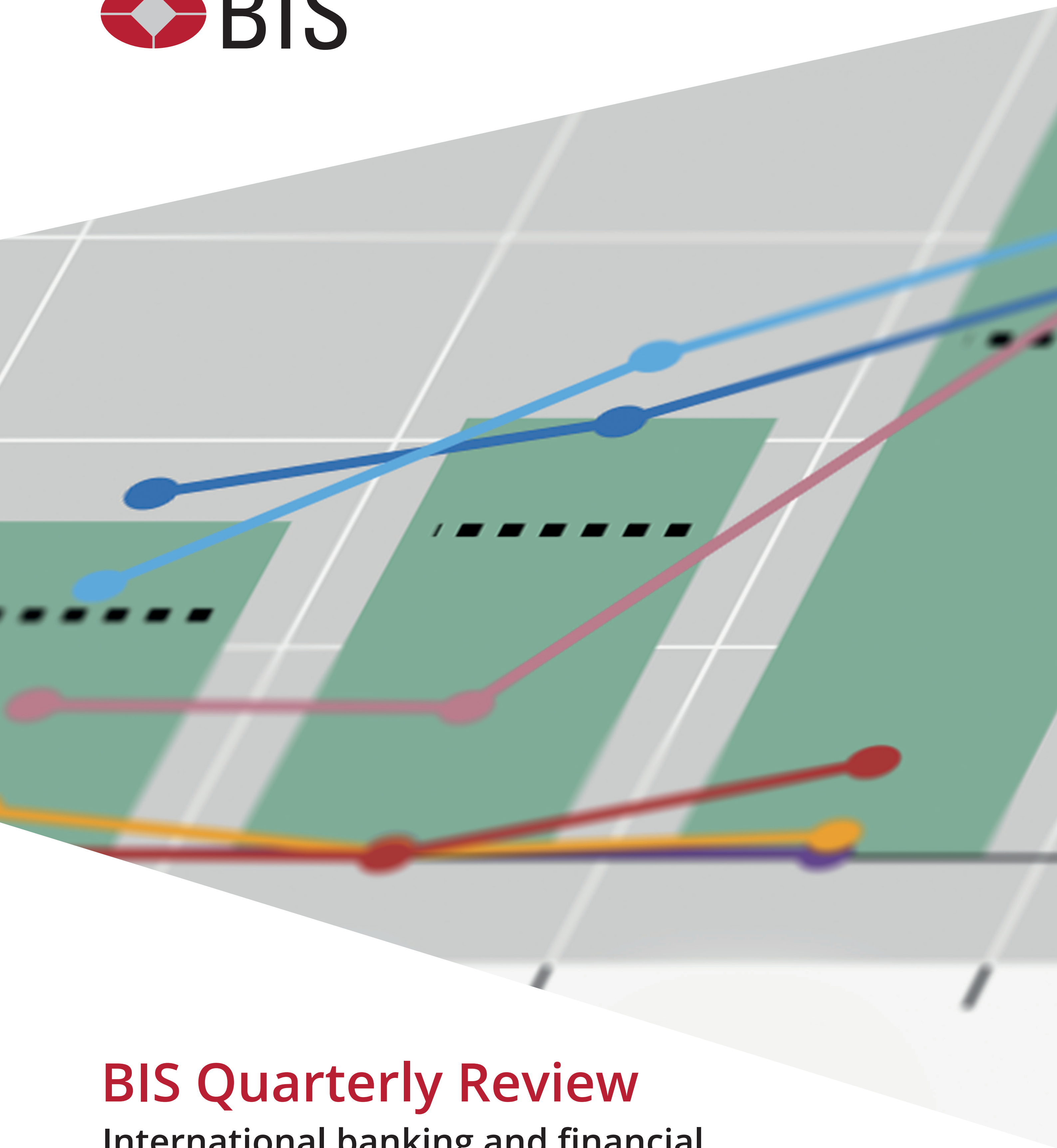

BIS Quarterly Review

International banking and financial market developments

December 2021

BIS Quarterly Review
Monetary and Economic Department

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Special features

Notations used in this Review

billion	thousand million
e	estimated
lhs, rhs	left-hand scale, right-hand scale
$	US dollar unless specified otherwise
…	not available
.	not applicable
–	nil or negligible

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

Abbreviations

Currencies

ALL	Albanian lek	MXN	Mexican peso
ARS	Argentine peso	MXV	Mexican unidad de inversión (UDI)
AUD	Australian dollar	MYR	Malaysian ringgit
BGN	Bulgarian lev	NAD	Namibian dollar
BHD	Bahraini dinar	NGN	Nigerian naira
BRL	Brazilian real	NOK	Norwegian krone
CAD	Canadian dollar	NZD	New Zealand dollar
CHF	Swiss franc	OTH	All other currencies
CLP	Chilean peso	PEN	Peruvian sol
CNY (RMB)	Chinese yuan (renminbi)	PHP	Philippine peso
COP	Colombian peso	PLN	Polish zloty
CZK	Czech koruna	RON	Romanian leu
DKK	Danish krone	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	Israeli new shekel	TWD	New Taiwan dollar
INR	Indian rupee	USD	US dollar
ISK	Icelandic króna	VES	bolívar soberano
JPY	Japanese yen	VND	Vietnamese dong
KRW	Korean won	XOF	CFA franc (BCEAO)
MAD	Moroccan dirham	ZAR	South African rand

Countries

AE	United Arab Emirates	CY	Cyprus
AF	Afghanistan	CZ	Czech Republic
AL	Albania	DE	Germany
AM	Armenia	DJ	Djibouti
AO	Angola	DK	Denmark
AR	Argentina	DM	Dominica
AT	Austria	DO	Dominican Republic
AU	Australia	DZ	Algeria
AZ	Azerbaijan	EA	euro area
BA	Bosnia and Herzegovina	EC	Ecuador
BD	Bangladesh	EE	Estonia
BE	Belgium	EG	Egypt
BF	Burkina Faso	ER	Eritrea
BG	Bulgaria	ES	Spain
BH	Bahrain	ET	Ethiopia
BI	Burundi	FI	Finland
BJ	Benin	FJ	Fiji
BM	Bermuda	FO	Faeroe Islands
BN	Brunei	FR	France
BO	Bolivia	GA	Gabon
BR	Brazil	GB	United Kingdom
BS	The Bahamas	GD	Grenada
BT	Bhutan	GE	Georgia
BW	British West Indies	GH	Ghana
BY	Belarus	GN	Guinea
BZ	Belize	GQ	Equatorial Guinea
CA	Canada	GR	Greece
CD	Democratic Republic of the Congo	GT	Guatemala
CF	Central African Republic	GW	Guinea-Bissau
CG	Republic of Congo	GY	Guyana
CH	Switzerland	HN	Honduras
CI	Côte d'Ivoire	HK	Hong Kong SAR
CL	Chile	HR	Croatia
CM	Cameroon	HT	Haiti
CN	China	HU	Hungary
CO	Colombia	ID	Indonesia
CR	Costa Rica	IE	Ireland
CV	Cabo Verde	IL	Israel

Countries (cont)

IN	India	MX	Mexico
IO	International organisations	MY	Malaysia
IQ	Iraq	MZ	Mozambique
IR	Iran	NA	Namibia
IS	Iceland	NC	New Caledonia
IT	Italy	NG	Nigeria
JE	Jersey	NL	Netherlands
JM	Jamaica	NO	Norway
JO	Jordan	NR	Nauru
JP	Japan	NZ	New Zealand
KE	Kenya	OM	Oman
KG	Kyrgyz Republic	PA	Panama
KH	Cambodia	PE	Peru
KR	Korea	PG	Papua New Guinea
KW	Kuwait	PH	Philippines
KY	Cayman Islands	PK	Pakistan
KZ	Kazakhstan	PL	Poland
LA	Laos	PT	Portugal
LB	Lebanon	PY	Paraguay
LC	St Lucia	QA	Qatar
LK	Sri Lanka	RO	Romania
LR	Liberia	RS	Serbia
LS	Lesotho	RU	Russia
LT	Lithuania	RW	Rwanda
LU	Luxembourg	SA	Saudi Arabia
LV	Latvia	SC	Seychelles
LY	Libya	SD	Sudan
MA	Morocco	SE	Sweden
MD	Moldova	SG	Singapore
ME	Montenegro	SK	Slovakia
MH	Marshall Islands	SI	Slovenia
MK	North Macedonia	SR	Suriname
ML	Mali	SS	South Sudan
MM	Myanmar	ST	São Tomé and Príncipe
MN	Mongolia	SV	El Salvador
MO	Macao SAR	SZ	Eswatini
MR	Mauritania	TD	Chad
MT	Malta	TG	Togo
MU	Mauritius	TH	Thailand
MV	Maldives	TJ	Tajikistan
MW	Malawi	TL	East Timor

Countries (cont)

TM	Turkmenistan	UY	Uruguay
TO	Tonga	UZ	Uzbekistan
TR	Turkey	VC	St Vincent and the Grenadines
TT	Trinidad and Tobago	VE	Venezuela
TW	Chinese Taipei	VG	British Virgin Islands
TZ	Tanzania	VN	Vietnam
UA	Ukraine	ZA	South Africa
US	United States	ZM	Zambia

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Non-bank financial sector: systemic regulation needed

Foreword by Agustín Carstens

Non-bank financial intermediaries (NBFIs) have massively increased their footprint since the Great Financial Crisis (GFC). In part, this represents a long-term structural trend; it has also been a response to retrenchment by banks.

NBFIs offer a broad range of investment and funding opportunities; as such, they are a healthy source of diversity in external financing. They cover areas that banks do not, they enhance innovation and economic growth, and they can help make the financial system more resilient to credit risk.

Given their heft, NBFIs have attracted increasing policy attention. While their activities have obvious implications for investor protection, their impact is more far-reaching. When things go wrong, NBFIs can trigger or amplify market stress. And they affect how monetary policy is transmitted to the economy, how it is implemented on a day-to-day basis, and even how it is calibrated and communicated. Recent ructions in government bond markets, covered by this Quarterly Review, are the latest illustration of how NBFIs can have a material effect even on the US government yield curve – a primary focus of policy and the benchmark for asset pricing worldwide.

Crucially, NBFIs have risen to prominence in policy discussions because they can be, and have been, a source of financial instability. In March 2020 and in previous episodes of similar market turmoil, the NBFI sector amplified stress through inherent structural vulnerabilities, notably liquidity mismatches and hidden leverage. With system-wide stability under threat, massive central bank support was necessary to restore the calm. Such repeated occurrences suggest that the status quo is unacceptable. Fundamental adjustments to the regulatory framework for NBFIs are called for, to make it fully fit for purpose.

This issue of the BIS Quarterly Review delves into selected aspects of the NBFI ecosystem, with the aim of shedding light on the challenges involved. Its special features focus on factors that could undermine financial stability, including in fast-growing areas such as sustainable finance and the crypto universe. The purpose is to inform policy discussions on how to design NBFI regulation from a system-wide perspective.

