liquidity risk is low but not absent. Insurance companies, in particular, can be exposed to liquidity shocks from margin calls and policy surrenders (see Box E). [3] For instance, information on fund leverage is publicly available for only 5% of private credit funds. See HKMA (2024). [4] See Erel et al (2024). [5] Vintage refers to the year of inception of the private credit fund. [6] See Block et al (2024).

come at the cost of larger fiscal deficits and a build-up in government debt. A financially induced downturn in China could have a broader impact on market sentiment elsewhere, especially for EMEs closely related to China (Graph 15.C). AE banks exposed to the Chinese real estate sector could also find themselves struggling.

Fiscal pressure points

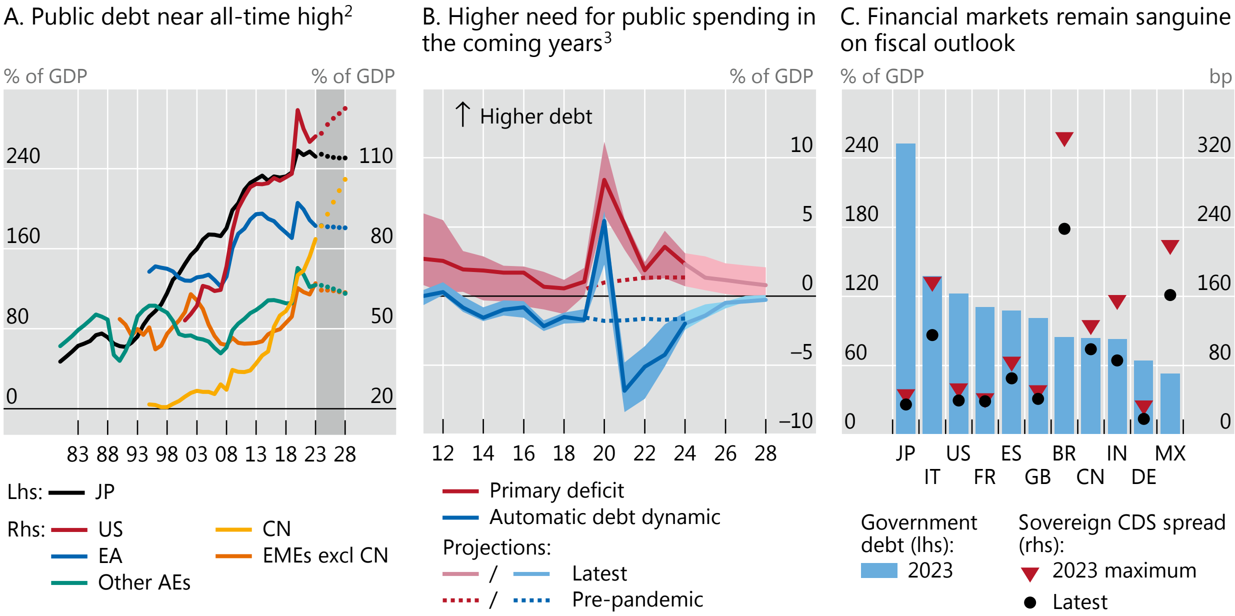
Expansionary fiscal policies could become a source of tension, with implications for inflation and macro-financial balances. As one possibility, an extended or renewed fiscal expansion could over-stimulate demand and complicate the disinflation task during the last mile.[12] The risk is especially high in a year of many elections such as this one. Another related possibility is that fiscal sustainability concerns come to the fore and create headwinds through higher risk premia and financial market dysfunction. As discussed in last year's Annual Economic Report, debt trajectories are a major concern globally going forward (Graph 16.A).

The environment of higher interest rates further weakens fiscal positions that are already stretched by historically high debt levels. Indeed, the support from the negative gap between real interest rates and growth rates (that is, r–g) has shrunk in recent years, is projected to stay much smaller going forward and could even turn positive (Graph 16.B, blue line). Curbing fiscal space further is rising public spending in the coming years (Graph 16.B, red line), given the needs stemming from the green transition, pensions and healthcare, and defence. Though financial market pricing points to only a small likelihood of public finance stress at present (Graph 16.C), confidence could quickly crumble if economic momentum weakens and an urgent need for public spending arises on both structural and cyclical fronts. Government bond markets would be hit first, but the strains could spread more broadly, as they have in the past.

Productivity pressure points

Lacklustre productivity growth could be longer-lasting than previously thought. With few exceptions – notably the United States – productivity growth has generally been

Greater public spending demand with dwindling fiscal space[1] Graph 16



[1] See technical annex for details. [2] Shaded area corresponds to forecasts from IMF WEO April 2024. [3] Lines show medians and shaded areas show interquartile ranges across countries.

Sources: IMF; S&P Global Market Intelligence; BIS.

Box E

Life insurance companies – legacy risks from “low for long”

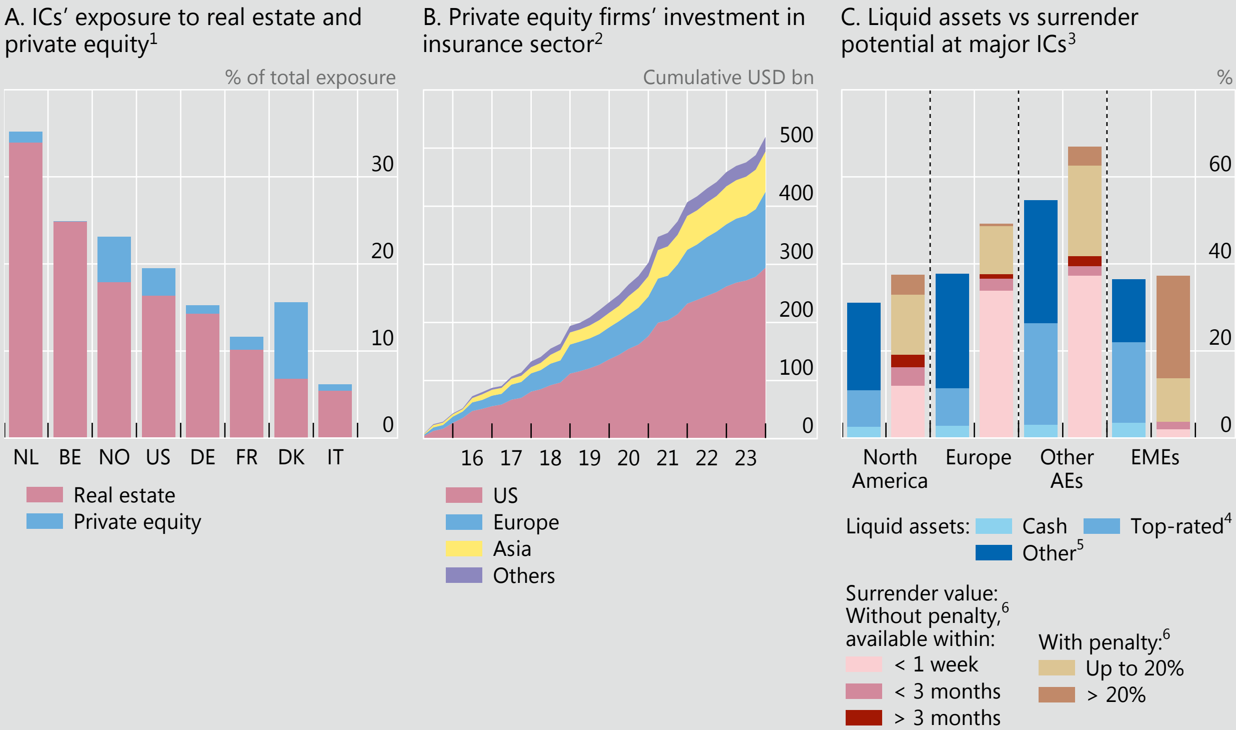
The widespread surge in inflation and the subsequent increase in interest rates from 2022 have put the spotlight on the vulnerabilities that may have piled up for long-term investors during the low-for-long era. The business model of life insurance companies (ICs), which have traditionally focused on highly rated long-term debt, was particularly exposed to the post-Great Financial Crisis long phase of exceptionally low nominal interest rates. To mitigate pressure on their returns, some ICs increased their exposure to credit risk and reached out to alternative, often illiquid, investments. In addition, they complemented these strategies with measures to reduce capital-intensive life insurance policies.[1] Examples include moving new business to unit-linked products (where risks are borne by the policyholder) or offloading risks to alternative investors, notably private equity (PE) companies, for example through reinsurance arrangements. This box looks into ICs’ exposure to credit risk, their rising interlinkages with PE companies and challenges for ICs’ liquidity risk management.

ICs’ credit risk has been at the fore over the past two years, as debt servicing costs have started to rise on the back of a persistent increase in interest rates. This is in addition to many ICs’ interest rate-induced valuation losses on their holdings of fixed income securities. To be sure, ICs’ focus on highly rated sovereign and corporate debt helps to shield them from credit losses. These exposures accounted for about 26% and 12% of major ICs’ total investment at end-2022, respectively.[2] Even so, their exposure to more risky corporate debt and to securitised products (eg collateralised debt obligations) had already grown to around 12% on average by 2022, overwhelmingly reflecting investments that preceded the significant rise in interest rates. Moreover, major ICs with higher exposures are also more leveraged, on average, indicating a generally higher risk appetite.

ICs’ exposure to real estate, a sector typically vulnerable to higher interest rates, has been rising over the past several years as well. In Europe, for example, the sum of direct (eg real estate investments) and indirect

Insurance companies’ real estate exposure, link to private equity and liquidity risk

Graph E1



[1] Data as of Q3 2023. Exposure to real estate includes eg investment in property and real estate funds, holdings of equity and corporate bonds of real estate-related companies and/or real estate loans and mortgages. [2] Cumulative investment by private equity companies in insurance companies from 2015 to 2023. [3] International Association of Insurance Supervisors, Individual Insurance Monitoring data as of end-2022; as a share of total assets including general and separate accounts; weighted averages across a sample of 41 major insurance companies. [4] Highest-quality sovereign and supranational securities. [5] Includes high-quality public and private debt, liquid stocks, certificates of deposits and liquid fund shares. [6] Economic penalty as defined in the insurance contract.

Sources: European Insurance and Occupational Pensions Authority; International Association of Insurance Supervisors; National Association of Insurance Commissioners; PitchBook Data Inc; national data; BIS.

(eg mortgages) exposures to the real estate sector increased from less than 10% of total exposures at end-2017 to more than 14% in the third quarter of 2023. Moreover, in some countries it exceeded 20% (Graph E1.A). Thus, significant setbacks in, say, the commercial real estate markets (see Box C) could weigh on ICs' performance and capital.

Deeper interconnections between the life insurance sectors and private markets have raised additional challenges. On the one hand, seeking higher returns, many ICs have increased their exposure to private markets by investing in PE and private credit funds (see also Box D), although typically from low levels. On the other hand, easy funding conditions during the low-for-long era spurred PE companies' expansion into the insurance sector: cumulative investments amounted to around $500 billion over the past decade, equivalent to about 10% of the global insurance industry's total equity (Graph E1.B). In particular, ICs with major PE investors have sought to boost profitability by taking on higher leverage as well as by investing in more risky and illiquid assets.[3]

The higher interest rate environment has also shifted attention back to ICs' funding profiles and liquidity management. The rise in returns offered by competing investments (eg investment funds, term deposits) provides incentives for policyholders to terminate ("surrender") their contracts. This would force ICs to either raise the returns offered on policies or seek alternative sources of funding at higher cost. For major ICs, the potential for surrenders is substantial. At end-2022, policies that allow surrenders amounted on average to around 40% of total assets in emerging market economies (EMEs), North America and Europe and as much as 70% in other advanced economies (AEs). In EMEs, the vast majority of these policies impose contractual penalties on policyholders, which provide a certain degree of protection to ICs. By contrast, for more than half of the policies in AEs, there are no economic penalties, and any protection relies primarily on tax treatments that raise the effective cost of surrenders for policyholders (Graph E1.C).[4]

ICs generally hold large amounts of liquid and high-quality assets to meet liquidity shocks. These mitigate the need to sell illiquid assets during episodes of market stress. However, only a small fraction of major ICs' liquidity buffers are held in the form of cash. The majority are typically invested in high-quality fixed income assets (Graph E1.C, blue bars). Thus, in case of liquidity shortfalls, ICs' liquidity management relies on the ability to borrow against or liquidate these assets quickly and at relatively small losses. The experience of past episodes of stress, such as the self-reinforcing acceleration of surrenders at a PE-owned European IC in early 2023, illustrates that such liquidations can prove challenging. It also highlights the importance of prudent liquidity risk management, such as assessing expected cash inflows and outflows under various stress scenarios and at different horizons.[5]

[1] See also International Association of Insurance Supervisors (IAIS), *Global Insurance Market Report*, December 2023. [2] For a discussion of ICs' sovereign debt holdings and the underlying data sources, see Farkas et al (2023a). [3] Concerns have also been raised about private equity-linked ICs' use of reinsurance with foreign affiliates to exploit regulatory and tax arbitrage opportunities. See eg Kirti and Sarin (2024). [4] Another potential source of ICs' liquidity needs are derivatives-related margin calls following an increase in interest rates, as discussed in Farkas et al (2023b). [5] See, for example, the liquidity metrics introduced by the IAIS in its Global Monitoring Exercise.

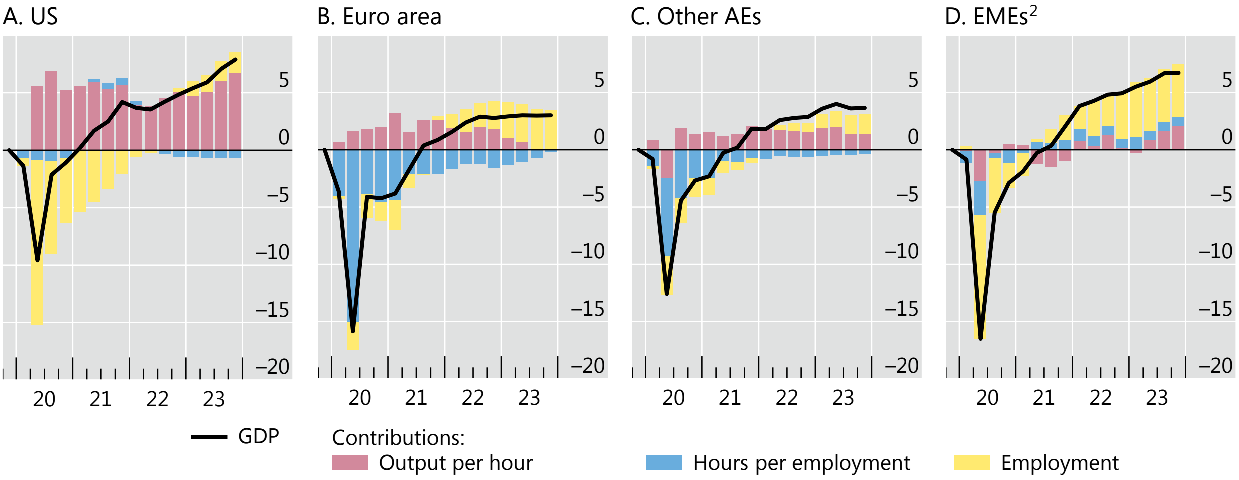
subdued since the pandemic, as employment held up growth (Graph 17). In the near term, the effects of the pandemic on productivity could linger for longer than expected, for example if strong demand for services continues to support employment in parts of the economy that have a lower level of productivity. This could keep overall labour productivity growth subdued (red bars), as has been the case especially in the euro area, even as hours per worker normalise (blue bars).

Indeed, while distinguishing cyclical from secular forces is not easy, slow trend productivity growth was already a concern pre-pandemic, not least owing to flagging structural reforms. Together with unfavourable demographic trends, slow productivity growth would weigh on potential growth.[13] One symptom of these headwinds is that, for most economies, GDP growth rates have remained moderate, similar to pre-pandemic averages, and in some cases, they have slowed further (Graph 18.A). Lower productivity growth would add to inflationary pressures, reduce the headroom for both monetary and fiscal policy and, more generally, widen the gap between society's expectations and policymakers' capacity to meet them, making any adjustments much harder.

Could ongoing technological progress help counteract these growth headwinds, powered by greater use of remote work technologies, digitalisation and artificial

Productivity has been sluggish as employment underpins economic growth[1]

Cumulative changes since Q4 2019, in per cent — Graph 17

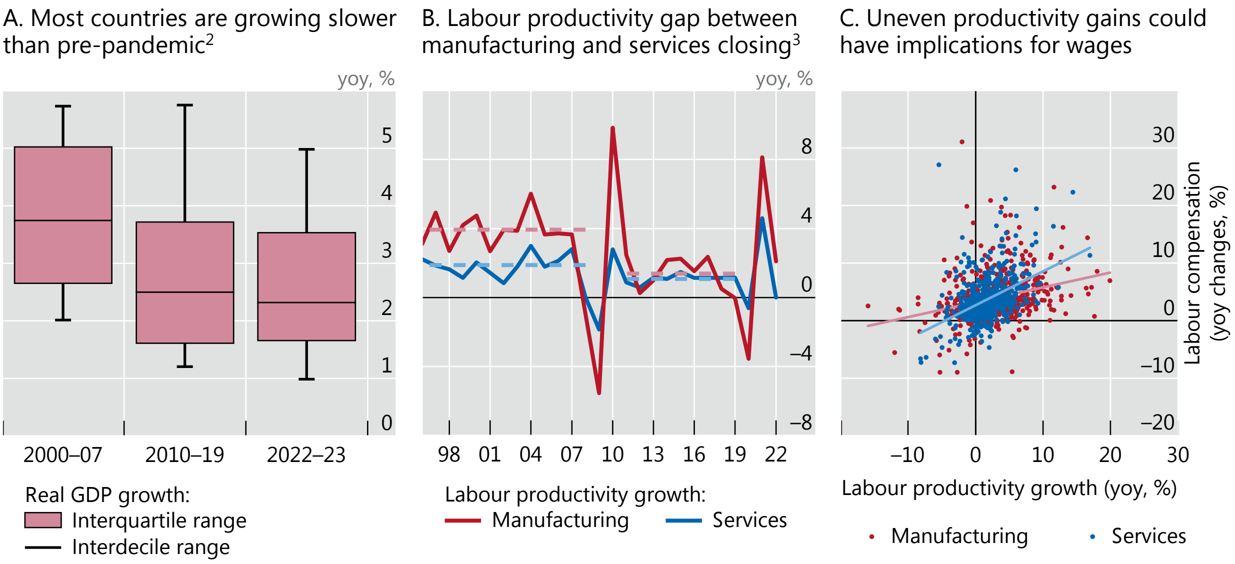


[1] See technical annex for details. [2] CZ, HU, IL, MX and PL.

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

intelligence (Chapter III)? Possibly. But even so, these would likely generate uneven benefits across sectors and countries.[14] The services sector arguably stands to gain the most from these technologies. As a result, the gap in labour productivity growth between the services and manufacturing sectors, which has already been narrowing since the mid-1990s, could close or even reverse (Graph 18.B). This could weigh on less diversified economies heavily reliant on manufacturing activities, particularly if they are slow to adapt to skills- and sector-biased technological advances.

Productivity growth at a crossroads[1] — Graph 18



[1] See technical annex for details. [2] Based on mean value of quarterly real GDP growth across the period for each economy. [3] Dashed lines show averages over the periods 1996–2007 and 2011–19.

Sources: OECD; national data; BIS.

A technology-driven productivity rotation could also have implications for price and wage dynamics over the longer term. One possibility is that relatively stronger productivity gains in the services sector pave the way for lower relative prices for services, as was the case for the manufacturing sector in past decades. If so, the inflation impact could be benign. Another possibility is that higher labour productivity allows services wages to increase. Indeed, there appears to be a stronger link between nominal wages and productivity in the services sector than in the manufacturing sector (Graph 18.C). In this case, broader wage pressures could ensue due to labour competition: goods-producing firms may need to bid up wages to prevent workers from leaving to the services sector. This could result in higher inflation.

Turbulence scenarios and policy implications

Turbulence scenarios

Inflation has continued to ease, and a smooth landing is within sight. Under this central scenario, inflation will come down further in the period ahead to be consistent with central bank targets. As economic growth stabilises around the medium-term trend, the associated weakening of labour markets is expected to be modest, with outcomes that, from a historical perspective, look benign.

That said, risks on the horizon could push economies off course. Constellations of pressure points could come together to produce destabilising outcomes. Two plausible alternative scenarios, spanning a wide range of possibilities, illustrate pertinent policy trade-offs and challenges.

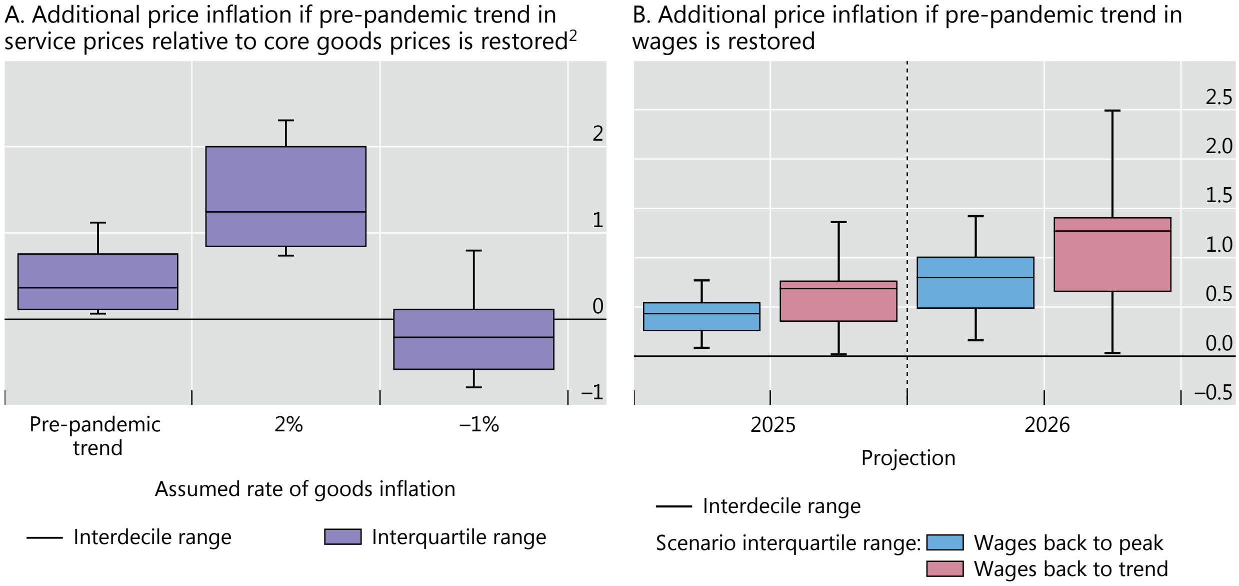
Scenario 1: inflation resurgence

In the first scenario, inflation pushes higher again. This could arise most obviously from inflation pressure points giving way, whether from persistent relative price adjustments or adverse supply shocks (eg geopolitical events leading to an abrupt surge in commodity prices). Other pressure points could also increase the likelihood of this scenario or even instigate it, for example if fiscal policy turns overly expansionary, overall productivity growth disappoints or sectoral productivity developments push up wages. For small open economies, the additional trigger could be a sharp exchange rate depreciation, prompted by core AEs' anticipated monetary policy response to stickier inflation, deteriorating inflation expectations or financial tensions giving rise to capital outflows.

The upward pressure on inflation from relative price adjustments alone could be sizeable. For illustrative purposes, consider the price adjustments that would be needed to restore the pre-pandemic relative price trend between core goods and services by the end of 2026. If core goods prices grow at the pre-pandemic average rate, then services price growth would need to be 1 percentage point higher than its historical norm, on average. With services accounting for around 50% of total consumption, this would mean that the overall rate of inflation would be around 0.5 percentage points higher than otherwise (Graph 19.A). For some countries, the increase in services price growth to restore the pre-pandemic relative price trend could be as large as 3 percentage points, implying overall inflation would be up to 1.5 percentage points higher than otherwise. And if core goods inflation is higher at 2%, for example due to diminishing tailwinds from cheap imports, overall inflation could increase by 1–2 percentage points on average for most countries. To prevent such a scenario from materialising, central banks would need to take further action.

Relative price adjustments could slow inflation's convergence to target[1]

Additional annual price growth, in percentage points | Graph 19



[1] See technical annex for details. [2] Based on AEs only.

Sources: Ampudia et al (2024); LSEG Datastream; national data; BIS.

Real wages are another relative price that could materially add to inflationary pressures. To recoup the purchasing power lost due to the recent inflation wave, growth in nominal wages would need to outpace prices. This could put pressure on firms to pass on higher production costs to protect their margins, leading to higher inflation. Empirical estimates suggest that such pressures could materialise over roughly two and a half years for services and one and a half years for goods and they could be stronger in services (Graph 11.C above). All else equal, recouping the purchasing power lost since mid-2021 could add up to 0.75 percentage points to inflation in 2025 and up to 1.5 percentage points in 2026 (Graph 19.B, blue boxes). If wages were to grow even faster and catch up with their pre-pandemic trend, this could add up to 1.5 percentage points to inflation in 2025 and over 2.5 percentage points in 2026 (red boxes). In this case too, central banks would need to take further action to avert the scenario.

These calculations preclude the possibility of a full-blown wage-price spiral. As the pass-through of wages to prices is partial, these calculations assume some compression of profit margins that allows for wage growth to make up for the lost purchasing power. But it is plausible that, with marked increases in wages, firms could attempt to protect their margins and increasingly pass on the costs, thereby reinforcing the wage-price feedback loop. Estimates from a joint model of wages and consumer prices underline this two-way interaction, as shortfalls of wages from their long-run relationship with prices tend to feed back into prices, and vice-versa.[15] Estimates also show that wages and consumer prices chase each other with greater intensity as inflation rises.

The extent of these relative price adjustments, in combination with how other pressure points play out, would dictate the characteristics of an inflation resurgence.

One possibility is that multiple forces align to produce a strong inflation burst. For instance, the initial shocks, even if short-lived, could be amplified by key relative price adjustments to produce concentrated effects on highly salient prices for households and firms. Further fiscal support for households and firms would make the inflationary impact larger and more enduring. The second-round effects, more likely to materialise in this case, could be more difficult to contain given the context of high inflation over the last few years. The urgency of re-establishing the credibility of inflation targets would regain prominence.

In another variant of this scenario, disinflation stalls and inflation hovers stubbornly above target even in the absence of large shocks. Key drivers could be persistent pressures from relative price adjustments and productivity developments. While the immediate impact on inflation may be smaller than in the first variant and relative price adjustment would be complete at some point, if inflation stays above target for long, the behavioural norms of workers and firms could change permanently. The feedback between wages and prices would then entrench higher inflation.

The inflationary scenario, especially the more virulent variant, would, in turn, represent a major threat to financial stability. Interest rates would go higher for longer, weighing heavily on financial conditions, economic agents' balance sheets and ultimately economic activity (see below).

Scenario 2: hard landing

In the second scenario, inflation continues to ease as anticipated, but growth deteriorates sharply. The culprits could be some combination of real and financial tensions reaching a point of fracture, possibly amplifying one another. With private sector balance sheet buffers running out, fiscal sustainability attracting focus, or stresses emerging in key segments of the financial markets, growth could lose momentum. Much weaker economic activity would undermine the strength of the labour market, the linchpin of the economy, precipitating the hard landing that policymakers have so far taken great care to avoid.

A hard landing could generate strains on the financial system even in the absence of any policy tightening. Most immediate would be a further tightening of financial conditions, with wider risk spreads and a sell-off of global risky assets. More frequent bouts of market dysfunction could ensue, adding to stress for financial institutions and investors. Tighter financial conditions and retrenchment in credit supply could, in turn, accelerate the depletion of borrowers' financial buffers, possibly impairing credit quality. A hard landing would entail both demand headwinds and heightened financial stability risks.

A hard-landing scenario could furthermore mask the role of secular supply-side developments taking place concurrently. The effects of any productivity slowdown or developments of other structural factors on growth would be all but concealed in the midst of strong demand headwinds. Determining the degree of economic slack would be even more challenging.

Policy implications

Guiding considerations

Any policy prescription depends on the balance of risks to the outlook. Although risks will vary across economies, some general considerations, informed by the lessons from recent decades, could help guide policy (see also Chapter II).

First, policies adopted today need to be *robust* to key risks on the horizon. In the spirit of robust control theory, the policy stance should deliver reasonable outcomes in a broad range of conceivable scenarios.

Second, in addressing near-term challenges, policymakers should be cognisant of any longer-term *costs* or *side effects* of their policy actions. Often, these costs may become evident only in the longer term, giving rise to intertemporal trade-offs that must be taken into consideration. Complementary policies, such as macroprudential measures and, where appropriate, foreign exchange interventions, can be used to mitigate these costs or side effects.

Third, and in the same spirit, policies should explicitly consider the importance of having sufficient *safety margins* or *room for manoeuvre*. This would bolster resilience by allowing policies to deal more effectively with the future materialisation of risks.

What do these considerations suggest for current policy settings? How could policymakers best navigate the risks of an inflation resurgence, on the one hand, and a hard landing, on the other?

Monetary policy

The primacy of price stability as a pre-condition for sustainable growth cautions against a rapid and substantial easing of policy. Policy rates will need to stay high for as long as needed to re-establish price stability. A premature easing could reignite inflationary pressures and force a costly policy reversal – all the costlier because credibility would be undermined.[16] Indeed, risks of de-anchored inflation expectations have not gone away, as pressure points remain. Macroeconomic and financial stability would be most vulnerable in this event. To guard against it, monetary policy needs to prioritise a sustainable return of inflation to target.

The need to preserve some policy space further underscores the case for a cautious policy approach. Stop-and-go policies should be avoided, as they could weaken central banks' abilities to address resurgent inflation. Most central banks have now regained the room for policy manoeuvre to face possible downturns – a silver lining from the recent flare-up of inflation and consistent with some goals of monetary policy framework reviews (Chapter II). In this sense, setting a high bar for policy easing is reasonably robust to the two adverse scenarios: it hedges against an inflation resurgence, and it provides room for manoeuvre in the event of a hard landing.

Conserving policy space also calls for a circumspect assessment of what is sometimes seen as determining the end point for interest rates (or "terminal rate"). This is technically known as the natural rate of interest or r-star (Chapter II). As the available evidence is inconclusive,[17] it would be highly imprudent to conclude that real interest rates must inevitably gravitate towards the ultra-low levels seen in the decade prior to the pandemic based on the view that these were necessarily equilibrium rates produced by deep-seated structural forces. There is simply too much uncertainty about the determinants of such equilibrium rates and their level at any given point in time. The cautious approach to policy easing would be robust to r-star uncertainty as well.

A cautious easing approach would also be consistent with central banks striking a good balance between keeping near-term macro-financial stresses at bay and promoting a less leveraged and more stable financial system in the longer term. Admittedly, easing monetary policy quickly at the sign of lower inflation may help pre-empt financial stresses and improve the prospect of a smooth landing *in the very near term*. But it could also fuel financial risk-taking and contribute to the build-up of financial imbalances down the road. The juncture offers a rare window of opportunity to wean economies off the long-standing dependence of growth on monetary policy and to lessen the likelihood of another era of low-for-long interest rates.

EMEs and small open economies can make their cautious easing approach more robust by judiciously deploying foreign exchange intervention, where necessary and appropriate, to shield against destabilising external developments. The pressure to do so could build as macroeconomic outlooks diverge across economies and interest rate differentials widen. On the bright side, many central banks today are better positioned to manage these external risks. Stronger policy frameworks, underpinned by central bank independence and foreign exchange reserve buffers, lessen the scope for sudden capital flight or runaway exchange rate depreciation. At the same time, there are limits to what foreign exchange intervention can achieve. It is no substitute for necessary macroeconomic adjustments and sound monetary and fiscal policy settings. A guiding consideration is to deploy foreign exchange intervention as a complementary tool akin in orientation to macroprudential ones (Chapter II).

Prudential policy

Prudential policy must remain vigilant and continue to strengthen the soundness of the financial system. The resilience of the system so far is in no small measure because of improvements in its loss-absorption capacity and governance. But it also reflects a surprisingly buoyant real sector. That resilience should not be taken for granted, especially as the economy could slow more than expected and asset price adjustments need to run their course. So far, the strains that have appeared have reflected mainly the materialisation of interest rate risk; credit losses are still largely to come.

It is crucial to avoid a premature easing of macroprudential policies. The evidence strongly indicates that tightening macroprudential measures can help reduce the likelihood of financial stress even once the monetary policy tightening phase is under way (Chapter II). Measures should be relaxed, releasing buffers if and only when signs of stress emerge: the measures are designed to address the financial cycle and financial stability, not shorter-term economic fluctuations as such. Beyond that, their adjustment will naturally depend on country-specific circumstances, as the cycles are not synchronised internationally and the impact of global financial conditions on individual jurisdictions varies.

At the microprudential level, there is need for action on two fronts. From a more conjunctural perspective, authorities need to stand ready to take prompt and preventive measures to minimise the likelihood of the emergence of stress. Tight supervisory scrutiny is of the essence. From a longer-term perspective, the priority is to continue to implement the agreed reforms to further enhance the resilience of the system. This includes the timely, full and consistent implementation of Basel III. It also involves further efforts to implement the agenda concerning recovery and resolution mechanisms and to strengthen the regulation of non-bank financial institutions (NBFIs) from a systemic (macroprudential) perspective.[18]

Strengthening the macroprudential regulation of the NBFI sector has met with significant difficulties. This applies, in particular, to some forms of asset management and private credit, where hidden leverage and liquidity mismatches are prevalent. Efforts have been under way since the GFC at both national and international levels. But the results have been modest so far. Making substantial progress may require more incisive steps, not least to include financial stability as an explicit objective in the mandate of securities regulators.

Fiscal policy

For fiscal policy, consolidation is an absolute priority. In the near term, this would help relieve pressure on inflation and lessen the need to keep interest rates high, in turn helping to preserve financial stability. The higher fiscal burdens under the inflation resurgence or hard landing scenarios further argue for consolidation to conserve near-term policy space. Meanwhile, in the longer term, the urgency to consolidate continues to grow given the historically high debt and the outlook for higher interest rates.[19]

The window of opportunity to take decisive action is narrowing. For example, as of last year, AEs would have needed to keep budget deficits below 1.6% of GDP to stabilise public debt; today, that number is 1% of GDP.[20] And the room for fiscal policy manoeuvre is rapidly shrinking. Looming ahead are much larger spending needs related to healthcare and pensions – given demographic trends – and the green transition and defence – considering the geopolitical landscape.

Multi-pronged consolidation strategies are called for, with an emphasis tailored to country-specific circumstances.

On the expenditure side, it is important to scale back discretionary measures, by terminating those enacted during the pandemic and refraining from new fiscal stimulus in the absence of compelling macroeconomic justifications. More ambitiously, there is a need to press ahead with social spending reform to better align fiscal obligations with fiscal sustainability. Prioritising growth-enhancing spending, for example on the green transition, human capital and structural reforms, would also help improve efficiency as long as that spending is executed effectively. Bringing in private capital to help meet long-term objectives could create additional policy space.

On the income side, governments need to strengthen revenue mobilisation further by expediting tax reforms and broadening tax bases. For example, the implementation of a minimum corporate tax rate for large multinational companies is a welcome step in that direction. In EMEs, where the informal sector tends to be larger and tax bases smaller, stronger enforcement and simpler tax codes would help increase revenue collection.

Structural policies

Last but not least, and considering the limited scope of monetary and fiscal policies to boost potential output, structural policies need to play a crucial role in promoting sustainable growth.[21] Only structural policies can strengthen the supply side of the economy, which holds the key to long-run economic well-being. Informed by recent experience, policymakers should recognise the importance of enhancing not only the level but also the resilience of growth. Stepping up structural reforms has gained particular urgency given the rapid global shifts on multiple fronts, ranging from technology to the green transition and to global trade. With so much at stake, delaying and falling short is a luxury no country can afford.

Structural reforms should aim to create an environment in which supply-side forces can play their full role. This means promoting competition, enhancing labour and product market flexibility, and spurring innovation. It also means a judicious deployment of scarce public funds to support the economy's adjustment to the new realities. In all this, there is also room for international dialogue to forge consensus on blueprints and best practices, not least in response to emerging priorities such as climate change and artificial intelligence. After all, these pose common challenges to humanity, and overcoming them will benefit everyone.

Endnotes

[1] See Doornik et al (2023).

[2] See Hardy et al (2024).

[3] See Shapiro (2022).

[4] See Miranda-Pinto et al (2023).

[5] The long-run trend reflects the confluence of several factors. First, a higher income elasticity of services: as income per capita rises, so does the relative demand for services and hence their relative price. Second, in what is commonly known as the Baumol cost disease, the services sector competes for labour with the higher-productivity manufacturing sector and, given the need to offer similar wages, must charge higher relative prices to compensate for the productivity gap. Third, international competition has a more pronounced effect on prices of goods than those of services.