Key takeaways

- Non-bank financial intermediaries (NBFIs) can make the financial system more efficient but also more unstable, as seen again in the March 2020 turmoil. Recent ructions in sovereign bond markets show that NBFIs can also influence the conduct of monetary policy.
- When ensuring financial stability, it is essential to reduce the need for emergency central bank support. A systemic approach to regulating NBFIs is the key to better addressing their structural vulnerabilities, notably liquidity mismatches and hidden leverage, and building adequate shock-absorbing capacity.
- This issue of the BIS Quarterly Review analyses non-bank financial intermediation, including mechanisms that could undermine financial stability. It focuses on decentralised finance, open-ended bond funds, NBFIs in emerging Asia, private markets and sustainable investing.

NBFIs and financial stability: cyclical and structural issues

The March 2020 events were another reminder that financial stability is best viewed by zooming out of the trees to consider the forest. The overall system may be unstable even if individual institutions, considered on a standalone basis, may appear stable. In other words, actions that seem prudent from the viewpoint of individual institutions may destabilise the system. This is known as the "fallacy of composition".

Like banks, NBFIs can be procyclical as a sector: they are vulnerable to fluctuations in leverage and liquidity runs that have system-wide consequences (Aramonte, Schrimpf and Shin) (2021)). In March 2020, as NBFIs retreated en masse, liquidity evaporated and markets froze amid deleveraging and feedback loops. These dynamics triggered or amplified global disruptions that not only threatened financial stability but strongly hampered the transmission of monetary policy to the broader economy.

The mechanisms underlying this instability are quite familiar from previous episodes of financial stress. At their core is the interaction between liquidity mismatches and leverage, on the one hand, and risk management practices, influenced in part by regulation, on the other. That said, the specific balance sheet composition and business models of NBFIs – together with market structures – determine how these factors will manifest themselves and how intensely.

Liquidity mismatches are quite common among NBFIs, in particular for prime money market and open-ended funds (OEFs) that promise on-demand convertibility of illiquid investments into cash. This generates a first-mover advantage, ie incentives for investors to move money out before others do, akin to bank depositors' incentives to run. Arguably, these incentives are smaller at exchange-traded funds (ETFs) that meet redemptions with securities in the investment pool (Todorov (2021)). Facing actual withdrawals or the threat thereof if redemption gates or fees become likely, prime fund and OEF managers tend to hoard liquidity and/or liquidate assets. But what is prudent from their viewpoint has potentially negative repercussions for the system ("externalities"): protecting the viability of individual funds exacerbates the system-wide liquidity shortage.

These mechanisms were at play in March 2020. Prime funds hoarded liquidity – eg by shortening the maturities of their commercial paper investments – rather than drawing down their buffers (Eren et al (2020)). Similarly, the discretionary asset sales by bond OEFs exceeded the amounts needed to cover redemptions, thus adding to the funds' cash positions, as documented in a special feature in this Review (Claessens and Lewrick (2021)). The upshot was a deterioration of system-wide funding liquidity conditions. In particular, market segments in which OEFs operate saw liquidity evaporate more quickly and to a greater extent.

As in previous episodes, the strains spilled over to US dollar funding markets outside the United States. Such strains are particularly severe for financial institutions that have US dollar assets but liabilities in local currencies and which can hedge most of the attendant foreign exchange risk only with short-term off-balance sheet instruments, largely FX swaps. The resultant rollover risk materialises during US dollar liquidity shortages. While this practice is common for advanced economy financial institutions, McGuire et al (2021) document it in this Review also for NBFIs in some Asian emerging market economies (EMEs), which have become significant creditors in global markets rather than just borrowers. When US dollar funding dried up in March 2020, these NBFIs ultimately had to obtain relief, directly or indirectly, from central bank swap lines. These disruptions also indicate how opaque such liquidity needs can be: FX swaps are a major form of "hidden debt" in the global financial system (Borio et al (2017)).

Concerns also arise in the growing crypto universe of decentralised finance – or DeFi, ie finance activity based on automated smart contracts on distributed ledger technologies, involving mainly permissionless mechanisms and anonymous transactions. As examined in an article in this Review (Aramonte, Huang and Schrimpf (2021)), DeFi supporters stress its potential efficiency gains. Being a new system of payments and transactions, it promises to overcome some of the disadvantages of traditional finance, such as high costs and slow speed. For now, these gains are difficult to detect: DeFi appears to be operating largely within its own ecosystem, with little in the way of financial intermediation services being provided to the real economy.

At the same time, besides giving rise to first-order money laundering and investor protection concerns, DeFi displays substantial financial vulnerabilities. These parallel but exceed those in more traditional forms of finance. For instance, stablecoins – the grease between DeFi wheels – are subject to classic runs: the backing of liquid claims with less liquid reserve assets can touch off downward price spirals akin to those stemming from redemptions in the investment fund industry. In the crypto ecosystem, risks have so far surfaced mainly in frequent and sizeable price crashes. Whether such fragilities are limited to this ecosystem or can spill over to the traditional one is still unclear. But the potential for spillovers should not be underestimated, especially since the stablecoin arrangements themselves can create important links. As history confirms, anything that grows exponentially is unlikely to remain self-contained and thus merits the closest attention.

Leverage at NBFIs can also result in destabilising dynamics due to perverse feedback loops. The archetypal example is the use of leverage by hedge funds and asset managers, notably for the purchase of securities with borrowed funds (eg repos). More recently, leverage has become high and pervasive in the DeFi world too. In such a context, price drops and increases in measured risks may make the lender call in the loan or charge a higher haircut, inducing forced selling.

One special feature in this issue documents that leverage is also pervasive in the rather opaque private markets, both on the part of investors – such as hedge funds – and the private-market funds themselves (Aramonte and Avalos (2021)). As banks have been retrenching post-GFC, these markets have gained ground. They tend to provide equity and debt funding to small firms, whose riskiness is difficult to assess. Private markets involve little liquidity transformation and feature long-horizon investments, which should make funding more resilient. However, just as in the larger public markets, risk-taking in private markets is procyclical, with investments increasing when stock markets do well and liquidity is ample. Such risk-taking has contributed to the recent accumulation of debt in the system at large and may have broader financial stability implications, not least because banks fund private market operations and investors.

Risk management strategies subject to the fallacy of composition often have perverse system-wide repercussions at times of high volatility, thus amplifying initial shocks. One example is the procyclical increase in margins to address heightened counterparty risks during volatility spikes (CGFS (2010)). In March 2020, concerns about counterparty credit risk were indeed allayed by such practices, helping to limit the erosion of confidence. But by triggering a need to come up with cash to meet margin calls at short notice, they gave rise to liquidity pressures elsewhere in the system (CPMI-IOSCO-BCBS (2021)). Another example is OEFs' reliance on liquidity management tools that do not take systemic considerations into account (Claessens and Lewrick (2021)). These private sector "best practices" have also found their way into current regulation.

Resilient **market structures** are key for absorbing spikes in the demand for funding liquidity. Ideally, private players would provide the "elastic nodes" in such structures ("first line of defence"). Banks are best placed to do this: through their lending activity, they can create their own liabilities, which are a means of payment; and they have direct access to the central bank. In March 2020, banks behaved as elastic nodes, supplying deposits to clients, including to NBFIs. But banks are subject to private incentives as any other market player and did not channel sufficient or timely liquidity to the NBFIs most in need. Thus, central banks– once again – had to step in (as the "ultimate line of defence").

Approaches to closing policy gaps

As the various analyses in this Review indicate, recent developments expose gaps in regulatory frameworks for NBFIs from a financial stability perspective. Two decades ago, the long-standing recognition of system-wide issues in the banking sector gave rise to the macroprudential approach to regulation and supervision (Crockett (2000)). In part drawing on that approach, post GFC-reforms have strengthened banks and reduced their systemic impact. Given the increasing role that the NBFI sector plays in the market ecosystem, it is now important to apply a macroprudential approach to it as well. The ultimate objective is to build individual NBFIs' war chests in good times in order to mitigate collective retrenchment in times of stress, thereby addressing the fallacy of composition.

Central bank liquidity assistance should not be the only means of filling these gaps. The expectation of such assistance creates moral hazard and distorts prices, leading to resource misallocation. In addition, it comes with implementation challenges and side effects, and is difficult to wind down. Liquidity assistance may also conflict with other policy objectives. For example, turmoil may arise precisely when a flareup in inflation calls for monetary policy to be tightened.

More effective prevention should be the main answer to regulatory gaps in the NBFI sector. Reducing the likelihood and intensity of financial stress in the first place would also reduce the need for emergency central bank assistance. Since this objective refers to the system as a whole, it calls for a macroprudential approach to regulation.

As always, one element of the multi-pronged policy response should be better information. This element is necessary even if not sufficient to combat the above-mentioned incentive distortions that are at the core of financial vulnerabilities. For authorities, this would come in the form of enhanced reporting as a basis for stronger monitoring. For markets, it would take the shape of enhanced disclosure.

The importance of reliable information comes to the fore in the context of climate change and green financing. This is emphasised in a special feature in this Review (Scatigna et al (2021)), which examines how investors seek to address environmental, social and governance (ESG) issues, largely through NBFIs. It finds that investors do respond to data on firm-level carbon emissions and to social bond designations, even if funding costs have seen little effect so far. But markets are grappling with unreliable taxonomies and inputs into these taxonomies, resulting in "greenwashing" or "ESG-washing", which stand in the way of the desired transition.

Another, essential, element in the policy response is to ensure that NBFIs have sufficient shock-absorbing capacity. This capacity will have to be tailored to the nature of the NBFI's vulnerabilities, and hence the inherent leverage and liquidity mismatches. When leverage is an issue, less stress-sensitive ("through-the-cycle") margining practices and, above all, higher and usable capital buffers will help. In turn, the options for mitigating liquidity mismatches include higher usable liquidity buffers, well designed limits to convertibility into cash and, more generally, less reliance on redemption methods that presume liquid markets (not in-cash but in-kind). Of course, the shock-absorbing capacity would also need to take into account the interaction between leverage and illiquidity.

Other pre-emptive steps include taking a less fragmented and more consolidated supervisory perspective. Gaps in supervision left NBFIs in Asian EMEs with excessive exposure to rollover risks while banks had limited capacity to mitigate these risks (McGuire et al (2021)). Regulatory challenges may appear insurmountable in the case of DeFi, which is designed to avoid central oversight and rulemaking. However, Aramonte, Huang and Schrimpf (2021) show that DeFi's decentralisation is an illusion: pivotal entities (typically, application developers) are ultimately in control. With appropriate adjustments to legal systems, these entities, as well as DeFi's links with the traditional system, could become the natural entry points for the regulation that is needed to address money laundering and other abuses as well as to achieve financial stability goals. Given DeFi's characteristics, these efforts will require international coordination. And any final coherent and inclusive framework may also have to include prohibitions for some DeFi activities.