[6] See Borio et al (2023).

[7] See Ampudia et al (2024); similar results for the United States are documented by Heise et al (2022).

[8] See Borio et al (2019). The financial cycle indicator uses bandpass filters with frequencies from eight to 32 years to extract medium-term cyclical fluctuations in the log-level of inflation-adjusted credit, the credit-to-GDP ratio and real property prices.

[9] See also Borio (2014).

[10] See also de Soyres et al (2023).

[11] Private equity investing involves taking an ownership stake in a company that is not currently traded on public markets. Private credit typically refers to lending by non-bank financial institutions that are often highly leveraged and cannot borrow in corporate bond markets. See Box D for further information.

[12] See also BIS (2023).

[13] Inefficient resource allocations, in addition to macroeconomic factors, could also contribute to weak productivity. See IMF (2024a, Chapter 3) and Andrews et al (2015).

[14] Acemoglu (2024) argues that artificial intelligence advances may generate only a modest boost to total factor productivity, only 0.5–0.7% over 10 years, while increasing inequality and widening the gap between capital and labour incomes. Meanwhile, Brynjolfsson et al (2023) show in an experimental setting that the use of generative AI tools in a customer service context could boost productivity by 14% on average.

[15] See BIS (2023).

[16] Policy credibility is a key part of trust in public policy, which, once lost, can be difficult to regain. See Carstens (2024).

[17] See Benigno et al (2024).

[18] See BIS (2023) for more in-depth discussion.

[19] See IMF (2024b).

[20] Average primary deficits required to keep the ratio of public debt to GDP constant over the next five years. Median of CA, DE, FR, IT, GB, JP and US, as of April 2023 and April 2024. See also the footnote to Graph 16 for methodology and assumptions.

[21] See OECD (2023).

Technical annex

Graph 2.A: Based on Okun's law, which describes a stable negative relationship between changes in output and changes in unemployment. Actual and predicted show the average unemployment rate between Q1 2022 and Q4 2023, where predicted outcomes are based on a linear regression model fitted from Q1 2000 and Q4 2019, subject to data availability.

Graph 2.B: AEs = AU, CA, EA, GB, JP and US.

Graph 2.C: Median values across NFC per country. For the regions, GDP-PPP weighted averages of the 20 EA member states, six other AEs, nine Asian EMEs and six Latin American economies. EA = AT, BE, CY, DE, EE, ES, FI, FR, GR, HR, IE, IT, LT, LU, LV, MT, NL, PT, SI and SK. Other AEs = AU, CH, GB, NO, NZ and SE. Asian EMEs = HK, ID, IN, KR, MY, PH, SG, TH and VN. Latin America = AR, BR, CL, CO, MX and PE.

Graph 4.A: Based on yearly averages. GDP-PPP weighted averages for: AEs = CA, CH, DK, EA, GB, JP, NO, SE and US; EMEs = BR, CL, CO, CZ, HU, IL, KR, MX, PH, PL, SG and ZA.

Graph 4.C: Other AEs = AU, CA, DK, GB, NO, NZ and SE; GDP-PPP weighted averages.

Graph 5.A: Based on sectoral personal consumption expenditures data up to Q3 2023, except for NL and SE up to Q4 2023.

Graph 5.B: Based on a linear regression model fitted from Q4 2000 to Q3 2022. Annualised quarter-on-quarter headline inflation is regressed on its own lag, job vacancy rate, oil price (West Texas Intermediate), Federal Reserve Bank of New York Global Supply Chain Pressure Index, Federal Reserve Bank of Cleveland estimates of one-year-ahead inflation expectations and output gap. The contributions are computed based on the year-on-year changes.

Graph 5.C: Cyclical sensitivity is measured based on estimates for AU, CA, DE, ES, FR, GB, IT, JP, KR and US since 1990, upon data availability, obtained by regressing sectoral inflation on its fourth lag and the output gap. Change in price growth corresponds to the change in year-on-year inflation from peak to latest (Q1 2024). For US, peak as of Q2 2022; for EA, as of Q1 2023. Euro area disinflation corresponds to the simple average across DE, ES, FR and IT.

Graph 6.C: Historical = GDP-PPP weighted average price-to-earnings ratios from 2 January 2010 until 31 May 2024. Latest = 31 May 2024. AEs = AU, CA, CH, EA, GB, JP and NZ. EMEs = BR, CL, CN, CO, CZ, HK, HU, ID, KR, MX, MY, PE, PH, PL, SG, TH and ZA. For major tech firms (Alphabet, Amazon, Apple, Meta, Microsoft, Nvidia and Tesla), the median is shown.

Graph 7.A: Showing option-adjusted spread, the yield spread over a benchmark yield curve adjusted for the value of embedded options.

Graph 7.B: Revisions to the federal funds rate expected to prevail at the end of the next calendar year from the perspectives of the Federal Reserve and the financial market (vertical axis), against the three-month moving average of the Bloomberg inflation surprise index (horizontal axis). June 2021–June 2024.

Graph 7.C: Weekly average for federal funds rate futures.

Graph 8.A: Goldman Sachs Financial Conditions Index (FCI): a weighted average of country-specific risk-free interest rates (both long- and short-term), exchange rates, equity valuations and credit spreads, with weights that correspond to the estimated impact of each variable on GDP. A value of 100 indicates average conditions. A higher (lower) value indicates tighter (looser) conditions.

Graph 8.B: Monthly averages. VIX = Chicago Board Options Exchange (CBOE) Volatility Index. VXTLT = CBOE 20+ Year Treasury Bond ETF Volatility Index.

Graph 8.C: GDP-PPP weighted averages for countries in the region. Asian EMEs = CN, ID, IN, KR, MY, PH, SG, TH and VN; Latin America = BR, CL, CO, MX and PE; other AEs = AU, CA, CH, EA, GB, NO, NZ and SE; other EMEs = CZ, DZ, HU, IL, KW, PL, RO and ZA.

Graph 9.A: Net percentage of bank loan officers reporting they are tightening lending standards.

Graph 9.B: Net percentage of bank loan officers reporting they are seeing increased loan demand.

Graph 10.A: Simple averages of the price-to-book ratio are calculated from the aggregates of country-specific constituents for EA, other AEs and EMEs. EA = AT, BE, DE, ES, FI, FR, IT and NL. Other AEs = AU, CA, CH, DK, GB, JP, NO, NZ and SE. EMEs = AE, AR, BR, CL, CN, CO, CZ, HU, ID, IN, KR, MX, MY, PE, PH, PL, SA, SG, TH, TR and ZA.

Graph 10.B: For EME gov yield, JPMorgan GBI-EM broad traded index. For EMBI spread, JPMorgan Emerging Market Bond Index. For EME portfolio flows, EPFR net equity and bond fund flows. End of the cycle is defined as the month prior to the first policy rate cut; Mar 2024 is treated as the end of the current cycle. FX rate is calculated as GDP-PPP weighted averages of the bilateral exchange rates of EMEs against the US dollar; an increase indicates an appreciation of the dollar. Equities calculated as the equally weighted average of broad local currency equity market indices of EMEs. For episodes in 1980–90s, simple averages across selected past US tightening cycles starting in: Mar 1983, Mar 1988, Feb 1994 and Jun 1999. Data are available for EMBI spread since 1991, equities since 1992, EME gov yields since 2002 and EME portfolio flows since 2003. EMEs = BR, CL, CN, CO, CZ, HU, ID, IN, KR, MX, MY, PH, PL, TH and ZA.

Graph 11.A: GDP-PPP weighted averages of six-month moving averages of seasonally adjusted series. AEs = AU, CA, CH, DK, EA, GB, JP, NO, NZ, SE and US. EMEs = BR, CL, CO, CZ, HU, IL, KR, MX, PE, PH, SG and ZA. Pre-pandemic trend estimates based on Q1 2015–Q4 2019 data.

Graph 11.B: Real wages are computed by deflating nominal wages with headline CPI. National definitions. Four-quarter moving averages. Pre-pandemic trend estimates based on Q1 2013–Q4 2019 data. Sample covers CA, CZ, EA, GB, HU, JP, MX, NO, SE and US.

Graph 11.C: Estimates are based on sectoral data from Eurostat, already aggregated across countries, between Q1 2009 and Q2 2023; for further details, see Ampudia et al (2024).

Graph 12.A: Based on Borio (2014). 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. AEs = AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, NL, NO, NZ, PT, SE and US. EMEs = BR, CL, CN, CO, CZ, HK, HU, ID, IL, IN, KR, MX, MY, SG, TH, TR and ZA.

Graph 12.B: Changes relative to the peak of the US financial cycle peaks, identified as Q4 1987, Q3 2005 and Q2 2023. Median across the episodes in AU, BE, BR, CA, CH, CL, CN, CZ, DE, DK, ES, FI, FR, GB, HU, ID, IE, IL, IN, IT, JP, KR, MX, MY, NL, NO, NZ, PT, SE, TH, US and ZA for GDP; and BR, CA, CN, DE, ES, FR, GB, ID, IN, IT, JP, KR, NL, PT, SE, TH and US for loan impairment ratio.

Graph 13.A: Excess savings are defined as savings accumulated when the household savings rate is above trend (based on the Hamilton (2018) filter, which extracts a time-varying trend). Accumulation starts in Q1 2020.

Graph 13.B: Annual data, 2023 if available, 2022 otherwise. EMEs = AR, BR, CL, CN, CO, CZ, HK, HU, ID, IL, IN, KR, KW, MA, MX, MY, PE, PH, PL, RO, SA, SG, TH, TR and ZA. Other AEs = AT, AU, BE, CA, CH, CY, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, JP, LT, LU, LV, MT, NL, NO, NZ, PT, SE, SI and SK.

Graph 13.C: 2023 or latest available. Definitions vary by country. New mortgages are available for residents of AU, BE, CA, FR, GB, HK, IE, LU, NL and SA. Existing mortgages are offered in KR and NZ. Variable rate corresponds to variable rate and fixed rate mortgages up to three months for KR and LU, and to variable rate and fixed rate up to one year for NL. Fixed rate up to two years corresponds to four months to three years for KR, and from four months to two years for LU. Fixed rate from three to five years corresponds to one to five years for NL. Fixed rate from six to 10 years corresponds to five to 10 years for KR. Fixed rate greater than 10 years corresponds to the duration of the loan for FR and HK.

Graphs 14.A and 14.C: The country sample considered is AU, CA, DE, DK, ES, FI, FR, GB, IT, JP, NL, NO, SE and US.

Graph 14.B: Estimated effects are in deviations from baseline projections, averaged over 2024–26. Estimates are based on a Bayesian VAR model with quarterly US data consisting of GDP growth, real commercial property price growth, real residential property price growth, credit to the non-financial sector growth, debt service ratio for the total private non-financial sector, policy rate and real equity price index returns. Sample covers Q1 1981 to Q3 2023. The commercial property price shock is identified via sign restrictions as one that induces an immediate fall in commercial property prices and credit growth, before generating a decline in GDP growth with a lag.

Graph 14.C: Latest is Q4 2023 for all countries except DK and NL (Q3 2023).

Graph 15.A: Loans considered are leveraged loans. Spreads to maturity.

Graph 15.B: Based on Shanghai interbank offered rate (Shibor) versus secured overnight financing rate (SOFR).

Graph 15.C: Equity index performance: latest relative to 1 June 2023. China beta: linear regression of daily log changes in equity price indices on the Chinese index, controlling for the US index. Regressions estimated between 7 January 2002 and 1 June 2023.

Graph 16.A: IMF projections, based on assumed policy paths, maintaining trends in government debt structure when specific budget information is lacking. Other AEs = AU, CA, CH, GB and SE. Other EMEs = AR, BR, CL, CO, HU, ID, IL, IN, KR, MX, MY, PE, PH, SA, SG, TH, TR and ZA.

Graph 16.B: Automatic debt dynamic is calculated as $(r_t - g_t) \times \mathrm{Debt}_{t-1}$, where r_t is a five-year rolling average of 10-year government bond yields (as a proxy for interest payments) adjusted for the annual change in the GDP deflator, and g_t is the annual real GDP growth. From 2024 on, 10-year government bond yields are assumed to stay constant. The country sample is CA, DE, FR, GB, JP, KR and US. Projections correspond to IMF calculations, based on assumed policy paths, maintaining trends in government debt structure when specific budget information is lacking.

Graph 16.C: Latest is 31 May 2024. CDS 10-year maturity.

Graph 17: GDP-PPP weighted averages for regions. Euro area = AT, BE, DE, EE, ES, FR, IE, IT, LT, NL, PT, SI and SK; other AEs = AU, CA, DK, GB, JP, NO, NZ and SE; EMEs = CZ, HU, IL, MX and PL.

Graph 18.A: Statistics across 44 economies showing mean value of real GDP growth for each period of time and each country. Sample covers: AR, AT, AU, BE, BR, CA, CH, CL, CN, CO, CZ, DE, DK, ES, FI, FR, GB, GR, HK, HU, ID, IE, IL, IN, IT, JP, KR, LU, MX, MY, NL, NO, NZ, PE, PH, PL, PT, RO, SE, SG, TH, TR, US and ZA.

Graphs 18.B and 18.C: Labour productivity is defined as gross value added per person employed.

Graph 18.C: The country sample is composed of AT, AU, BE, BR, CA, CH, CL, CO, CZ, DE, DK, ES, FI, FR, GB, GR, HR, HU, ID, IE, IL, IT, JP, KR, LU, MX, NL, NO, NZ, PE, PL, PT, SE, US and ZA. Dots represent country-year pairs. Lines show simple regression and are both statistically significant at the 1/5/10% level.

Graph 19.A: Aggregates showing median and interquartile range over CA, CH, DK, EA, GB, JP, KR, NO, SE and US. Core goods corresponds to goods excluding food and energy.

Graph 19.B: Scenarios show the annual inflation at the end of each year for a number of countries in the euro area. Aggregates show median and interquartile range over AT, BE, DE, ES, FI, FR, IT, NL and PL. Additional price inflation is calculated using the cumulated response of different horizons (in quarters) of producers' price indices in the industrial and services sectors to a 1 percentage point increase in hourly wages. Estimates are based on euro area data from Q1 2009 to Q2 2023; for further details, see Ampudia et al (2024).

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II. Monetary policy in the 21st century: lessons learned and challenges ahead

Key takeaways

- Since the turn of the 21st century, a series of extraordinary events – major financial crises, a pandemic and an unexpected surge in inflation – have profoundly shaped the conduct of monetary policy.
- This tumultuous experience points to several lessons regarding what monetary policy can and cannot deliver. They concern the ability to control runaway inflation, the power to stabilise the financial system at times of crises, the limits to forceful and prolonged monetary easing, the growing complexity of communication, and the complementary role of foreign exchange (FX) intervention and macroprudential policies.
- The lessons point to a number of key considerations that could guide monetary policy in the years ahead. These stress the importance of robustness, realism in ambition, safety margins and nimbleness. Coherence across policy domains is essential to ensure the lasting achievement of macroeconomic and financial stability.

Introduction

Since the turn of the 21st century, a series of extraordinary events have severely tested the conduct of monetary policy. The Great Financial Crisis (GFC) and the subsequent sovereign debt crisis in the euro area shattered the deceptive tranquillity of the so-called Great Moderation – the decades-long phase of low output and inflation volatility enjoyed by most advanced economies (AEs). The subsequent decade saw central banks struggle to push inflation back to target before, like a bolt from the blue, the Covid-19 pandemic once again caused widespread financial system stress and plunged economies into a deep recession. The pandemic's aftermath, complicated by geopolitical events, saw the largest and most persistent inflationary outbreak in half a century, alongside bank strains on both sides of the Atlantic.

Central banks have risen to the challenge. Their forceful and repeated responses to financial stress stabilised the system and limited the damage to the economy. The shortfall of inflation from targets always remained contained. And following vigorous global tightening of the policy stance, inflation is now again returning to the price stability region while economic activity and labour markets have proved resilient (Chapter I).

These extraordinary events have left a deep imprint on the conduct of policy. Central bank responses have been unprecedented. Even before the pandemic, nominal policy rates had reached historical troughs, in some cases even hovering in negative territory. And central bank balance sheets have climbed to historical peaks, within ranges previously seen only during wars. Moreover, looking ahead, further challenges loom. Public debt is on a worrisome trajectory around the world and several structural forces, such as deglobalisation, ageing societies and the uncertainties of the green transition, could further complicate policy.

This chapter stands back and takes stock of this tumultuous historical phase. After summarising the key developments, it draws lessons from the conduct of monetary policy, fleshing out what has been learned about the effectiveness of strategies and tools. Based on these lessons, it then identifies a number of key considerations that could guide monetary policy in the years ahead and, where appropriate, help refine frameworks. These considerations stress the importance of robustness, realism in ambition, safety margins, nimbleness as well as the complementary role of other policies.

Monetary policy conduct in the 21st century: a brief review

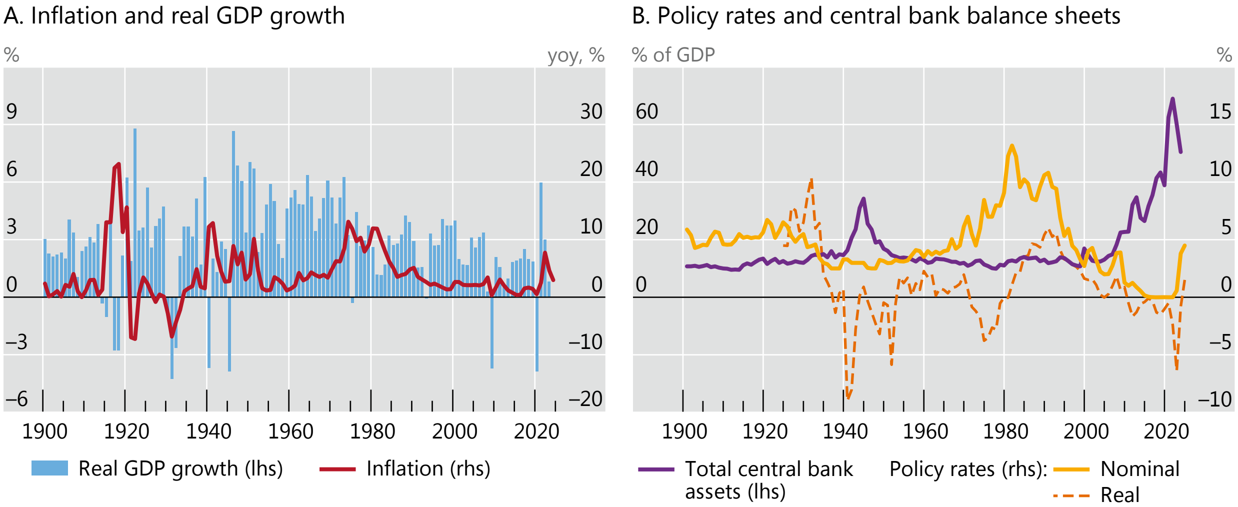
The conduct of monetary policy in the 21st century can be broadly classified into two phases: (i) the GFC in AEs and its aftermath; and (ii) the global outbreak of the Covid-19 pandemic and its consequences. The two phases saw very different macroeconomic challenges, which deeply shaped the policy response (Graph 1).

The GFC marked the end of the so-called Great Moderation – a period of remarkable macroeconomic stability, at least in advanced economies, that began in the mid-1980s. Under the surface of stable inflation and growth, however, financial vulnerabilities were building up, in particular in core AE housing and mortgage markets. Credit was surging, asset prices were booming, and balance sheets were becoming overstretched. The financial system looked deceptively strong, and its ever greater sophistication was mistaken for resilience. The build-up of vulnerabilities was reinforced by low nominal and real interest rates, as central banks eased policy in response to the fallout of the bursting of the dotcom bubble in 2001 and had little reason to raise them much subsequently, given subdued inflation. In the background, prudential regulation and supervision had failed to keep up with developments.

The subsequent unwinding of financial imbalances ushered in the GFC and plunged many economies into the deepest recession since the Great Depression. Matters came to a head when the US investment bank Lehman Brothers filed for bankruptcy in September 2008. Many financial institutions teetered on the verge of insolvency, large segments of funding markets froze, and asset prices collapsed.

Central banks responded forcefully. They cut policy rates aggressively and activated their balance sheets to provide badly needed support (Graph 2). In the early

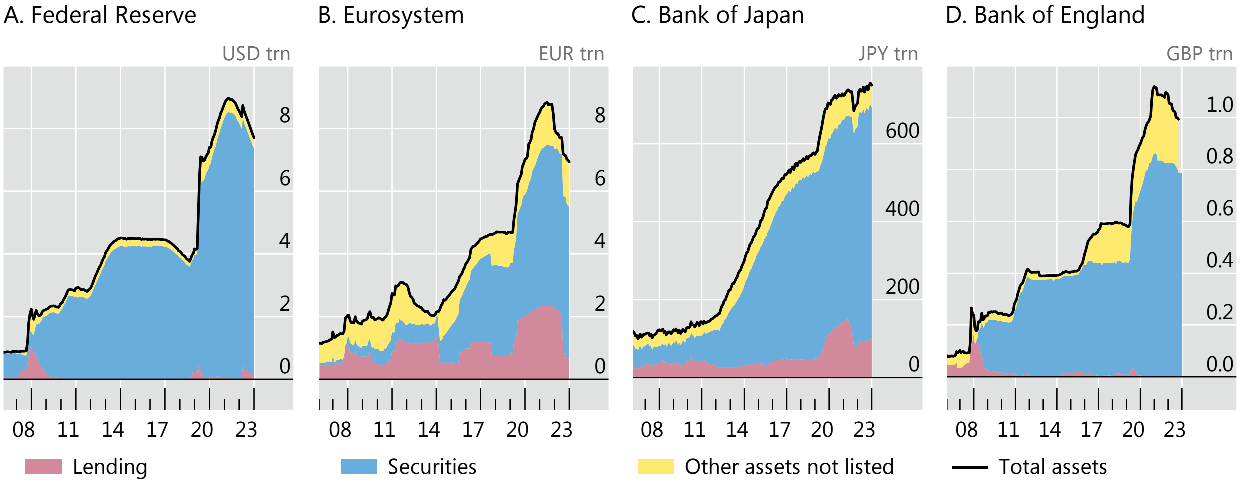
Inflation, growth and monetary policy since 1900[1] Graph 1



[1] See technical annex for details.

Sources: IMF; OECD; Global Financial Data; national data; BIS.

Central bank balance sheet size and composition[1] Graph 2



[1] See technical annex for details.

Sources: ECB; Bank of Japan; Bank of England; Board of Governors of the Federal Reserve System; Bloomberg; LSEG Datastream; national data; BIS.

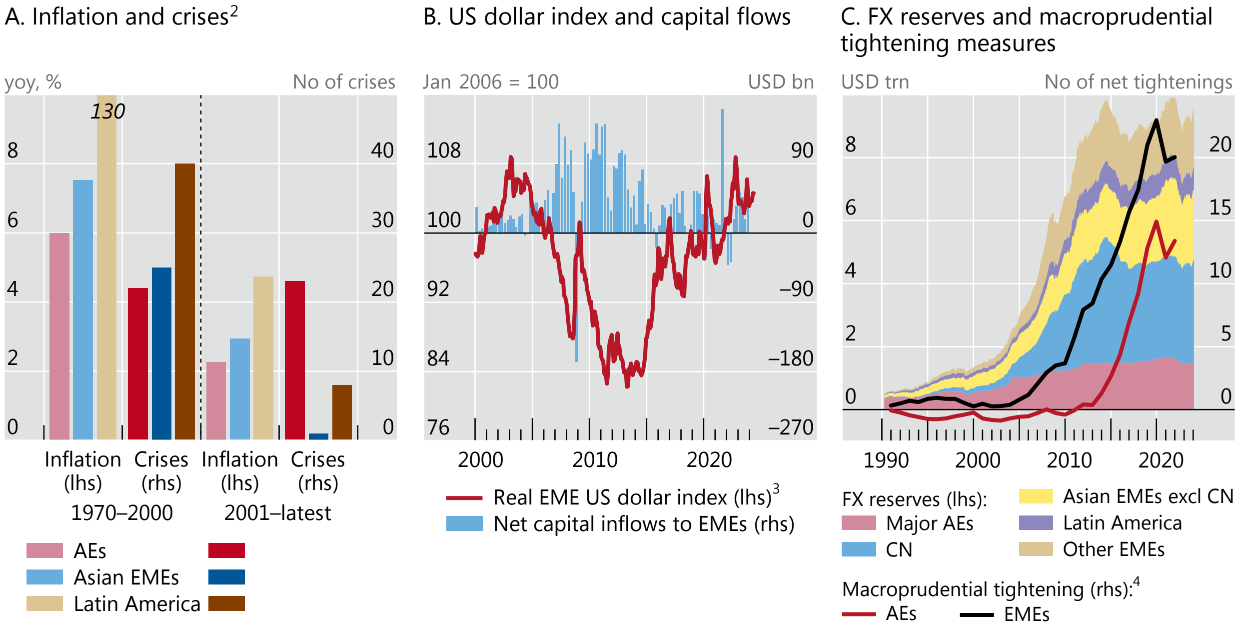
phase of the crisis, they stepped in to provide liquidity to the financial sector, playing their role of lenders of last resort, often drawing on governments' solvency backing. Thus, the initial increase in major central banks' balance sheets largely took the form of lending to financial institutions. Subsequently, several central banks started large-scale asset purchases (LSAPs) to further ease financial conditions. As a result, their balance sheets expanded further, driven by large holdings of long-term bonds, notably government bonds, often financed by bank reserves ("quantitative easing" (QE)).

Once the post-GFC years saw a shallow economic recovery and persistent shortfalls of inflation from target, raising concerns about deflation, AE central banks engaged in an unprecedented forceful and prolonged monetary easing. In doing so, they naturally built on the same toolkit that they had deployed to contain the crisis and sought to influence financial conditions beyond the short-term interest rate more directly. They lowered policy rates to zero and sometimes even into negative territory; they resorted to forward guidance to signal their commitment to keep policy rates low for long; and they further expanded their LSAPs, sometimes including private sector assets such as corporate bonds or equity exchange-traded funds.

The Covid-19 pandemic abruptly ended an incipient monetary policy normalisation. As the global economy was put in hibernation to forestall a public health catastrophe, a deep economic contraction put the stability of the financial system at risk. Once again, central banks moved swiftly and forcefully to prevent financial collapse and restore confidence. They cut policy rates, where still possible, and launched new balance sheet measures, combining emergency or subsidised lending to banks with bond purchase programmes. In the wake of these measures, central bank balance sheets surged to new historical highs.

As the global economy rebounded from the pandemic, central banks faced an enemy they thought they had long defeated for good – a global outbreak of inflation, in many cases well into double digits. Supply had failed to respond elastically to the partly monetary and fiscal policy-induced recovery in demand and the major rotation of that demand from services to goods. The subsequent steep commodity price increases in the wake of the Russian invasion of Ukraine further fuelled the inflation surge.

Crises, FX reserves and macroprudential measures[1] Graph 3



[1] See technical annex for details. [2] Latest is 2023 for inflation and 2017 for crises. [3] An increase indicates an appreciation of the US dollar. [4] Cumulative sum of net tightening decisions across 17 macroprudential tools, average across economies.

Sources: Alam et al (2019); Laeven and Valencia (2020); Board of Governors of the Federal Reserve System; Federal Reserve Bank of St Louis; IMF; LSEG Datastream; national data; BIS.

Once it became clear that the inflation surge was not transitory and was raising the risk of a transition to a high-inflation regime, central banks responded forcefully. They embarked on the sharpest and globally most synchronised monetary tightening in a generation. They hiked policy rates strongly, at least in nominal terms, and began to shrink their balance sheets – so-called quantitative tightening.

This big picture summary of events since the beginning of the century hints at some significant differences between AEs and emerging market economies (EMEs). To be sure, just like AEs, EMEs battled the Covid-19 crisis and the subsequent inflation surge. But they were largely spared the travails of banking crises such as the GFC or sovereign crises such as the one in the euro area (Graph 3.A). Their enduring challenge was coping with swings in capital flows and exchange rates originating primarily from developments in AEs, not least due to the post-GFC extraordinary monetary easing in major AEs (Graph 3.B). These trends reversed sharply as the Federal Reserve took the first steps to normalise policy in 2013.

EME central banks weathered these challenges by relying on broad-based policy frameworks honed following their own crises in the early to mid-1990s. The frameworks often combined inflation targeting and greater exchange flexibility with varying degrees of FX intervention and active deployment of macroprudential tools (Graph 3.C).[1] This represented a major welcome shift from previous frameworks that had helped generate the conditions of the EME crises pre-2000.

Lessons learned

Looking back at the experience since the GFC as well as the build-up to it, it is possible to draw lessons about the conduct of monetary policy and complementary tools under the central banks' influence. These lessons underscore the power of monetary policy but also shed light on its limitations, some of which were less appreciated during the period of the Great Moderation. The five lessons pertain, respectively, to central banks' ability to fight inflation; their ability to tackle financial system stress; the impact of prolonged easing; communication; and the deployment of tools such as FX intervention – part of the monetary policy toolkit – and macroprudential measures.

Central banks can forestall inflation de-anchoring

The post-pandemic experience with inflation has shown once again one of the major strengths of monetary policy. In particular, it has highlighted how forceful monetary tightening can prevent high inflation from becoming entrenched. It has also confirmed central banks' determination to avoid a repeat of the experience of the Great Inflation of the 1970s.

Admittedly, central banks, like most observers, were taken by surprise by the global inflation surge. The prevailing consensus was that the supply restrictions might raise prices, but that the post-pandemic environment would remain disinflationary: if anything, the pandemic-induced psychological and financial scars would depress demand and keep prices under pressure for years to come. There was initially also an underappreciation of the inflationary implications of the large demand stimulus from the monetary and fiscal policy response to the pandemic.[2] This, in turn, reflected the difficulties in calibrating the response to those exceptional circumstances.

Moreover, it took some time for central banks to react. Initially, they judged the inflationary pressures to be temporary. In addition, the forward guidance they had provided to nurture the recovery may also have played a role, as may have the reviews of monetary policy frameworks that several major central banks completed at the time. They envisaged a world of persistent disinflationary pressures, in which the core problem would still be how to push inflation back to target and pre-empt a downward drift in inflation expectations. After such a long period of stubborn shortfalls from target, inflation overshoots could actually be helpful in that regard as long as they remained contained.

As soon as central banks realised that inflation threatened to become unmoored, they were quick to react and recover the ground lost. Hence the most intense and synchronised tightening in decades. In the end, the timing of this tightening did not prove crucial. True, countries that responded earlier gained precious room for policy manoeuvre, most notably those in Latin America with a longer inflation history. But, on balance, inflation outcomes did not vary systematically with the timing of the first hike. The global nature of the inflationary forces swamped the slight differences in timing.

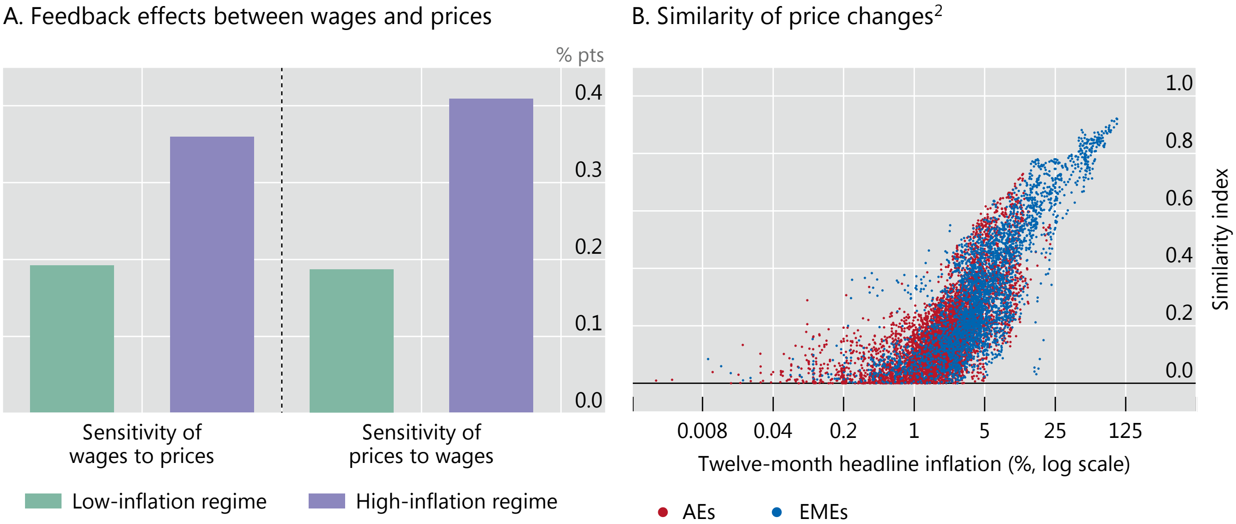
The forceful response was justified by the nature of the inflation process. Evidence indicates that it is useful to think of inflation as evolving differently in a low- and a high-inflation regime, with transitions from low- to high-inflation regimes tending to be self-reinforcing.[3]

In a low-inflation regime, inflation has important self-stabilising properties. What is measured as inflation is, in fact, largely the result of idiosyncratic or sector-specific price changes that leave little imprint on the inflation rate itself. That is, the co-movement of prices, or the "common component" of price changes, is small. And wages and prices are only loosely linked.

By contrast, a high-inflation regime has no such self-stabilising properties. The common component of price changes is higher, and wages and prices are much more closely linked (Graph 4.A). As a result, inflation becomes more responsive to one-off inflationary shocks, such as increases in commodity prices or sharp depreciations of the exchange rate.

Low- versus high-inflation regimes[1]

Graph 4



[1] See technical annex for details. [2] Similarity index measures the co-movement of sectoral prices within each economy, with higher numbers indicating greater similarity of price changes at each point in time. Each dot represents the similarity index-headline inflation pair per economy.

Sources: OECD; Macrobond; national data; BIS.

Transitions from low- to high-inflation regimes are self-reinforcing for several reasons. For one, inflation moves from the region of rational inattention, in which it is hardly noticed, into that of sharp focus. In addition, inflation becomes more representative: as the co-movement of prices increases (Graph 4.B), the inflation rates that different agents experience become more similar. Thus, inflation becomes a more relevant focal point and coordinating device for the decisions of economic agents. And the longer inflation remains high, the greater the risk that behaviour adjusts, entrenching an inflation psychology.

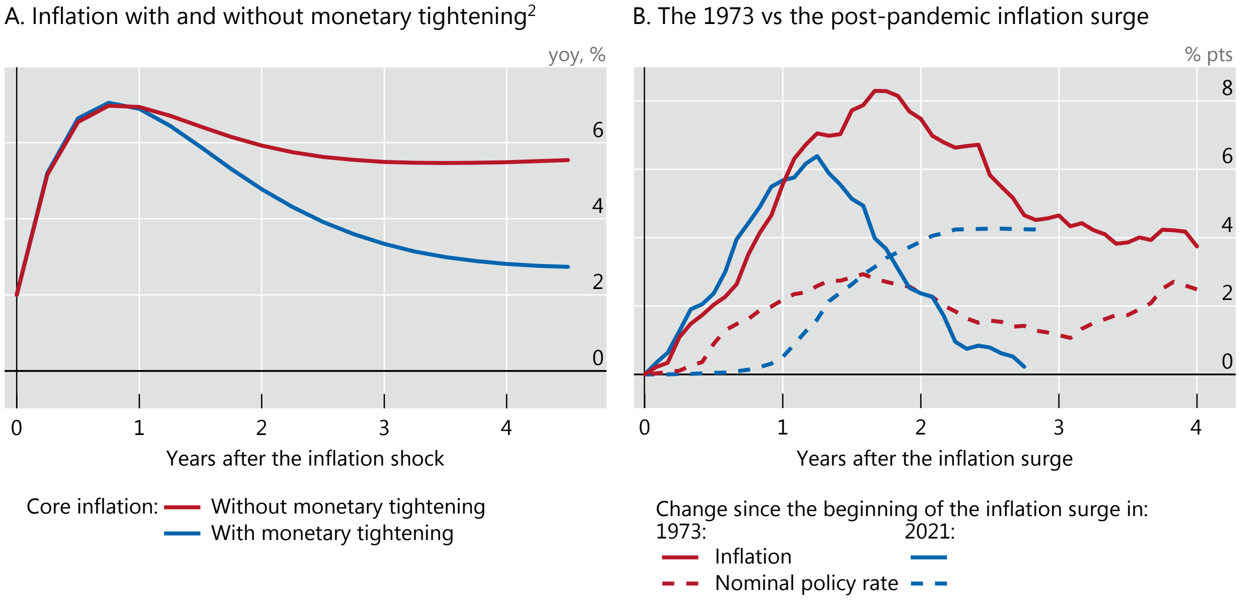
Monetary policy has contributed to bringing inflation under control in two ways (Chapter I). First, it has compressed aggregate demand relative to what it would otherwise have been. The resilience of economic activity and tightness of labour markets suggest that the compression of aggregate demand has also been supported by an increase in supply. Second, the commitment to bringing inflation under control provided a strong signal to markets, firms and workers that the central bank would do what it took to restore price stability. This helped prevent an inflation psychology from setting in, with behaviour adjusting to a high-inflation regime.

A look at simple models and at previous historical experience sheds light on the key role of policy.[4] Graph 5.A illustrates simulations based on a model in which inflation expectations are influenced by inflation outcomes rather than being mechanically linked to the central bank's inflation target. Tightening monetary policy during an inflation surge is critical to prevent a de-anchoring of inflation expectations and avoid a transition to a high-inflation regime. This is broadly consistent with experience in the early 1970s, when a smaller and shorter-lived monetary policy response failed to prevent a shift to a high-inflation regime (Graph 5.B).

Central banks can stabilise the financial system in times of stress

The events of the past two decades have confirmed once again that central banks play a key role in the management of financial crises. During episodes of financial stress, stabilising the financial system is essential to prevent the economy from falling

The role of monetary policy in countering the inflation surge[1] Graph 5



[1] See technical annex for details. [2] Simulations based on the semi-structural model by Hofmann et al (2021).

Sources: Amatyakul et al (2023); Global Financial Data; national data; BIS.

into a tailspin. As central banks are the ultimate source of liquidity, their actions are critical to boost confidence, tackle market dysfunction and support the flow of credit to firms and households. Thus, by deploying their firepower effectively, central banks can not only prevent inflation from becoming entrenched but also tackle a key source of deflationary pressures – major financial crises.

While at such times policy rates are typically cut, it is the forceful deployment of the balance sheet that does the heavy lifting. Following the GFC and the Covid-19 crisis, central banks deployed a whole range of tools.[5] Reflecting the nature of the shock, the response to the Covid-19 crisis was even broader than that to the GFC and more heavily tilted towards markets.

Underlying the criticality of confidence, the evidence confirms that announcements play a key role in stabilising the system, well beyond the actual deployment of tools.[6] A credible announcement signals the central bank's willingness to take the necessary actions to tackle dysfunctions. As an illustration, Graph 6.A documents the major impact of the announcement of LSAPs during the GFC, Mario Draghi's "whatever it takes" statement during the euro area sovereign debt crisis and the Federal Reserve's announcement of several measures during the Covid-19 crisis.

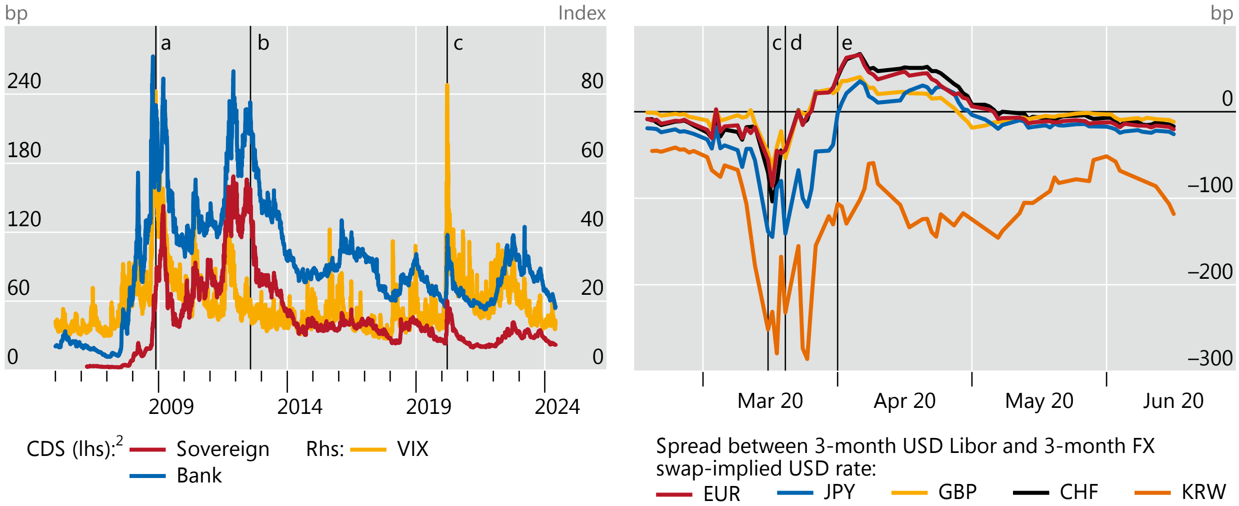
Episodes of financial stress also confirmed the importance of providing liquidity in foreign currency, highlighting the need for central bank cooperation. Here, international currencies are front and centre, especially the US dollar globally and the euro on a more regional scale.[7] Self-insurance through the build-up of FX reserves helps but only up to a point (see below). Swap lines were repeatedly and effectively used to alleviate dollar funding shortages. During the GFC, the swap lines helped avoid the meltdown of the global financial system,[8] and they again played a key role during the euro area sovereign debt crisis and the Covid-19 crisis. For example, during the Covid crisis, the announcement of better terms on the standing swap lines between five central banks and their reopening with nine others had an immediate impact on the US dollar FX swap basis – an indicator of global dollar funding conditions (Graph 6.B).[9] The basis narrowed further as these swap lines were

Central bank policies during crises alleviate stress[1]

Graph 6

A. Financial stress and major policy announcements

B. The impact of swap lines on FX swap basis in 2020



[a] Federal Reserve announcement of large-scale asset purchases (25 November 2008). [b] "Whatever it takes" statement by Mario Draghi (26 July 2012). [c] Federal Reserve announcement of measures during the Covid-19 crisis, including the one on enhancing the provision of liquidity via the standing US dollar swap line arrangements with five central banks (15 March 2020). [d] Federal Reserve announcement of the establishment of US dollar swap line arrangements with nine more central banks (19 March 2020). [e] Federal Reserve announcement of the establishment of Foreign and International Monetary Authorities (FIMA) Repo Facility (31 March 2020).

[1] See technical annex for details. [2] CDS = credit default swaps.

Sources: Bloomberg; S&P Global Market Intelligence; national data; BIS.

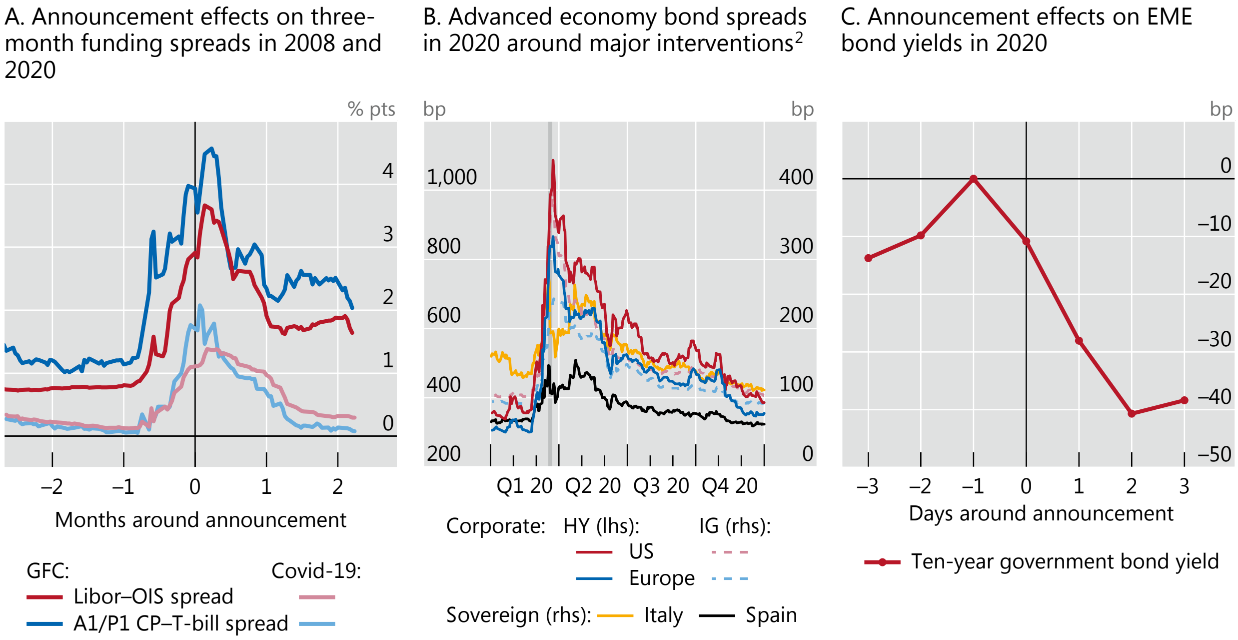
deployed. At the time, the Federal Reserve also complemented swap lines with a new repurchase agreement (repo) facility with much broader country access, allowing countries to deploy their FX reserves more easily while relieving selling pressure in the US Treasury market.

The financial crises also saw an important evolution in the role that central banks play in crisis management. Historically, central banks had focused on providing emergency funding to financial institutions, largely banks – the standard lender of last resort function. But that role could no longer suffice given the rapid growth of financial markets, of more complex financial instruments and of non-bank financial institutions (NBFIs).[10] The setting up of asset purchase facilities also turned central banks into de facto market-makers or buyers of last resort and brought them into closer contact with non-banks, including investment vehicles.[11] This allowed them to have a more direct impact on both funding spreads and secondary market spreads (Graphs 7.A and 7.B). In EMEs, this function was especially important during the pandemic, to alleviate market stress in domestic currency bond markets as foreign investors retreated (Graph 7.C).[12]

While successful, central bank interventions also pointed once again to certain limitations.

For one, liquidity provision alone is insufficient when broader solvency concerns are present. Hence the need to draw on government support, as the sovereign is the ultimate backstop of the financial system. For example, during both the GFC and Covid-19 crisis, government support through extensive guarantees and other measures was crucial to allow central banks to extend longer-term funding and assume credit risk.[13] All this puts a premium on close cooperation. At the same time, it can raise delicate issues related to the relationship between the central bank and the government and their interlocking balance sheets. These issues can complicate the conduct of monetary policy in more normal times.[14]

From lender of last resort to market-maker of last resort[1] Graph 7



The shaded area in panel B indicates the period from 18 March 2020 (ECB announced €750 billion pandemic emergency purchase programme) to 23 March 2020 (Federal Reserve announced extensive new measures).

[1] See technical annex for details. [2] HY = high-yield; IG = investment grade.

Sources: Arslan et al (2020); Bloomberg; ICE Data Indices; LSEG Datastream; BIS.

In addition, and relatedly, interventions are not costless. Directly or indirectly, the central bank typically puts its balance sheet at risk, absorbing risks that the private sector is unable or unwilling to take on. Moreover, the calibration of the support is difficult, and there is a natural tendency to err on the side of doing too much rather than too little. In turn, the expectation of such interventions in the future can temper market discipline and fuel risk-taking – moral hazard.[15] The issue is especially relevant when central banks purchase assets outright, absorbing risk more directly. The standard way to limit moral hazard is by ensuring that risks are adequately priced and borne by market participants, especially through regulation, but this has proved especially hard in the NBFI sector (Chapter I).

Prolonged monetary easing runs into limits

If the post-pandemic fight against inflation and the management of two major episodes of stress highlighted the strengths of monetary policy, the post-GFC years also brought to light some of its limitations. To be sure, the post-GFC unprecedented phase of monetary easing through a wide range of new tools was instrumental in promoting economic recovery and maintaining price stability. That said, as time wore on, some limitations that had tended to be underplayed at the outset became more evident.[16] These include, in particular, signs of reduced traction as well as longer-term side effects on the financial system and the economy.

Limited traction

The empirical evidence clearly indicates that unconventional policy measures allowed central banks to ease financial conditions much further.[17] Large-scale asset purchases helped compress risk (term and credit) premia and, by underlining central banks' willingness to keep interest rates low, influenced expectations of policy rates further out in the future – the signalling channel.[18] Forward guidance helped shape those expectations more directly and, by reducing uncertainty about the policy rate path, compressed risk premia too. Negative interest rates were transmitted to money market and capital market rates very much like other policy rate cuts, thereby also having a similar impact on the exchange rate. And special lending programmes supported banks' profitability and encouraged lending.

At the same time, the evidence also points to some limitations.[19] They concern the impact on financial conditions and that of financial conditions on economic activity and inflation.

Some of the limitations regarding the influence on financial conditions are instrument-specific. The power of LSAPs is weaker when markets are not under stress, as the emergency support role of the central bank is not at work.[20] That power also appears to wane at the margin as purchases grow, although the evidence here may also reflect difficulties in identifying the "surprise" element if the central bank becomes more predictable (Box A).[21] The pass-through of negative interest rates to the rates charged by intermediaries has proven to be somewhat weaker than that to money and capital market rates. This has particularly been the case for deposit rates, given banks' reluctance to cut them below zero, especially for retail depositors. And special lending schemes may not always have encouraged the targeted lending.[22]

Other limitations regarding the influence on financial conditions are of a more general nature. There are limits to how far risk premia can be compressed, to how far central banks can commit to keeping interest rates low in future and to how far they can push rates into negative territory – and do so without unnerving private market participants, potentially signalling dire conditions or weakening intermediation. For instance, this may be a reason why the impact of monetary easing on bank lending appears to diminish when interest rates are very low for long periods.[23]

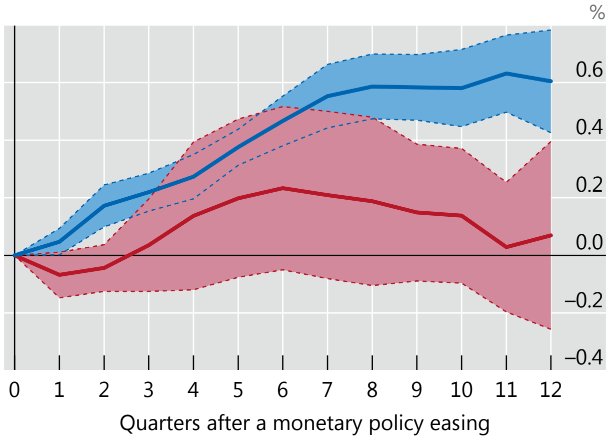
A sense of diminishing returns to strong and prolonged easing also comes from the behaviour of the economy and inflation. There is evidence that easing had a lesser impact on real activity after the GFC compared with the preceding decades (Graph 8.A).[24] One important reason is that financial recessions blow powerful headwinds. Agents give priority to repairing balance sheets and it takes time for resources to be reallocated and for the capital overhang to be reabsorbed.[25] In addition, broader factors appear to have been at work.

One factor is that low interest rates may lose traction on economic activity as they reach low levels and stay there. There may be several reasons for this. Not least, there are limits to the extent to which expenditure may be brought forward from the future. Moreover, a few basis points may hardly be noticed once borrowing costs are already very low; sticky hurdle rates for investment are a case in point. Empirical evidence is consistent with this loss of traction.[26] It shows a weaker impact at the margin in a very low interest rate environment even when controlling for phases of economic recession and high debt (Graph 8.B).

Similarly, there is evidence that in a low-inflation regime, inflation becomes less sensitive to monetary policy easing.[27] One possible reason is that, as low inflation becomes entrenched, the common component of price changes drops substantially (Graph 9.A), and this is the component on which changes in the monetary policy stance mainly operate. It is the one closely linked to economy-wide forces such as aggregate demand or the exchange rate. Indeed, monetary policy surprises appear to have a persistent impact on the common component of price changes (Graph 9.B) but a much more limited one on the idiosyncratic elements (Graph 9.C). Consistent with this finding, in a low-inflation regime, monetary policy appears to operate

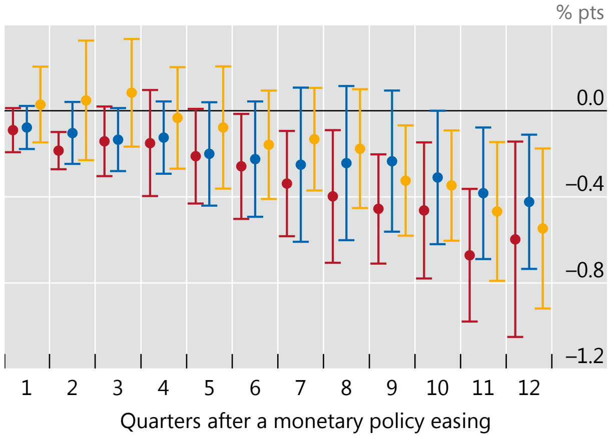
Weaker traction of monetary policy when interest rates are low[1] Graph 8

A. Real GDP response to monetary stimulus: high vs low interest rate regimes[2]



Low interest rate: High interest rate:
Impact of 100 bp rate cut
90% confidence interval

B. Low interest rates, high debt and downturns reduce traction of expansionary monetary policy[3]



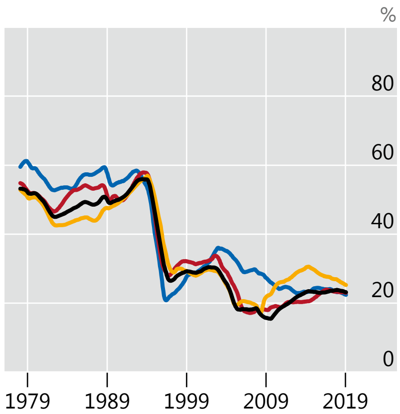
Reduction in monetary easing impact on real GDP:
Estimate: +/– two standard errors:
Low interest rate
High debt
Downturns

[1] See technical annex for details. [2] Impulse response of real GDP to a 100 bp expansionary monetary policy shock. [3] Marginal effects of a 100 bp expansionary monetary policy shock under different regimes at respective horizons.

Source: Ahmed et al (2024).

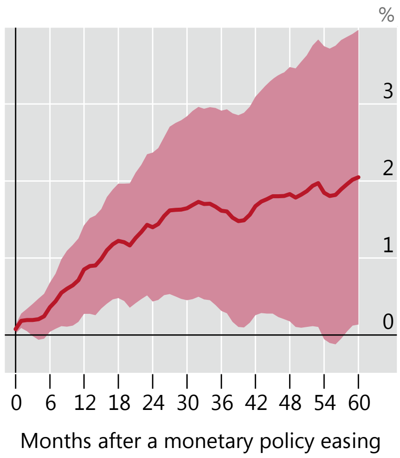
The impact of monetary policy on inflation in the US[1] Graph 9

A. Time-varying fraction of total price-change variance due to the common component



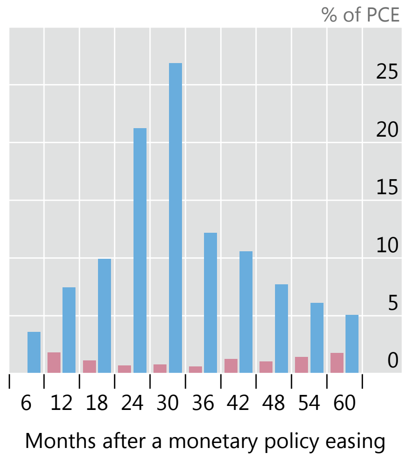
Share of variance explained by the common component:
All sectors
Durable goods
Non-durable goods
Services

B. Response of the common component of PCE prices to monetary policy easing[2]



Estimate
90% confidence interval

C. Statistically significant idiosyncratic and overall sectoral price increases[2]



Idiosyncratic response
Overall sectoral response

[1] See technical annex for details. [2] PCE = personal consumption expenditures. Based on a standard local projections exercise to assess the impact of monetary policy shocks (25 bp).

Source: Borio et al (2023).

Box A

Are the effects of balance sheet policies (a)symmetric?

When policy rates hit the effective lower bound, central banks turned to unconventional monetary policy tools – above all, balance sheet policies in the form of large-scale asset purchases – to provide additional monetary easing. Against the backdrop of the recent tightening cycle, a relevant question is whether and to what extent the unwinding of asset purchases also contributes to a tighter policy stance – that is, whether balance sheet policies have symmetric effects. The goal of this box is to tease out conceptually and empirically key reasons behind possible asymmetries. Specifically, the box highlights that any assessment of the effects of balance sheet policies needs to consider the specific circumstances under which announcements were made. Hence, announcements made at times of market turbulence will have larger observable effects compared with those made under calm market conditions.

To understand the drivers of potential asymmetries in the transmission of balance sheet policies, it is useful to consider the channels through which these affect financial prices. The literature has commonly focused on distinguishing "signalling" from "portfolio rebalancing" effects.[1] But there is also another, somewhat less appreciated, "confidence" channel, typically mostly operational during stress episodes.

The signalling effects of balance sheet policies work through investor expectations. Large-scale asset purchases reinforce central banks' commitment – sometimes also bolstered through forward guidance – to keep an easy policy stance for an extended period; this in turn influences the expected short rates embedded in longer-term yields. Against this backdrop, large-scale asset purchases reinforce central banks' commitment by "putting their money where their mouth is", underpinning the credibility of their announcements.

The portfolio rebalancing channel works more squarely via quantities.[2] Changes in central banks' asset holdings mechanically affect the quantities of government debt securities available to private investors and hence induce them to adjust their holdings.[3] For example, if the central bank absorbs duration risk by acquiring long-term securities, term premia embedded in long-term yields are likely to fall.[4] This may in turn induce market participants to search for yield by shifting to longer maturities or by loading up on securities with more credit risk.

The confidence channel plays a more episodic role at times of acute stress. It is the mix of confidence-inducing and risk-relieving effects that central banks' interventions as lenders (or market-makers) of last resort can generate. Importantly, such "confidence" effects interact with and strengthen signalling and portfolio rebalancing effects by restoring calm to markets and preventing dysfunction.

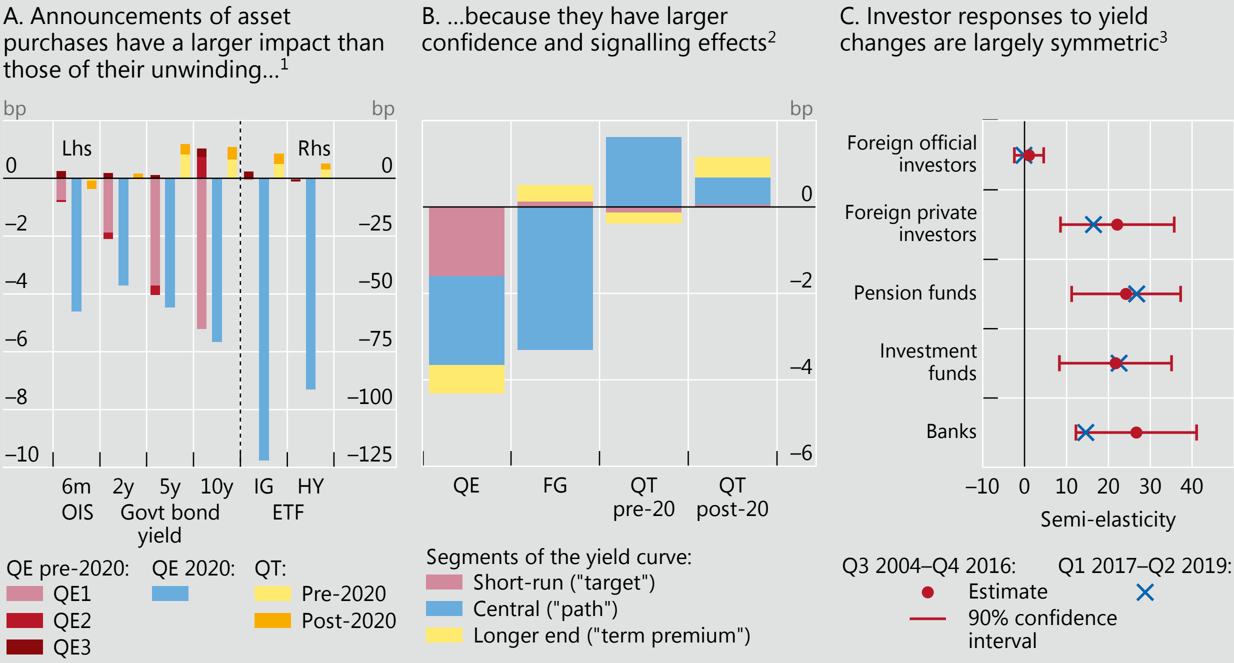
There is a sense among observers that the effects of the balance sheet run-off have been smaller than those of asset purchases, hinting at an asymmetric impact.[5] Prima facie, this is apparent if one looks at the magnitude of changes in financial prices around announcements related to asset purchases and their unwinding (Graph A1.A). Yet it does not necessarily indicate that the unwinding had little effect. As noted above, the observed market reactions are to an important degree shaped by the different circumstances in which balance sheet policies were deployed.

Central banks first designed and deployed balance sheet policies amid acute financial stress – times in which confidence effects were most pronounced. Their main objective was mending severe market disruptions by alleviating the constraints faced by market participants and restoring an effective monetary transmission. As such, large-scale asset purchases had very large market effects at first: not only did they reveal central banks' resolve to prevent a financial meltdown, but they also underscored their commitment to keep monetary accommodation in place as long as necessary, thereby strengthening the potency of signalling effects (Graph A1.A, pink bars).[6]

In subsequent rounds, the circumstances changed. As market functioning was restored, providing monetary stimulus at the effective lower bound became paramount. Progressively, market participants became more familiar with the new balance sheet tools, not least thanks to central banks being more forthcoming about their deployment through their communication. Hence, the surprise element of announcements waned, and so did their immediately visible effects on financial markets (Graph A1.A, red and maroon bars). So, over time, a larger share of the transmission occurred through portfolio rebalancing rather than signalling effects.

As, later on, central banks deliberated on how to best unwind large balance sheets, they emphasised predictability to minimise the consequences on financial markets. In parallel, they de-emphasised the role of the balance sheet run-off as a policy tool on its own: in the principles underlying the unwinding of their balance sheets, major central banks underscored that the main tool to set the monetary policy stance would be the policy rate, while the balance sheet unwinding would play only an ancillary role.[7] Consistently, they relied heavily on passive strategies, ie gradually reducing the pace of reinvestment or just letting bond holdings mature. Moreover, they sought to unwind when markets were calm and well prepared. Central banks wanted the unwinding to be "like watching paint dry". Consistently, the lack of a significant surprise component gave rise to a generally smaller immediate market response to balance sheet unwinding announcements compared with purchases. This is also evident from the smaller effects of recent announcements on the speed of unwinding (Graph A1.A, orange bars), which market participants were better prepared to digest, compared with the earlier tapering announcements in 2013–14 (Graph A1.A, yellow bars), which took market participants by surprise, unleashing the so-called taper tantrum.

The effects of balance sheet expansions and contractions in the US — Graph A1



ETF = exchange-traded fund; FG = forward guidance; HY = high-yield; IG = investment grade; OIS = overnight indexed swap; QE = quantitative easing; QT = quantitative tightening.

[1] QE1 corresponds to events between November 2008 and early August 2010; QE2 from late August to November 2010; QE3 from January to December 2012; and QE 2020 to those in 2020. QE and QT average responses are weighted by the number of events. IG and HY credit ETFs are inverted. [2] Average of responses to announcements categorised based on the impact they exert on the segments of the yield curve. [3] Percentage change in government bond holdings of each sector for 1 percentage point change in the eight-year zero coupon yield computed based on Eren et al (2023). Q1 2017–Q2 2019 indicates the first QT period in the US.

Sources: Eren et al (2023); LSEG Datascope; BIS.

One way of distinguishing the relative importance of signalling and portfolio balancing effects is via the different impact they exert on different segments of the yield curve. Announcements for which the signalling component is prevalent should mainly affect short to intermediate bond maturities, given that they reinforce the desired policy stance in the short to medium run. By contrast, announcements for which the portfolio rebalancing channel is prevalent should mainly move the longer end of the curve, as the absorption of duration risk by the central bank compresses term premia that are most pronounced at the long end.

In line with this reasoning, Graph A1.B seeks to decompose changes in 10-year yields around monetary policy announcements into the contributions of the short-run segment ("target"), the central segment ("path") and the longer end ("term premium"). Early announcements of large-scale asset purchases, as well as those related to their tapering in 2013–14, operated mainly through the "path" component,[8] which indicates a predominant role of the signalling channel. This is also consistent with forward guidance announcements affecting the "path" segment of the yield curve.[9] By contrast, in the last wave of unwinding announcements, the "premium" component has become more relevant, highlighting the role of the portfolio rebalancing channel when decisions are more predictable.

While the impact of the signalling channel depends heavily on market conditions, the portfolio rebalancing channel, at least as it pertains to purchases of safe government paper, should largely operate in the same way irrespective of the circumstances. As the mechanics of this channel involve quantity adjustments, it is useful to look at it by focusing on changes in investment holdings. Graph A1.C shows that, for a given change in yields, the incremental demand for government bonds by different investors is essentially the same for large-scale asset purchases and their unwinding.[10] Overall, estimates of demand sensitivities across investors imply that, on aggregate, investors require a yield increase of 10 basis points for an additional absorption of debt of around $250 billion – during both quantitative easing and quantitative tightening episodes.

To sum up, any perceived asymmetry in the immediate market effects of large-scale asset purchases and their unwinding can be ascribed to the more powerful effect of asset purchase announcements at times of stress and uncertainty. As central banks deliberately tried to avoid surprising markets when unwinding their balance sheets, market movements around run-off announcements became smaller. However, this does not mean that balance sheet unwinding had no impact on yields: while the signalling impact and surprise elements may have been more muted, the portfolio rebalancing channel had similar effects on investors' portfolio decisions for large-scale asset purchases and their unwinding.

[1] See for example Christensen and Rudebusch (2012). [2] For a general discussion on the portfolio rebalancing channel, see Duarte and Umar (2024). Selgrad (2023) provides evidence in the context of quantitative easing. [3] As financial markets are forward-looking, the effects should in principle occur when announcements about large-scale asset purchases and their unwinding are made. Yet the adjustment can take time, hence the effects of this channel can also be diluted over time, when changes in the balance sheet are actually implemented. [4] Note that the overall effects of central banks' interventions also depend on the supply of government debt, which is determined by fiscal policy (ie how much funding is necessary) as well as by the debt management strategies (ie the maturity and specifics of the bonds to be issued). [5] See Du et al (2024). [6] The prominent role of confidence effects is apparent when looking at announcements made around the outbreak of the Covid-19 pandemic (Graph A1.A, blue bars) and especially at the strong impact they had on riskier bonds. [7] See for example Board of Governors of the Federal Reserve System (2022), Schnabel (2023) or Bank of England (2021). [8] Note that this is also consistent with the idea that the signalling component is prevalent in announcements that take markets by surprise. [9] See also Kearns et al (2023) and Swanson (2021). [10] Results are based on the framework by Eren et al (2023).

through a remarkably narrow set of prices, with a statistically significant impact for only about a quarter of the sectors, even after 36 months (Graph 9.C).

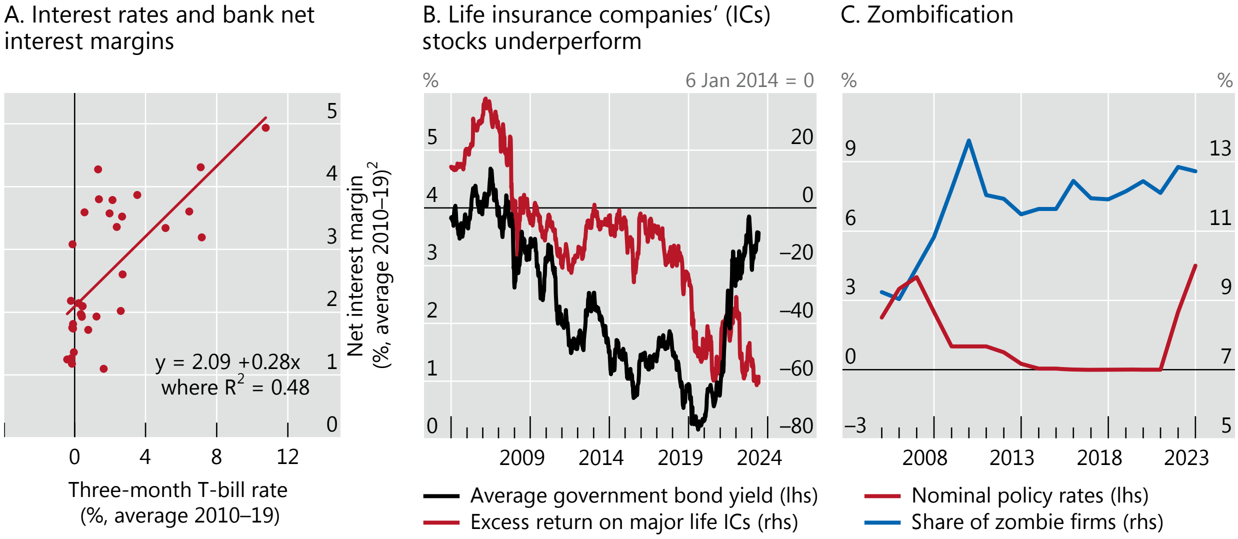
Side effects and costs

A more limited traction worsens the trade-off between the benefits and costs of prolonged and aggressive monetary easing. Some of the costs become apparent only when interest rates remain exceptionally low for very long. These include the build-up of debt, capital misallocation, the declining profitability of financial intermediaries and impaired market functioning. In addition, such policies can have undesirable consequences for central banks themselves to the extent that they narrow the room for policy manoeuvre, reflecting difficulties in devising exit strategies and tighter interlinkages with the government.

Prolonged periods of very low interest rates can weaken the profitability of financial intermediaries and erode their resilience.[28] Banks are a case in point. To be sure, an easy stance lifts profits by boosting asset values and spurring economic activity. But in the longer run these effects tend to wane or even reverse, and the more lasting impact operates through compressed net interest margins, as deposit rates are sticky, and through lower returns to maturity transformation, particularly if LSAPs depress the term premium (Graph 10.A). Central banks have actively sought to limit such side effects by providing relief through interest offered on intra-marginal reserve holdings. Insurance companies and pension funds also suffer (Graph 10.B). This is mainly because the maturity of their liabilities exceeds that of their assets, so that their value increases by more as interest rates decline.

Prolonged periods of low interest rates can also weaken non-financial firms. It is easier for unprofitable enterprises to remain in business when borrowing costs are very low and lenders have a greater incentive to "extend and pretend", given the lower opportunity cost of forbearance. Eventually, some firms might even borrow primarily to service existing debt and avoid exiting or restructuring – so-called zombies (Graph 10.C). This contributes to the misallocation of labour and

Side effects of prolonged monetary easing[1] Graph 10



[1] See technical annex for details. [2] Simple average of net interest margin across banks within each economy.

Sources: Banerjee and Hofmann (2022); Bloomberg; Fitch; Global Financial Data; LSEG Datastream; S&P Capital IQ; national data; BIS.

capital by crowding out more productive businesses. Empirical evidence tends to confirm this observation.[29] It finds a ratcheting up in the prevalence of zombies since the late 1980s linked to reduced financial pressure and hence lower interest rates even after accounting for other factors. The evidence also points to crowding out effects.

More generally, prolonged monetary easing can inadvertently contribute to the build-up of financial vulnerabilities. This is in part inherent to the transmission mechanism. Monetary policy works to an important extent by boosting credit and asset prices, including by compressing risk premia and encouraging risk-taking. These effects remain contained during normal business fluctuations but can generate vulnerabilities if the easing is prolonged. Indeed, growing empirical evidence indicates that such easing can, over time, increase the probability of financial stress.[30] For example, the sharp increase in interest rates to fight the recent inflation flare-up tested the business and trading strategies put in place during the low-for-long period and was at the root of valuation losses on government and mortgage bonds that caused banking strains in March 2023. Likewise, the GFC itself was arguably in part the result of the period of low rates that preceded it.

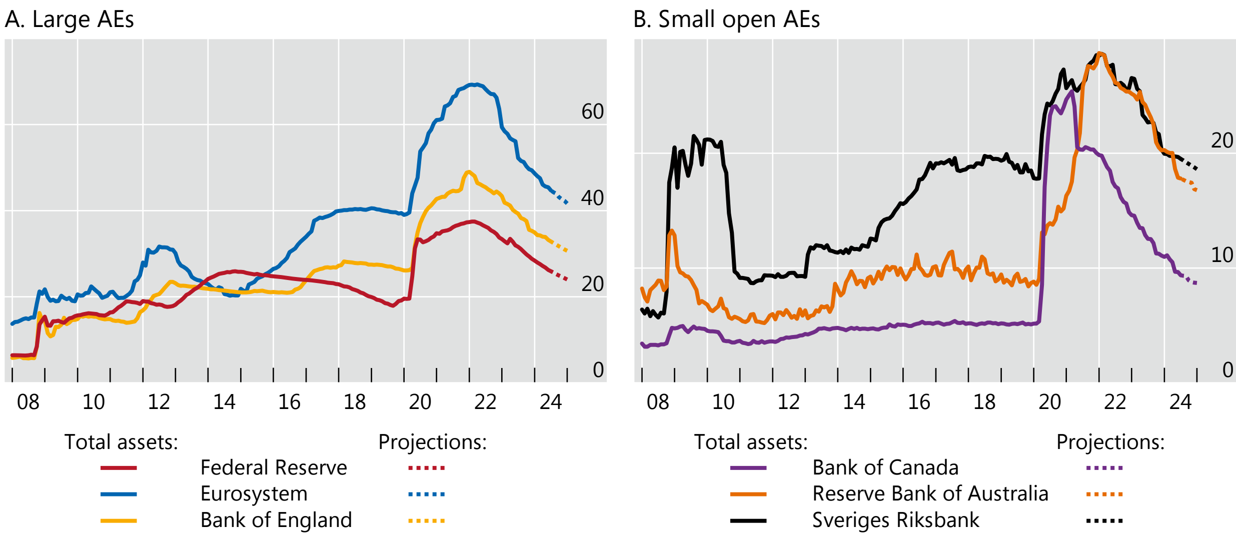
This raises the risk that, over time and successive cycles, monetary policy may lose room for manoeuvre. As the post-GFC experience has highlighted, financial recessions are especially deep and call for strong and prolonged easing. And inflation can be less responsive to such easing in a low-inflation regime (see above).