The policy challenges are daunting. Addressing them is urgent and, indeed, many efforts are under way, nationally and internationally. How best to address them requires further thought. Further discussions will be needed between authorities to reach a common understanding of the pressing issues. Along the way, it is important to keep in mind that the task does not have a clear beginning and a clear end. This will be a continuing endeavour. People inevitably want higher returns and higher liquidity. The financial system will try to deliver, in part by adapting to regulation as it evolves. All this inevitably raises system-wide risks. The challenge for the authorities is to manage those risks effectively while allowing the financial system to perform its basic functions in the interest of society. Policymakers cannot afford to fall behind the curve.

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Pandemic twist and inflation challenge markets

Risk appetite proved resilient during most of the review period, but a wake-up call from renewed Covid-19 concerns curtailed the gains in late November.[1] Before the news of a new and threatening virus strain emerged, equity indices had risen strongly in many advanced economies (AEs). Corporate credit spreads in AEs had remained compressed, with issuance close to past records, indicating that financial conditions were still exceptionally accommodative. Government bond yields had increased, particularly sharply at the short end, as investors wrestled with fluid prospects of increased inflation and a removal of monetary accommodation. Government bond yields had also risen in emerging market economies (EMEs), as the fall in their currencies' value against a broadly appreciating US dollar revealed concerns about their economic outlook.

After what had been a strong quarter in most markets, stocks suffered important losses late in the review period. Equity prices in AEs, especially the United States, had climbed on the back of continued strength in both realised and expected earnings. However, the perceived risk of sharp corrections – as implied by option prices – remained elevated, pointing to persistent investor unease. The correction that eventually shook markets at the end of the period erased part of the previous gains in the United States, and left most other markets flat or with some losses.

Resilient risk appetite sustained strong corporate credit through the period. Bond spreads were almost as narrow as at any time since 2010, even for companies at the lower end of the ratings spectrum, although they widened in late November. Investment grade issuance remained strong, while that in the high-yield segment approached record highs. Exceptionally easy credit conditions prevailed beyond public markets, especially in the demand for cryptoassets and the private capital markets that serve smaller and startup borrowers.

Yield curves in AEs rose and flattened, as short-term yields surged midway through the review period, amid sometimes disorderly trading conditions. Central banks in AEs continued dialling down the extraordinary support required by the pandemic, but they generally maintained cautious guidance for the short and medium term. The apparent disconnect between this guidance and the sharp moves in front-end yields raised questions about whether investors disagreed on the outlook for inflation or on the most likely policy response, or whether other factors were at play, such as the forced unwinding of leveraged positions.

Financial conditions continued to tighten for many EMEs. Government bond yields rose, especially outside emerging Asia. US dollar strength, which intensified at end-November, also contributed to the tightening and added to inflationary pressures. This worsened monetary policy trade-offs, especially for countries grappling with pandemic-related challenges against a background of limited fiscal space. The stability of the Chinese renminbi stood out, despite the headwinds from a weakening growth outlook amid challenges for its real estate sector.

[1] The period under review is from 13 September to 29 November 2021.

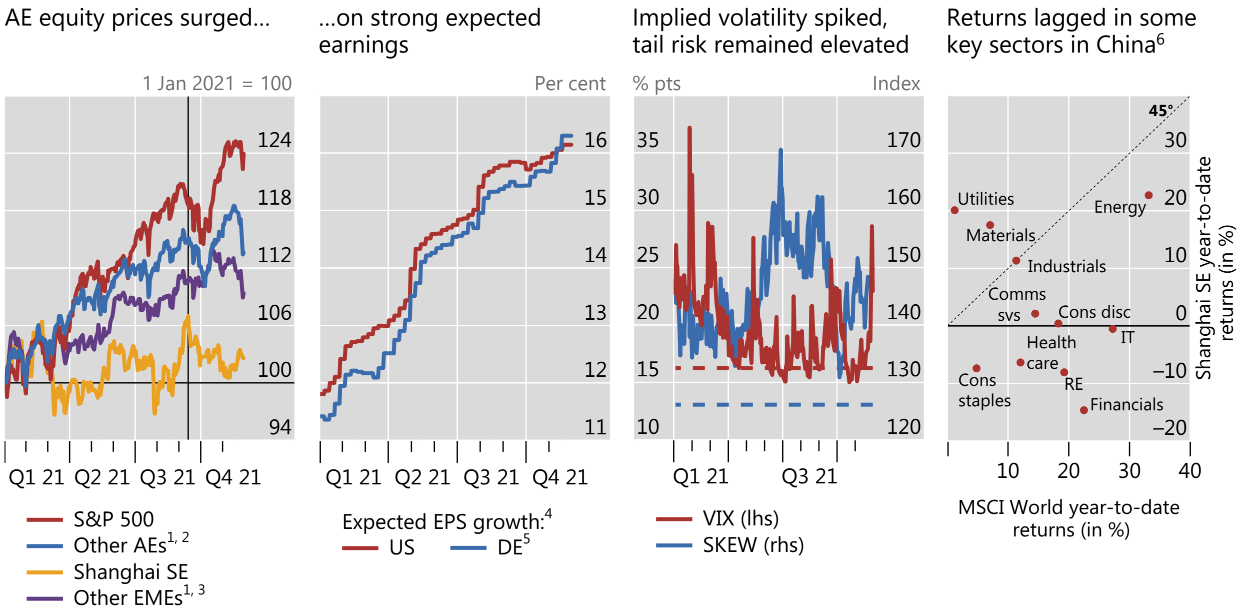
Key takeaways

- Advanced economies' equity and corporate credit markets remained well supported, but sentiment was curtailed by concerns over a new virus variant as the period drew to a close.
- Government bond markets saw sharp yield moves, particularly at the front end, as investors' expectations for short-term rates diverged from central bank guidance.
- US dollar strength added to tightening financial conditions in several emerging market economies, where monetary authorities continued to fight persistent inflationary pressures.

Risky assets rise on earnings strength

Global markets for risky assets had proved resilient during the period under review, before the resurgence of virus concerns at end-November. Equity markets had posted material gains, which were curtailed or fully erased on the news at the end of the period. Conditions were brisk in corporate credit markets, where issuance and pricing remained very supportive, despite the later souring of investors' sentiment.

Stock markets in AEs gained on strong earnings before the virus-induced setback Graph 1



The vertical line in the first panel indicates 13 September 2021 (start of period under review). The dashed lines in the third panel indicate 2010–current medians.

[1] GDP and PPP exchange rate weighted-average. [2] AU, CA, CH, DK, GB, NO, NZ and SE. [3] BR, CL, CO, CZ, HK, HU, ID, IN, KR, MY, MX, PE, PH, PL, RU, SG, TH, TR and ZA. [4] Growth of expected earnings per share (EPS) between end-2020 and end-2023. [5] On 23 September the DAX index added 10 members, applying a selection criterion based on market capitalisation. For consistency, pre-22 September data are adjusted to match the new post-22 September level. [6] Based on local currency-denominated stock indices.

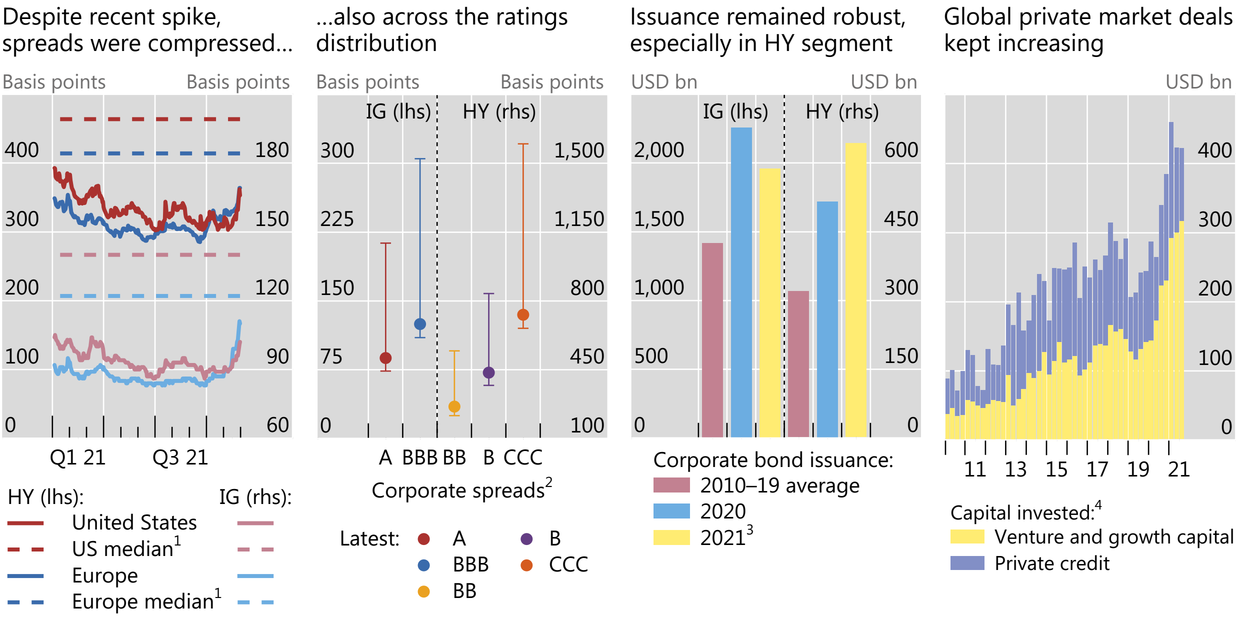
Sources: IMF; OECD; Bloomberg; Datastream; BIS calculations.

After a faltering start, equity markets gained strong momentum before recoiling at end-November. Early in the review period, stock prices lost ground in most jurisdictions, as persistent pressure on supply chains and rising commodity prices weighed on risk-taking (Graph 1, first panel). In AEs, particularly the United States, equity markets subsequently rebounded on the back of sustained strength in expected earnings (second panel). This positive turn also temporarily boosted the stock prices of EMEs other than China. However, tail risks still loomed large for investors. During most of the review period, perceived downside risk – as derived from option prices – remained high by historical standards (third panel, solid and dashed blue lines). Implied volatility, in turn, spiked when the emergence of the Omicron variant of Covid-19 made the downside risk more tangible (solid red line). The news erased gains in most markets, hitting sectors such as energy, financials, and industrials particularly hard. The S&P 500, however, still managed to end the review period with some gains.

Stock markets were subdued in China, staying largely detached from global trends. Developments in real estate markets and the policy pivot towards greater state oversight of key economic activities compounded concerns about slowing growth. Accordingly, the sectors with the most solid performance year-to-date globally (IT, real estate, financials) suffered valuation losses (Graph 1, fourth panel). The exceptions were energy, materials and industrials, where performance was in line with global benchmarks.

The corporate bond market remained buoyant, especially in its riskiest segments, notwithstanding the recent virus-induced spike. Spreads on investment grade (IG) and high-yield (HY) corporate bonds remained below historical norms in both the United States and the euro area, (Graph 2, first panel). For individual rating categories, spreads stayed at the lower end of their post-Great Financial Crisis (GFC) distribution

Brisk corporate credit markets supported record issuance by lower-rated firms — Graph 2



[1] 2010–current. [2] Whiskers show fifth and 95th percentiles; data starting in 2010. The corporate spreads displayed are the GDP and PPP exchange rate-weighted average of euro area and US ICE BofA Corporate spread indices. [3] For 2021, issuance data up to 29 November, projected to the full fourth quarter. [4] Data for Q3 2021 are still preliminary.