The risk of loss of room for manoeuvre in part also reflects "exit" difficulties. There are inherent asymmetries in the conduct of policy. When central banks seek to stabilise the system, they naturally act forcefully. And the effectiveness of their actions partly hinges on the ability to surprise markets, thereby maximising the impact. By contrast, when exiting, they naturally seek to limit that impact, in part to simplify communication about the policy stance (see below). This counsels gradualism. And this gradualism is reinforced by concerns about untoward market reactions, not least those stemming from the vulnerabilities that may have built up over time. Examples abound, ranging from the taper tantrum in May 2013 (see below) to

Projected central bank balance sheet trajectories in AEs[1]

As a percentage of GDP

Graph 11



[1] See technical annex for details.

Sources: Reserve Bank of Australia; Bank of Canada; ECB; Federal Reserve Bank of St Louis; IMF; LSEG Datastream; BIS.

the US money market ructions in September 2019 or the tremors in the UK bond market in September 2022.

This explains why the speed in the contraction of central bank balance sheets has been so gradual and is projected to remain so (Graph 11). Many central banks opted for a measured approach, employing strategies like letting bonds mature; only a few resorted to outright sales. Apart from a few incidents, the experience so far suggests that the impact of the balance sheet unwinding on financial markets has been benign.[31]

Large and risky balance sheets, in turn, may constrain the central banks' room for policy manoeuvre. In part, this stems from the political economy of central bank financial results, especially losses (Box B). Central banks can operate even with negative equity, as many have. Moreover, their performance should not be judged on financial results but on how well they fulfil the assigned mandate. Even so, largely because of the impact on the government's fiscal position and the central bank's credibility, losses can raise political economy challenges that, unless properly addressed, could unduly constrain policy. More generally, the constraints simply reflect the costs that larger balance sheets can have on the financial system and economy through the channels discussed in this section.

Communication has become more complicated

Communication has always been integral to monetary policy. Moreover, its role has grown over decades, as central banks have become more transparent due to changes in intellectual paradigms, in the heft of markets and in institutional set-ups. Greater transparency has been seen as essential to strengthen effectiveness and accountability.

At the same time, since the GFC communication has become more complicated. Three factors have been responsible: the willingness to influence financial conditions beyond changes in policy rates, the multiplicity of tools used to set the stance, and surprising changes in macroeconomic conditions.

Box B

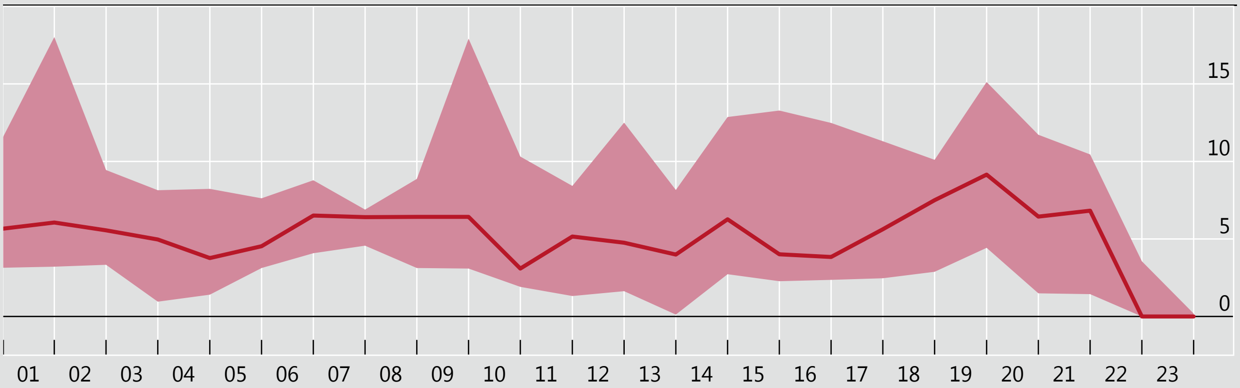
Central bank financial results and their economic implications

As inflation has surged, many central banks have incurred financial losses and have stopped distributing remittances to governments (Graph B1). These financial results have become the focus of debate. This box takes a step back and addresses a number of questions. What influences the sign and size of central banks' financial results? What implications do they have for fiscal positions? And to what extent can financial results influence a central bank's ability to fulfil its mandate?

Central bank remittances

As a percentage of government interest payments

Graph B1



[1] The sample covers AT, AU, BE, CA, CH, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, JP, LT, LU, LV, NL, NO, NZ, PT, SE, SI, SK and US, subject to data availability. For 2023, data are not available for CA, CH, EE, FR, GB, IE, JP, LU, LV, NL, NZ, PT, SE, SI and SK.

Sources: Federal Reserve Bank of St Louis; IMF; OECD; LSEG Datastream; national data; BIS.

To fulfil their macroeconomic and financial stability mandates, central banks must deploy their balance sheets. This means taking positions that can result in profits and losses. These profits and losses can arise from both domestic and foreign currency positions.

Structurally, central banks tend to earn profits on their domestic currency positions. Their interest-bearing domestic assets – notably government securities – are in part financed with non-interest-bearing cash and, possibly, non- or low-interest-bearing reserve requirements. But losses can also arise. Recently, sizeable losses have reflected the increase in interest rates following large-scale government bond purchases in the wake of the Great Financial Crisis and Covid-19 pandemic: borrowing costs on interest-bearing reserves, indexed to the overnight rate, have increased while the interest rate on central banks' longer-maturity assets has remained unchanged.[1] Less commonly, central banks may also incur credit losses on crisis management operations.[2]

There is no equivalent structural profit on the financial results on foreign currency positions. The gains and losses, when measured in the domestic unit of account, largely reflect exchange rate-driven valuation effects on holdings of foreign exchange (FX) reserves that may or may not compensate for interest rate differentials. Where reserves are sizeable, the profits and losses on FX positions can easily dwarf the financial results on domestic currency operations. This has been the case for many emerging market economies and some small open advanced economies.

Technically, whether a central bank is making losses or, indeed, whether its capital is negative, is of little consequence for its operations. Indeed, history shows that central banks have been able to operate successfully notwithstanding extended periods of losses and with negative capital (for example, the central banks of Chile, Czechia, Israel and Mexico), without compromising their mandates.[3]

What could prevent the central bank from fulfilling its mandate is the public losing confidence in the currency. This ultimately depends on the condition of the *consolidated* central bank and government financial position. Central banks can prevent the *technical* default of the sovereign through their power to issue money, ie irredeemable liabilities. But acceptance of those liabilities, in turn, ultimately hinges on the sovereign's power to tax. Central bank losses can weaken the fiscal position of the state. In accounting terms, this impact crystallises most visibly in central bank remittances to the government.[4] But central bank losses are generally not large enough to play a decisive role in this respect.

Regardless of these fundamental considerations, financial results can give rise to political economy challenges. They can, for instance, raise questions about the central bank's financial independence. And they can make central banks the target of public criticism based on misunderstandings about the nature of the institution and its fundamental difference from commercial enterprises. This puts a premium on communication and institutional arrangements that can shield the central bank's operational autonomy and room for manoeuvre.[5]

Central banks are organs of the state that pursue the public good. Ultimately, they should be judged based on whether they deliver on their mandates rather than on their financial results.[6] And there is no systematic relationship between the two.

[1] These developments reflect the impact of large-scale asset purchases by central banks on the consolidated maturity of public debt. These purchases are equivalent to large debt management operations, whereby the public sector buys back long-term bonds and replaces them with debt indexed to the overnight rate. This raises the sensitivity of fiscal positions to higher interest rates (see, for example, Disyatat and Borio (2021)). [2] See, for example, the case of Chile in the 1980s, when the central bank experienced heavy losses from measures to rescue the banking system (Caputo and Saravia (2021)). [3] Hampl and Havránek (2018) conduct an extensive review of the literature and find no systematic evidence that central bank financial strength affects inflation outcomes. See also Nordström and Vredlin (2022) and Bell et al (2024). [4] In principle, since the concern is about the *consolidated* position, whether transfers between the central bank and the government take place is immaterial. In practice, transfers can make a difference if they change perceptions about the government's fiscal position. [5] See Bell et al (2023) for a more extensive discussion of central banks' approaches to accounting, distribution and risk transfer. [6] See Carstens (2023).

Financial conditions depend not only on what monetary policy does today but also on what it is expected to do in the future. This influences interest rates at longer maturities and the whole array of financial conditions. Therefore, even when policy was limited to adjustments in the (short-term) policy rate prior to the GFC, central banks provided information about how they thought policy would evolve. That said, at the time communication was largely designed to provide guidance about the central bank reaction function. This was so even when central banks published the likely path of policy rates, as a handful did.

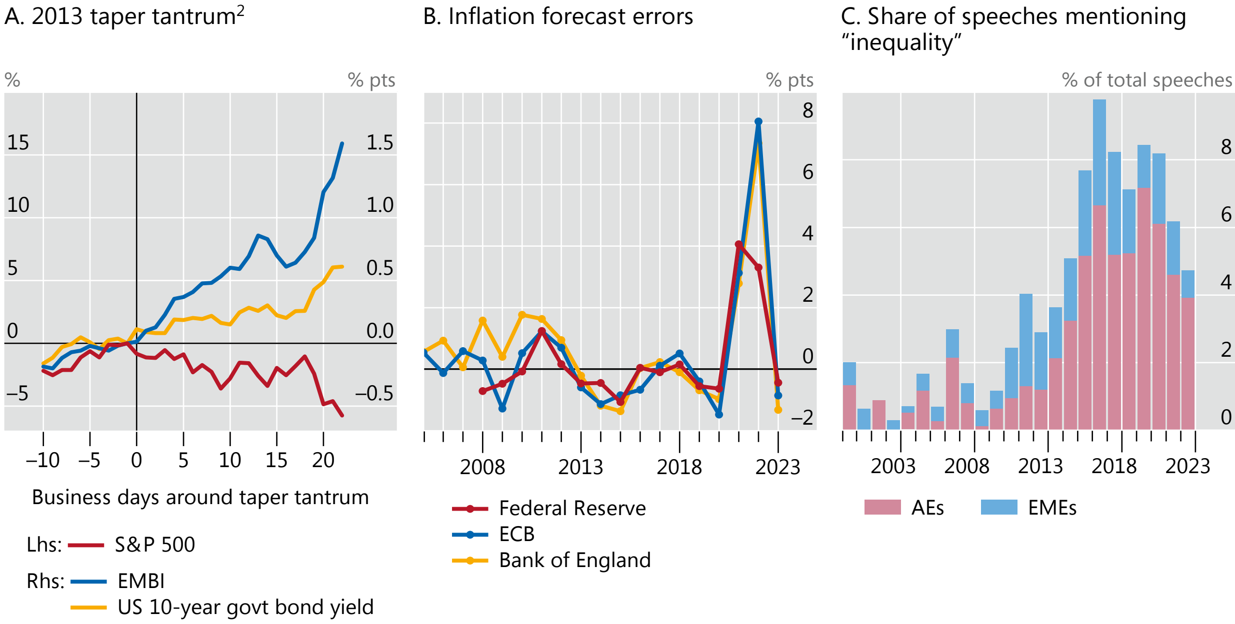
The nature of forward guidance changed once policy rates hit the perceived effective lower bound. At that point, forward guidance was explicitly employed to ease the monetary policy stance further. This meant providing some form of assurance that interest rates would remain lower for longer. In turn, this involved an element of commitment. Commitment, by its very nature, reduces flexibility to respond to unexpected events. Central banks addressed this trade-off in various ways, by emphasising to different degrees the conditionality of the guidance.[32] But given the underlying intention, even when conditionality was emphasised, it was often discounted by markets and the public at large. In some cases, this ended up either constraining the flexibility to adjust to rapidly changing conditions or undermining the credibility of the institution when it did change course.

The sheer multiplicity of tools has complicated communication by making it harder to understand the policy stance. First, the stance could no longer be identified with the behaviour of a single variable, and aggregating the impact of different tools proved exceedingly hard. Second, the very impact of the tools in some cases was difficult to disentangle. An obvious example is the information that LSAPs could convey about future policy interest rates, underpinning forward guidance. Third, the fact that the same tool can be used for quite different purposes – setting the stance and managing market stress – made it hard to distinguish the two objectives.

At times, these complications caused unwelcome market reactions. The taper tantrum is probably the most salient example. The mere announcement of a slowdown in the pace of asset purchases by the Federal Reserve triggered turmoil in US financial markets, with major global reverberations, in particular for EMEs (Graph 12.A).

Central banks have taken steps to manage this complexity. On the one hand, they have de-emphasised the role of asset purchases as an element of the monetary

Communication challenges: market reactions, inflation and wider topic range[1] Graph 12



[1] See technical annex for details. [2] Taper tantrum on 22 May 2013. Growth rate for S&P 500 and change for EMBI and the US 10-year government bond yield, with respect to 21 May 2013.

Sources: ECB; Bank of England; Board of Governors of the Federal Reserve System; Bloomberg; JPMorgan Chase; LSEG Datastream; national data; BIS.

policy stance. As central bank balance sheets have started contracting, the pace of reduction has either been put on autopilot or portrayed as reflecting objectives other than managing the economy and inflation. On the other hand, they have sought to distinguish balance sheet operations designed to manage financial stress from those designed to alter financial conditions in the light of macroeconomic developments. For instance, during the government bond market turmoil in September 2022, the Bank of England explicitly clarified that the asset purchases should in no way be interpreted as slowing down the tightening of policy.

The main macroeconomic development complicating communication has been the surprising behaviour of inflation. In the aftermath of the GFC, when inflation remained stubbornly below target, a common challenge was to justify unprecedented policy settings designed to push it back up despite concerns about its perceived adverse effects, not least on inequality.[33] The possible impact of exceptionally low rates on income and wealth distribution was more easily understandable than the costs of low inflation. When inflation subsequently surged, the challenge was to explain the reasons for the failure to anticipate it, as reflected in large forecast errors across central banks (Graph 12.B), to convey the exceptional uncertainty surrounding the outlook without sapping confidence and to underline the unwavering commitment to restoring price stability.[34] Both situations risked undermining the central bank's reputation and credibility.

Meeting these challenges required central banks to go out of their comfort zone. They had to address topics that would normally be the preserve of other authorities, such as inequality (Graph 12.C). And they had to address the public more directly, adjusting their language and communication style to the targeted audience.[35] Tackling these challenges did not prove easy. Central banks had to address a dangerous expectations gap between what they can deliver and what they are expected to deliver. This challenge will also be a defining one in the years ahead.

FX intervention and macroprudential policies can enhance stability

While the GFC appeared as an isolated meteor strike, it had in fact followed a growing number of banking and financial crises in both AEs and EMEs. These events have underlined the near-term trade-offs between price and financial stability and hence the need for instruments that could complement interest rate policy to manage them.

In that context, FX intervention and macroprudential policies can play an important role. They can help tackle the challenges arising from swings in global financial conditions and from the build-up and unwinding of domestic financial imbalances.[36] This is the lesson in particular from EMEs, which have experienced much greater financial and external stability than in preceding decades. Of course, over the past decades, by far the most fundamental shift in EME monetary policy frameworks has been the adoption of variants of inflation targeting regimes together with the pursuit of a more coherent macroeconomic policy stance, including a greater degree of exchange rate flexibility. At the same time, FX intervention has remained a common complementary tool, and macroprudential measures have further enriched the toolkit.[37]

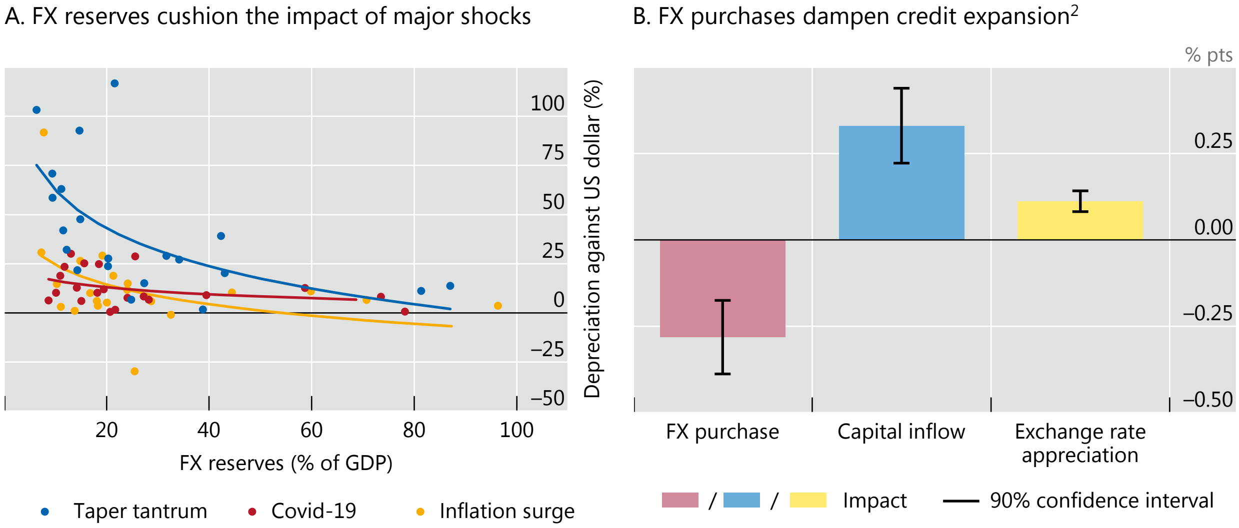
Used wisely and prudently, FX intervention can help improve the trade-off between price and financial stability in two ways.[38] First, it can build FX buffers against future sudden outflows and depreciations.[39] For this, it does not even need to influence the exchange rate. Second, it can help lean against the unwelcome domestic consequences of capital flow and exchange rate fluctuations. Specifically, during a phase of strong capital inflows that put upward pressure on the currency, FX purchases can dampen the build-up of financial imbalances through the financial channel of the exchange rate and, possibly, by "crowding out" lending through the sale of sterilisation instruments.[40] Moreover, it allows interest rates to be kept somewhat higher than would otherwise be the case, limiting at least for some time the build-up of domestic financial imbalances. These two functions of FX intervention apply regardless of specific intervention strategies, tactics and instruments, which have varied considerably over time and across countries.[41]

There is empirical evidence supporting both functions. For instance, during several episodes of financial stress, including the GFC, the taper tantrum and the Covid-19 pandemic, EMEs with larger reserve buffers experienced smaller currency depreciations (Graph 13.A).[42] Similarly, FX intervention can restrain the impact of capital flows and exchange rate appreciation on domestic credit expansion. As an illustration, Graph 13.B shows that FX purchases dampen domestic credit growth in a way that is quantitatively similar to the expansionary effects of capital inflows and exchange rate appreciation.

At the same time, central banks also face difficult trade-offs in the use of FX intervention. The fiscal cost of carrying reserves can be considerable. This is especially true when interest rates are very low in reserve currencies, and for countries with high domestic interest rates. Moreover, to the extent that FX intervention reduces exchange rate volatility and possibly even the sense of two-way risk, it may induce further pressure on the exchange rate. And in the longer run, it may encourage currency mismatches, making economies more vulnerable to global financial conditions. How far precautionary reserves are accumulated and intervention is used as a stabilisation tool will depend on a cost-benefit analysis, which will vary across countries and over time. Restraint is of the essence, especially to ensure that it is not perceived as a substitute for necessary monetary and fiscal adjustments.

In contrast to FX intervention, macroprudential measures are one step removed from monetary policy and are of more recent vintage. The measures are

FX intervention as a quasi-macroprudential tool in EMEs[1] Graph 13



[1] See technical annex for details. [2] Based on estimated coefficients from a panel regression of the change in domestic credit-to-GDP ratio over variables shown on the x-axis, controlling for confounding factors.

Sources: Boissay et al (2023); IMF; Bloomberg; LSEG Datastream; national data; BIS.

designed to complement microprudential regulation and supervision in strengthening the resilience of the financial system. Unlike their microprudential counterparts, macroprudential tools are explicitly calibrated with respect to system-wide variables, such as credit expansion (eg the countercyclical capital buffer) or the state of borrowers' balance sheets (eg maximum debt-to-income or loan-to-value ratios).

Much like FX reserves, macroprudential measures perform a dual function. They build up resilience in case stress emerges; and they can lean against the build-up of financial imbalances. As such, they can also enhance the monetary policy room for manoeuvre.

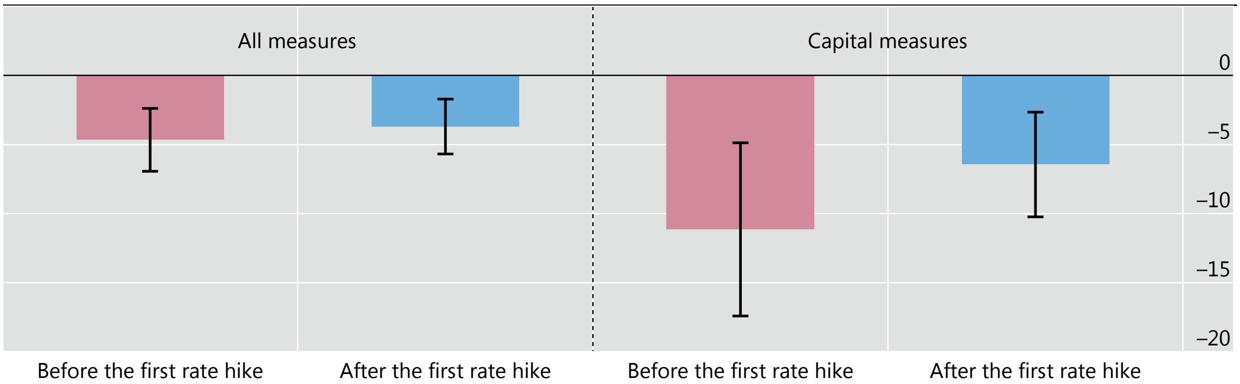
There is increasing evidence that macroprudential tools can play a key role in this context. The evidence indicates that the active use of macroprudential measures reduces the likelihood of crises. And it also indicates that, to varying degrees, such measures help reduce credit expansion and asset price increases, thereby dampening the amplitude of financial cycles. As an illustration, Graph 14 shows that the tightening of macroprudential policies reduces the likelihood of a crisis, regardless of whether it precedes or follows an interest rate hike. The impact of macroprudential tightening through instruments related to bank capital in reducing distress is stronger, especially when they are tightened prior to the tightening of monetary policy.

That said, as is the case with FX interventions, macroprudential measures are no panacea. Macroprudential tools are largely bank-based – a drawback that has become more relevant given the rapid growth of the NBFI sector. Like any form of regulation, they are prone to circumvention, ie they "leak". And their activation is subject to an "inaction bias", since the benefits are much more distant and less visible than the costs, including those of a political economy nature. Not surprisingly, the evidence suggests that macroprudential measures alone cannot always sufficiently contain the build-up of financial imbalances. They are best regarded as complements rather than substitutes for monetary and fiscal policy in the pursuit of macro-financial stability.

Macroprudential tightening reduces the likelihood of financial stress[1]

In percentage points

Graph 14



[1] Estimates of the change in the probability of a banking crisis within three years of an interest rate hike due to the adoption of macroprudential tightening measures based on regression analysis, controlling for confounding factors. See technical annex for details.

Source: Boissay et al (2023).

Challenges ahead

Going forward, monetary policy may well face an environment no less challenging than the one that has prevailed in the past decades. Two related factors are especially worrisome: fiscal trajectories and deep-seated adverse supply-side forces.

As argued in detail in last year's Annual Economic Report (AER), longer-term government debt trajectories pose the biggest threat to macroeconomic and financial stability.[43] Stylised projections underline this point. Even if interest rates return to levels below growth rates, absent consolidation, ratios of debt to GDP will continue to climb in the long term from their current historical peaks (Graphs 15.A and 15.B). The increase would be substantially larger if one factored in the spending pressures arising from population ageing, the green transition and higher defence spending linked to possible geopolitical tensions. The picture would be bleaker should interest rates settle above growth rates – something that has happened quite often in the past and would be more likely should the sovereign's creditworthiness come into doubt at some point. The trend decline in credit ratings in AEs and EMEs highlights this risk.

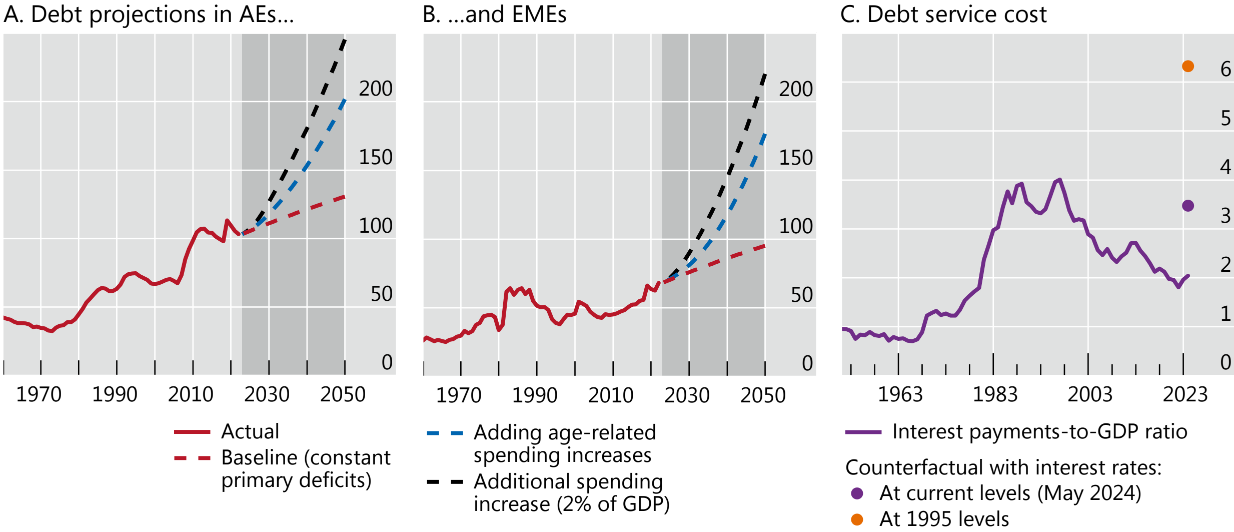
To fix ideas, consider some sensitivity analysis regarding the debt service. If interest rates remain at current levels, as governments refinance maturing bonds, the debt service burden will rise close to the record levels of the 1980s and 1990s. Should rates climb further, say, reaching the levels prevailing in the mid-1990s, debt service burdens would soar to new historical peaks, above 6% of GDP (Graph 15.C).

Higher public sector debt can constrain the room for monetary policy manoeuvre by worsening trade-offs. It can make it harder to achieve price stability. Higher debt raises the sensitivity of fiscal positions to policy rates. This increases the costs of a tightening and partly offsets its effects by boosting the interest income of the private sector. In the extreme, if high debt cripples the credibility of fiscal policy or the creditworthiness of the sovereign, it can hamstring monetary policy: a tightening would simply heighten those concerns and fuel inflation, typically through an uncontrolled exchange rate depreciation.[44] High debt can also threaten financial stability. Losses on public sector debt, whether caused by credit or interest rate risk,

Public debt projections and debt service cost counterfactuals[1]

As a percentage of GDP

Graph 15



The shaded areas in panel A and panel B indicate projections.

[1] See technical annex for details.

Sources: Federal Reserve Bank of St Louis; IMF; OECD; Bloomberg; LSEG Datastream; national data; BIS.

can generate financial stress; in turn, a weak sovereign cannot provide adequate backing for the financial system, regardless of the origin of the stress.

The historical record has driven this message home repeatedly. Quite apart from inflationary pressures induced by expansionary fiscal policy, in evidence post-pandemic, there are many instances in which unsustainable fiscal policies have derailed inflation, especially in EMEs. Similarly, the past decade has shown the potential for the sovereign sector to cause financial instability, first as a result of credit risk (the euro area sovereign crisis) and more recently because of interest rate risk (eg the strains in the US banking sector in March 2023 or those in the UK NBFI sector in September 2022).

In addition, the evolution of deep-seated structural forces could sap the growth potential of the global economy and make supply less "elastic", ie less responsive to shifts in demand. In some cases, this would be a reversal of previous trends. The globalisation of the real side of the economy has been a major factor making supply more resilient, through trade integration and migration flows. Now, there are signs that it may be in retreat, largely driven by geopolitical forces and domestic politics. And the demographic dividend is set to vanish: populations are ageing and population growth is declining. In other cases, previous trends would continue, if not accelerate, but they would interact with new policy responses. This is the case of climate change. If left unchecked, physical events would cause growing damage to the world's productive capacity. But the transition towards a greener economy also calls for a major reallocation of resources that can be painful, especially if disorderly.

A slower-growing and less elastic supply could make the world more inflation-prone. Globalisation has been a major disinflationary force. It has greatly increased the size and reduced the cost of the effective global labour force; it has sapped the pricing power of labour and firms; and it has made inflation less responsive to country-specific excess demand. Demographics may also have played a role in keeping inflation low, not least by reducing wage pressures. And the green transition could lead to major commodity price increases if excess demand for the needed new minerals coexists with underinvestment in fossil fuels. Moreover, these same forces could also raise inflationary pressures indirectly by weakening fiscal positions.

At the same time, a return to the pre-pandemic less-inflationary world cannot be ruled out. Deglobalisation is not a given. Demographic forces may turn out to exert less pressure on inflation than anticipated. The green transition could be smoother than expected, especially if technological breakthroughs occur. And, more generally, technological change could accelerate, as suggested by the artificial intelligence revolution (Chapter III). In such a world, central banks would likely face similar challenges to those they tackled pre-pandemic, with persistent inflation shortfalls from target. If the events of the 21st century have highlighted one thing, it is the genuine uncertainty and unpredictability of the challenges central banks face.

Implications for monetary policy

Central banks need to continuously evaluate the effectiveness and credibility of their frameworks to bolster trust in monetary policy. The lessons learned so far in the 21st century and the challenges ahead can be helpful in informing that exercise. They suggest that it would be desirable for monetary policy frameworks to pay particular attention to four aspects: robustness, realism in ambition, safety margins and nimbleness. They also point to the importance of complementary policies.

Robustness

Monetary policy frameworks need to be robust to radically different scenarios. The global economic environment is constantly changing and producing challenges from unexpected quarters. Sometimes those challenges result from a complex interaction between structural forces and the policy regimes themselves. For example, as argued in detail in last year's AER, the combination of financial liberalisation, the globalisation of the real economy and monetary policy regimes focused on near-term inflation control shaped the nature of pre-pandemic business fluctuations. It was not so much rising inflation but the build-up of financial imbalances that signalled unsustainable economic expansions. Sometimes those challenges result from forces that have no economic origin or are more loosely related to economic factors. Examples include the Covid-19 crisis and the geopolitical and political tectonic shifts under way.

Looking ahead, this means two things. Frameworks should be fit for purpose regardless of whether inflationary or disinflationary pressures will prevail. And they should not be overly reliant on concepts that are very hard to measure.

Monetary policy strategy reviews conducted in the early 2020s were largely based on the premise that stubbornly low inflation would continue to prevail. In such a world, a key consideration was how to regain precious room for manoeuvre to fight downturns and prevent price declines from becoming unmoored, not least by anchoring inflation expectations. This also meant greater tolerance for target overshoots. The unexpected and prolonged post-pandemic inflation surge demonstrated that the challenges were in fact much more symmetric.

A notion motivating the reviews was that the equilibrium *real* interest rate – in jargon, the natural rate of interest, or r-star – was structurally very low by historical standards and independent of monetary policy even over long horizons. Given that premise, regaining room for policy manoeuvre on a sustainable basis necessarily meant trying to push inflation up even when it was not that far away from target. That is, it called for *losing* room for manoeuvre today in the *expectation* of regaining it tomorrow. As it turned out, this proved a risky strategy given the limited responsiveness of inflation to changes in the policy stance in the low-inflation regime. Analytically, r-star is a compelling concept. But its measurement is fraught with difficulties, and our understanding of its drivers is quite limited (Box C). Ideally, frameworks as well as policy calibration should limit as far as possible dependence on notions such as r-star, which are so hard to pin down.

Realism in ambition

An overarching consideration in the design of the conduct of monetary policy is realism in the degree of ambition, ie a realistic view of what monetary policy can and cannot deliver. This also shapes the institutional arrangements and communication strategies that support the execution of policy.

The experience of recent decades confirms what the broader history of central banking had indicated all along: an appropriate objective for monetary policy is to keep inflation within the region of price stability while helping to safeguard financial stability. In other words, the objective is simply to try to keep the economy roughly on an even keel, so that monetary and financial forces do not derail it. This is the best way to promote an environment conducive to sustainable growth, in which supply forces are fully allowed to play their role. To be sure, this is not something monetary policy can do on its own: it requires coherence across policy domains (see below). But the objective does provide guidance about the conduct of policy.

Realism in ambition in the context of the price stability objective means two things. First, it means not seeking to fine-tune inflation when it is already evolving within a low-inflation regime. The post-GFC experience underscored how difficult this is to do. A more realistic objective is to seek to keep inflation broadly within that regime, in which its impact on behaviour is not material and self-stabilising properties rule. This, in turn, would not be consistent with adjusting current inflation targets upwards. Second, it means reacting strongly when inflation moves sharply above the region and threatens to become entrenched, especially given the self-reinforcing nature of transitions from low- to high-inflation regimes. It is one thing to avoid fine-tuning, leveraging the self-stabilising properties of the low-inflation regime; it is quite another to put the system's self-equilibrating properties to the test.

Realism in ambition also means avoiding testing the limits of sustainable economic expansions. This is true regardless of whether those limits are signalled by higher inflation, as in the 1970s and more recently, or by the build-up of financial imbalances, as during much of the pre-pandemic era. In both cases, this requires tackling head on the serious intertemporal trade-offs involved. In the case of inflation, the temptation to boost economic activity in the short term can call for a larger contraction down the road, as monetary policy needs to squeeze inflation out of the system. In the case of financial imbalances, their spontaneous unwinding would itself cause a costly recession and possibly financial crises. The differences between the two cases relate to the time frame – financial imbalances normally take considerably longer to build up and unwind than excess demand-induced inflation – and the room for policy manoeuvre – interest rates rise to tame inflation but drop substantially to fight a financial recession.

Managing these intertemporal trade-offs calls for supporting institutional arrangements. This is because it requires taking unpalatable and politically unpopular decisions, which imply incurring short-term costs to reap larger longer-term, but less visible, benefits. Central bank independence that is broadly supported by society provides a precious degree of insulation.

Communication has an important role to play too. The challenge is to narrow the perceptions gap between what central banks can deliver and what they are expected to deliver. This gap can increase the general pressure on the central bank to abandon the appropriate degree of realism in ambition. Narrowing the gap calls for a continuous education effort.

Box C

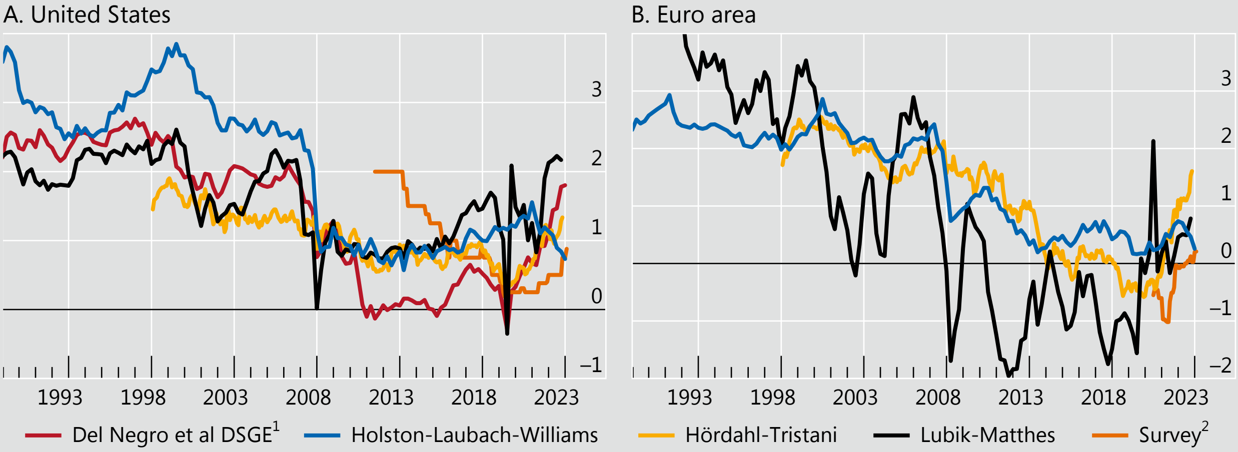
The natural rate of interest: a blurry guidepost for monetary policy

The natural rate of interest, or r-star, is generally defined as the level of the risk-free short-term real interest rate that would prevail in the absence of business cycle fluctuations, with output at potential, saving equal to investment and inflation stable.[1] In principle, this concept provides a yardstick for where real policy interest rates are heading in the medium term, once current business cycle disturbances dissipate and the economy gravitates towards its equilibrium. The natural rate is also often used as a benchmark to assess whether the monetary policy stance is restrictive or expansionary.

Operationalising this concept to inform actual monetary policy decisions is, however, remarkably challenging.[2] A first complication arises from the fact that, being a theoretical construct, the natural rate cannot be directly observed but must be estimated. Various alternative approaches have been proposed to estimate r-star, including semi-structural models,[3] time-series models,[4] dynamic stochastic general equilibrium models,[5] term structure models[6] and survey-based measures. Graph C1 displays estimates of r-star for the United States and the euro area. The range of the estimates often stretches beyond 2 percentage points, making it difficult to draw reliable conclusions about the level of the natural rate. Uncertainty about r-star is particularly pronounced at the current juncture, with most estimates suggesting an increase in r-star relative to pre-pandemic levels, but some pointing to a decline. Furthermore, there is also a high degree of statistical uncertainty around individual estimates.

Natural rate estimates

In per cent | Graph C1



[1] DSGE = dynamic stochastic general equilibrium. [2] Survey of primary dealers for the US; survey of monetary analysts for the euro area.

Sources: Del Negro et al (2017); Holston et al (2023); Hördahl and Tristani (2014); Lubik and Matthes (2015); ECB; Federal Reserve Bank of New York; Federal Reserve Bank of Richmond; BIS.

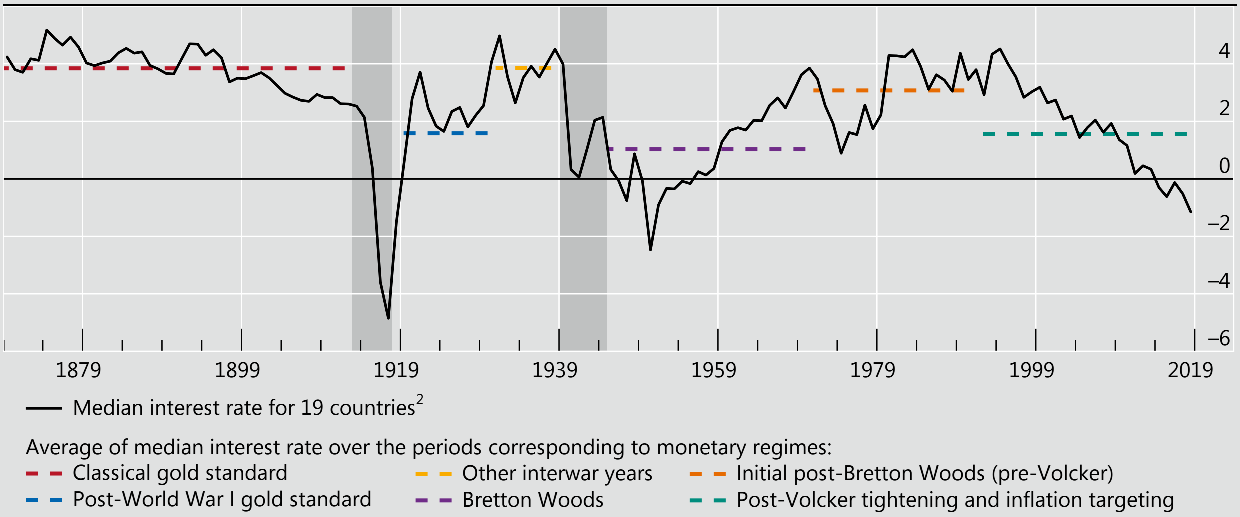
The assessment of r-star is also complicated by a limited understanding of its drivers. From a theoretical perspective, the natural rate is affected by forces that shape the balance between actual and potential output, or equivalently between saving and investment. Specifically, higher saving calls for a lower real rate and higher investment for a higher one. The literature has proposed a wide range of possible drivers of r-star, including economic growth, demographics, risk aversion, globalisation and fiscal policy. Empirical analyses using post-1980s data have found patterns consistent with theoretical predictions. However, links between r-star and its alleged determinants often become statistically insignificant and unstable when the sample is extended back in time.[7]

An additional challenge in using r-star to inform monetary policy decisions is posed by the possible endogeneity of r-star to monetary policy. Standard macroeconomic theory posits that r-star is driven by persistent changes in saving and investment decisions linked to structural developments in the economy, such as, for example, productivity growth and demographic trends.[8] However, recent studies underscore how monetary policy may itself have highly persistent effects on the economy and thus on r-star, or at least perceptions thereof. For example, a prolonged period of monetary policy accommodation can fuel debt accumulation that can in turn weigh on aggregate demand.[9] Furthermore, financial imbalances tend to increase the likelihood of financial crises that have very persistent, if not permanent, effects on economic activity.[10] The potential role of monetary policy in influencing r-star is consistent with the historical patterns of long-term interest rates, displaying significant differences in levels and trends across monetary policy regimes (Graph C2).

Monetary regimes and real long-term rates[1]

In per cent

Graph C2



The shaded areas indicate World War I and World War II (excluded from the empirical analysis).

[1] The real long-term interest rate is calculated as nominal rate minus ex ante expected inflation. See Borio et al (2017a) for details. [2] AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, IT, JP, NL, NO, NZ, PT, SE and US.

Sources: Borio et al (2017a); Bank of England; Global Financial Data; International Historical Statistics; national data; BIS.

[1] The natural rate concept traces back at least to Wicksell (1898). It can be conceived of as representing the intercept in a monetary policy rule, as in a Taylor rule (Taylor (1993)). Together with the long-run inflation rate, defined by the central bank inflation target, it pins down the long-run level of the nominal policy rate. [2] Benigno et al (2024). [3] Holston et al (2023). [4] Lubik and Matthes (2015). [5] Del Negro et al (2017). [6] Hördahl and Tristani (2014). [7] Hamilton et al (2016); Lunsford and West (2019); Borio et al (2022); Rogoff et al (2022). [8] Gagnon et al (2021); Cesa-Bianchi et al (2023); IMF (2023). [9] Mian et al (2021). [10] Borio and Disyatat (2014); Kashyap and Stein (2023).

Finally, realism in ambition also means focusing on the pursuit of objectives for which monetary policy is well equipped. Monetary policy has appropriate tools to pursue price and financial stability, by helping to keep the economy on an even keel over the medium term. But it can easily become overburdened when required to trade off these objectives against others, such as inequality or overly ambitious climate change agendas.[45] Having many objectives without adequate tools to pursue them raises potentially serious reputational risks, which may only become apparent over time.

Safety margins

The post-GFC period highlights that there is a premium on retaining safety margins, ie room for policy manoeuvre. In general, an economy operating without safety margins is vulnerable to the inevitable slowdown and to unexpected costly developments. Safety margins, or buffers, are essential for resilience.

Retaining safety margins has proved very hard for monetary policy – just as it has for fiscal policy. As policy rates trended down and central bank balance sheets soared, the monetary policy room for manoeuvre progressively narrowed. This posed a major challenge when the pandemic hit and central banks had to provide support. Central banks did rise to the challenge, but at the inevitable cost of narrowing safety margins further.

Retaining safety margins requires integrating this consideration explicitly in the conduct of policy. One option would be greater tolerance for moderate, even if persistent, shortfalls of inflation from narrowly defined targets. This would leverage the self-stabilising properties of inflation in low-inflation regimes. It would recognise the more limited traction of changes in the policy stance in those circumstances. And it would allow monetary policy to more systematically incorporate longer-run considerations associated with the slow-moving but disruptive evolution of financial imbalances.[46]

Operating with safety margins also means regaining them once they are lost. This puts a premium on exit strategies. Experience indicates that rebuilding buffers can be hard. One reason has to do with incentives. Especially when emerging from a crisis, policymakers tend to tilt the balance of risks towards doing too much rather than too little, prolonging the support to the economy to nurture it back to health. This is entirely natural and can be quite compelling at any given decision point. That said, it maximises the probability that, looking back, policymakers will realise they have prolonged support for too long. Adopting and communicating exit strategies based on an explicit incorporation of safety margins in policy frameworks could help reduce this bias. If something is valuable, it is worth paying a price for it.

The importance of safety margins has specific implications for balance sheet policies. Retaining room for manoeuvre also means keeping central bank balance sheets as small and as riskless as possible, subject to delivering successfully on the central bank's mandate. Larger and riskier balance sheets have both economic and political economy costs. Thus, following this guideline would *maximise* the central bank's ability to expand the balance sheet in line with needs. More generally, it would also limit the footprint of the central bank in the economy, thereby reducing the institution's involvement in resource allocation and reducing the risk of inhibiting market functioning. Put differently, the balance sheet needs to be elastic, not large. Small size and low riskiness enhance this elasticity (Box D).

The feasibility of retaining safety margins can only be assessed in a global context. This is because of the influence of global financial conditions and the high sensitivity of exchange rates to them. In practice, it is hard for countries to operate with policy rates that deviate substantially from those prevailing in global markets. FX intervention provides only limited additional room for manoeuvre. The role of countries that are home to international currencies and have an outsize influence on global financial conditions is especially important.

Nimbleness

Retaining room for policy manoeuvre is of little value unless this room can be exploited quickly. Nimbleness is needed to respond to unexpected developments. Nimbleness means being able to change course at little cost. The various policy tools differ in this regard.

In addition to clarity in communication, nimbleness explains why central banks rightly prefer to adjust the policy stance through interest rates than shifts in balance sheets. Balance sheets take longer to shift and are harder to calibrate. Moreover, the corresponding adjustment costs are perceived as larger for reductions than increases: it is easier to use than to gain room for manoeuvre. Given the importance of safety margins, this provides an additional justification for having interest rates as the primary tool.

Box D

Central bank balance sheet choices

What considerations could guide the size and composition of central bank balance sheets? A reasonable general principle could be that the balance sheet should be as small and riskless as possible *subject to the central bank being able to perform its mandate effectively*. In other words, the balance sheet should be as lean as possible, but no more.

The reason is that, all else equal, size and riskiness involve costs, of both an economic and political economy nature. A lean balance sheet limits the central bank's footprint in the financial system and economy, and hence its involvement in resource allocation, and the risk of inhibiting market functioning.[1] It also limits the interaction with the government's own balance sheet and hence the impact on the government's financial position through the size of remittances.[2] These quasi-fiscal transactions can also open the central bank to political economy pressures that could undermine its reputation and autonomy (Box B). Given the costs of large and risky balance sheets, a lean balance sheet maximises the central bank's ability to increase its size and absorb risk in line with needs, ie maximises its "elasticity".

Going beyond the general principle requires considering in more detail the core central bank functions that call for balance sheet deployment: underpinning payment systems, crisis management and implementing monetary policy. While underpinning payment systems is a quintessential domestic currency function, crisis management and implementing monetary policy may involve foreign currencies as well. Due to foreign-currency specificities, they are best discussed separately.

In general, underpinning payment systems does not require large balance sheets. What is essential is the ability to provide *intraday* credit to allow the settlement of transactions. Typically, the amounts involved are very large – multiples of GDP – and reflect financial activity.[3] By contrast, once settled, the balances banks *need* to hold at the end of the day for (precautionary) settlement purposes are tiny, given the nature of wholesale payment systems. To limit the risks involved, intraday credit is generally collateralised, although normally interest-free.

Crisis management requires only *temporarily* larger balance sheets. Forceful balance sheet deployment – or at least the declared willingness to do so – is necessary to stabilise the financial system, either through emergency lending or emergency asset purchases. This buttresses confidence and can stem runs and fire sales. By its very nature, however, the support is intended to last for the duration of the crisis and to be withdrawn once the crisis is over. The exception is when the central bank decides to keep the monetary policy stance accommodative through the deployment of the balance sheet itself, thereby changing the nature of the operations.

The implementation of monetary policy has several aspects: setting the (short-term) interest rate – interest rate policy; and actively using the balance sheet to set the policy stance – balance sheet policies – such as large-scale asset purchases or special lending schemes.

The general principle would suggest limiting balance sheet policies to conditions in which interest rate policy is not sufficiently effective. This is consistent with central banks' revealed preference for relying on balance sheet policies only if the effective lower bound is reached. It also tallies with central banks' shift to setting the policy stance exclusively through interest rate policy once they started normalising and responding to higher inflation. In this context, the benefits of a lean balance sheet reinforce other considerations, such as the less predictable impact of balance sheet policies on economic activity and the additional complexity in communication.

The choice of operating framework for interest rate policy, through which the central bank influences short-term interest rates, helps determine the *minimum* size of the balance sheet. Regardless of the choice of framework, cash with the public is purely demand-determined: the balance sheet cannot be any smaller. Beyond that, the key difference is between scarce reserve systems (SRS) and (versions of) abundant reserve systems (ARS).[4] An SRS ensures that banks' reserve holdings are limited to settlement needs: the central bank supplies that amount and, in the process, makes sure that there is an opportunity cost to holding reserves, ie that the (overnight) rate is above the deposit facility rate – the rate the central bank pays on the reserves. Additional requirements can increase the size of those holdings, such as minimum reserve requirements or prudential liquidity requirements. By contrast, in an ARS the central bank supplies reserves in excess of settlement needs, including the various requirements. As a result, bank holdings are remunerated at the deposit facility rate and incur no opportunity cost, with the overnight rate being at, and often below, that on the deposit facility. In this case, the size of reserve holdings can be very large.

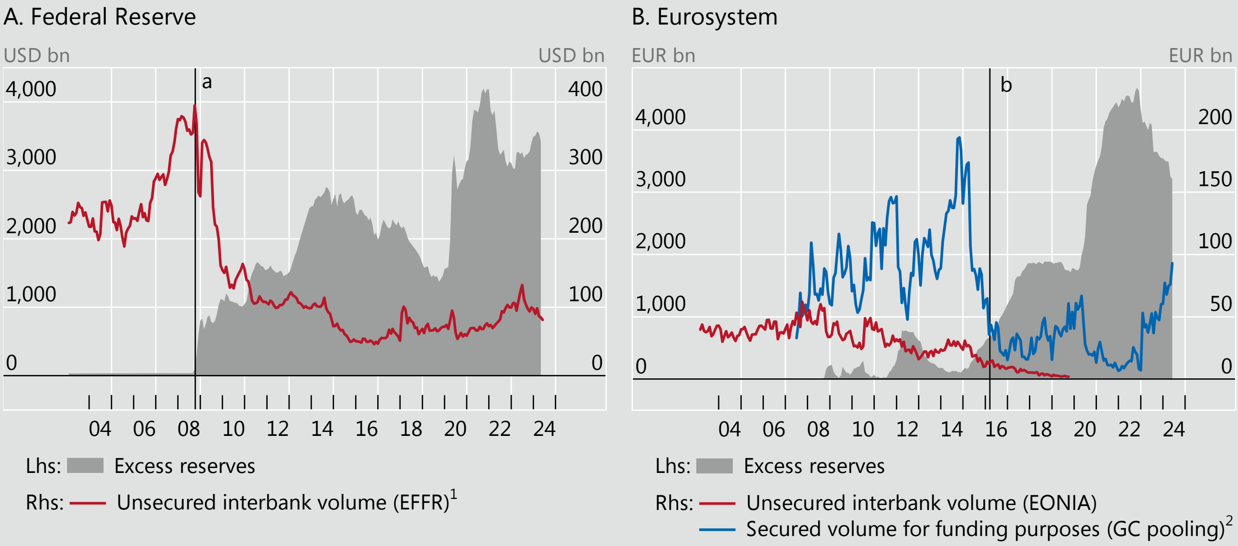
The Great Financial Crisis (GFC) marked a big shift in frameworks. SRS were the rule pre-crisis, but many central banks that engaged in large-scale balance sheet policies shifted to ARS thereafter (see below). There is, however, no necessary link between the size of the central bank balance sheet and the operating system: central banks can, and do, run SRS even when their balance sheets are very large. To do so, they simply need to finance the corresponding assets through instruments other than bank reserves, such as longer-term deposits, securities, reverse repos or foreign exchange (FX) swaps. For instance, many emerging market economy central banks with large balance sheets due to FX holdings still run SRS.

The choice hinges on differences in the cost-benefit analysis of the two systems.[5]

The central banks that adopted ARS in response to the GFC did so because they found it difficult to keep control over short-term rates while providing the necessary liquidity to manage system stress. An ARS de facto delinks the policy rate from the amount of bank reserves outstanding. Thereafter, they retained ARS for at least three reasons. First, the system has proved capable of operating seamlessly at times of stress and in normal times, easily accommodating large-scale asset purchases. Second, these central banks prefer to supply banks with sufficient reserves for financial stability reasons, which they see as relieving pressure on the lender and market-maker of last resort functions. Third, they often note that SRS are too hard to operate in the post-GFC environment, thereby not guaranteeing the desired degree of control over the overnight rate. Examples of the factors at play include greater unpredictability in the demand for bank reserves owing to changes in banks' liquidity management practices or supervisory requirements as well as greater interbank market fragmentation.

The central banks that have kept SRS have found that these systems deliver the desired results for them even in the post-GFC environment. This suggests that the factors leading to the unpredictability of reserves may to a considerable extent reflect features of the ARS themselves. For example, ARS inhibit interbank activity by ensuring that banks have no need *individually* to resort to the market (Graph D1). Similarly, one reason for the unpredictability in the demand for reserves may be that banks have no incentive to economise on those holdings, given that they carry no opportunity cost. These central banks are also more concerned that inhibiting interbank funding activity weakens the disciplinary role of the market and could paradoxically call for more, not less, central bank support at times of stress, as the market no longer distributes reserves within the system.

Excess liquidity and the decline in interbank money market activity — Graph D1



EFFR = effective federal funds rate; EONIA = euro overnight index average.

[a] Start of reserve remuneration by the Federal Reserve, which marked the switch to a floor system (9 October 2008). [b] Convergence of EONIA to the deposit facility rate, when excess reserves rose as a result of the Eurosystem's public sector purchase programme (PSPP) (16 March 2016).

[1] The market for the EFFR includes participants that are not eligible to receive interest on reserves. [2] GC pooling is a platform for trading with price transparency on ECB-eligible collateral baskets provided by Clearstream (a subsidiary of Deutsche Börse).

Sources: Federal Reserve Bank of St Louis; Bloomberg; LSEG Datastream; BIS.

Even among the central banks currently operating ARS, a common challenge is how to reduce the size of the reserves outstanding over time while still retaining control of short-term interest rates and meeting financial stability objectives. Some have also taken steps to increase activity in the interbank market (eg through tiered remuneration schemes).[6]

Balance sheet deployment in foreign currency differs from that in domestic currency in one critical respect: the central bank does not issue the relevant currency. This has important implications for crisis management and monetary policy implementation.

For crisis management, the central bank must either borrow the foreign currency or have it in the first place. Hence the precautionary role of foreign currency reserves. Borrowing in stress conditions can be hard, especially if sovereign risk is a concern. Such precautionary needs set a floor for the size of the central bank's balance sheet for countries which need to support the financial system and domestic firms in foreign currencies, especially if they do not have standing FX swap facilities with other central banks. While the amounts involved will depend on the details of the foreign exchange regime, country-specific features and the adequacy of multilateral and global safety net arrangements, they can be sizeable.

For monetary policy implementation, the key issue is the degree of reliance on FX intervention to complement monetary policy. To the extent that such intervention evens out over business and financial cycles, it should not, in principle, require a *structural* increase in the size of the central bank balance sheet over time. Just as with domestic currency operations, however, unwelcome ratcheting effects could be present.

[1] To be sure, market development may require the central bank to be an active participant in the corresponding market segment, but this does not generally call for size. For instance, historically central banks have often acted as catalysts for the development of specific market segments by being prepared to discount or lend against certain securities as collateral. [2] For instance, central bank large-scale purchases of government debt amount to a debt management operation. If, say, the central bank buys long-term government debt and replaces it with interest-bearing bank reserves, it de facto increases the sensitivity of government debt to changes in interest rates: increases in the policy rate will feed through to the government's fiscal position not through higher borrowing costs but through lower central bank remittances. [3] See, for example, Borio (1995) and Duca-Radu and Testi (2021). [4] For a more detailed description of the difference between the two systems, see eg Borio et al (2024) and Afonso et al (2024). [5] For different views on the pros and cons of the two types of system, see eg Borio (2023), Hauser (2023) and Logan (2024). [6] See, for example, Maechler and Moser (2022) and Schnabel (2024).

Nimbleness also raises the question of the appropriate use of forward guidance. Forward guidance does not constrain the ability to adjust to changing circumstances when it simply provides information about the central bank's reaction function. Conditional forward guidance has this character. By contrast, when forward guidance contains an element of perceived commitment to a particular policy path, a degree of constraint is inevitable. Deviating from such a commitment can weaken credibility and cause unwelcome market reactions.

This suggests limiting the use of forward guidance that contains elements of commitment. It explains why central banks routinely stress conditionality when communicating policy intentions. At the same time, experience shows that the *perceived* unconditional element in forward guidance is generally greater than intended. In part, this reflects financial market participants' natural tendency to translate conditions into points in calendar time – the basis for taking positions. Here, too, realism in ambition can help, suggesting limiting the degree of ambition in the deployment of the tool.

Complementary policies

Robustness, realism in ambition, safety margins and nimbleness are key for monetary policy to maintain stability and retain trust. But, in the end, other policies need to play their role, too. Otherwise, the trade-offs monetary policy faces become unmanageable. Sustainable macroeconomic and financial stability will remain beyond reach if fiscal expansions are disproportionate, the sustainability of fiscal positions is in doubt, or prudential policies – both microprudential and macroprudential – fail to strengthen the resilience of the financial system. There is a need for coherence across different policies. Moreover, as discussed in detail in last year's AER, ultimately a broad change of mindset is called for to dispel a deeply rooted "growth illusion" – a de facto excessive reliance on monetary and fiscal policy to drive growth. Only structural policies designed to strengthen the supply side of the economy can deliver higher sustainable growth.

Conclusion

Monetary policy has faced historically severe tests since the GFC. And it has delivered. This tumultuous period, as well as the deceptive tranquillity of the preceding Great Moderation, provide a number of lessons. Some of these confirm previous widely held beliefs; others nuance previous expectations; together, they help to better understand monetary policy's strengths and limitations. They can thus shed light on the challenges central banks could face in the future and on how monetary policy frameworks could be refined to address them most effectively.

Five lessons stand out. First, forceful monetary tightening can prevent inflation from transitioning to a high-inflation regime. Even if central banks may be slow in responding initially, they can succeed, provided they catch up quickly and display the necessary determination to finish the job. Second, forceful action, notably the deployment of the central bank balance sheet, can stabilise the financial system at times of stress and prevent the economy from falling into a tailspin, thereby eliminating a major source of deflationary pressures. Whenever the solvency of borrowers, financial or non-financial, is threatened, this requires government backstops. Third, exceptionally strong and prolonged monetary easing has limitations: it exhibits diminishing returns, it cannot by itself fine-tune inflation in a low-inflation regime, and it can generate unwelcome side effects. These include weakening financial intermediation and inducing resource misallocations, encouraging excessive risk-taking and the build-up of vulnerabilities, and raising economic and political economy challenges for central banks as their balance sheets balloon. Fourth, communication has become more complicated. This has reflected the multiplicity of instruments, the failure to anticipate the surge in inflation and, more generally, a growing expectations gap between what central banks can deliver and what they are expected to deliver. Finally, the experience of EMEs, in particular, has illustrated how the complementary deployment of FX intervention and macroprudential tools can help improve the trade-off between price and financial stability. Using the tools judiciously also requires a keen awareness of their limitations, especially in the case of FX intervention.

In the years ahead monetary policy may well face an equally challenging environment. The unsustainability of fiscal trajectories poses the biggest threat to monetary and financial stability. And supply may not be as elastic as in the decades preceding the pandemic due to changes in the degree of global integration, demographics and climate change. The world could become more inflation-prone. At the same time, a return to a world of more persistent disinflationary pressures cannot be ruled out, especially if the wave of technological advances under way bears fruit (Chapter III).

Against this backdrop, it would be desirable for monetary policy frameworks to pay particular attention to four aspects: robustness, realism in ambition, safety margins and nimbleness. Together, they can reduce the risk that monetary policy, just as fiscal policy, is relied upon excessively to drive growth – a growth illusion. All this means focusing on maintaining inflation within the region of price stability while safeguarding financial stability. This calls for forceful responses when a transition to a high-inflation regime threatens and greater tolerance for modest, even if persistent, shortfalls of inflation from narrowly defined targets. It means seeking to put in place policies that retain policy room for manoeuvre over successive business and financial cycles. It means putting a premium on exit strategies from extreme policy settings designed to stabilise the economy and on keeping balance sheets as small and riskless as possible, subject to effectively fulfilling mandates. It means avoiding overreliance on approaches that may unduly hinder flexibility, such as variants of forward guidance, critical dependencies on unobservable and highly model-specific concepts, or frameworks designed for seemingly invariant economic environments. It means working hard through communication to close the expectations gap. And it means retaining institutional arrangements that shield the central bank from political economy pressures which make it difficult to address tough intertemporal trade-offs, be these linked to inflation or the build-up of financial imbalances.

In the end, though, the trade-offs that monetary policy faces can become unmanageable absent more holistic and coherent policy frameworks in which other policies – prudential, fiscal or structural – play their part. Indeed, the growth illusion cannot be finally dispelled without a keener recognition that only structural policies can deliver higher sustainable growth.

Endnotes

1 While not always fully in charge of the deployment of macroprudential tools, central banks typically play a key role in the decision-making process, eg as a leading member of a financial stability council or committee.

2 Eickmeier and Hofmann (2022) and Shapiro (2022) provide evidence suggesting that the inflation surge was to a significant extent driven by strong demand, reflecting at least in part the effects of monetary and fiscal stimulus.

3 See BIS (2022) and Carstens (2022).

4 See Amatyakul et al (2023) and De Fiore et al (2023).

5 See BIS (2009, 2020) for a detailed analysis of the emergency measures deployed during the GFC and the Covid-19 crisis, respectively.

6 See eg Gagnon et al (2011), Joyce et al (2011), Krishnamurthy and Vissing-Jorgensen (2011), Bauer and Neely (2014), Neely (2015), Swanson (2015) and Altavilla et al (2021).

7 See CGFS (2020) for a comprehensive account of the role of the US dollar from an international perspective.

8 For the impact of swap lines during the GFC, see eg Baba and Packer (2009) and McGuire and von Peter (2009).

9 For the impact of swap lines on financial markets and cross-border flows during the Covid-19 crisis, see eg Avdjiev et al (2020), Eren et al (2020) and Aldasoro et al (2020). See also Bahaj and Reis (2022) for a theoretical and empirical analysis of international lender of last resort policies through swap lines.

10 See Eren and Wooldridge (2021), Aramonte et al (2022) and FSB (2022).

11 See BIS (2020) for a detailed account of the evolution of central bank lender of last resort policies into market-maker or buyer of last resort. See also Markets Committee (2022a) and CGFS (2023) for a related discussion.

12 See Arslan et al (2020).

13 See BIS (2009) and Alberola-Ila et al (2020) for a detailed account of fiscal policies during the GFC and the Covid-19 crisis, respectively.

14 See BIS (2023) for a detailed analysis of interlinkages between monetary and fiscal policies.

15 See Acharya et al (2023) for suggestive evidence on higher liquidity risks at commercial bank balance sheets in response to central bank balance sheet expansions.

16 See eg Bernanke (2002).

[17] See Borio and Zabai (2016), CGFS (2019) and Cecchetti et al (2020) for a review of the evidence on the impact of unconventional monetary policy tools on economic activity. See also Markets Committee (2019) on the impact of large balance sheets on market functioning.

[18] See eg Woodford (2012) and Bauer and Rudebusch (2014).

[19] See also Group of Thirty (2023) and Rajan (2023) for a related discussion.

[20] See also BIS (2016) for evidence on smaller announcement effects outside stress periods.

[21] The higher bar for what constitutes a significant stimulus at the margin is a possible reason why several central banks, such as the Bank of Japan and the Reserve Bank of Australia, resorted to yield curve control policies. In this case, the central bank commits to a target for a given long-term interest rate and potentially reduces the need to increase the size of the balance sheet through this commitment (eg the Bank of Japan targeted the 10-year yield and the Reserve Bank of Australia targeted the three-year yield). See eg Hattori and Yoshida (2023) and Lucca and Wright (2022) for an analysis of yield curve control in Japan and Australia, respectively.

[22] See Heider et al (2021) and Brandão-Marques et al (2024) for a literature review on the transmission of negative interest rates.

[23] See Borio and Gambacorta (2017).

[24] There is also evidence that LSAPs affect financial variables through other channels. Asset purchases had an impact also through the gross "flow" of purchases and the total "stock" absorbed by the central bank (or expected to be absorbed). In general, the stock effect had a larger and more persistent impact. However, the flow effect was often important during periods of acute market dysfunction and low market liquidity. See CGFS (2023) for a discussion of the channels through which LSAPs affect financial variables.

[25] See Borio and Hofmann (2017) and the references therein.

[26] See Ahmed et al (2024).

[27] See Borio et al (2021) and Borio et al (2023).

[28] For evidence on the impact of low rates on banks, pension funds and insurance companies, see eg Borio et al (2017b), Claessens et al (2018) and CGFS (2018). However, focusing on the euro area, Altavilla et al (2018) do not find a significant relationship between interest rates and bank profitability.

[29] See Banerjee and Hofmann (2018) and the references therein for the empirical evidence.

[30] See Grimm et al (2023) and Boyarchenko et al (2022).

[31] See Du et al (2024).

32 Forward guidance can be distinguished along two dimensions. One relates to the period or circumstances under which the guidance applies. Specifically, forward guidance could apply to a particular period of time ("calendar-based") or be made conditional on economic developments ("state-contingent"). A second characteristic relates to the nature of the guidance, whether it provides specific numerical values ("quantitative") or is expressed in vaguer terms ("qualitative"). See Filardo and Hofmann (2014) and Borio and Zabai (2016) for detailed discussions.

33 See BIS (2021).

34 For a related analysis reviewing economic forecasting at the Bank of England, see Bernanke (2024).

35 See Blinder et al (2024) for a review of the literature on central bank communication with the public.

36 For evidence of the link between global financial conditions and capital flows to EMEs, see eg Ahmed and Zlate (2014) and Bräuning and Ivashina (2020). For evidence about the role of macroprudential regulation in dampening the impact of global financial shocks on EMEs, see Brandão-Marques et al (2021), Gelos et al (2022) and Bergant et al (2023).

37 See BIS (2019) for a detailed discussion of monetary policy frameworks in EMEs and their evolution.

38 FX interventions can also affect the exchange rate through signalling and portfolio rebalancing channels. For a survey of the early literature, see Sarno and Taylor (2001). For recent theoretical contributions, see Gabaix and Maggiori (2015) and Cavallino (2019).

39 See eg Frankel (2019).

40 The financial channel of the exchange rate operates through the balance sheets of domestic borrowers borrowing foreign currency debt (original sin) and foreign lenders lending in local currency (original sin redux) (see Carstens and Shin (2019)). In both cases, currency appreciation embellishes balance sheets and enables greater borrowing or lending, which in turn reinforce currency appreciation (Hofmann et al (2020)). FX purchases depreciating the currency can therefore break this circle. The sterilisation leg of FX intervention can further mute credit expansion if banks are balance sheet constrained (Chang (2018)). See Hofmann et al (2019) for a simple model featuring both channels, and supportive evidence based on Colombian micro data.

41 The choice of FX intervention instruments and tactics depends on fundamental assessments of the benefits and costs of intervention, the specific objective and market conditions. For a more detailed discussion, see eg Patel and Cavallino (2019), BIS (2019), Adler et al (2021) and Markets Committee (2022b).

42 More generally, Blanchard et al (2015) find that FX intervention mitigates the impact of shifts in global capital flows on the economy.

43 See BIS (2023).

[44] In this vein, survey evidence suggests that high public debt increases household inflation expectations, especially among people that have less confidence in the central bank's determination to fight inflation (Grigoli and Sandri (2023)).

[45] For an in-depth analysis of the effects of monetary policy on inequality, see BIS (2021).

[46] In addition, the concerns with the output costs of periods of falling goods and services prices ("deflation") may be overstated. The historical record points to only a weak association, presumably because of the relevance of benign supply factors. The link derives largely from the unique experience of the Great Depression (Goodhart and Hofmann (2007) and Borio et al (2015)). By contrast, the evidence suggests a closer link with asset price deflations, especially property price ones, which can go hand in hand with financial crises. See also Feldstein (2015) and Rajan (2015) who refer to the "deflation bogeyman".

Technical annex

Graph 1: Medians across AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, LU, NL, NO, NZ, PT, SE and US. Aggregates are computed using a smaller set of economies when data are not available. For inflation and policy rates, latest available for 2024.

Graph 1.B: The real policy rate is calculated by adjusting the nominal rate for inflation.

Graph 2: The lending corresponds to outstanding repos for the Federal Reserve and the Eurosystem; for the Federal Reserve, additionally, it includes term auction facilities, other loans and net portfolio holdings of the Commercial Paper Funding Facility; for the Bank of Japan, it consists of receivables under resale agreements and loans excluding those to the Deposit Insurance Corporation of Japan; for the Bank of England, short-term lending with one-week and other maturities within the maintenance period, as well as longer-term lending from fine-tuning repo operations, are included. For the Federal Reserve, securities include the face value of US Treasury securities, mortgage-backed securities and agency debt held outright; for the Bank of Japan, it corresponds to Japanese government and corporate bonds; and for the Bank of England, proceeds from gilt holdings of the Asset Purchase Facility. For the Eurosystem, it includes holdings of securities for monetary policy operations.

Graphs 3.A and 3.C: Asian EMEs = CN, HK, ID, IN, KR, MY, PH, SG, TH and VN; Latin America = AR, BR, CL, CO, MX and PE.

Graph 3.A: Median annual inflation across economies within each region, simple average for each period. Identification and classification of crises are based on Laeven and Valencia (2020). Crises include currency crises, sovereign debt crises, sovereign debt restructuring and systemic banking crises.

Graph 3.B: EMEs = BR, CL, CO, CZ, HU, ID, IN, KR, MX, PE, PH, PL, RU, TH, TR and ZA. The sample covers inflation targeting economies only. Net capital inflow is the sum of direct, portfolio and other investments, excluding reserves and related items.

Graph 3.C: For the FX reserves, EA consolidated values are reported; for the macroprudential policies, EA member states' values are reported. Other EMEs = AE, CZ, DZ, HU, IL, KW, MA, PL, RO, RU, SA, TR and ZA. EMEs = Asian EMEs + Latin America + other EMEs.

Graph 4.A: The sample covers AU, BE, CA, DE, DK, ES, FR, GB, IE, IT, JP, NL, SE and US; from Q1 1960 to Q3 2023, subject to data availability. Sensitivity of wages to prices estimates are computed at quarterly frequency based on a wage equation, in which nominal wage growth at time $t + 4$ is regressed on inflation and its interaction with the high-inflation regime dummy as well as on the unemployment gap, productivity growth at time t and country and time fixed effects. High- and low-inflation regime estimates are computed for pre- and post-1990, respectively. Sensitivity of prices to wages estimates are computed at quarterly frequency based on a wage equation, in which inflation at time $t + 4$ is regressed on nominal wage growth and its interaction with the high-inflation regime dummy as well as on the unemployment gap and productivity growth at time t and country and time fixed effects. High-inflation regime is defined as the periods in which the eight-quarter moving median of past core inflation is above 5%.

Graph 4.B: Similarity index based on Mink et al (2007), modified by adding one so that it lies in the range between zero and one. The reference rate used in the computation of the similarity index is the unweighted cross-sectional median of sectoral prices. The sample covers AEs = AT, BE, CA, CH, DE, DK, ES, FI, FR, GB, IE, IT, JP, NL, NO, PT, SE and US; EMEs = BR, CL, CO, CZ, HU, KR, MX, PE, PL, RO, SG and TR for the period from January 1950 to April 2024, subject to data availability. Twelve-month headline inflation is shown on a logarithmic scale. Total number of sectors per economy range from 11 to 205.