Sources: Bloomberg; Dealogic; ICE BofAML indices; Pitchbook; BIS calculations.

(second panel). Likewise, after a strong third quarter, corporate debt issuance rose comfortably above the average of the pre-pandemic decade (third panel). In particular, HY issuance in both the United States and the euro area surpassed the 2020 peaks on an annualised basis. Against this background, a record 80% of corporate bonds outstanding is currently rated BBB (ie just above HY) or below (HY), up from 75% in 2009.

The exceptionally easy financial conditions in credit markets were visible beyond corporate bonds, which are usually tapped by large companies. Indeed, the private credit markets, which serve smaller – typically, highly leveraged – borrowers, also sustained their post-GFC momentum (Graph 2, fourth panel; see also Aramonte and Avalos (2021, in this issue)). These strong flows continued while survey data indicated a material increase in non-performing loans (from nearly 1% in 2018 to 3% in 2020), declines in estimated recovery rates and a higher likelihood of covenant suspensions and acceptance of payment-in-kind. Resilient risk appetite extended beyond traditional finance, generating a growing demand for cryptoassets. Hence the introduction of the first bitcoin exchange-traded fund in the United States (Box A) and the continued startling growth in decentralised finance (see Aramonte et al (2021) in this issue).

Yield curves wobble amid unusual volatility

During most of the review period, while corporate asset markets remained ebullient, government bond markets saw significant volatility and heightened illiquidity. Two related developments characterised the path of fixed income markets: an apparent disconnect between central bank policy guidance and front-end rates that surfaced in October; and wide fluctuations in the shape of yield curves. As the review period drew to an end, the emergence of the new variant added some volatility to yields, but did not materially affect the disconnect – which had already narrowed somewhat.

Central banks in the largest AEs began to gradually lift the extraordinary measures deployed during the pandemic, while remaining on a cautious watch. In November, the Federal Reserve confirmed the widely anticipated beginning of its tapering of asset purchases, while the Bank of Canada stopped its securities purchasing programme altogether. The ECB had already indicated in December 2020 that purchases under the Pandemic Emergency Purchasing Programme (PEPP) would last at least until March 2022. Yet most major central banks indicated that the policy rate lift-off, while drawing closer, would not start soon, given the pandemic's lingering effects. Furthermore, they repeatedly stressed that the increase in inflation was transitory, even if more protracted than originally anticipated.

In the wake of a cluster of CPI releases in early October, fixed income markets swung and began pricing in policy rate hikes well in advance of central bank guidance. The extent of the gap can be assessed by comparing the time to lift-off implied by surveys of professional forecasters – typically well attuned to central bank communication – with that implied by overnight index swap (OIS) rates. While the two sets of expectations were perfectly aligned for most AEs in June (Graph 3, left-hand panel, blue dots on the 45-degree line), by late October OIS rates suggested that the first hike would occur much earlier than forecasters anticipated (red dots below the 45-degree line). The gap became particularly large in the case of Australia and the euro area, where the time to lift-off implied in OIS was less than half of that implied by surveys.

Box A

Launch of the first US bitcoin ETF: mechanics, impact, and risks

*Karamfil Todorov*①

The first US bitcoin (BTC) exchange-traded fund (ETF), "BITO", started trading on 19 October 2021. The fund debuted as one of the most heavily traded ETFs in market history, attracting more than $1 billion in assets in the first few days. Subsequently, the ETF accumulated a significant share of all short-term bitcoin futures contracts, reaching about one third of the underlying futures market just 10 days after its launch (Graph 1, first panel). This box explains how the futures-based structure of BITO differs from that of more traditional, non-futures-based equity ETFs and analyses the possible implications for prices and risks.

Background

So far, the Securities and Exchange Commission (SEC) has delayed or declined applications to launch an ETF investing directly in bitcoin, due mainly to concerns that the asset is predominantly traded on non-regulated exchanges.② BITO is the first SEC-approved bitcoin ETF, largely because the fund is based on futures contracts that are traded on the regulated Chicago Mercantile Exchange (CME).

A futures contract is a legal agreement to buy or sell a particular asset at a predetermined price at a specified time in the future. Such a contract allows investors to take positions without holding the underlying asset. Since holding that asset gives rise to cost of carry – which may be positive in the presence of storage costs or negative due to a convenience yield – the futures price is typically different from the asset's spot price. In the particular case of BITO, the asset is bitcoin and the cost of carry tends to be positive,③ thus implying that the futures price is generally above the spot price, and that the futures curve tends to be upward-sloping (long-term futures contracts are more expensive than short-term ones).

How it works

To obtain bitcoin exposure, BITO enters into long positions in near-term (one-month) CME bitcoin futures contracts. As the contracts near expiration, the fund gradually sells them and buys longer-dated contracts – a strategy called "roll". In addition, BITO holds a liquid pool of cash or cash equivalents, such as Treasury bills (Graph A, second panel). When the bitcoin price goes up, BITO uses the gains from the futures contract to expand its liquid pool. Conversely, when the bitcoin price goes down, BITO uses some of its liquidity to pay for the losses on the futures contract. This structure is different from that of traditional bond or equity ETFs, which simply hold bonds and stocks, but is similar to the way commodity or VIX ETFs are structured (Table A).

Futures-based ETFs vs. more standard equity and bond ETFs — Table A

	Futures-based ETFs (eg, bitcoin or commodities)	Standard ETFs (eg, equity or bond)
Holdings	Futures contracts and cash equivalents	Physical stocks/bonds
Creations and redemptions	Predominantly in cash	Predominantly in-kind
Rebalancing	Frequent, due to expiring futures contracts	Rare, except for inflows/outflows
Performance relative to spot	Under/outperforms if futures curve is upward/downward-sloping	Similar, up to a tracking error

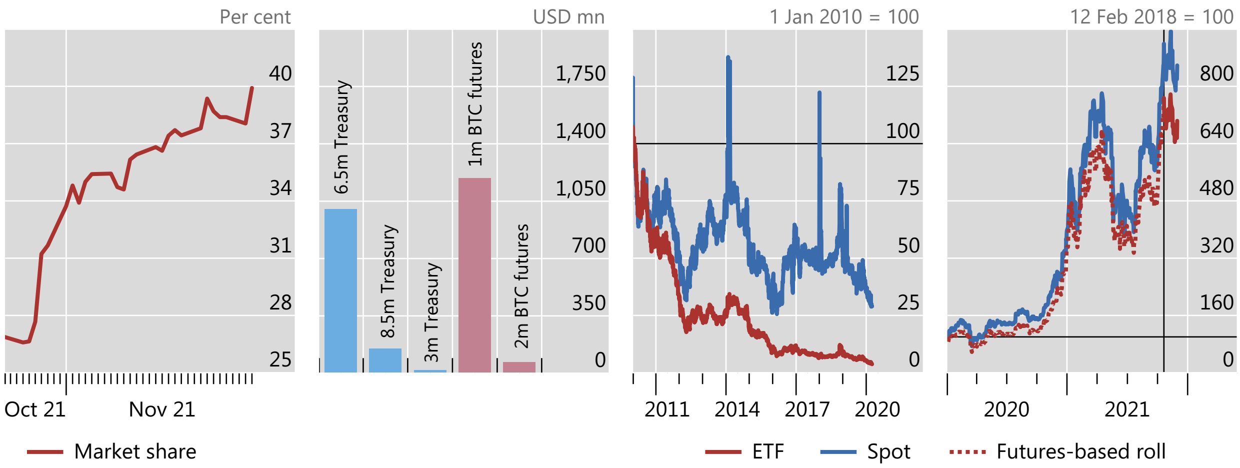
Source: Author's elaboration.

The rebalancing strategy of BITO can erode performance over time in a similar way to that seen in other commodity futures-based ETFs. Facing an upward-sloping futures curve, BITO pays "roll costs" when it rebalances its positions by selling expiring short-term contracts to buy long-term ones. Commodity futures-based ETFs provide examples of substantial cumulative erosion due to an upward-sloping futures curve (Graph A, third panel). Likewise, had it been launched in 2018, BITO would have underperformed spot prices by about 18% on a cumulative basis over the following four years to date (fourth panel).

Futures-based bitcoin ETF: share of the market, holdings and performance

Graph A

BITO quickly became a key player in the market[1] | The ETF holds futures and cash equivalents[2] | Underperformance of gas futures-based ETF vs spot | Hypothetical BTC futures-based ETF vs spot[3]



[1] Total dollar position of the first US bitcoin (BTC) exchange-traded fund (ETF) BITO in the nearest two futures contracts divided by the total dollar open interest in those contracts. [2] Holdings as of 4 November 2021. Futures holdings are reported in terms of exposure values; Treasury holdings are reported as market values. The chart excludes "net other assets/cash". [3] For better visibility, the graph starts in January 2020. The vertical line marks the launch of BITO (19 October 2021). For the period before the launch, the ETF return is approximated with a rolling futures position that rolls over a period of one week before expiration. Rolling over a week is a common strategy for many commodity ETFs; see K Todorov, "Passive funds affect prices: evidence from the most ETF-dominated markets", *BIS Working Papers*, no 952, July 2021. The bitcoin ETF does not have a clearly defined rolling period in the prospectus.

Sources: Bloomberg; author's calculations.

Impact on prices and risks

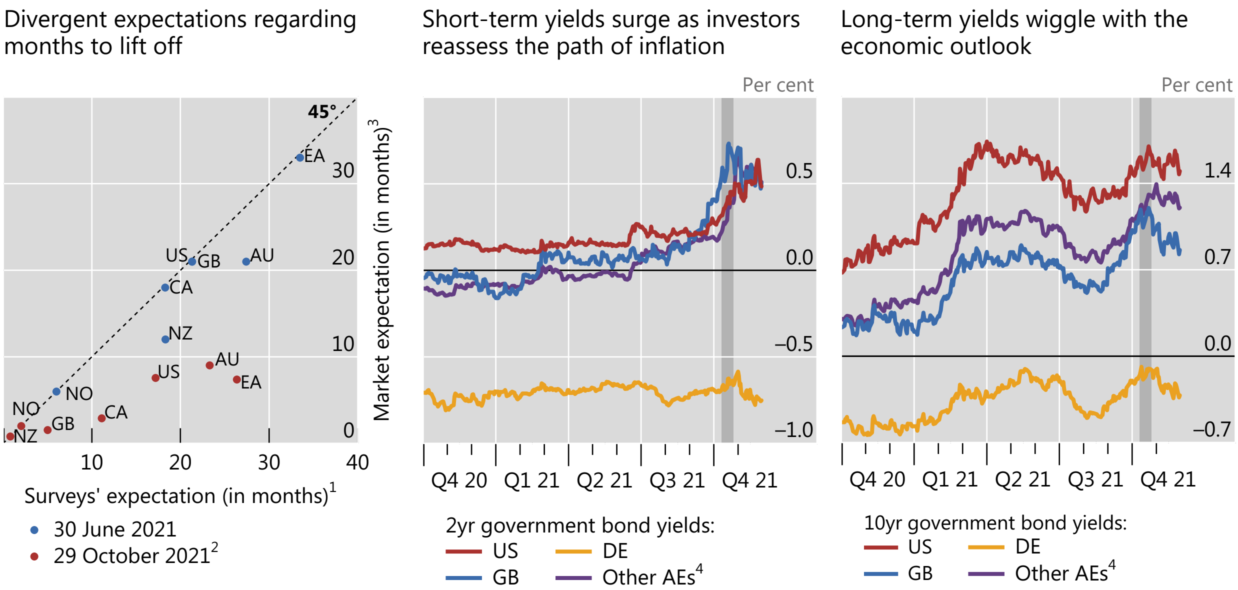
In general, a futures-based ETF is likely to affect prices in two main ways. The first effect works through flow rebalancing: when an ETF buys futures contracts in response to inflows, it pushes futures prices up, and vice versa for outflows. The second effect works through calendar rebalancing: as the ETF gradually sells futures contracts before expiration, their prices fall. At the same time, as the ETF buys longer-dated futures contracts, their prices increase.④ The predictable rebalancing behaviour of the ETF may also give rise to "front-running" incentives, motivating investors to purchase longer-dated bitcoin futures in anticipation of the ETF rolling into those contracts. The price impact in the futures market can also spill over to spot prices through investors' hedging behaviour, especially for assets with physical settlements of the futures contract and large storage costs. A prominent example is the drop of oil spot prices into negative territory in April 2020, when futures-based ETFs probably contributed to the increase in storage costs and the subsequent decline in spot prices.⑤

The bitcoin ETF may amplify volatility in prices and create risks for investors if the fund is a large share of the futures market. Experience suggests that futures-based ETFs can exacerbate price movements and create additional volatility when they have a large footprint in the underlying asset. For example, heavy ETF-induced trading unsettled VIX futures prices and contributed to the spike in VIX in February 2018.④ This led to investor losses and subsequent delisting of the largest inverse VIX ETF. The trading by BITO could also spill over to fixed income markets through its holdings of cash equivalents. If the ETF were to liquidate these instruments in response to bitcoin depreciation or excessive outflows, that could put pressure on bond markets. At present, BITO is unlikely to cause such disruptions, as it holds mostly highly liquid short-term Treasuries and it is small relative to the market for these instruments.

① The views expressed are those of the author and do not necessarily reflect the views of the BIS. The author thanks Claudio Borio, Stijn Claessens and Nikola Tarashev for valuable comments. ② Spot-based bitcoin ETFs predated BITO in several non-US jurisdictions, including Canada and some European countries. ③ This is presumably due to a negative convenience yield, related to demand from investors using futures to lever up. ④ See K Todorov, "Passive funds affect prices: evidence from the most ETF-dominated markets", *BIS Working Papers*, no 952, July 2021. ⑤ See S Aramonte and K Todorov, "Futures-based commodity ETFs when storage is constrained", *BIS Bulletin*, no 41, April 2021.

Markets and central banks do not see eye to eye on the policy rate path in AEs

Graph 3



The shaded area in the centre and right-hand panels indicates 11–26 October 2021 (release of September 2021 CPI data).

[1] Based on Bloomberg's weighted average of policy rate forecasts. [2] Date selected to capture markets' reactions to the 11–26 October 2021 cluster of CPI releases. The picture remains roughly unchanged also when considering market expectations as of 29 November 2021. [3] Based on implied policy rates derived from OIS contracts. [4] Simple average across AU, CA, DK, NZ and SE.

Sources: Bloomberg; BIS calculations.

The relative shift in lift-off expectations raised questions about an apparent disconnect between central bank guidance and fixed income markets. Market repositioning aside (see below), such a disconnect could arise from differences in perceptions of the outlook – most notably as regards inflation – or a misunderstanding of central banks' reaction function. In analysing these alternative explanations, Box B presents suggestive evidence supporting the former. As the period under review wore on, some central banks gradually pivoted to less accommodative guidance, which appeared to soften the disconnect with market perceptions.

The disconnect had a forceful expression at the front end of AE term structures. With mounting evidence that supply shortages and energy price surges sustained the inflationary momentum, short- to medium-term yields increased markedly after the CPI releases (Graph 3, centre panel). Indeed, under market pressure, the Reserve Bank of Australia abandoned its yield control programme in late October, a few days before the Board meeting in which monetary policy decisions are routinely taken. Yields fell somewhat as the Omicron variant emerged in late November.

Long-term yields also saw some volatility during the review period. They had been on the rise since mid-August, particularly outside the United States (Graph 3, right-hand panel). In most AEs, 10-year yields had increased between 40 and 60 basis points between August and early October, in a move that seemed to closely track the sudden increase in energy prices. As volatility took off in October at the front end of the yield curve (centre panel), longer yields eased, notably in the United Kingdom and the United States.

Box B

Front-end yields and central bank guidance: what can explain the disconnect?

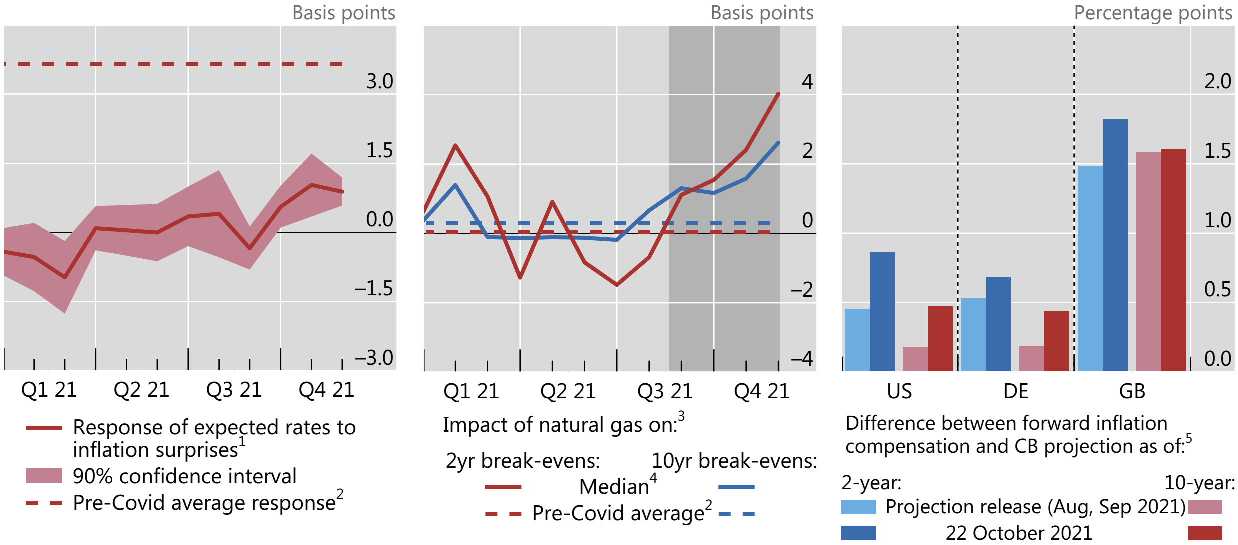
Iñaki Aldasoro and Fernando Avalos[1,2]

The increase in advanced economies' front-end government yields between late September and late October exhibited signs of a disconnect from central bank policy guidance. This is because central banks had expressed the view that inflationary pressures were temporary, and policy rate increases, according to their guidance, were still some time away. In principle, two drivers could have accounted for the disconnect: investors' disagreement with respect to central banks' inflation outlook, or a misunderstanding of their reaction function.[3] This box examines these drivers and provides suggestive evidence that the disconnect was more likely to have stemmed from disagreements on the inflation outlook.

The disconnect seems to hinge on the inflation outlook

Graph B

Market reaction to inflation surprises remains below pre-Covid norms | The impact of natural gas prices on break-evens has strengthened | Inflation compensation diverged further from central bank projections



The shaded area in the centre panel indicates 20 August 2021–latest (period covering the rally in natural gas prices).

[1] Coefficient obtained from a panel regression of changes in expected policy rate 12-months ahead (OIS) on inflation surprises. Inflation surprises are computed as the difference between reported inflation and Bloomberg's average of survey forecasts. The regression includes GDP and unemployment rates as controls, as well as country fixed effects. Coefficients are estimated on six-month rolling windows, with a one-month jump between windows. [2] Based on data from January 2017 to January 2020. [3] Based on vector autoregressions including the two- or 10-year break-evens and natural gas prices (in logs). The lines depict the respective semi-elasticities of break-evens with respect to natural gas prices. Coefficients are estimated on windows of 120 trading days, with a 20-day jump between windows. [4] Median coefficient of a sample of four AEs (AU, DE, IT and US) for two-year break-evens, and eight AEs (AU, CA, DE, GB, IT, JP, NZ, and US) for 10-year break-evens. [5] The forward inflation rates are based on zero coupon inflation swaps: for the two-year horizon, this corresponds to the one-year /one-year forward rate, while for the 10-year horizon this corresponds to the nine-year/one-year forward rate. Central banks' projections are obtained from the FOMC Summary of Economic Projections (22 September 2021) for US, the ECB Economic Bulletin issue 6 (23 September 2021) for DE and the BoE Monetary Policy Report (5 August 2021) for GB.

Sources: Bank of England; Board of Governors of the Federal Reserve System; ECB; Federal Reserve Bank of St Louis, FRED; Bloomberg; national data; authors' calculations.

The shifts in advanced economies' (AEs) fixed income markets did not appear to be driven by any questioning of central bank guidance. If investors doubted the guidance, inflationary surprises – ie differences between realised inflation and the market consensus expectations – would have raised market-implied measures of expected policy rates. In fact, the sensitivity of such a measure (12 months ahead) to inflation surprises has been close to zero throughout this year (Graph B, left-hand panel, solid line). Indeed, this sensitivity was much lower than before the pandemic, when most central banks were on a path to normalising monetary conditions (dashed line). Taken at face value, these findings suggest that investors seemed convinced that, by and large, central banks were sticking to their guidance by "looking through" short-term inflation realisations.

By contrast, the outlook for inflation seems to loom large in bond market pricing. Inflation compensation (or break-evens) across AEs was particularly sensitive to changes in energy prices in recent months, notably in the wake of the extraordinary rally in the price of natural gas. The sensitivity of AE inflation break-evens to gas prices – which can drive inflationary pressures through wholesale electricity costs – has become much larger in recent months than in the pre-Covid period (Graph B, centre panel, solid vs dashed lines). Remarkably, both short- and long-term break-evens have shown a large sensitivity to the price of this energy source, in turn suggesting that investors were concerned not only about the immediate impact of gas prices but also about the lingering effects.④

The material increase in the gap between inflation compensations – as captured by break-even rates – and central bank inflation projections during October can be seen as a further indication of disagreement on the outlook. The relatively large widening of the gap in October (Graph B, right-hand panel) points to a significant change in the attitude or perceptions of investors with regard to the inflationary outlook. That change seems to have transpired irrespective of the magnitude of the inflation surprises observed in October. The variations in an already complex inflationary outlook reduced investors' incentives to hold nominal bonds that were providing deeply negative yields in real terms (ie after inflation).