Graph 5.A: The model is calibrated on US data, see Hofmann et al (2021) for details. The shock is a 3 percentage point increase in inflation with persistence of 0.6. With monetary tightening, monetary policy follows a standard inertial Taylor rule, and without tightening, the monetary policy rates stay unchanged.

Graph 5.B: Simple average across AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, LU, NL, NO, NZ, PT, SE and US. The starting dates of the inflation surges are January 1973 and July 2021.

Graph 6.A: For sovereign CDS, simple average across AU, CA, CH, DE, DK, ES, FR, GB, IT, JP, NO, NZ and US. For bank CDS, simple average across an unbalanced sample of 82 banks in the same sample of economies. CDS with maturity of five years, priced in US dollars, subject to data availability. VIX = Chicago Board Options Exchange (CBOE) Volatility Index.

Graph 6.B: Libor = London interbank offered rate.

Graph 7.A: Libor = London interbank offered rate. OIS = overnight indexed swap. A1/P1 CP = highest-rated commercial papers with a maturity of less than 270 days. T-bill = Treasury bill. Announcements = 7 October 2008 for GFC (the establishment of the Commercial Paper Funding Facility) and 23 March 2020 for Covid-19 (Federal Reserve announcement of extensive new measures).

Graph 7.B: High-yield (HY) and investment grade (IG) refer to ICE BofA option-adjusted corporate bond spreads. Italy and Spain sovereign spread over 10-year German sovereign yields.

Graph 7.C: Responses to EME central banks' bond purchase announcements in 2020 calculated as the cumulative changes relative to the day prior to the announcement. Simple average of the responses for announcements that did not coincide with interest rate changes in CL, CO, ID, IN, KR, PH, TH, TR and ZA. See Arslan et al (2023) for details.

Graph 8: The sample covers AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, IE, IT, JP, NL, NO, NZ, SE and US for the period between Q1 1985 and Q4 2019. Threshold for the low interest rate regime is 2.25%, chosen to maximise empirical fit using grid-search procedures. Derived using a non-linear empirical model based on the local projection method to estimate the interest elasticity of aggregate demand. The model includes control variables: CPI, exchange rates, stock prices, real house prices, long-term interest rates and household debt ratios. Non-linearity is introduced through indicator variables differentiating between high and low interest rate regimes, high- and low-debt regimes, and expansionary and recessionary regimes. An economy is classified as being in a high-debt regime when its credit gap is in the top 25th percentile of its distribution. Classification of downturn is based on the recession dates identified by the OECD. See Ahmed et al (2024) for details.

Graph 9: Based on the US price index of personal consumption expenditures (PCE) data. The common inflation component in panels A and B is defined as the first principal component of monthly log changes of 131 PCE categories. The share of variance explained by the common component in panel A is estimated over a 15-year moving window. The sample used in estimations in panels B and C covers data from July 1992 to December 2019. The idiosyncratic component of sectoral log price changes in panel C corresponds to the residuals from the regression of monthly sector-specific log price changes on the common component. Panel C shows the proportion of price decreases that are statistically significant at the 5% level. See Borio et al (2023) for details.

Graph 10.A: The sample covers 3,520 banks in AT, AU, BE, BR, CH, CN, CZ, DE, DK, ES, FI, FR, GB, HK, HU, IN, IT, JP, KR, MX, NL, NO, PH, PL, RO, RU, SE, SG, TH, TR, US and ZA.

Graph 10.B: The sample covers 13 large life insurance companies (ICs) in CA, CH, FR, GB, JP, NL and US. For excess return, asset-weighted average of cumulative equity returns relative to the domestic stock market since 6 January 2014. Average government bond yield is the asset-weighted average of the 10-year government bond yields prevailing in the home jurisdictions of the ICs.

Graph 10.C: The sample covers AU, BE, CA, CH, DE, DK, ES, FR, GB, IT, JP, NL, SE and US. A firm is classified as a zombie if the following conditions are met over two years: (i) earnings before interest and taxes (EBIT) is less than interest payments and (ii) the ratio of the market value of its assets to replacement cost (Tobin's q) is below the median within its sector. To exit from the zombie status, a firm needs to have an EBIT greater than interest payments or a Tobin's q above the median for two consecutive years before it is declassified from the status. The nominal policy rate is the simple average across the sample economies.

Graph 11: Projections are based on exit plans announced up to May 2024. For the Bank of England, Federal Reserve and Sveriges Riksbank, projections assume a reduction in assets of respectively GBP 100 billion per year (GBP 8.33 billion per month), USD 60 billion per month and SEK 6.5 billion per month. For the Reserve Bank of Australia and Bank of Canada, projections assume no reinvestment of maturing securities. For the Eurosystem, the projection assumes no reinvestment of maturing securities of the asset purchase programme (APP), a reduction in assets of EUR 7.5 billion per month of the pandemic emergency purchase programme (PEPP) and considers maturing open market operations.

Graph 12.A: EMBI = JPMorgan Emerging Markets Bond Index Global, yield to maturity.

Graph 12.B: Actual headline inflation less one-year-ahead (or closest) inflation forecast of the respective central bank. For the Federal Reserve, midpoint of the central tendency for the personal consumption expenditures inflation rate in the Federal Open Market Committee's summary of economic projections. For the ECB, Eurosystem and ECB staff macroeconomic projections for the harmonised index of consumer prices (HICP). For the Bank of England, the Monetary Policy Committee's median CPI inflation projection assuming that rates will follow the market expectation of interest rates.

Graph 12.C: All speeches of central bankers mentioning the keyword "inequality" expressed as a share of all central bankers' speeches in the BIS database (www.bis.org/cbspeeches/index.htm). Only selected speeches in English and, for the United States, only speeches by members of the Board of Governors of the Federal Reserve System and the Federal Reserve Bank of New York are included in the database.

Graph 13.A: The sample covers AR, BR, CL, CN, CO, CZ, HU, ID, IN, KR, MX, MY, PE, PH, PL, RU, SG, TH, TR, TW and ZA. For the taper tantrum, FX reserves as of 2012 and depreciation against the US dollar from Q1 2013 to Q4 2015; for Covid-19, reserves as of 2019 and depreciation from January to March 2020; and for the inflation surge, reserves as of Q2 2021 and depreciation against the US dollar from Q3 2021 to Q2 2022.

Graph 13.B: FX purchase: change of FX reserve as a percentage of nominal GDP in US dollars; capital inflow: net capital flows as a percentage of nominal GDP in US dollars; exchange rate appreciation: log change in bilateral FX rate against the US dollar. The sample covers BR, CL, CN, CO, CZ, HK, HU, ID, IN, KR, MX, MY, PE, PH, PL, RU, SG, TH, TR and ZA from Q3 2000 to Q1 2024. The control variables comprise the lagged dependent variables, the short-term interest rate spread against the US equivalent, the log change in the Chicago Board Options Exchange Volatility Index (VIX) and the Commodity Research Bureau (CRB) commodity price index, dummy for the Great Financial Crisis and country fixed effects.

Graph 14: The sample covers 157 monetary tightening episodes for AT, AU, BE, CA, CH, CL, CO, CZ, DE, DK, ES, FI, FR, GB, GR, HK, HU, IL, IN, IS, IT, JP, KR, LU, LV, MX, NL, NO, NZ, PE, PL, PT, RO, SK, TH, TW and US. Capital measures include prudential measures taken to strengthen banks' capital positions, such as minimum capital ratios, adjustments in risk weights and limits on bank leverage. See Boissay et al (2023) for details.

Graph 15: The sample covers AEs = AT, BE, DE, ES, FI, FR, GB, IE, IT, JP, NL, PT and US. EMEs = AR, BR, CL, CN, CO, CZ, HU, ID, IL, IN, KR, MX, PL and ZA. Aggregates are computed using a smaller set of economies when data are not available.

Graphs 15.A and 15.B: Projections assume an interest rate growth differential equal to –1%; constant primary fiscal deficit as a percentage of GDP as of 2023; and increases in pension and healthcare spending based on IMF projections for 2030 and 2050. Simple average across economies.

Graph 15.C: Median across economies. Counterfactuals are computed by multiplying end-2023 public debt-to-GDP ratios by the average of short- and long-term interest rates.

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III. Artificial intelligence and the economy: implications for central banks

Key takeaways

- Machine learning models excel at harnessing massive computing power to impose structure on unstructured data, giving rise to artificial intelligence (AI) applications that have seen rapid and widespread adoption in many fields.
- The rise of AI has implications for the financial system and its stability, as well as for macroeconomic outcomes via changes in aggregate supply (through productivity) and demand (through investment, consumption and wages).
- Central banks are directly affected by AI's impact, both in their role as stewards of monetary and financial stability and as users of AI tools. To address emerging challenges, they need to anticipate AI's effects across the economy and harness AI in their own operations.
- Data availability and data governance are key enabling factors for central banks' use of AI, and both rely on cooperation along several fronts. Central banks need to come together and foster a "community of practice" to share knowledge, data, best practices and AI tools.

Introduction

The advent of large language models (LLMs) has catapulted generative artificial intelligence (gen AI) into popular discourse. LLMs have transformed the way people interact with computers – away from code and programming interfaces to ordinary text and speech. This ability to converse through ordinary language as well as gen AI's human-like capabilities in creating content have captured our collective imagination.

Below the surface, the underlying mathematics of the latest AI models follow basic principles that would be familiar to earlier generations of computer scientists. Words or sentences are converted into arrays of numbers, making them amenable to arithmetic operations and geometric manipulations that computers excel at.

What is new is the ability to bring mathematical order at scale to everyday unstructured data, whether they be text, images, videos or music. Recent AI developments have been enabled by two factors. First is the accumulation of vast reservoirs of data. The latest LLMs draw on the totality of textual and audiovisual information available on the internet. Second is the massive computing power of the latest generation of hardware. These elements turn AI models into highly refined prediction machines, possessing a remarkable ability to detect patterns in data and fill in gaps.

There is an active debate on whether enhanced pattern recognition is sufficient to approximate "artificial general intelligence" (AGI), rendering AI with full human-like cognitive capabilities. Irrespective of whether AGI can be attained, the ability to impose structure on unstructured data has already unlocked new capabilities in many tasks that eluded earlier generations of AI tools.[1] The new generation of AI models could be a game changer for many activities and have a profound impact on the broader economy and the financial system. Not least, these same capabilities can be harnessed by central banks in pursuit of their policy objectives, potentially transforming key areas of their operations.

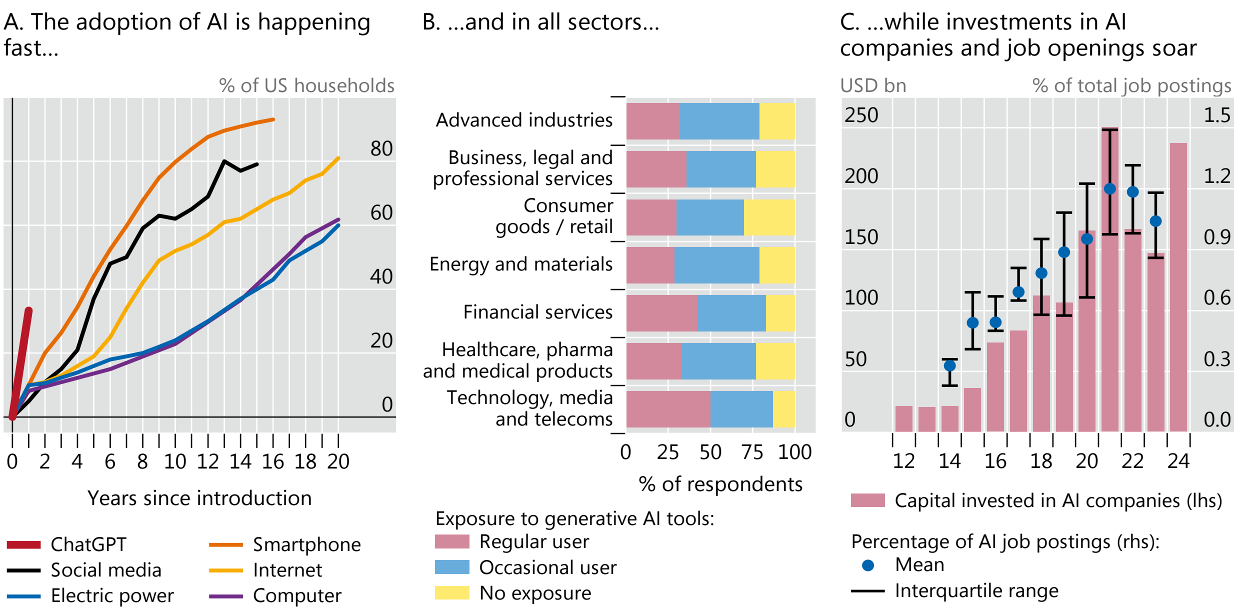
The economic potential of AI has set off a gold rush across the economy. The adoption of LLMs and gen AI tools is proceeding at such breathtaking speed that it easily outpaces previous waves of technology adoption (Graph 1.A). For example, ChatGPT alone reached one million users in less than a week and nearly half of US households have used gen AI tools in the past 12 months. Mirroring rapid adoption by users, firms are already integrating AI in their daily operations: global survey evidence suggests firms in all industries use gen AI tools (Graph 1.B). To do so, they are investing heavily in AI technology to tailor it to their specific needs and have embarked on a hiring spree of workers with AI-related skills (Graph 1.C). Most firms expect these trends to only accelerate.[2]

This chapter lays out the implications of these developments for central banks, which impinge on them in two important ways.

First, AI will influence central banks' core activities as stewards of the economy. Central bank mandates revolve around price and financial stability. AI will affect financial systems as well as productivity, consumption, investment and labour markets, which themselves have direct effects on price and financial stability. Widespread adoption of AI could also enhance firms' ability to quickly adjust prices in response to macroeconomic changes, with repercussions for inflation dynamics. These developments are therefore of paramount concern to central banks.

Second, the use of AI will have a direct bearing on the operations of central banks through its impact on the financial system. For one, financial institutions such as commercial banks increasingly employ AI tools, which will change how they interact with and are supervised by central banks. Moreover, central banks and other authorities are likely to increasingly use AI in pursuing their missions in monetary policy, supervision and financial stability.

The adoption of AI[1] Graph 1



[1] See technical annex for details.

Sources: Allcot (2023); Comin and Hobijn (2004); Maslej et al (2024); McKinsey & Company (2023); IMF, *World Economic Outlook*; US Census Bureau, *Current Population Survey*; International Telecommunication Union (ITU); PitchBook Data Inc; Our World in Data; Statista, *Digital Market Insights*; BIS.

Overall, the rapid and widespread adoption of AI implies that there is an urgent need for central banks to raise their game. To address the new challenges, central banks need to upgrade their capabilities both as *informed observers* of the effects of technological advancements as well as *users* of the technology itself. As observers, central banks need to stay ahead of the impact of AI on economic activity through its effects on aggregate supply and demand. As users, they need to build expertise in incorporating AI and non-traditional data in their own analytical tools. Central banks will face important trade-offs in using external vs internal AI models, as well as in collecting and providing in-house data vs purchasing them from external providers. Together with the centrality of data, the rise of AI will require a rethink of central banks' traditional roles as compilers, users and providers of data. To harness the benefits of AI, collaboration and the sharing of experiences emerge as key avenues for central banks to mitigate these trade-offs, in particular by reducing the demands on information technology (IT) infrastructure and human capital. Central banks need to come together to form a "community of practice" to share knowledge, data, best practices and AI tools.

The chapter starts with an overview of developments in AI, providing a deep dive into the underlying technology. It then examines the implications of the rise of AI for the financial sector. The discussion includes current use cases of AI by financial institutions and implications for financial stability. It also outlines the emerging opportunities and challenges and the implications for central banks, including how they can harness AI to fulfil their policy objectives. The chapter then discusses how AI affects firms' productive capacity and investment, as well as labour markets and household consumption, and how these changes in aggregate demand and supply affect inflation dynamics. The chapter concludes by examining the trade-offs arising from the use of AI and the centrality of data for central banks and regulatory authorities. In doing so, it highlights the urgent need for central banks to cooperate.

Developments in artificial intelligence

Artificial intelligence is a broad term, referring to computer systems performing tasks that require human-like intelligence. While the roots of AI can be traced back to the late 1950s, the advances in the field of **machine learning** in the 1990s laid the foundations of the current generation of AI models. Machine learning is a collective term referring to techniques designed to detect patterns in the data and use them in prediction or to aid decision-making.[3]

The development of **deep learning** in the 2010s constituted the next big leap. Deep learning uses neural networks, perhaps the most important technique in machine learning, underpinning everyday applications such as facial recognition or voice assistants. The main building block of neural networks is *artificial neurons*, which take multiple input values and transform them to output as a set of numbers that can be readily analysed. The artificial neurons are organised to form a sequence of *layers* that can be stacked: the neurons of the first layer take the input data and output an activation value. Subsequent layers then take the output of the previous layer as input, transform it and output another value, and so forth. A network's *depth* refers to the number of layers. More layers allow neural networks to capture increasingly complex relationships in the data. The weights determining the strength of connections between different neurons and layers are collectively called *parameters*, which are improved (known as *learning*) iteratively during training. Deeper networks with more parameters require more training data but predict more accurately.

A key advantage of deep learning models is their ability to work with unstructured data. They achieve this by "**embedding**" qualitative, categorical or visual data, such as words, sentences, proteins or images, into arrays of numbers – an approach pioneered at scale by the Word2Vec model (see Box A). These arrays of numbers (ie vectors) are interpreted as points in a vector space. The distance between vectors conveys some dimension of similarity, enabling algebraic manipulations on what is originally qualitative data. For example, the vector linking the embeddings of the words "big" and "biggest" is very similar to that between "small" and "smallest". Word2Vec predicts a word based on the surrounding words in a sentence. The body of text used for the embedding exercise is drawn from the open internet through the "common crawl" database. The concept of embedding can be taken further into mapping the space of economic ideas, uncovering latent viewpoints or methodological approaches of individual economists or institutions ("**personas**"). The space of ideas can be linked to concrete policy actions, including monetary policy decisions.[4]

The advent of **LLMs** allows neural networks to access the whole context of a word rather than just its neighbour in the sentence. Unlike Word2Vec, LLMs can now capture the nuances of translating uncommon languages, answer ambiguous questions or analyse the sentiment of texts. LLMs are based on the **transformer** model (see Box B). Transformers rely on "multi-headed attention" and "positional encoding" mechanisms to efficiently evaluate the context of any word in the document. The context influences how words with multiple meanings map into arrays of numbers. For example, "bond" could refer to a fixed income security, a connection or link, or a famous espionage character. Depending on the context, the "bond" embedding vector lies geometrically closer to words such as "treasury", "unconventional" and "policy"; to "family" and "cultural"; or to "spy" and "martini". These developments have enabled AI to move from narrow systems that solve one specific task to more general systems that deal with a wide range of tasks.

LLMs are a leading example of **gen AI applications** because of their capacity to understand and generate accurate responses with minimal or even no prior examples (so-called **few-shot** or **zero-shot** learning abilities). Gen AI refers to AIs capable of generating content, including text, images or music, from a natural language prompt. The prompts contain instructions in plain language or examples of what users want from the model. Before LLMs, machine learning models were trained to solve one task (eg image classification, sentiment analysis or translating from French to English). It required the user to code, train and roll out the model into production after acquiring sufficient training data. This procedure was possible for only selected companies with researchers and engineers with specific skills. An LLM has few-shot learning abilities in that it can be given a task in plain language. There is no need for coding, training or acquiring training data. Moreover, it displays considerable versatility in the range of tasks it can take on. It can be used to first classify an image, then analyse the sentiment of a paragraph and finally translate it into any language. Therefore, LLMs and gen AI have enabled people using ordinary language to automate tasks that were previously performed by highly specialised models.

The capabilities of the most recent crop of AI models are underpinned by advances in **data** and **computing power**. The increasing availability of data plays a key role in training and improving models. The more data a model is trained on, the more capable it usually becomes. Furthermore, machine learning models with more parameters improve predictions when trained with sufficient data. In contrast to the previous conventional wisdom that "over-parameterisation" degrades the forecasting ability of models, more recent evidence points to a remarkable resilience of machine learning models to over-parameterisation. As a consequence, LLMs with well designed learning mechanisms can provide more accurate predictions than traditional parametric models in diverse scenarios such as computer vision, signal processing and natural language processing (NLP).[5]

Box A

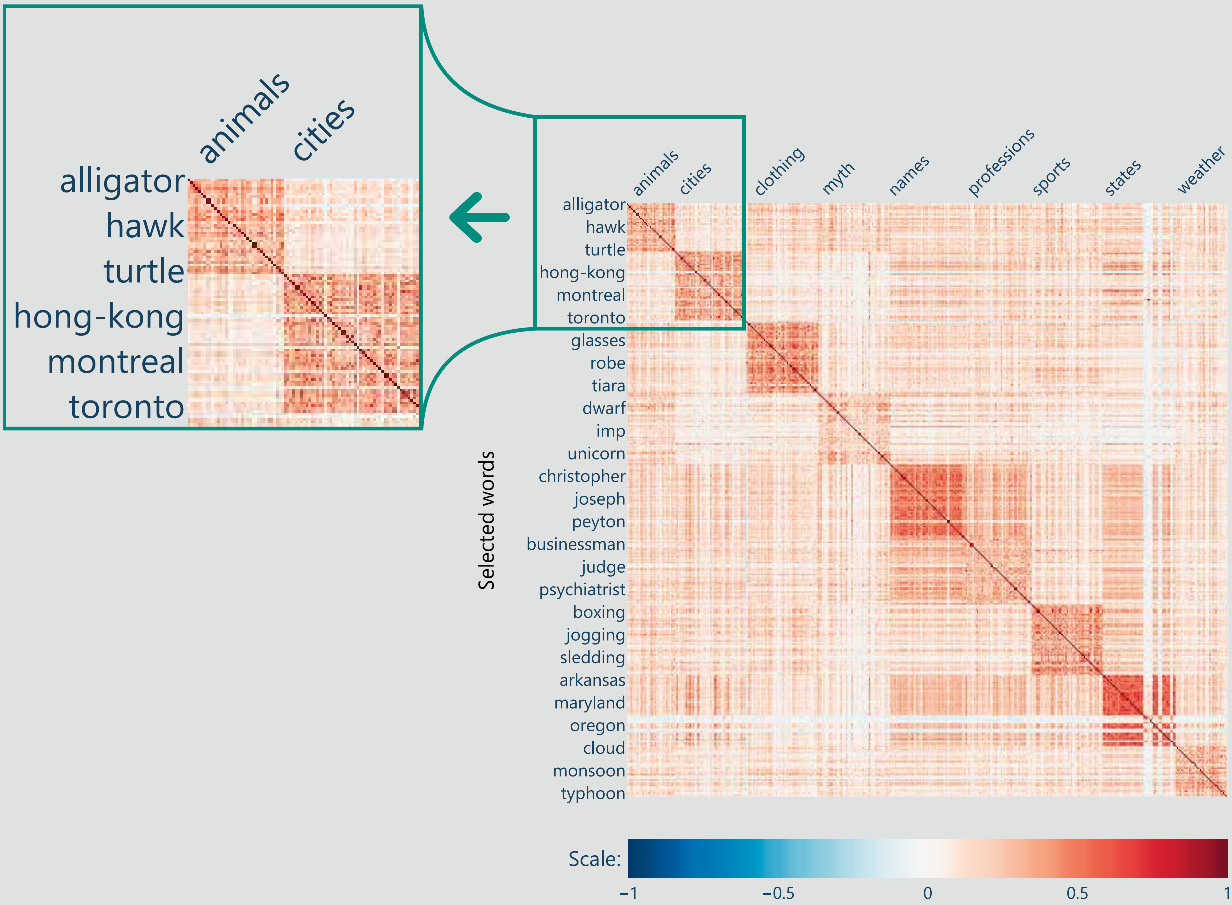
Words as vectors: a primer on embeddings

Modern machine learning methods excel at imposing mathematical structure on unstructured data, allowing massive computing power to be unleashed in processing information. The mapping that imposes such structure is known as an "embedding", and the canonical example is the embedding of words as points in a vector space, so that each word is associated with an array of numbers.

An early example of word embedding is Word2Vec,[1] which maps a word to an embedding vector of a few hundred dimensions that is learned by a neural network. The neural network is refined by being asked to predict the centre word in a short window of text (typically four to eight words before and after the centre word) and being scored by its success rate. This procedure is known as the "Continuous Bag of Words" method because all surrounding words are first added into a single vector. The Word2Vec learning algorithm computes the prediction error over all the words in a corpus (which can be trillions of words) and iteratively adjusts the embedding vector for each word to reduce this classification error and optimise prediction.

Embedding distances between 420 words in nine categories of words[1]

Graph A1



[1] Cosine similarity matrix between 420 words. The value ranges from –1 (completely dissimilar) to 1 (completely similar), with 0 indicating orthogonality (no similarity). The y-axis labels correspond to selected 420 words; the axis labels indicate the categories to which these words belong.

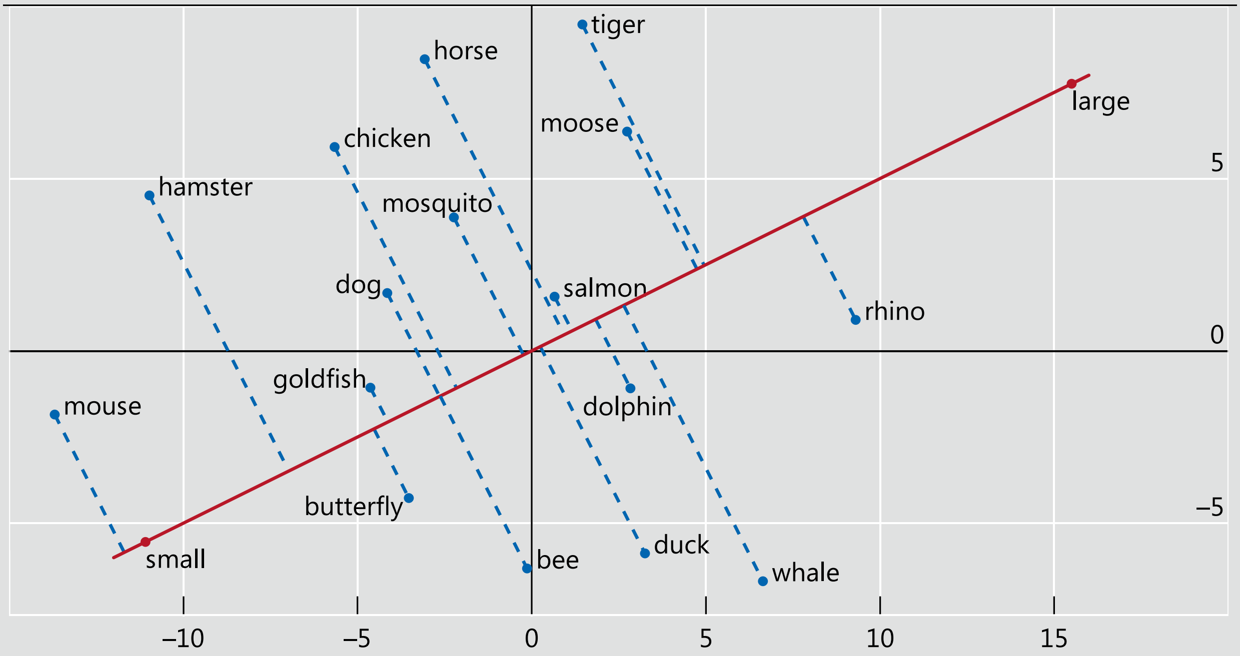
Source: Adapted from Grand et al (2022).

These procedures result in similar embeddings for words with similar meaning, in the sense that the distance between the vectors representing the two words is mathematically close. For example, the embedding of the word "cat" is close to that of the word "mouse", and that of "Mexico" close to "Indonesia". Graph A1 illustrates the "cosine similarity" between 420 words in nine different word categories (animals, cities etc).

Cosine similarity measures the cosine of the angle between two non-zero vectors, reflecting how similar their directions are. It calculates the dot product of the vectors divided by the product of their norms. The value ranges from –1 (completely dissimilar) to 1 (completely similar), with 0 indicating orthogonality (no similarity). In Graph A1, the colour scheme indicates the degree of similarity between word pairs. The diagonal of this matrix consists of 1 everywhere, as the diagonal measures each word's similarity with itself. Darker red indicates high cosine similarity, while lighter red indicates low similarity. Graph A1 shows that words from the same category (eg animals) have a high cosine similarity, while they have low cosine similarity with words from other categories (eg cities or sports). The resulting vectors give rise to embeddings that can be used in various natural language processing tasks such as text classification, sentiment analysis and machine translation with minimal or no human-labelled data.

The embeddings uncover the mathematical relationships between words. Not only are similar words placed closer together in the vector space, but the semantic connections are also captured through the mathematical relationships between the vector embedding of each word. For instance, analogies like "man is to woman as king is to?" can be solved directly from vector addition and subtraction operations: $\overrightarrow{queen} = \overrightarrow{woman} + \overrightarrow{king} - \overrightarrow{man}$. These embedding relationships also apply to the link between countries and their capitals ($\overrightarrow{Quito} = \overrightarrow{Ecuador} + \overrightarrow{Oslo} - \overrightarrow{Norway}$), opposites ($\overrightarrow{unethical} = \overrightarrow{ethical} + \overrightarrow{impossibly} - \overrightarrow{possibly}$), and the tense of words ($\overrightarrow{swam} = \overrightarrow{swimming} + \overrightarrow{walked} - \overrightarrow{walking}$). Semantic relationships between words can also be projected to concepts. Graph A2 illustrates how by projecting the word embeddings of animals to the vector representing variation in size (ie the difference between the word embedding for "large" and "small"), the animals are mostly sorted according to their sizes.

Embedding projection of animal words onto size concept vector[1] Graph A2



[1] Two-dimensional illustration, as the embeddings are in a 300-dimensional vector space.

Source: Adapted from Grand et al (2022).

Word2Vec has subsequently been superseded by other methods that achieve more meaningful embedding, such as GloVe, ELMo, BERT and GPT,[2] by employing more sophisticated learning of concepts with more complex neural network architectures. The latest models (BERT and GPT) rely on the transformer architecture (see Box B). BERT and GPT are referred to as language models, not word embeddings. They use the whole text as context, multiple paths to capture different meanings and neural networks with trillions of tunable parameters.

[1] Mikolov et al (2013) [2] Pennington et al (2014), Peters et al (2018), Devlin et al (2018) and Brown et al (2019).

An implication is that more capable models tend to be larger models that need more data. Bigger models and larger data sets therefore go together and increase computational demands. The use of advanced techniques on vast troves of data would not have been possible without substantial increases in computing power – in particular, the computational resources employed by AI systems – which has been doubling every six months.[6] The interplay between large amounts of data and computational resources implies that just a handful of companies provide cutting-edge LLMs, an issue revisited later in the chapter.

Some commentators have argued that AI has the potential to become the next **general-purpose technology**, profoundly impacting the economy and society. General-purpose technologies, like electricity or the internet, eventually achieve widespread usage, give rise to versatile applications and generate spillover effects that can improve other technologies. The adoption pattern of general-purpose technologies typically follows a J-curve: it is slow at first, but eventually accelerates. Over time, the pace of technology adoption has been speeding up. While it took electricity or the telephone decades to reach widespread adoption, smartphones accomplished the same in less than a decade. AI features two distinct characteristics that suggest an even steeper J-curve. First is its remarkable speed of adoption, reflecting ease of use and negligible cost for users. Second is its widespread use at an early stage by households as well as firms in all industries.

Of course, there is substantial uncertainty about the long-term capabilities of gen AI. Current LLMs can **fail elementary logical reasoning** tasks and struggle with counterfactual reasoning, as illustrated in recent BIS work.[7] For example, when posed with a logical puzzle that demands reasoning about the knowledge of others and about counterfactuals, LLMs display a distinctive pattern of failure. They perform flawlessly when presented with the original wording of a puzzle, which they have likely seen during their training. They falter when the same problem is presented with small changes of innocuous details such as names and dates, suggesting a lack of true understanding of the underlying logic of statements. Ultimately, current LLMs do not know what they do not know. LLMs also suffer from the **hallucination problem**: they can present a factually incorrect answer as if it were correct, and even invent secondary sources to back up their fake claims. Unfortunately, hallucinations are a feature rather than a bug in these models. LLMs hallucinate because they are trained to predict the statistically plausible word based on some input. But they cannot distinguish what is linguistically probable from what is factually correct.

Do these problems merely reflect the limits posed by the size of the training data set and the number of model parameters? Or do they reflect more fundamental limits to knowledge that is acquired through language alone? Optimists acknowledge current limitations but emphasise the potential of LLMs to exceed human performance in certain domains. In particular, they argue that terms such as "reason", "knowledge" and "learning" rightly apply to such models. Sceptics point out the limitations of LLMs in reasoning and planning. They argue that the main limitation of LLMs derives from their exclusive reliance on language as the medium of knowledge. As LLMs are confined to interacting with the world purely through language, they lack the tacit non-linguistic, shared understanding that can be acquired only through active engagement with the real world.[8]

Whether AI will eventually be able to perform tasks that require deep logical reasoning has implications for its long-run economic impact. Assessing which tasks will be impacted by AI depends on the specific cognitive abilities required in those tasks. The discussion above suggests that, at least in the near term, AI faces challenges in reaching human-like performance. While it may be able to perform tasks that require moderate cognitive abilities and even develop "emergent" capabilities, it is not yet able to perform tasks that require logical reasoning and judgment.

Box B

A primer on the transformer architecture

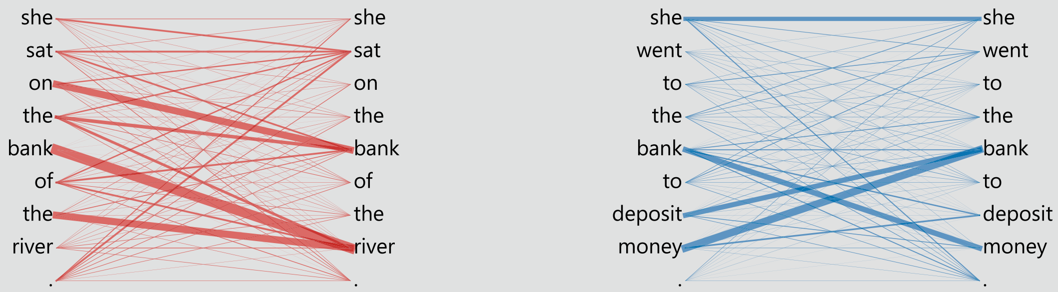
The transformer architecture[1] has been a breakthrough in natural language processing (NLP), laying the foundation for the development of advanced large language models (LLMs) such as BERT (Bidirectional Encoder Representations from Transformers)[2] and GPT (Generative Pre-trained Transformer).[3] At the heart of the transformer architecture are two innovations: "multi-headed attention" and "positional encoding".

Attention allows each word in a text to be understood in relation to every other word, enhancing the models' capacity to take account of context and relationships within the text. Multi-headed attention allows several parallel neural networks to capture different meanings for the same word. For instance, it can discern the different meanings of "bank" in "She sat on the bank of the river" versus "She went to the bank to deposit money" by focusing on surrounding words like "river" versus "money" or "deposit" (Graph B1). The attention mechanism computes dot products of the input query vector ("bank") with key vectors (each word in the text), resulting in a score matrix. This matrix is then used to obtain so-called attention weights, which measure the similarity between the query and key vectors. By combining the information into a value vector, the model relates each word to the most relevant parts of the query vector. This ability to interpret the meaning of words based on much wider contexts is a significant advance over previous NLP models.

Visualised examples of the attention mechanism in transformers[1]

Graph B1

A. Understanding the meaning of "bank": first example… B. …and second example



[1] Examples of the attention mechanism within 10th head of specific layers in the BERT model. The connecting lines and their thickness represent the attention scores (ie the relevance) between words. This visualisation illustrates how the word "bank" varies in its attention to different words depending on the context.

Sources: Devlin et al (2018); Vig (2019); BIS.

Positional encoding enables transformers to process data concurrently rather than sequentially. This sets them apart from earlier neural network models such as Recurrent Neural Networks and Long Short-Term Memory. Sequential models are slow to train and memory-consuming, and they suffer from the so-called vanishing gradient problem (ie the signals that carry information about how to update the weights in a neural network eventually become too weak to effectively train deep layers). By embedding each word with positional information, transformers preserve the sequence of words, and the model can be parallelised during training. This capability allows training with more data and the building of bigger models, which leads them to accurately differentiate between sentences like "Inflation causes a rate hike" and "A rate hike causes inflation", where word order determines meaning.

The integration of multi-headed attention and positional encoding has significantly enhanced the performance of language models. Transformer-based models exhibit remarkable proficiency in interpreting context and managing complex relationships within text. The result is superior accuracy and fluency in a variety of NLP tasks. The parallel computation capabilities of transformers, facilitated by advances in graphics processing unit technology, enable rapid processing of vast data sets and a complex linguistic structure.