① The views expressed are those of the authors and do not necessarily reflect the views of the BIS. ② The authors thank Claudio Borio, Stijn Claessens, Andreas Schrimpf, Hyun Song Shin and Nikola Tarashev for helpful comments and discussions. ③ Granted, price shifts due to investor repositioning, or other technical issues reflected in impaired arbitrage, may have exacerbated the disconnect. ④ Other bottlenecks may be playing a role in the surge of inflation compensation as well, especially the shortage of semiconductors constraining several areas of manufacturing, and logistical bottlenecks that brake international trade and clog global value chains. See D Rees and P Rungcharoenkitkul, "Bottlenecks: causes and macroeconomic implications", *BIS Bulletin*, no 48, November 2021.

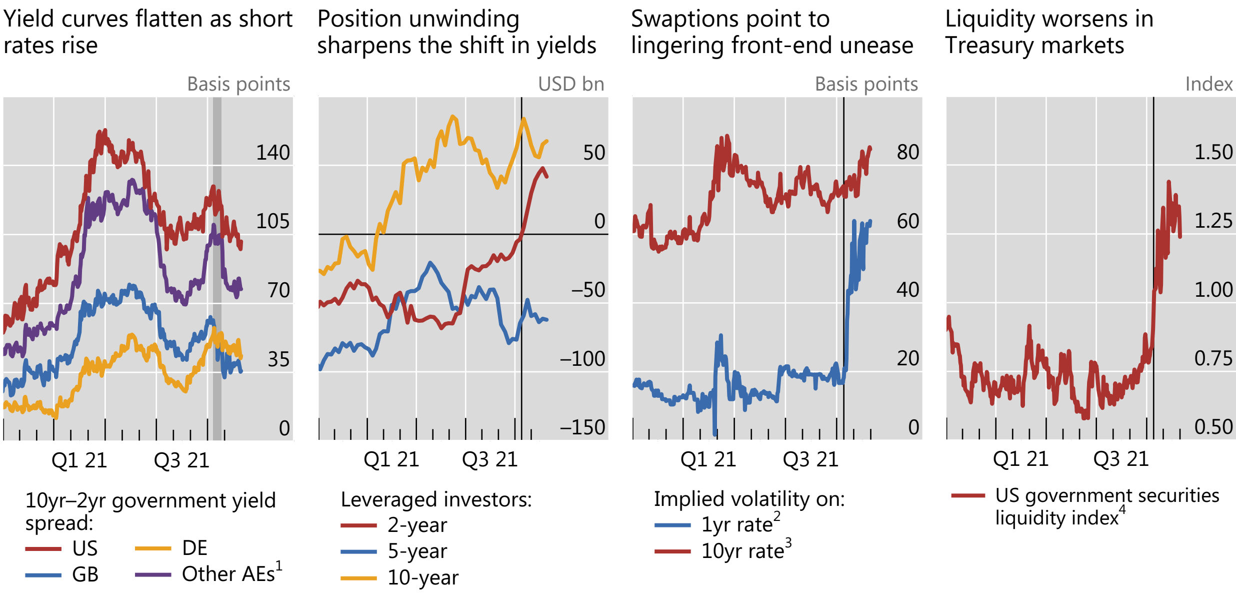
Yield curves whipsawed as action shifted between the two ends of the term structures. In a matter of a few days following the CPI news in October, term structures that had been steepening over several weeks suddenly flattened, compressing term spreads to the levels prevailing in mid-year (Graph 4, first panel). The additional swings caused by the news of the Omicron virus strain affected all yields similarly, resulting in a parallel downward shift in term structures that had little impact on term spreads.

Investor positioning and leverage exacerbated the violent movement in yields. Market intelligence suggests that the initial jump in front-end yields caught leveraged investors wrong-footed, forcing them to unwind their positions. Indeed, in line with this interpretation, futures positions across several Treasuries contracts suddenly reversed in early October, following the US CPI release (Graph 4, second panel).

The sharp bout of volatility in Treasuries left scars in several closely related market segments. The implied volatility in short-rate swaptions remained very elevated (Graph 4, third panel). Moreover, a broad measure of liquidity conditions in Treasury markets, based on yield curve fitting errors, also worsened significantly in the wake of the dislocations (fourth panel). Similar developments took place in the bond markets of other AEs. This is a tell-tale sign of arbitrage capital's inability or unwillingness to lean against mispricing.

Market dynamics exacerbate yield gyrations

Graph 4



The shaded area in the first panel indicates 11–26 October 2021 (release of September CPI data). The vertical line in the second, third and fourth panels indicates 13 October 2021 (release of US September 2021 CPI data).

[1] Simple average across AU, CA, DK, NZ and SE. [2] Based on USD swaptions with three-month maturity that give the right to enter a one-year overnight indexed swap. [3] Based on USD swaptions with three-month maturity that give the right to enter a 10-year overnight indexed swap. [4] Average yield-curve fitting error across the universe of US Treasury notes and bonds with remaining maturity of one year or longer, based on the intra-day Bloomberg relative value curve fitter.

Sources: Bloomberg; CFTC; BIS calculations.

Investors' concern about the inflation outlook in AEs was an important factor behind these yield adjustments. Indeed, market measures of inflation compensation increased markedly during the period under review, following a long pause in some cases (Australia, Canada, New Zealand, Sweden and the United States) and continuing an earlier trend in others, such as the United Kingdom and the euro area (Graph 5, first panel). The surge was especially stark in the euro area, where the outsize increase in natural gas prices passed through to wholesale electricity prices.

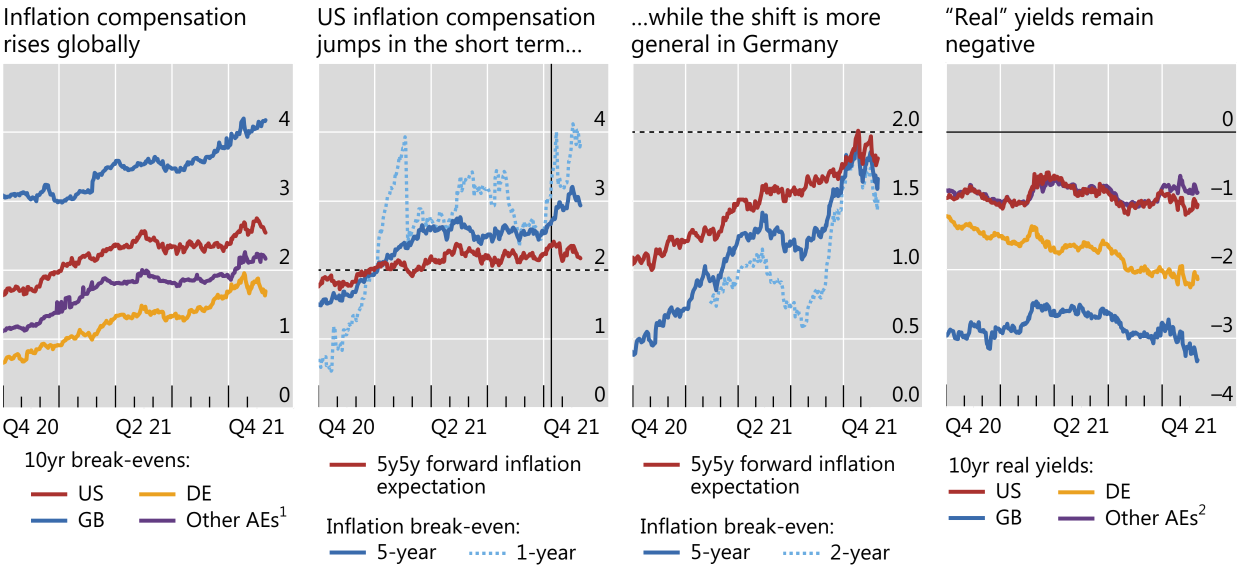
The repricing of the inflation outlook was concentrated mainly on the short and medium term. This was most visible in the United States, where compensation for inflation over the one- and five-year horizons moved sharply above the Federal Reserve's 2% inflation target in October and November, after having been broadly in line with it (Graph 5, second panel, solid and dashed blue lines). In contrast, inflation compensation beyond five years continued fluctuating very close to the target (red line). In Germany, all measures of inflation compensation have been gradually approaching the ECB's target throughout the year, with shorter-term measures in particular surging during the review period (third panel).

Yields on inflation-linked government securities ("real yields") remained deeply negative. Despite the increase in nominal yields, not least during the review period, real yields fell further across all AEs (Graph 5, fourth panel). The 10-year US real yield has remained negative for about 22 months in a row, a record since the US Treasury began issuing inflation-protected securities in 1997. Some observers have interpreted this fact as an enduringly sober outlook for long-term economic growth. Market commentary also points to persistent supply-demand imbalances in this market segment against the backdrop of strong investor appetite for inflation hedges.

The inflation outlook looms large in bond markets

In per cent

Graph 5



The vertical line in the second panel indicates 13 October 2021 (release of US September 2021 CPI data). The horizontal dashed line in the second and third panels indicates the respective inflation target.

[1] Simple average of AU, CA, NZ and SE. [2] Simple average of AU, CA and SE.

Sources: Federal Reserve Bank of St Louis, FRED; Bloomberg; BIS calculations.

Clouds on the horizon for EMEs

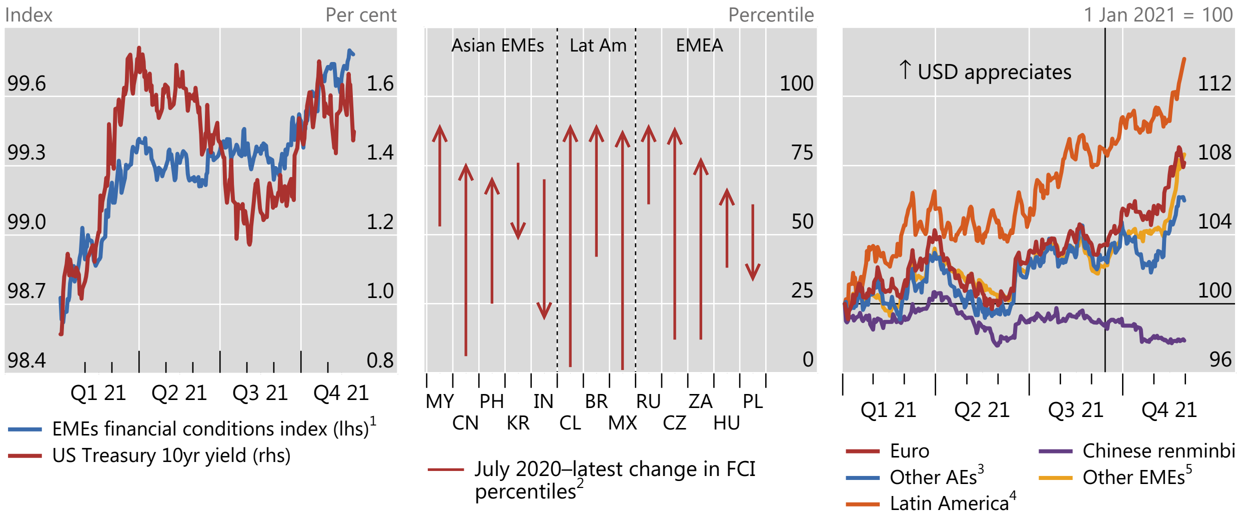
Several EMEs were battered by a combination of rising global rates and stubbornly high domestic inflation. Rising AE long-term rates early in the review period intensified funding strains, putting additional pressure on exchange rates. This compounded concerns about reduced fiscal space and persistent inflation in most countries, especially in Latin America. Home-grown challenges characterised the plight of other EMEs, notably China, which faced continued stress in its large property sector and a softening growth outlook. Several countries confronted worsening policy trade-offs, with inflation calling for tighter policy while recoveries lagged. The pandemic news at the end of the period only exacerbated these developments: broad financial conditions continued tightening, as sovereign yields rose further and exchange rates extended their depreciation.

Financial conditions tightened for most EMEs. A commonly used gauge – combining information from riskless rates, credit spreads, exchange rates, and stock prices – pointed to a tightening just as AE long-term rates inched up early in the review period (Graph 6, left-hand panel). This mimicked developments during the first quarter, when the reflation trade had been in full swing. However, unlike then, financial conditions did not ease much when AE long yields reversed course. This probably reflected exchange rate weakness and rising local currency yields, as central banks fought persistent inflationary pressures (see below). Over the past 18 months, the financial headwinds have been particularly strong in Latin America, followed by China and Europe, the Middle East and Africa (centre panel). For many EMEs, the most recent conditions are close to the tightest they have been over the past year and a half.

Financial conditions tighten in EMEs on the back of a stronger dollar

Graph 6

EME financial conditions tightened with rising AE yields | Tightening was broad-based | The dollar appreciated against most currencies, notably those from Latin America



The vertical line in the right-hand panel indicates 13 September 2021 (the start of the period under review).

[1] Goldman Sachs financial conditions index (FCI), which is a weighted average of country-specific riskless interest rates, exchange rate, 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. [2] For each country, the arrow's starting point indicates the percentile of the FCI on 1 July 2020, calculated using the country-specific FCI distribution from 1 July 2020 to 29 November 2021. The endpoint of the arrow indicates the percentile of the FCI on 29 November 2021, calculated using the same FCI distribution. The arrows thus express the size and direction of the change in FCI percentiles over the period. An upward (downward) arrow indicates tightening (loosening). [3] AU, CA, CH, DK, GB, JP, NO, NZ and SE. [4] AR, BR, CL, CO, MX and PE. [5] CZ, HK, HU, ID, IL, IN, KR, MY, PH, PL, RU, SA, SG, TH, TR, TW and ZA.

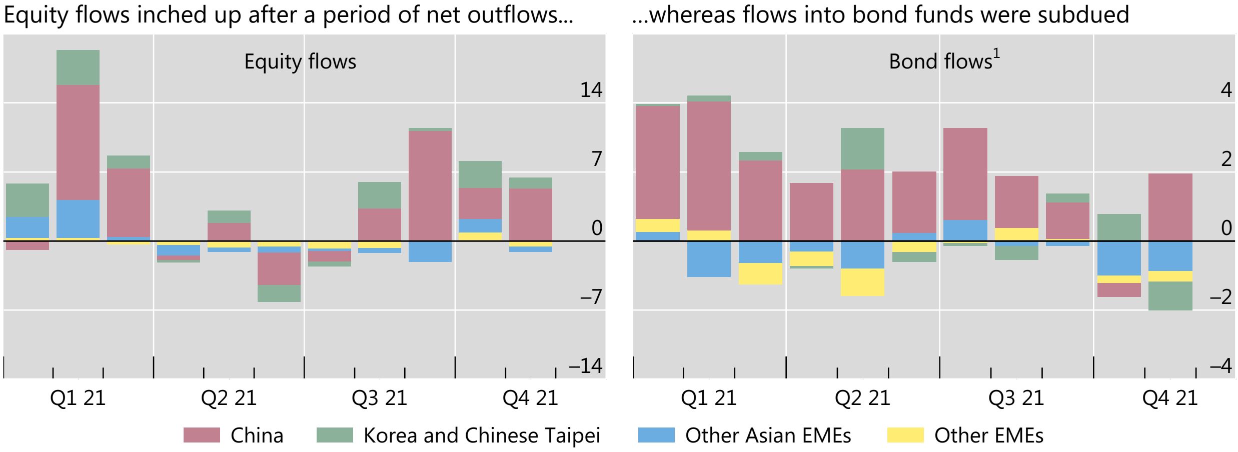
Sources: Bloomberg; Goldman Sachs, Marquee; BIS calculations.

Exchange rates were a key factor in most countries. While the dollar appreciated broadly during the period under review, especially towards the end, gains were particularly large vis-à-vis EME currencies, most notably in Latin America (Graph 6, right-hand panel). Together with rising energy prices, renewed currency weakness exacerbated the inflationary pressures that had been building earlier in the year. The Turkish lira was hard hit, plunging by as much as 15% on a single day, in the wake of a third consecutive rate cut despite high inflation. The Chinese renminbi, in contrast, was the most notable exception.

Flows into equity and bond funds painted a mixed picture, with the swings affecting Asian EMEs almost exclusively. Despite China's challenges, flows to equity funds in this country picked up after a few months of net outflows (Graph 7, left-hand panel). The rebound came after closer scrutiny on listings outside China made it difficult to get exposure to Chinese assets offshore. Equity flows to Korea and Chinese Taipei remained strong, as had been the case for these two global semiconductor hubs almost continuously since the outbreak of Covid-19. Other EMEs, in contrast, saw no equity flows on net over the period under review. Flows to bond mutual funds displayed varying country patterns. Positive inflows towards Chinese funds contrasted with large outflows from Asian EMEs other than China, Korea and Chinese Taipei (right-hand panel).

Portfolio inflows remained tilted towards Asian EMEs

In billions of US dollars Graph 7



[1] Flows to local currency bond funds.

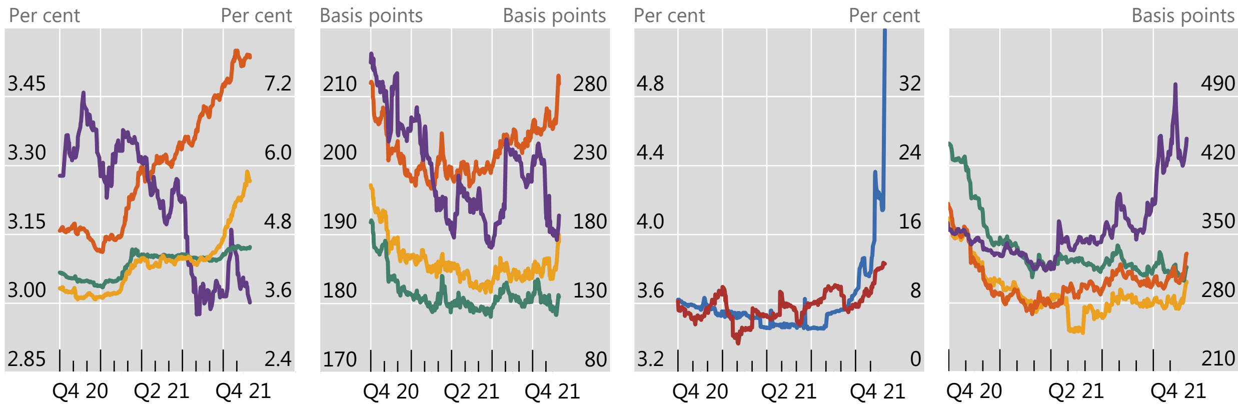
Sources: EPFR; BIS calculations.

The predicament of several EMEs was visible in sovereign funding markets, especially in local currency. Prompted by persistent inflation, many central banks continued their hiking cycles (eg those of Brazil, Chile, the Czech Republic, Russia) or began tightening (eg Colombia, Poland). Accordingly, local currency sovereign bond yields rose in most EMEs, contributing to the tightening of financial conditions (Graph 8, first panel). By contrast, spreads on US dollar-denominated sovereign bonds pointed to a somewhat more benign picture, suggesting only moderate investor concerns about credit risk (second panel). Exceptions include China, where a temporary rise was probably due to spillovers from sectoral stress, and Latin America, where an ongoing upward path was boosted by the news on the pandemic front.

Turning to corporate markets, stress remained concentrated in China. As regards local currency yields, they inched up only slightly for investment grade Chinese borrowers but spiked sharply for the riskiest companies (Graph 8, third panel), not least in the wake of the recent Covid news. While spreads rose substantially in China, also for dollar-denominated corporate debt, they barely budged in other EMEs (fourth panel). As in AEs, credit spreads recorded an uptick towards the end of the review period.

Local currency yields rose in some EMEs; contagion from China remained limited Graph 8

Sovereign yields picked up, especially outside Asia	Latin America also saw rising sovereign USD spreads	Bond yields spiked for riskiest Chinese borrowers	Credit risk rose in China, with no visible contagion



Local currency bond yields:[1]

Lhs: — China

Rhs: — Asian EMEs (excl CN) — Latin America (excl AR) — EMEA (excl TR)

USD bond spreads:[2]

China offshore RMB corporate bond yields:

— IG (lhs) — HY (rhs)

USD corporate bond spreads:[3]

— China
— Asian EMEs (excl CN)
— Latin America (excl AR)
— EMEA (excl TR)

[1] Simple averages of JPMorgan Chase GBI sub-indices, traded yields. [2] JPMorgan Chase EMBI Global sub-indices, stripped spreads. [3] JPMorgan Chase CEMBI sub-indices, stripped spreads.

Sources: IHS Markit; JPMorgan Chase; BIS calculations.

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DeFi risks and the decentralisation illusion[1]

Decentralised finance (DeFi) is touted as a new form of intermediation in crypto markets. The key elements of this ecosystem are novel automated protocols on blockchains – to support trading, lending and investment of cryptoassets – and stablecoins that facilitate fund transfers. There is a "decentralisation illusion" in DeFi since the need for governance makes some level of centralisation inevitable and structural aspects of the system lead to a concentration of power. If DeFi were to become widespread, its vulnerabilities might undermine financial stability. These can be severe because of high leverage, liquidity mismatches, built-in interconnectedness and the lack of shock absorbers such as banks. Existing governance mechanisms in DeFi would provide natural reference points for authorities in addressing issues related to financial stability, investor protection and illicit activities.