[1] See Vaswani et al (2017). [2] See Devlin et al (2018). [3] GPT is an underlying model of ChatGPT. See Radford et al (2018).

Financial system impact of AI

The financial sector is among those facing the greatest opportunities and risks from the rise of AI, due to its high share of cognitively demanding tasks and data-intensive nature.[9] Table 1 illustrates the impact of AI in four key areas: payments, lending, insurance and asset management.

Across all four areas, AI can substantially **enhance efficiency and lower costs** in back-end processing, regulatory compliance, fraud detection and customer service. These activities give full play to the ability of AI models to identify patterns of interest in seemingly unstructured data. Indeed, "finding a needle in the haystack" is an activity that plays to the greatest strength of machine learning models. A striking example is the improvement of know-your-customer (KYC) processes through quicker data processing and the enhanced ability to detect fraud, allowing financial institutions to ensure better compliance with regulations while lowering costs.[10] LLMs are also increasingly being deployed for customer service operations through AI chatbots and co-pilots.

In **payments**, the abundance of transaction-level data enables AI models to overcome long-standing pain points. A prime example comes from correspondent banking, which has become a high-risk, low-margin activity. Correspondent banks played a key role in the expansion of cross-border payment activity by enabling transaction settlement, cheque clearance and foreign exchange operations. Facing heightened customer verification and anti-money laundering (AML) requirements, banks have systematically retreated from the business (Graphs 2.A and 2.B). Such retreat fragments the global payment system by leaving some regions less connected (Graph 2.C), handicapping their connectivity with the rest of the financial system. The decline in correspondent banking is part of a general de-risking trend, with returns from processing transactions being small compared with the risks of penalties from breaching AML, KYC and countering the financing of terrorism (CFT) requirements.[11]

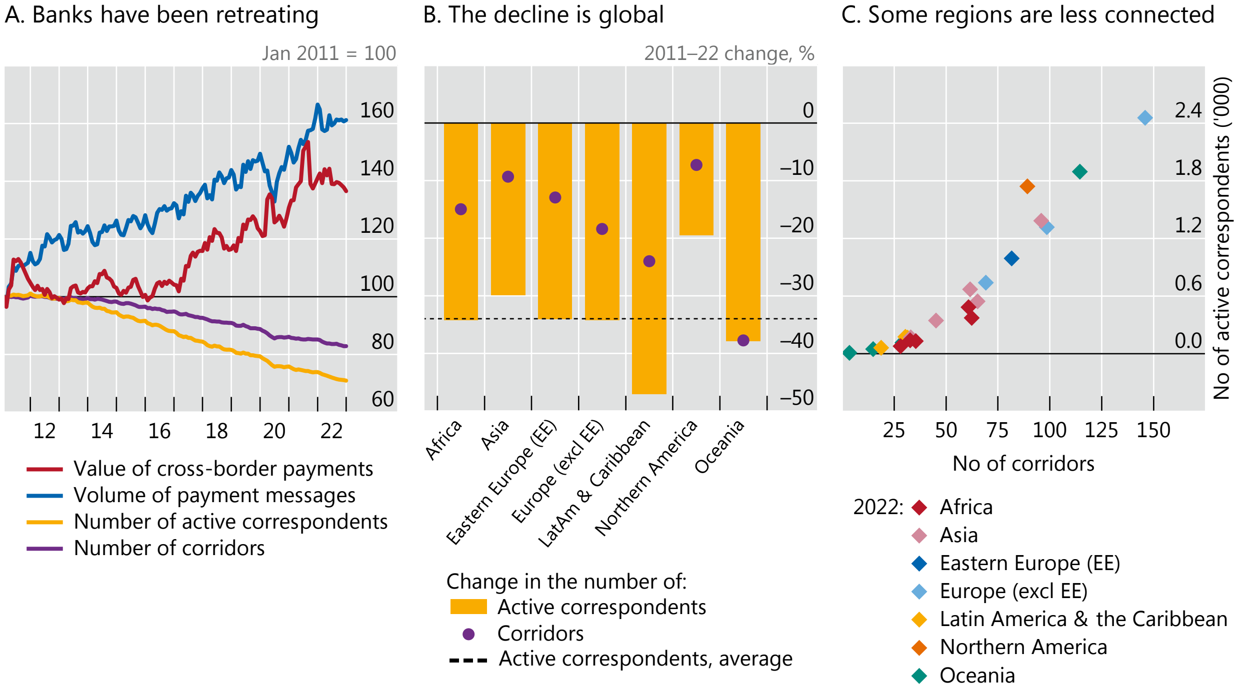
A key use case of AI models is to improve KYC and AML processes by enhancing (i) the ability to understand the compliance and reputational risks that clients might carry, (ii) due diligence on the counterparties of a transaction and (iii) the analysis of

Opportunities, challenges and financial stability risks of AI in the financial sector — Table 1

	Payments	Lending	Insurance	Asset management
General opportunities	Back-end processing, virtual assistants, co-pilots, fraud detection, regulatory compliance			
Sector-specific opportunities	Liquidity management, AML/KYC	Credit risk analysis, financial inclusion	Risk assessment, pricing, claims processing	Portfolio allocation, algorithmic trading, robo-advising, asset embeddings
General challenges	Lack of explainability, data silos, third-party dependencies, algorithmic collusion, hallucinations, cyber security risks			
Sector-specific challenges	Liquidity crises, sophisticated fraud and cyber attacks	Algorithmic discrimination, privacy concerns		Zero-sum arms race for private gains, herding, algorithmic coordination
Financial stability challenges	Herding, network interconnectedness and procyclicality, single point of failure, incorrect decisions based on short samples of non-representative data, spillovers from real sector			

Source: Adapted from Aldasoro, Gambacorta, Korinek, Shreeti and Stein (2024).

Decline in correspondent banking has changed the global payments landscape[1] Graph 2



[1] See technical annex for details.

Sources: Garratt et al (2024); Rice et al (2020); CPMI (2023).

payment patterns and anomaly detection. By bringing down costs and reducing risks through greater speed and automation, AI holds the promise to reverse the decline in correspondent banking.

The ability of AI models to detect patterns in the data is helping financial institutions address many of these challenges. For example, financial institutions are using AI tools to enhance fraud detection and to identify security vulnerabilities. At the global level, surveys indicate that around 70% of all financial services firms are using AI to enhance cash flow predictions and improve liquidity management, fine-tune credit scores and improve fraud detection.[12]

In **credit assessment and lending**, banks have used machine learning for many years, but AI can bring further capabilities. For one, AI could greatly enhance credit scoring by making use of unstructured data. In deciding whether to grant a loan, lenders traditionally rely on standardised credit scores, at times combined with easily accessible variables such as loan-to-value or debt-to-income ratios. AI-based tools enable lenders to assess individuals' creditworthiness with alternative data. These can include consumers' bank account transactions or their rental, utility and telecommunications payments data. But they can also be of a non-financial nature, for example applicants' educational history or online shopping habits. The use of non-traditional data can significantly improve default prediction, especially among underserved groups for whom traditional credit scores provide an imprecise signal about default probability. By being better able to spot patterns in unstructured data and detect "invisible primes", ie borrowers that are of high quality even if their credit scores indicate low quality, AI can enhance financial inclusion.[13]

AI has numerous applications in **insurance**, particularly in risk assessment and pricing. For example, companies use AI to automatically analyse images and videos to assess property damage due to natural disasters or, in the context of compliance, whether claims of damages correspond to actual damages. Underwriters, actuaries or claims adjusters further stand to benefit from AI summarising and synthesising data gathered during a claim's life cycle, such as call transcripts and notes, as well as legal and medical paperwork. More generally, AI is bound to play an increasingly important role in assessing different types of risks. For example, some insurance companies are experimenting with AI methods to assess climate risks by identifying and quantifying emissions based on aerial images of pollution. However, to the extent that AI is better at analysing or inferring individual-level characteristics in risk assessments, including those whose use is prohibited by regulation, existing inequalities could be exacerbated – an issue revisited in the discussion on the macroeconomic impact of AI.

In **asset management**, AI models are used to predict returns, evaluate risk-return trade-offs and optimise portfolio allocation. Just as LLMs assign different characteristics to each word they process, they can be used to elicit unobservable features of financial data (so-called asset embeddings). This allows market participants to extract information (such as firm quality or investor preferences) that is difficult to discern from existing data. In this way, AI models can provide a better understanding of the risk-return properties of portfolios. Models that use asset embeddings can outperform traditional models that rely only on observable characteristics of financial data. Separately, AI models are useful in algorithmic trading, owing to their ability to analyse large volumes of data quickly. As a result, investors benefit from quicker and more precise information as well as lower management fees.[14]

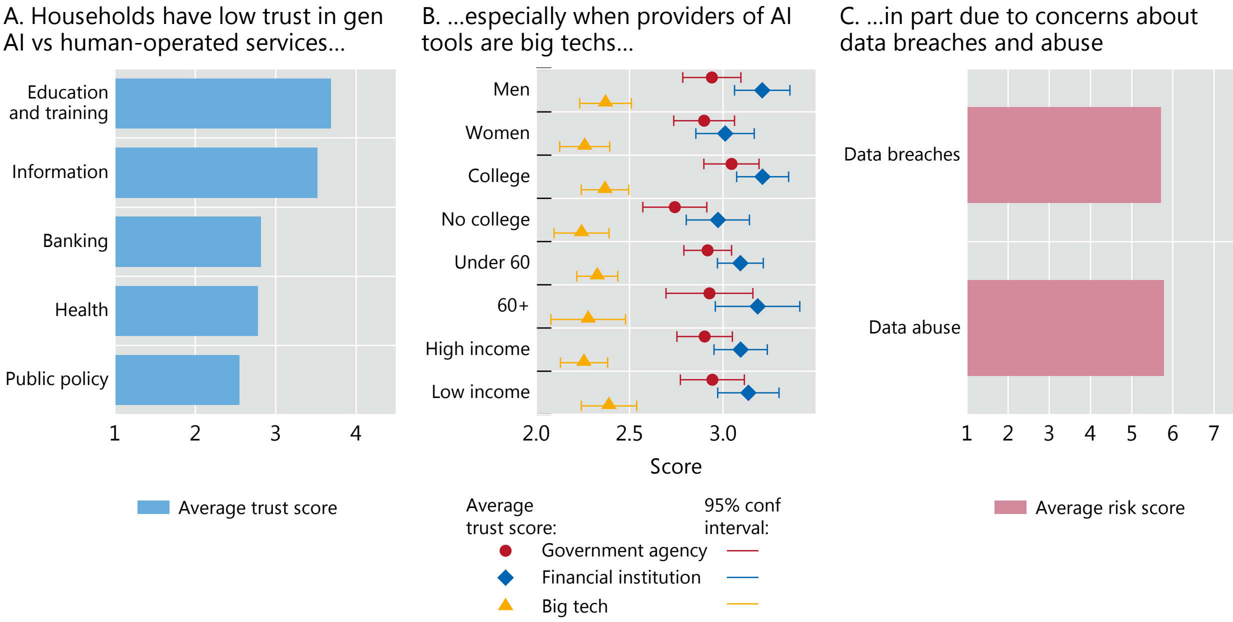
The widespread use of AI applications in the financial sector, however, brings new challenges. These pertain to cyber security and operational resilience as well as financial stability.

The reliance on AI heightens concerns about **cyber attacks**, which regularly feature among the top worries in the financial industry. Traditionally, phishing emails have been used to trick a user to run a malicious code (malware) to take over the user's device. Credential phishing is the practice of stealing a user's login and password combination by masquerading as a reputable or known entity in an email, instant message or another communication channel. Attackers then use the victim's credentials to carry out attacks on additional targets and gain further access.[15] Gen AI could vastly expand hackers' ability to write credible phishing emails or to write malware and use it to steal valuable information or encrypt a company's files for ransom. Moreover, gen AI allows hackers to imitate the writing style or voice of individuals, or even create fake avatars, which could lead to a dramatic rise in phishing attacks. These developments expose financial institutions and their customers to a greater risk of fraud.

But AI also introduces altogether **new sources of cyber risk**. *Prompt injection attacks*, one of the most widely reported weaknesses in LLMs, refer to an attacker creating an input to make the model behave in an unintended way. For example, LLMs are usually instructed not to provide dangerous information, such as how to manufacture napalm. However, in the infamous *grandma jailbreak*, where the prompter asked ChatGPT to pretend to be their deceased grandmother telling a bedtime story about the steps to produce napalm, the chatbot did reveal this information. While this vulnerability has been fixed, others remain. *Data poisoning attacks* refer to malicious tampering with the data an AI model is trained on. For example, an attacker could adjust input data so that the AI model fails to detect phishing emails. *Model poisoning attacks* deliberately introduce malware, manipulating the training process of an AI system to compromise its integrity or functionality. This attack aims to alter the model behaviour to serve the attacker's purposes.[16] As more applications use data created by LLMs themselves, such attacks could have increasingly severe consequences, leading to heightened operational risks among financial institutions.

Households' trust in generative AI (gen AI)[1]

Score, 1 (lowest)–7 (highest) Graph 3



[1] Based on a representative sample of US households from the Survey of Consumer Expectations. See technical annex for details.

Sources: Aldasoro, Armantier, Doerr, Gambacorta and Oliviero (2024a); Federal Reserve Bank of New York, *Survey of Consumer Expectations*.

Greater use of AI raises issues of **bias and discrimination**. Two examples stand out. The first relates to consumer protection and fair lending practices. As with traditional models, AI models can reflect biases and inaccuracies in the data they are trained on, posing risks of unjust decisions, excluding some groups from socially desirable insurance markets and perpetuating disparities in access to credit through algorithmic discrimination.[17] Consumers care about these risks: recent evidence from a representative survey of US households suggests a lower level of trust in gen AI than in human-operated services, especially in high-stakes areas such as banking and public policy (Graph 3.A) and when AI tools are provided by big techs (Graph 3.B).[18] The second example relates to the challenge of ensuring data privacy and confidentiality when dealing with growing volumes of data, another key concern for users (Graph 3.C). In the light of the high privacy standards that financial institutions need to adhere to, this heightens **legal risks**. The lack of explainability of AI models (ie their black box nature) as well as their tendency to hallucinate amplify these risks.

Another operational risk arises from relying on just a few providers of AI models, which increases **third-party dependency risks**. Market concentration arises from the centrality of data and the vast costs of developing and implementing data-hungry models. Heavy up-front investment is required to build data storage facilities, hire and train staff, gather and clean data and develop or refine algorithms. However, once the infrastructure is in place, the cost of adding each extra unit of data is negligible. This centrality leads to so-called data gravity: companies that already have an edge in collecting, storing and analysing data can provide better-trained AI tools, whose use creates ever more data over time. The consequence of data gravity is that only a few companies provide cutting-edge LLMs. Any failure among or cyber attack on these providers, or their models, poses risks to financial institutions relying on them.

The reliance of market participants on the same handful of algorithms could lead to **financial stability risks**. These could arise from AI's ubiquitous adoption throughout the financial system and its growing capability to make decisions independently and without human intervention ("automaticity") at a speed far beyond human capacity. The behaviour of financial institutions using the same algorithms could amplify procyclicality and market volatility by exacerbating herding, liquidity hoarding, runs and fire sales. Using similar algorithms trained on the same data can also lead to coordinated recommendations or outright collusive outcomes that run afoul of regulations against market manipulation, even if algorithms are not trained or instructed to collude.[19] In addition, AI may hasten the development and introduction of new products, potentially leading to new and little understood risks.

Harnessing AI for policy objectives

Central banks stand at the intersection of the monetary and financial systems. As stewards of the economy through their monetary policy mandate, they play a pivotal role in maintaining economic stability, with a primary objective of ensuring price stability. Another essential role is to safeguard financial stability and the payment system. Many central banks also have a role in supervising and regulating commercial banks and other participants of the financial system.

Central banks are not simply passive observers in monitoring the impact of AI on the economy and the financial system. They can harness AI tools themselves in pursuit of their policy objectives and in addressing emerging challenges. In particular, the use of LLMs and AI can support central banks' key tasks of information collection and statistical compilation, macroeconomic and financial analysis to support monetary policy, supervision, oversight of payment systems and ensuring financial stability. As early adopters of machine learning methods, central banks are well positioned to reap the benefits of AI tools.[20]

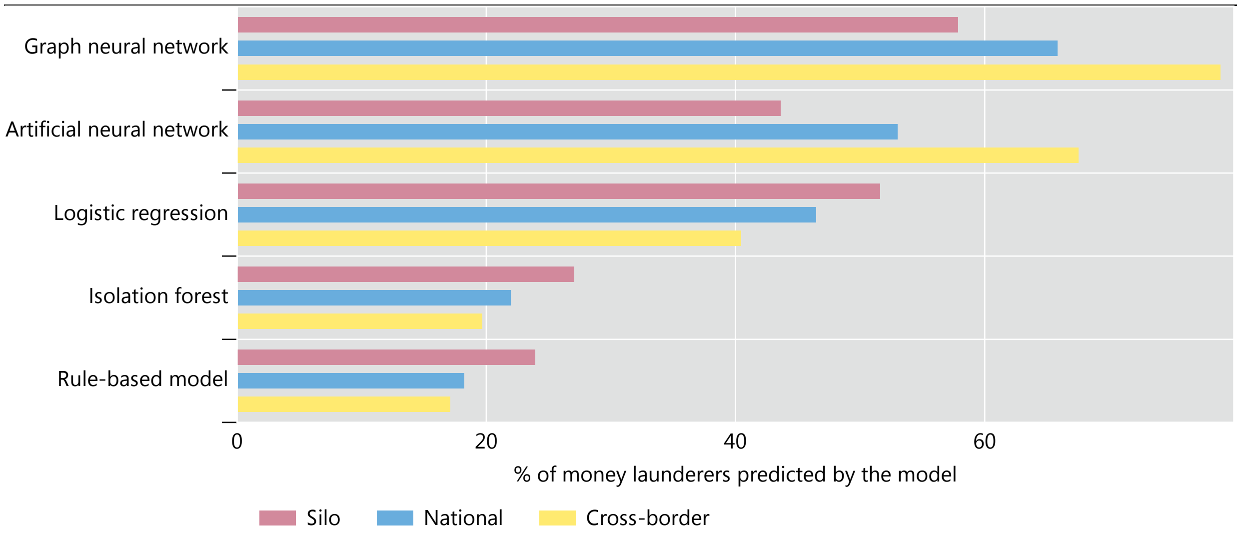
Data are the major resource that stand to become more valuable due to the advent of AI. A particularly rich source of data is the payment system. Such data present an enormous amount of information on economic transactions, which naturally lends itself to the powers of AI to detect patterns.[21] Dealing with such data necessitates adequate privacy-preserving techniques and the appropriate data governance frameworks.

The BIS Innovation Hub's Project Aurora explores some of these issues. Using a synthetic data set emulating money laundering activities, it compares various machine learning models, taking into account payment relationships as input. The comparison occurs under three scenarios: transaction data that are siloed at the bank level, national-level pooling of data and cross-border pooling. The models undergo training with known simulated money laundering transactions and subsequently predict the likelihood of money laundering in unseen synthetic data.

The project offers two key insights. First, machine learning models outperform the traditional rule-based methods prevalent in most jurisdictions. Graph neural networks, in particular, demonstrate superior performance, effectively leveraging comprehensive payment relationships available in pooled data to more accurately identify suspect transaction networks. And second, machine learning models are particularly effective when data from different institutions in one or multiple jurisdictions are pooled, underscoring a premium on cross-border coordination in AML efforts (Graph 4).

The benefits of coordination are further illustrated by Project Agorá. This project gathers seven central banks and private sector participants to bring tokenised central bank money and tokenised deposits together on the same programmable platform.

Machine learning models' performance in different monitoring scenarios[1] Graph 4



[1] Transaction data visible on three different levels of analysis: the view of each financial institution (silo), the national view of a single country (national) and the cross-border view across countries (cross-border).

Source: BIS Innovation Hub (2023).

The tokenisation built into Agorá would allow the platform to harness three capabilities: (i) combining messaging and account updates as a single operation; (ii) executing payments atomically rather than as a series of sequential updates; and (iii) drawing on privacy-preserving platform resources for KYC/AML compliance. In traditional correspondent banking, information checks and account updates are made sequentially and independently, with significant duplication of effort (Graph 5.A). In contrast, in Agorá the contingent performance of actions enabled by tokenisation allows for the combination of assets, information, messaging and clearing into a single atomic operation, eliminating the risk of reversals (Graph 5.B). In turn, privacy-enhancing data-sharing techniques can significantly simplify compliance checks, while all existing rules and regulations are adhered to as part of the pre-screening process.[22]

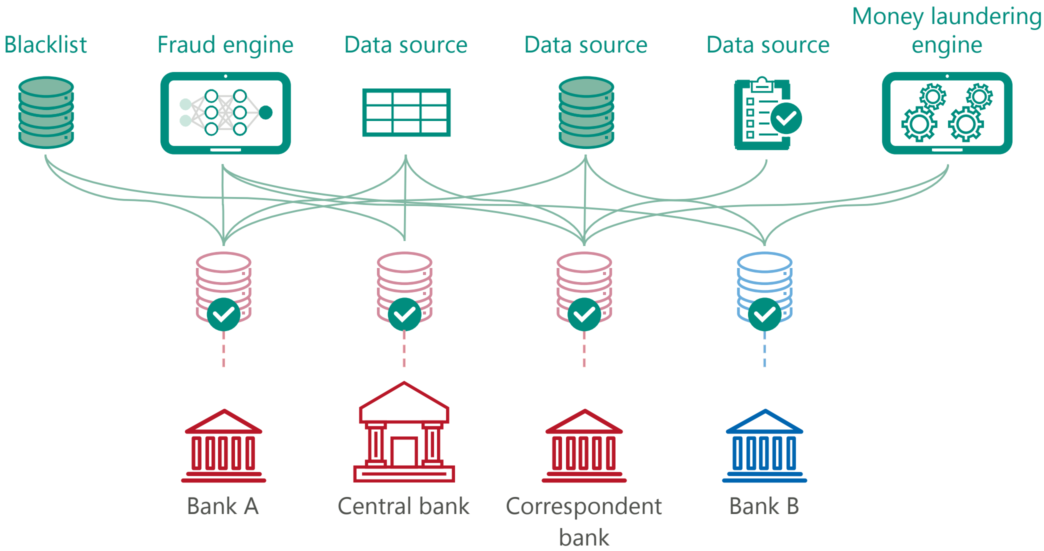
In the development of a new payment infrastructure like Agorá, great care must be taken to ensure potential gains are not lost due to fragmentation. This can be done via access policies to the infrastructure or via interoperability, as advocated in the idea of the Finternet. This refers to multiple interconnected financial ecosystems, much like the internet, designed to empower individuals and businesses by placing them at the centre of their financial lives. The Finternet leverages innovative technologies such as tokenisation and unified ledgers, underpinned by a robust economic and regulatory framework, to expand the range and quality of savings and financial services. Starting with assets that can be easily tokenised holds the greatest promise in the near term.[23]

Central banks also see great benefits in using gen AI to **improve cyber security**. In a recent BIS survey of central bank cyber experts, a majority deem gen AI to offer more benefits than risks (Graph 6.A) and think it can outperform traditional methods in enhancing cyber security management.[24] Benefits are largely expected in areas such as the automation of routine tasks, which can reduce the costs of time-consuming activities traditionally performed by humans (Graph 6.B). But human expertise will remain important. In particular, data scientists and cyber security experts are expected to play an increasingly important role. Additional cyber-related benefits from AI

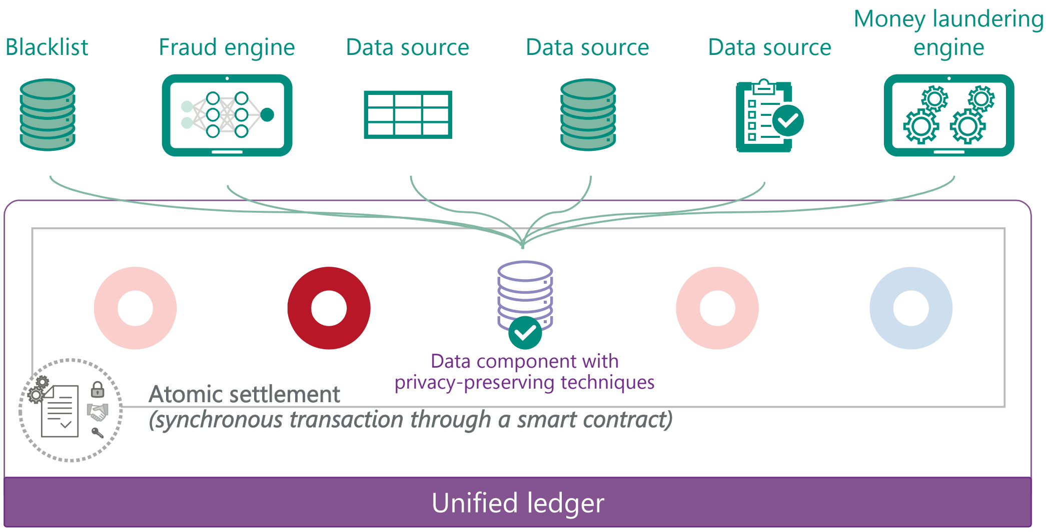
Anti-money laundering (AML) in the next generation of correspondent banking

Graph 5

A. Silos lead to duplication of effort in AML screening



B. Collective effort and data-sharing

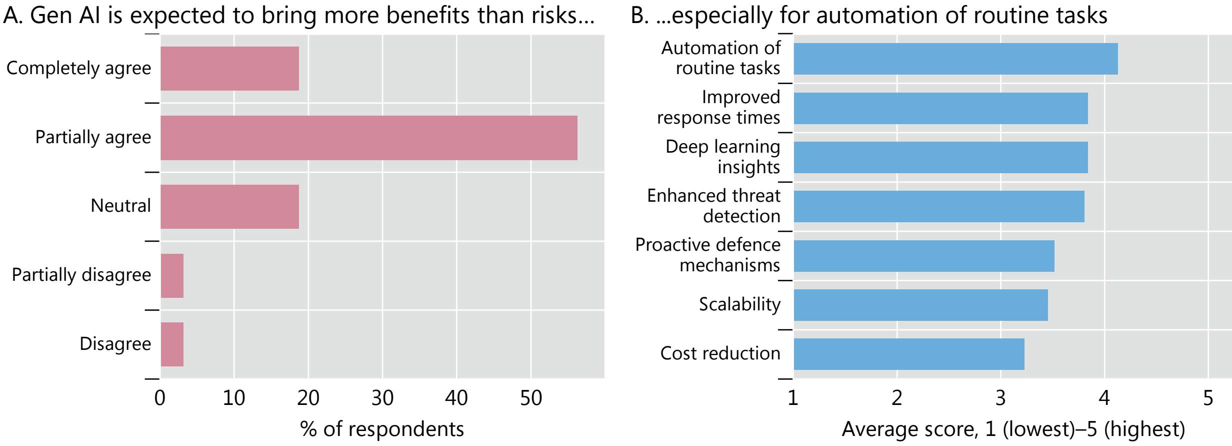


Source: Garratt et al (2024).

include the enhancement of threat detection, faster response times to cyber attacks and the learning of new trends, anomalies or correlations that might not be obvious to human analysts. In addition, by leveraging AI, central banks can now craft and deploy highly convincing phishing attacks as part of their cyber security training. Project Raven of the BIS Innovation Hub is one example of the use of AI to enhance cyber resilience (see Box C).

The challenge for central banks in using AI tools comes in two parts. The first is the availability of timely data, which is a necessary condition for any machine learning application. Assuming this issue is solved, the second challenge is to structure the data in a way that yields insights. This second challenge is where machine learning tools, and in particular LLMs, excel. They can transform unstructured data from a variety of sources into structured form in real time. Moreover, by converting time series data into

Opportunities from generative AI adoption for cyber security in central banks[1] Graph 6



[1] Based on a survey of 32 members of the Global Cyber Resilience Group in January 2024. See technical annex for details.

Source: Aldasoro, Doerr, Gambacorta, Notra, Oliviero and Whyte (2024).

tokens resembling textual sequences, LLMs can be applied to a wide array of time series forecasting tasks. Just as LLMs are trained to guess the next word in a sentence using a vast database of textual information, LLM-based forecasting models use similar techniques to estimate the next numerical observation in a statistical series.

These capabilities are particularly promising for **nowcasting**. Nowcasting is a technique that uses real-time data to provide timely insights. This method can significantly improve the accuracy and timeliness of economic predictions, particularly during periods of heightened market volatility. However, it currently faces two important challenges, namely the limited usability of timely data and the necessity to pre-specify and train models for concrete tasks.[25] LLMs and gen AI hold promise to overcome both bottlenecks (see Box D). For example, an LLM fine-tuned with financial news can readily extract information from social media posts or non-financial firms' and banks' financial statements or transcripts of earning reports and create a sentiment index. The index can then be used to nowcast financial conditions, monitor the build-up of risks or predict the probability of recessions.[26] Moreover, by categorising texts into specific economic topics (eg consumer demand and credit conditions), the model can pinpoint the source of changes in sentiment (eg consumer sentiment or credit risk). Such data are particularly relevant early in the forecasting process when traditional hard data are scarce.

Beyond financial applications, AI-based nowcasting can also be useful to understand real-economy developments. For example, transaction-level data on household-to-firm or firm-to-firm payments, together with machine learning models, can improve nowcasting of consumption and investment. Another use case is measuring supply chain bottlenecks with NLP, eg based on text in the so-called Beige Book. After classifying sentences related to supply chains, a deep learning algorithm classifies the sentiment of each sentence and provides an index that offers a real-time view of supply chain bottlenecks. Such an index can be used to predict inflationary pressures. Many more examples exist, ranging from nowcasting world trade to climate risks.[27]

Access to granular data can also enhance central banks' ability to **track developments across different industries and regions**. For example, with the help of AI, data from job postings or online retailers can be used to track wage developments and employment dynamics across occupations, tasks and industries. Such a real-time and detailed view of labour market developments can help central

Box C

BIS Innovation Hub projects in artificial intelligence

The BIS Innovation Hub is exploring the use of artificial intelligence (AI) to support central banks and supervisors in their missions. So far, eight projects – Ellipse, Aurora, Gaia, Symbiosis, Raven, Neo, Spectrum and Insight – have employed AI methods. They cover a wide range of use cases from information collection and statistical compilation, payments oversight and supervision, and macroeconomic and financial analysis to monetary policy analysis (Table C1). These projects draw on both in-house expertise and that of external providers.

An overview of BIS Innovation Hub projects using AI — Table C1

	Ellipse	Aurora	Gaia	Symbiosis	Raven	Neo	Spectrum	Insight
Main use case	Match entities in news with those of supervisory interest	Enhance AML suspicious transaction monitoring across firms & borders	Extract climate-related data from ESG reports	Develop methods for Scope 3 emission disclosure	Process cyber security & resilience documents to generate answers to assessment questions	Create and forecast economic indicators using timely and granular data	Structure big data on micro prices for inflation nowcasting	Extract info & data on firm supply chain dependencies
BIS IH Centre	Singapore	Nordic	Eurosystem	Hong Kong	Nordic	Swiss	Eurosystem	Hong Kong
Status	Completed	Ongoing (Phase 2)	Completed	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Key theme	Suptech/regtech		Green finance		Cyber security	Monetary policy tech		
NLP	✓	✗	✓	✓	✓	✗	✓	✗
LLM	✗	✗	✓	✓	✓	✓	✓	✗
SML	✗	✓	✗	✓	✗	✓	✗	✗
UML	✗	✓	✗	✓	✗	✓	✓	✗
Other	✗	✓	✗	✗	✓	✗	✗	✓[1]

LLM = large language model; NLP = natural language processing; SML = supervised machine learning (ML); UML = unsupervised ML.

[1] As the project is in early stages, the types of AI technologies to be used are still to be determined.

Source: BIS Innovation Hub.

The experiments showcase the value of AI-enabled applications for central banks and the financial sector. For example, Project Gaia demonstrated the power of creating AI-enabled intelligent tools to automate data extraction from unstructured environmental, social and governance (ESG) reports for climate risk analysis. The combination of semantic search together with the iterative and systematic prompting of a large language model (LLM) enabled Gaia to navigate differences in disclosure frameworks, thereby enhancing the comparability of climate-related information. Project Aurora demonstrated that machine learning using graph neural networks and privacy-enhancing methods for sharing underlying network data can substantially improve detection of complex schemes such as “mule accounts” or “smurfing” activities in money laundering networks. Project Ellipse showed that machine learning methods are useful in risk assessment and analysis, alerting supervisors in real time about issues that might need further investigation.

Several technical challenges were also identified. These include LLMs’ long response times, randomness (non-repeatability) in their responses and hallucinations (Gaia), and computational costs and insufficient data quality and consistency across financial institutions (Aurora and Ellipse). Appropriate design choices and collaboration will help mitigate these challenges, as discussed further in the final section of this chapter.

Box D

Nowcasting with artificial intelligence

Most central banks support their economic analysis with so-called nowcasting models. The goal of nowcasting is to produce high-frequency assessments and forecasts, for example of gross domestic product (GDP) growth or inflation, that can be updated easily as soon as new data become available.

A crucial input to nowcasting models is timely data. As no single indicator suffices to accurately track economic activity in real time, nowcasting models often process large and complex data sets that contain dozens, if not hundreds, of indicators. Data series can include information ranging from industrial production to surveys on the sentiment of purchasing managers to credit card spending data. They can also include web data scraped from online retailers or social media. Recent advances in the econometrics of high-dimensional data, which enabled models to synthesise important parts of the complexity of the aggregate economy into just a few indicators, have substantially improved nowcasting. An example is the Federal Reserve Bank of New York's nowcasting model. It uses a wide range of data to extract the latent factors that drive movements in the data and produces a forecast of several economic series, in particular GDP.[1] However, the limited availability of timely data makes nowcasting challenging. For example, structured data on firms' hiring or consumer spending are only available with a lag, rendering the nowcasting exercise only as good as the data lags.

Nowcasting models could benefit from deep neural networks' embeddings and their ability to quickly convert unstructured data into a structured format. Thanks to data embeddings, large language models (LLMs) have the ability to process vast amounts of text- or image-based data, and they can create readily available data series from, for example, news reports, social media postings, web searches or aerial images, such as of car traffic in retailers' parking lots. Moreover, novel LLMs can process these data further to extract sentiment or tone in text or speech data. Such sentiment indices can substantially improve forecasts for key macroeconomic quantities, such as unemployment, GDP growth and inflation.[2] In this way, nowcasting models could draw on a much richer set of real-time data.

Another way LLMs can improve nowcasting models is through their "few-shot learning" abilities, ie the capacity to generate accurate responses with minimal or even no prior examples. Currently, most models used for time series forecasting are highly specialised, designed for specific settings, especially if they use natural language processing. A model that is used to nowcast GDP looks different from one used to nowcast the build-up of financial risks. Expert judgment is required to choose the right input variables and specify model parameters. This means that, as economic conditions and the focus of analysis change, it takes some time to adjust models accordingly. In contrast, few-shot learners display much greater versatility in what they can do. Recent work shows that LLMs trained to predict (forecast) the next word, by converting time series data into tokens resembling textual sequences (ie embedding), can be directly used for time series prediction.[3] In other words, due to their advanced capabilities for few-shot learning, they can be readily applied to a wide array of time series forecasting tasks without additional training. This stands in contrast to existing forecasting models, for which optimisation often requires significant fine-tuning ex ante. Pre-trained foundation models have been shown to outperform state-of-the-art specialised forecasting models.

[1] Bok et al (2018). [2] Sharpe et al (2023). [3] Jin et al (2023).

banks understand the extent of technology-induced job displacements, how quickly workers find new jobs and attendant wage dynamics. Similarly, satellite data on aerial pollution or nighttime lights can be used to predict short-term economic activity, while data on electricity consumption can shed light on industrial production in different regions and industries.[28] Central banks can thereby obtain a more nuanced picture of firms' capital expenditure and production, and how the supply of and demand for goods and services are changing.

Central banks can also use AI, together with human expertise, to better **understand factors that contribute to inflation**. Neural networks can handle more input variables compared with traditional econometric models, making it possible to work with detailed data sets rather than relying solely on aggregated data. They can further reflect intricate non-linear relationships, offering valuable insights during periods of rapidly changing inflation dynamics. If AI's impact varies by industry but materialises rapidly, such advantages are particularly beneficial for assessing inflationary dynamics.

Recent work in this area decomposes aggregate inflation into various sub-components.[29] In a first step, economic theory is used to pre-specify four factors shaping aggregate inflation: past inflation patterns, inflation expectations, the output gap and international prices. A neural network then uses aggregate series (eg the unemployment rate or total services inflation) and disaggregate series (eg two-digit industry output) to estimate the contribution of each of the four subcomponents to overall inflation, accounting for possible non-linearities.

The use of AI could play an important role in supporting **financial stability analysis**. The strongest suit of machine learning and AI methodologies is identifying patterns in a cross-section. As such, they can be particularly useful to identify and enhance the understanding of risks in a large sample of observations, helping identify the cross-section of risk across financial and non-financial firms. Again, availability of timely data is key. For example, during increasingly frequent periods of low liquidity and market dysfunction, AI could help prediction through better monitoring of anomalies across markets.[30]

Finally, pairing AI-based insights with human judgment could help support **macroprudential regulation**. Systemic risks often result from the slow build-up of imbalances and vulnerabilities, materialising in infrequent but very costly stress events. The scarcity of data on such events and the uniqueness of financial crises limit the stand-alone use of data-intensive AI models in macroprudential regulation.[31] However, together with human expertise and informed economic reasoning to see through the cycle, gen AI tools could yield large benefits to regulators and supervisors. When combined with rich data sets that provide sufficient scope to find patterns in the data, AI could help in building early warning indicators that alert supervisors to emerging pressure points known to be associated with system-wide risks.

In sum, with sufficient data, AI tools offer central banks an opportunity to get a much better understanding of economic developments. They enable central banks to draw on a richer set of structured and unstructured data, and complementarily, speed up data collection and analysis. In this way, the use of AI enables the analysis of economic activity in real time at a granular level. Such enhanced capabilities are all the more important in the light of AI's potential impact on employment, output and inflation, as discussed in the next section.

Macroeconomic impact of AI

AI is poised to increase productivity growth. For workers, recent evidence suggests that AI directly raises productivity in tasks that require cognitive skills (Graph 7.A). The use of generative AI-based tools has had a sizeable and rapid positive effect on the productivity of customer support agents and of college-educated professionals solving writing tasks. Software developers that used LLMs through the GitHub Copilot AI could code more than twice as many projects per week. A recent collaborative study by the BIS with Ant Group shows that productivity gains are immediate and largest among less experienced and junior staff (Box E).[32]

Early studies also suggest positive effects of AI on firm performance. Patenting activity related to AI and the use of AI are associated with faster employment and output growth as well as higher revenue growth relative to comparable firms. Firms that adopt AI also experience higher growth in sales, employment and market valuations, which is primarily driven by increased product innovation. These effects have materialised over a horizon of one to two years. In a global sample, AI patent applications generate a positive effect on the labour productivity of small and medium-sized enterprises, especially in services industries.[33]

Box E

Gen AI and labour productivity: a field experiment on coding

Generative artificial intelligence (gen AI) tools have the potential to enhance workers' productivity, but experimental evidence is scarce so far. To study the impact of gen AI on productivity, recent BIS work leverages data from Ant Group. In September 2023, Ant Group unveiled CodeFuse, a specific large language model (LLM) designed to assist software programmer teams in coding. Prior to its widespread release, this LLM was accessible for an initial six-week trial period only to a select group of programmers.

The evidence suggests that LLMs can boost productivity for coders. Comparing programmer groups with similar productivity levels and work experience but with or without access to the LLM shows a 55% increase in productivity (measured by the number of lines of code produced) on average for the group with access to the LLM. Roughly one third of this increase can be attributed directly to the code lines generated by the LLM, with the rest resulting from improved programmers' efficiency in coding elsewhere (likely reflecting additional time available for other programming tasks).

Dividing programmers by their experience levels reveals significant differences: productivity increased only among junior programmers (see Graphs E1.A and E1.B). Comparing the number of requests and acceptance rate of LLM suggestions by workers with different levels of experience sheds light on these differences, as senior programmers used the LLM less. The purple line in Graph E1.C indicates a negative correlation between the volume of requests following the LLM's introduction and the programmers' years of experience. At the same time, the acceptance rate (the frequency at which programmers used the LLM's suggestions) did not vary with the level of experience (orange line). These findings suggest that the lower impact of the LLM on senior programmers' productivity stems from their lower engagement with the LLM rather than a lack of usefulness.

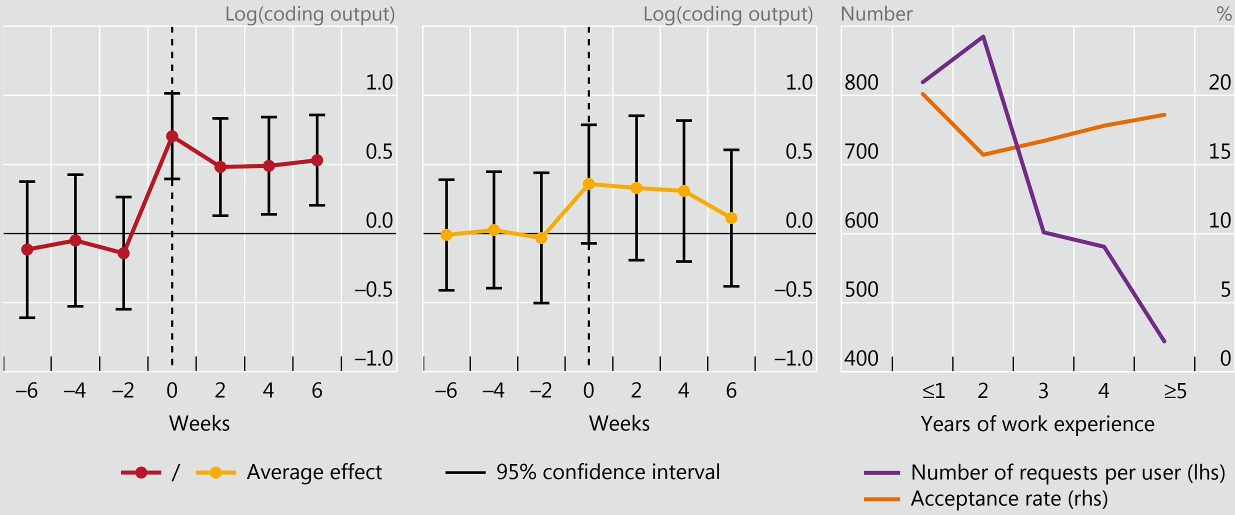
Effect of generative AI on productivity for different levels of work experience

Graph E1

A. Junior programmers become much more productive…[1]

B. …whereas gains for senior programmers are more modest[1]

C. Generative AI use and acceptance rate by work experience[2]

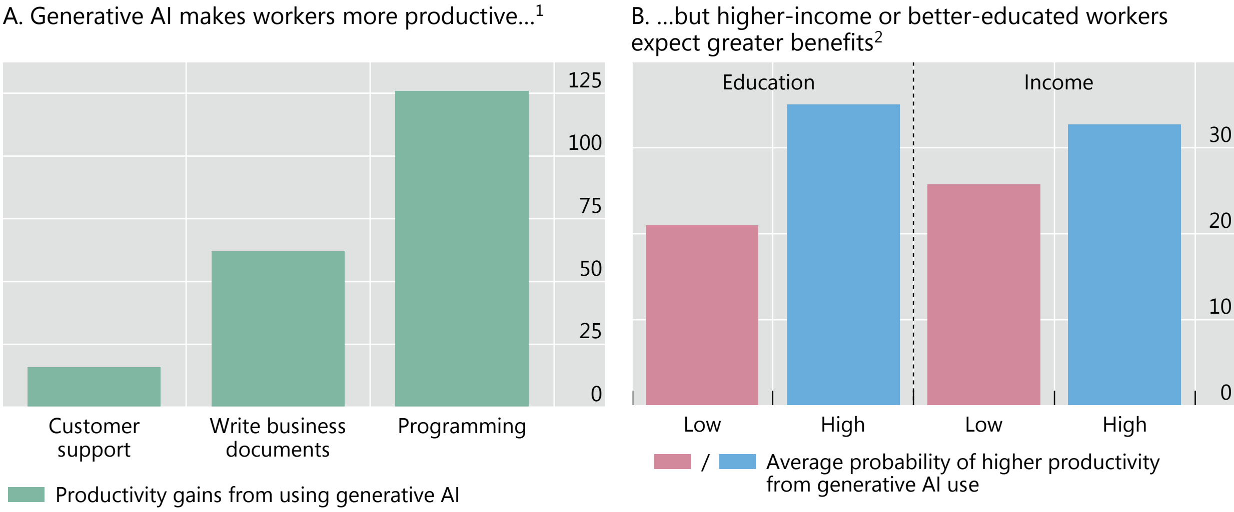


[1] Based on a difference-in-differences analysis to evaluate the effects on labour productivity between two groups of programmers: those with access to CodeFuse (treatment group) and those without (control group). The comparison spans six weeks before the introduction of CodeFuse and eight weeks afterwards (with time 0 marking the two-week introduction period). The y-axis approximates the growth rate in the number of lines of code produced (in logarithm). Junior programmers (panel A) are defined as those with up to one year of experience. Senior programmers (panel B) have more than one year of experience. [2] The number of requests per user is determined by the average number of times a programmer, categorised by years of work experience, has requested assistance from the LLM in the eight weeks following its introduction. The acceptance rate represents the proportion of these requests for which a programmer has accepted the suggestions offered by the LLM application with less than 50% human modification.

Source: Gambacorta, Qiu, Rees and Shian (2024).

AI and productivity

In per cent Graph 7



[1] See technical annex for details. [2] Based on 893 respondents from the Survey of Consumer Expectations conducted by the Federal Reserve Bank of New York.

Sources: Aldasoro, Armantier, Doerr, Gambacorta and Oliviero (2024a); Brynjolfsson et al (2023); Nielsen (2023); Noy and Zhang (2023); Peng et al (2024); Federal Reserve Bank of New York, *Survey of Consumer Expectations*.

The **macroeconomic impact of AI** on productivity growth could be sizeable. Beyond directly enhancing productivity growth by raising workers' and firms' efficiency, AI can spur innovation and thereby future productivity growth indirectly. Most innovation is generated in occupations that require high cognitive abilities. Improving the efficiency of cognitive work therefore holds great potential to generate further innovation. The estimates provided by the literature for AI's impact on annual labour productivity growth (ie output per employee) are thus substantive, although their range varies.[34] Through faster productivity growth, AI will expand the economy's productive capacity and thus raise aggregate supply.

Higher productivity growth will also affect aggregate demand through changes in firms' **investment**. While gen AI is a relatively new technology, firms are already investing heavily in the necessary IT infrastructure and integrating AI models into their operations – on top of what they already spend on IT in general. In 2023 alone, spending on AI exceeded $150 billion worldwide, and a survey of US companies' technology officers across all sectors suggests almost 50% rank AI as their top budget item over the next years.[35]

An additional boost to investment could come from **improved prediction**. AI adoption will lead to more accurate predictions at a lower cost, which reduces uncertainty and enables better decision-making.[36] Of course, AI could also introduce new sources of uncertainty that counteract some of its positive impact on firm investment, eg by changing market and price dynamics.

Another substantial part of aggregate demand is household **consumption**. AI could spur consumption by reducing search frictions and improving matching, making markets more competitive. For example, the use of AI agents could improve consumers' ability to search for products and services they want or need and help firms in advertising and targeting services and products to consumers.[37]

AI's impact on household consumption will also depend on how it affects labour markets, notably labour demand and wages. The overall impact depends on the relative strength of three forces (Graph 8): by how much AI raises productivity, how many new tasks it creates and how many workers it displaces by making existing tasks obsolete.

If AI is a true general-purpose technology that raises total factor productivity in all industries to a similar extent, the **demand for labour** is set to increase across the board (Graph 8, blue boxes). Like previous general-purpose technologies, AI could also **create altogether new tasks**, further increasing the demand for labour and spurring wage growth (green boxes). If so, AI would increase aggregate demand.

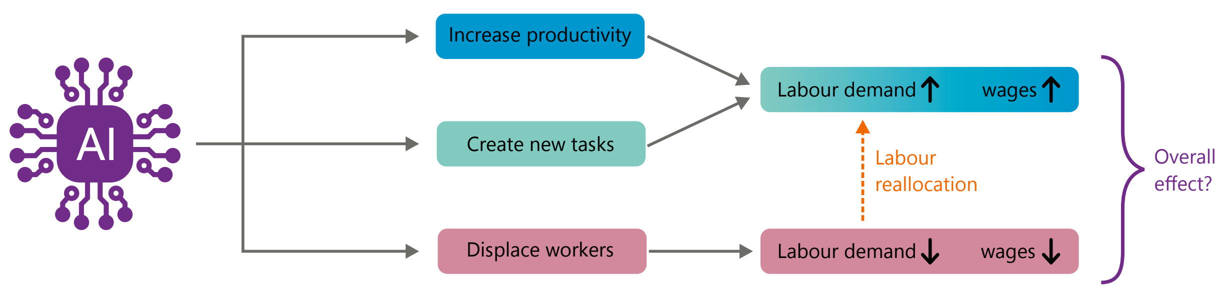
However, the **effects of AI might differ across tasks and occupations**. AI might benefit only some workers, eg those whose tasks require logical reasoning. Think of nurses who, with the assistance of AI, can more accurately interpret x-ray pictures. At the same time, gen AI could make other tasks obsolete, for example summarising documents, processing claims or answering standardised emails, which lend themselves to automation by LLMs. If so, increased AI adoption would lead to displacement of some workers (Graph 8, red boxes). This could lead to declines in employment and lower wage growth, with distributional consequences. Indeed, results from a recent survey of US households by economists in the BIS Monetary and Economic Department in collaboration with the Federal Reserve Bank of New York indicate that men, better-educated individuals or those with higher incomes think that they will benefit more from the use of gen AI than women and those with lower educational attainment or incomes (Graph 7.B).[38]

These considerations suggest that AI could have implications for **economic inequality**. Displacement might eliminate jobs faster than the economy can create new ones, potentially exacerbating income inequality. A differential impact of benefits across job categories would strengthen this effect. The "digital divide" could widen, with individuals lacking access to technology or with low digital literacy being further marginalised. The elderly are particularly at risk of exclusion.[39]

Through the effects on productivity, investment and consumption the deployment of AI has implications for output and inflation. A BIS study illustrates the key mechanisms at work.[40] As the source of a permanent increase in productivity, AI will raise aggregate supply. An increase in consumption and investment raises aggregate demand. Through higher aggregate demand and supply, **output** increases (Graph 9.A). In the short term, if households and firms fully anticipate that they will be richer in the future, they will increase consumption at the expense of investment, slowing down output growth.

The response of **inflation** will also depend on households' and businesses' anticipation of future gains from AI. If the average household does not fully anticipate gains, it will increase today's consumption only modestly. AI will act as a disinflationary

The impact of AI on labour demand and wages | Graph 8



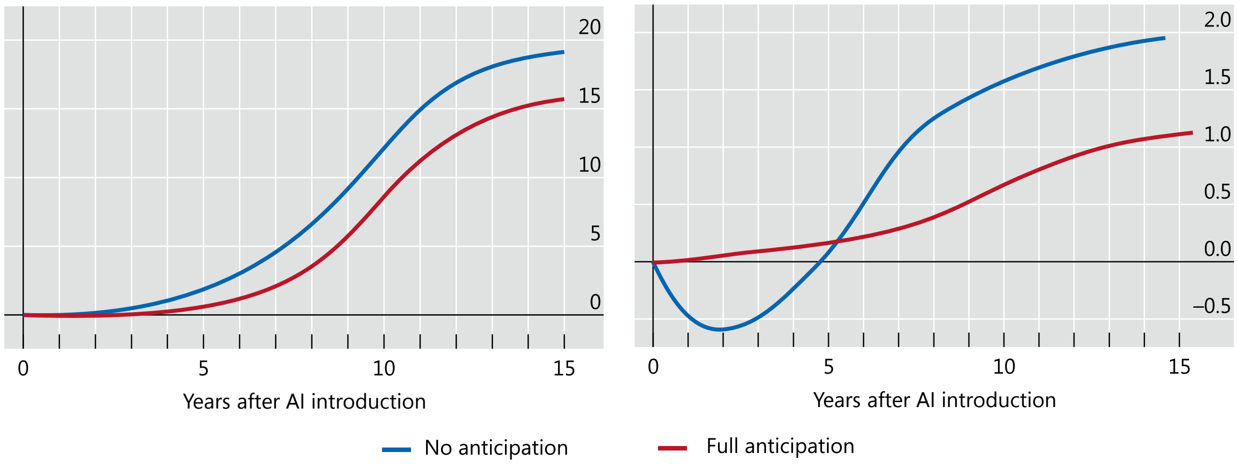
Source: Aldasoro, Doerr, Gambacorta, Gelos and Rees (2024).

The impact of AI on output and inflation[1]

Changes relative to the initial steady state, in per cent — Graph 9

A. AI will raise output in the short and long run…

B. …but could be inflationary or disinflationary in the short run



[1] The vertical axis measures the change relative to the initial steady state value of output (panel A) and inflation (panel B). No anticipation refers to the case where households and firms do not anticipate the future effects of AI on productivity growth. Full anticipation refers to the case where households and firms perfectly anticipate the future effects of AI. For more details, see Aldasoro, Doerr, Gambacorta and Rees (2024).

Source: Adapted from Aldasoro, Doerr, Gambacorta and Rees (2024).

force in the short run (blue line in Graph 9.B), as the impact on aggregate supply dominates. In contrast, if households anticipate future gains, they will consume more, making AI's initial impact inflationary (red line in Graph 9.B). Since past general-purpose technologies have had an initial disinflationary impact, the former scenario appears more likely. But in either scenario, as economic capacity expands and wages rise, the demand for capital and labour will steadily increase. If these demand effects dominate the initial positive shock to output capacity over time, higher inflation would eventually materialise. How quickly demand forces increase output and prices will depend not only on households' expectations but also on the **mismatch in skills** required in obsolete and newly created tasks. The greater the skill mismatch (other things being equal), the lower employment growth will be, as it takes displaced workers longer to find new work. It might also be the case that some segments of the population will remain permanently unemployable without retraining. This, in turn, implies lower consumption and aggregate demand, and a longer disinflationary impact of AI.

Another aspect that warrants further investigation is the effect of AI adoption on **price formation**. Large retail companies that predominately sell online use AI extensively in their price-setting processes. Algorithmic pricing by these retailers has been shown to increase both the uniformity of prices across locations and the frequency of price changes.[41] For example, when gas prices or exchange rates move, these companies quickly adjust the prices in their online stores. As the use of AI becomes more widespread, also among smaller companies, these effects could become stronger. Increased uniformity and flexibility in pricing can mean greater and quicker pass-through of aggregate shocks to local prices, and hence inflation, than in the past. This can ultimately change inflation dynamics. An important aspect to consider is how these effects could differ depending on the degree of competition in the AI model and data market, which could influence the variety of models used.

Finally, the impact of AI on **fiscal sustainability** remains an open question. All things equal, an AI-induced boost to productivity and growth would lead to a reduced debt burden. However, to the extent that faster growth is associated with higher interest rates, combined with the potential need for fiscal programmes to manage AI-induced labour relocation or sustained spells of higher unemployment rates, the impact of AI on the fiscal outlook might be modest. More generally, the AI growth dividend is unlikely to fully offset the spending needs that may arise from the green transition or population ageing over the next decades.

Toward an action plan for central banks

The use of AI models opens up new opportunities for central banks in pursuit of their policy objectives. A consistent theme running through the chapter has been the availability of data as a critical precondition for successful applications of machine learning and AI. Data governance frameworks will be part and parcel of any successful application of AI. Central banks' policy challenges thus encompass both **models** and **data**.

An important trade-off arises between **using "off-the-shelf" models versus developing in-house fine-tuned ones**. Using external models may be more cost-effective, at least in the short run, and leverages the comparative advantage of private sector companies. Yet reliance on external models comes with reduced transparency and exposes central banks to concerns about dependence on a few external providers. Beyond the general risks that market concentration poses to innovation and economic dynamism, the high concentration of resources could create significant operational risks for central banks, potentially affecting their ability to fulfil their mandates.

Another important aspect relates to central banks' role as **users, compilers and disseminators of data**. Central banks use data as a crucial ingredient in their decision-making and communication with the public. And they have always been extensive compilers of data, either collecting them on their own or drawing on other official agencies and commercial sources. Finally, central banks are also providers of data, to inform other parts of government as well as the general public. This role helps them fulfil their obligations as key stakeholders in national statistical systems.

The rise of machine learning and AI, together with advances in computing and storage capacity, have cast these aspects in an urgent new light. For one, central banks now need to make sense of and use increasingly large and diverse sets of structured and unstructured data. And these data often reside in the hands of the private sector. While LLMs can help process such data, hallucinations or prompt injection attacks can lead to biased or inaccurate analyses. In addition, commercial data vendors have become increasingly important, and central banks make extensive use of them. But in recent years, the cost of commercial data has increased markedly, and vendors have imposed tighter use conditions.

The decision on whether to use external or internal models and data has far-reaching implications for central banks' investments and human capital. A key challenge is **setting up the necessary IT infrastructure**, which is greater if central banks pursue the road of developing internal models and collecting or producing their own data. Providing adequate computing power and software, as well as training existing or hiring new staff, involves high up-front costs. The same holds for creating a data lake, ie pooling different curated data sets. Yet a reliable and safe IT infrastructure is a prerequisite not only for big data analyses but also to prevent cyber attacks.

Hiring new or retaining existing staff with the right mix of economic understanding and programming skills can be challenging. As AI applications increase the sophistication of the financial system over time, the premium on having the right mix of skills will only grow. Survey-based evidence suggests this is a top concern for central banks (Graph 10). There is high demand for data scientists and other AI-related roles, but public institutions often cannot match private sector salaries for top AI talent. The need for staff with the right skills also arises from the fact that the use of AI models to aid financial stability monitoring faces limitations, as discussed above. Indeed, AI is not a substitute for human judgment. It requires supervision by experts with a solid understanding of macroeconomic and financial processes.

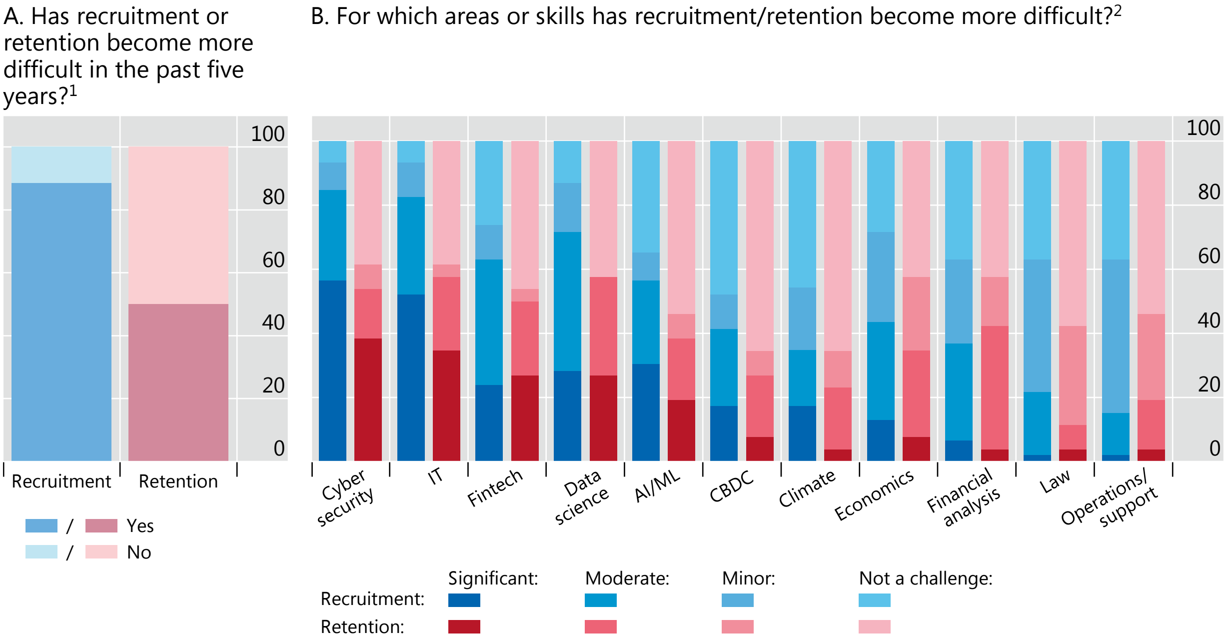
How can central banks address these challenges and mitigate trade-offs? The answer lies, in large part, in cooperation paired with sound data governance practices.

Collaboration can yield significant benefits and relax constraints on human capital and IT. For one, the **pooling of resources and knowledge** can lower demands among central banks and could ease the resource constraints on collecting, storing and analysing big data as well as developing algorithms and training models. For example, central banks could address rising costs of commercial data, especially for smaller institutions, by sharing more granular data themselves or by acquiring data from vendors through joint procurement. Cooperation could also facilitate training staff through workshops in the use of AI or the sharing of experiences in conferences. This would particularly benefit central banks with fewer staff and resources and with limited economies of scale. Cooperation, for example by re-using trained models, could also mitigate the environmental costs associated with training algorithms and storing large amounts of data, which consume enormous amounts of energy.

Central bank collaboration and the sharing of experiences could also help identify areas in which AI adds the most value and how to **leverage synergies**.

Challenges in recruitment and retention

As a percentage of respondent central banks — Graph 10



[1] Based on a survey of 52 members of the Central Bank Governance Network conducted in May 2024. [2] Shares based on the subset of central banks experiencing more difficulties with recruitment and/or retention.

Source: CBGN (2024).

Common data standards could facilitate access to publicly available data and facilitate the automated collection of relevant data from various official sources, thereby enhancing the training and performance of machine learning models. Additionally, dedicated repositories could be set up to share the open source code of data tools, either with the broader public or, at least initially, only with other central banks. An example is a platform such as BIS Open Tech, which supports international cooperation and coordination in sharing statistical and financial software. More generally, central banks could consider sharing domain-adapted or fine-tuned models in the central banking community, which could significantly lower the hurdles for adoption.[42] Joint work on AI models is possible without sharing data, so they can be applied even where there are concerns about confidentiality.

An example of how collaboration supports data collection and dissemination is the jurisdiction-level statistics on international banking, debt securities and over-the-counter derivatives by the BIS. These data sets have a long history – the international banking statistics started in the 1970s. They are a critical element for monitoring developments and risks in the global financial system. They are compiled from submissions by participating authorities under clear governance rules and using well established statistical processes. At a more granular level, arrangements for the sharing of confidential bank-level data include the quantitative impact study data collected by the Basel Committee on Banking Supervision and the data on large global banks collected by the International Data Hub. Other avenues to explore include sharing synthetic or anonymised data that protect confidential information.

The rising importance of data and emergence of new sources and tools call for **sound data governance practices**. Central banks must establish robust governance frameworks that include guidelines for selecting, implementing and monitoring both data and algorithms. These frameworks should comprise adequate quality control and cover data management and auditing practices. The importance of metadata, in particular, increases as the range and variety of data expand. Sometimes referred to as "the data about the data", metadata include the definitions, source, frequency, units and other information that define a given data set. This metadata is crucial when privacy-preserving methods are used to draw lessons from several data sets overseen by different central banks. Machine readability is greatly enhanced when metadata are standardised so that the machines know what they are looking for. For example, the "Findable, Accessible, Interoperable and Reusable" (FAIR) principles provide guidance in organising data and metadata to ease the burden of sharing data and algorithms.[43]

More generally, metadata frameworks are crucial for a better understanding of the comparability and limits of data series. Central banks can also cooperate in this domain. For example, the Statistical Data and Metadata Exchange (SDMX) standard provides a common language and structure for metadata. Such standards are crucial to foster data-sharing, lower the reporting burden and facilitate interoperability. Similarly, the Generic Statistical Business Process Model lays out business processes for official statistics with a unified framework and consistent terminology. Sound data governance practices would also facilitate the sharing of confidential data.

In sum, there is an urgent need for central banks to collaborate in fostering the development of a **community of practice** to share knowledge, data, best practices and AI tools. In the light of rapid technological change, the exchange of information on policy issues arising from the role of central banks as data producers, users and disseminators is crucial. Collaboration lowers costs, and such a community would foster the development of common standards. Central banks have a history of successful collaboration to overcome new challenges. The emergence of AI has hastened the need for cooperation in the field of data and data governance.

Endnotes

1 "Structured data" refers to organised, quantitative information that is stored in relational databases and is easily searchable, such as categorical and numeric information. In contrast, unstructured data are not organised based on pre-defined models and can include information such as audio, video, emails, presentations, satellite images, etc.

2 For an analysis of how gen AI impacts household and firm behaviour, see Aldasoro, Armantier, Doerr, Gambacorta and Oliviero (2024a) and McKinsey & Company (2023).

3 For technical and non-technical introductions to AI, see Russell and Nordvig (2021) and Mitchell (2019), respectively. For a definition of machine learning, see Murphy (2012).

4 See Park et al (2024).

5 See Belkin et al (2019).

6 See Aldasoro, Gambacorta, Korinek, Shreeti and Stein (2024). An important (and open) question is whether increasing (or "scaling") the number of parameters and the amount of input data in training AI models will continue to deliver proportional gains in capabilities – the so-called scaling hypothesis; see Korinek and Vipra (2024).

7 See Perez-Cruz and Shin (2024).

8 See Bender and Koller (2020), Browning and LeCun (2022), Bubeck et al (2023) and Wei et al (2022).

9 Common measures of exposure, as computed for example in Felten et al (2021) and Aldasoro, Doerr, Gambacorta and Rees (2024), show that the financial sector ranks highest in exposure to AI.

10 See BCBS (2024).

11 On the decline of correspondent banking, see Rice et al (2020). For an analysis of the negative real effects suffered by jurisdictions severed from the network of correspondent banking relationships, see Borchert et al (2023).

12 See BCBS (2024).

13 See Doerr et al (2023) for a discussion on alternative data, Berg et al (2022) for evidence on default prediction, Cornelli, Frost, Gambacorta, Rau, Wardrop and Ziegler (2023) and Di Maggio et al (2023) for evidence on the use of alternative data by fintechs and big techs to detect "invisible primes", and Gambacorta, Huang, Qiu and Wang (2024) for evidence on financial inclusion.

14 On asset embeddings, see Zhu et al (2023) and Gabaix et al (2023). On fees, see OECD (2021).

15 See Doerr, Gambacorta, Leach, Legros and Whyte (2022).

16 See Hitaj et al (2022).

17 For example, there is evidence from machine learning-based credit scoring models that, in the US mortgage market, Black and Hispanic borrowers were less likely to benefit from lower interest rates than borrowers from other communities; see Fuster et al (2019).

18 Distrust in big techs to safely handle data, relative to traditional financial institutions and the government, has been shown to also exist in other countries (Chen et al (2023)). A related risk is that alternative data are correlated with certain consumer characteristics that lenders are, for good reason, not allowed to use in their credit assessment process (eg gender or minority status). Moreover, gen AI could exacerbate and perpetuate biases by creating biased data itself (either because of biased training data or hallucination), which are then used by other models.

19 For a general policy discussion of financial stability risks from AI and machine learning, see Hernández de Cos (2024), Gensler and Bailey (2020), and OECD (2023). Calvano et al (2020) present an academic treatment of AI, algorithmic pricing and collusion. Assad et al (2024) find evidence of collusion by pricing algorithms in retail gasoline markets. More specifically for financial markets, Georges and Pereira (2021) find that even if traders pay a lot of attention to model selection, the risk of destabilising speculation cannot be entirely eliminated.

20 See Doerr et al (2021) and Araujo et al (2024) for more information on the use of big data and AI in central banks.

21 See Desai et al (2024) for a recent application of machine learning to anomaly detection in payment systems.

22 See Garratt et al (2024).

23 See Carstens and Nilekani (2024) for details on the Finternet. See Aldasoro et al (2023) for a primer on tokenisation.

24 See Aldasoro, Doerr, Gambacorta, Notra, Oliviero and Whyte (2024), who investigate the link between gen AI and cyber risk in central banks by drawing on the results of an ad hoc survey of members of the Global Cyber Resilience Group in January 2024.

25 See a recent report by Bernanke (2024), which argues that central banks need to improve their forecasting abilities by gathering more timely data and integrating advanced data analytics.

26 See Du et al (2024).

27 See Barlas et al (2021) for a discussion on using transaction-level data for nowcasting consumption and investment. The Beige Book aggregates narratives that are collected from business contacts to summarise the economic conditions of each of the 12 Federal Reserve districts. See Soto (2023).

28 See Bricongne et al (2021), Dasgupta (2022) and Lehman and Möhrle (2022).

29 See Buckman et al (2023).

[30] See Aquilina et al (2024).

[31] Synthetic data are unlikely to help. In most cases, their generation relies on known data-generating processes, which do not apply to financial crises. And continued reliance on these data by AI models diminishes the information coming from the tails of the distribution (ie rare but highly consequential events), which are of particular concern for macroprudential policy. See Shumailov et al (2023).

[32] Brynjolfsson et al (2023) document that access to a gen AI-based conversational assistant improved customer support agents' productivity by 14%. Noy and Zhang (2023) find that support by the chatbot ChatGPT raised productivity in solving writing tasks for college-educated professionals from a variety of fields, reducing the time required by 40% and raising output quality by 18%. For evidence on productivity improvements in coding, see Gambacorta, Qiu, Rees and Shian (2024) and Peng et al (2024).

[33] On employment and output growth, see Yang (2022) and Czarnitzki et al (2023) for Taiwan and Germany, respectively. For revenue growth, see Alderucci et al (2020). Babina et al (2024) present evidence for product innovation, whereas Damioli et al (2021) do so for labour productivity.

[34] On innovation, see Brynjolfsson et al (2018). Estimates range from 0.5 to 1.5 percentage points over the next decade; see eg Baily et al (2023) and Goldman Sachs (2023). Acemoglu (2024) provides lower yet still positive estimates.

[35] See Statista and Anwah and Rosenbaum (2023).

[36] See Agrawal et al (2019, 2022) as well as Ahir et al (2022).

[37] "AI agents" refers to systems that build on advanced LLMs and are endowed with planning capabilities, long-term memory and, typically, access to external tools (eg the ability to execute code, use the internet or perform market trades).

[38] See Aldasoro, Armantier, Doerr, Gambacorta and Oliviero (2024a, b). See also Pizzinelli et al (2023) on the effects of AI on labour markets and inequality.

[39] Cornelli, Frost and Mishra (2023) find that investments in AI are associated with greater inequality and a shift from mid-skill jobs to high-skill and managerial positions. On the digital divide, see Doerr, Frost, Gambacorta and Qiu (2022). For more details on the impact of AI on income inequality, see Cazzaniga et al (2024).

[40] See Aldasoro, Doerr, Gambacorta and Rees (2024).

[41] See Cavallo (2019).

[42] See Gambacorta, Kwon, Park, Patelli and Zhu (2024).

[43] See Wilkinson et al (2016).

Technical annex

Graph 1.A: The adoption of ChatGPT is proxied by the ratio of the maximum number of website visits worldwide for the period November 2022–April 2023 and the worldwide population with internet connectivity. For more details on computer see US Census Bureau; for electric power, internet and social media see Comin and Hobijn (2004) and Our World in Data; for smartphones, see Statista.

Graph 1.B: Based on an April 2023 global survey with 1,684 participants.

Graph 1.C: Data for capital invested in AI companies for 2024 are annualised based on data up to mid-May. Data on the percentage of AI job postings for AU, CA, GB, NZ and US are available for the period 2014–23; for AT, BE, CH, DE, ES, FR, IT, NL and SE, data are available for the period 2018–23.

Graph 2.A: Three-month moving averages.

Graphs 2.B and 2.C: Correspondent banks that are active in several corridors are counted several times. Averages across countries in each region. Markers in panel C represent subregions within each region. Grouping of countries by region according to the United Nations Statistics Division; for further details see unstats.un.org/unsd/methodology/m49/.

Graph 3.A: Average scores in answers to the following question: "In the following areas, would you trust artificial intelligence (AI) tools less or more than traditional human-operated services? For each item, please indicate your level of trust on a scale from 1 (much less trust than in a human) to 7 (much more trust)."

Graph 3.B: Average scores and 95% confidence intervals in answers to the following question: "How much do you trust the following entities to safely store your personal data when they use artificial intelligence tools? For each of them, please indicate your level of trust on a scale from 1 (no trust at all in the ability to safely store personal data) to 7 (complete trust)."

Graph 3.C: Average scores (with scores ranging from 1 (lowest) to 7 (highest)) in answers to the following questions: (1) "Do you think that sharing your personal information with artificial intelligence tools will decrease or increase the risk of data breaches (that is, your data becoming publicly available without your consent)?"; (2) "Are you concerned that sharing your personal information with artificial intelligence tools could lead to the abuse of your data for unintended purposes (such as for targeted ads)?".

Graph 6.A: The bars show the share of respondents to the question, "Do you agree that the use of AI can provide more benefits than risks to your organisation?".

Graph 6.B: The bars show the average score that respondents gave to each option when asked to "Rate the level of significance of the following benefits of AI in cyber security"; the score scale of each option is from 1 (lowest) to 5 (highest).

Graph 7.A: The bars correspond to estimates of the increase in productivity of users that rely on generative AI tools relative to a control group that did not.

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