JEL classification: G18, G23, O39.

Crypto markets are underpinned by various forms of intermediation. While some forms of crypto intermediation have direct analogues in traditional finance, others – known as decentralised finance, or "DeFi" – are fundamentally new and have recently gained more traction. DeFi provides financial services without centralised intermediaries, by operating through automated protocols on blockchains. The DeFi ecosystem revolves around two elements: (i) novel protocols for trading, lending and investing, and (ii) stablecoins, which are cryptoassets that facilitate fund transfers and aim to maintain a fixed face value vis-à-vis fiat currencies, mainly the US dollar.

While the main vision of DeFi's proponents is intermediation without centralised entities, we argue that some form of centralisation is inevitable. As such, there is a "decentralisation illusion". First and foremost, centralised governance is needed to take strategic and operational decisions. In addition, some features in DeFi, notably the consensus mechanism, favour a concentration of power.

In principle, DeFi has the potential to complement traditional financial activities. At present, however, it has few real-economy uses and, for the most part, supports speculation and arbitrage across multiple cryptoassets. Given this self-contained nature, the potential for DeFi-driven disruptions in the broader financial system and the real economy seems limited for now.

[1] The authors thank Mike Alonso, Raphael Auer, Marcel Bluhm, Claudio Borio, Stijn Claessens, Sebastian Doerr, Jon Frost, Anneke Kosse, Asad Khan, Ulf Lewrick, Benoît Mojon, Benedicte Nolens, Tara Rice, Hyun Song Shin, Vladyslav Sushko and Nikola Tarashev for helpful comments and discussions, and Ilaria Mattei for excellent research assistance. The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

Key takeaways

- Decentralised finance (DeFi) aims to provide financial services without intermediaries, using automated protocols on blockchains and stablecoins to facilitate fund transfers.
- There is a "decentralisation illusion" in DeFi due to the inescapable need for centralised governance and the tendency of blockchain consensus mechanisms to concentrate power. DeFi's inherent governance structures are the natural entry points for public policy.
- DeFi's vulnerabilities are severe because of high leverage, liquidity mismatches, built-in interconnectedness and the lack of shock-absorbing capacity.

DeFi would need to satisfy a number of conditions if it is to become a widely used form of financial intermediation. For one, blockchain scalability and large-scale tokenisation of traditional securities would need to be improved. No less importantly, DeFi will need to be properly regulated. Public authorities would need to interface with DeFi's inherent governance structures, so as to ensure sufficient financial stability safeguards as well as to enhance trust by addressing investor protection issues and illegal activities.

This special feature examines DeFi mainly from a financial stability perspective, drawing attention to vulnerabilities that stem from leverage and liquidity mismatches. As a key attribute of crypto markets, leverage amplifies their volatility and procyclicality. In addition, the crypto ecosystem lacks internal shock absorbers, such as banks, that can provide liquidity at times of stress. This increases the potential for stablecoin runs that could sever links across investors and platforms, eroding the "networked liquidity" that is a defining feature of DeFi.

The rest of this special feature is organised as follows. The first section provides an overview, focusing on the building blocks of the DeFi ecosystem. The second outlines the decentralisation illusion. The third discusses key vulnerabilities from a financial stability perspective. The final section concludes with policy considerations.

The DeFi ecosystem

An overview

Decentralised finance (DeFi) is a fast-growing part of the crypto financial system. The rise of cryptoassets can be traced back to a whitepaper (Nakamoto (2008)) outlining a peer-to-peer transaction mechanism – blockchain – and the creation in 2009 of the first consequential cryptoasset – Bitcoin (BTC). Numerous blockchain technologies, as well as the respective cryptoassets that serve as mediums of exchange, have mushroomed since then. A key milestone was the development of Ethereum and its associated cryptoasset Ether (ETH). This technology supports automated contracts with pre-defined protocols hosted on blockchains, commonly referred to as "smart contracts",[2] and was instrumental to spurring on the DeFi ecosystem.

[2] Blockchains like Ethereum enable the execution and validation of more elaborate contracts than simply user A pays a certain amount of cryptoassets to user B (which is an accounting system first operationalised by the Bitcoin blockchain). For instance, an automated trading contract allows A and

Crypto vs traditional financial system[1] Table 1

Function	Service	Crypto financial system: Decentralised finance (DeFi)	Crypto financial system: Centralised finance (CeFi)	Traditional finance
Trading	Funds transfer	DeFi stablecoins (DAI)	CeFi stablecoins (USDT, USDC)	Traditional payment platforms
	Asset trading	Crypto asset DEX (Uniswap)	Crypto CEX (Binance, Coinbase)	Exchanges and OTC brokers
	Derivatives trading	Crypto derivatives DEX (Synthetix, dYdX)		
Lending	Secured lending	Crypto decentralised lending platforms (Aave, Compound)	Crypto centralised lending platforms (BlockFi, Celsius)	Broker-dealers active in repo and securities lending
	Unsecured lending	Crypto credit delegation (Aave)	Crypto banks (Silvergate)	Commercial banks and non-bank lenders
Investing	Investment vehicles	Crypto decentralised portfolios (yearn, Convex)	Crypto funds (Grayscale, Galaxy)	Investment funds

CEX = centralised exchanges; DEX = decentralised exchanges; OTC = over-the-counter; USDC = USD Coin; USDT = Tether.

[1] Illustrative examples are given in parentheses.

Source: Authors' elaboration.

The term DeFi refers to the *financial applications* run by smart contracts on a blockchain, typically a permissionless (ie public) chain.[3] Table 1 juxtaposes DeFi with centralised finance (CeFi) in crypto markets, as well as with the traditional financial system. The key difference between DeFi and CeFi lies in whether the financial service is automated via smart contracts on a blockchain or is provided by centralised intermediaries. While DeFi records all the contractual and transaction details on the blockchain (ie on-chain), CeFi relies on the private records of intermediaries, such as centralised exchanges and other platforms (ie off-chain).

DeFi aims to provide financial services without using centralised entities. Namely, it digitises and automates the contracting processes, which – according to its proponents – could in the future improve efficiency by reducing intermediation layers. Importantly, it also provides users with much greater anonymity than transactions in CeFi or traditional finance. Such propositions have been key drivers of the heightened interest in DeFi platforms and the strong price rises of the attendant cryptoassets (Graph 1 left-hand panel). The expansion of DeFi in turn has hastened

B to exchange their assets according to an agreement on the terms of the transfer, contingent on pre-specified conditions. This is essentially an over-the-counter (OTC) trade without the traditional intermediaries, such as dealer banks.

3 A permissionless blockchain allows anyone to participate in the validation of transactions, while a permissioned one allows only a pre-selected group of participants to validate transactions.

the emergence of alternative blockchain designs that host smart contracts and seek to rival Ethereum.[4]

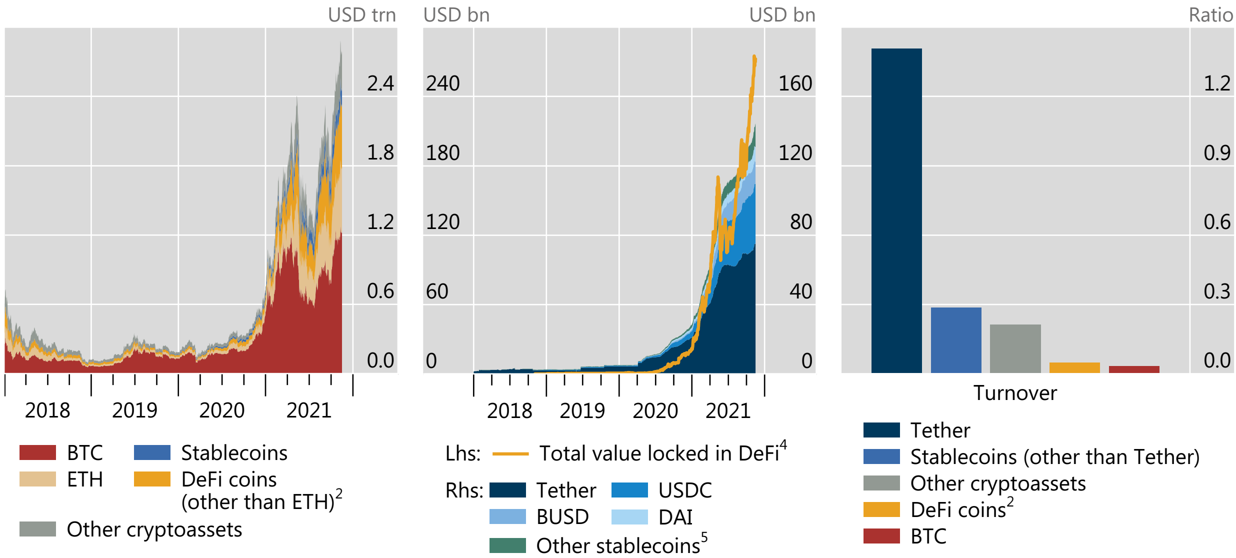
The building blocks of DeFi

DeFi differs from traditional finance not so much in terms of the types of service it seeks to provide, but rather in how it performs them. Each row in Table 1 represents a specific service, grouped under three broad functions: trading, lending and investment. This section analyses the main building blocks of these services, and how the underlying mechanisms compare with those in CeFi and traditional finance.

Stablecoins are cryptoassets that strive to tie their values to fiat currencies, such as the US dollar. They play an important role in the DeFi ecosystem, facilitating fund transfers across platforms and between users. Stablecoins allow DeFi market participants to avoid converting to and from fiat money at every turn. They also act as a bridge between the crypto and the traditional financial systems, which share a common numeraire – ie fiat currencies.

DeFi underpins the rapid growth in crypto activities — Graph 1

Market cap of cryptoassets surges, boosted by DeFi-related coins[1] | Stablecoins gained ground as capital in DeFi apps climbed[3] | Turnover of stablecoins dwarfs that of other cryptoassets[6]



BTC = Bitcoin; BUSD = Binance USD; ETH = Ether; USDC = USD Coin.

[1] Market capitalisation of top 100 cryptoassets as of 15 November 2021 (seven stablecoins, 36 DeFi coins and 55 other cryptoassets). [2] Cryptoassets issued by DeFi platforms. [3] Stacked areas plot stablecoins' value in circulation. The selected stablecoins are those ranked as the top four by market capitalisation as of 15 November 2021. [4] Total value locked refers to the size of capital pools underpinning DeFi protocols. The sample includes 679 protocols. [5] Includes 57 other stablecoins. [6] Based on the top 20 cryptoassets by market capitalisation as of 15 November 2021 (three stablecoins, 10 DeFi coins and seven other cryptoassets). Turnover is the monthly average of the daily volume-to-market capitalisation ratio from 15 October to 15 November 2021.

Sources: CoinGecko; Defi Llama; authors' calculations.

[4] Transactions are validated and added to a blockchain via consensus, ie a network of "validators" need to expend resources to agree on which transactions are legitimate. Bitcoin and Ethereum blockchains build on proof-of-work, which is energy-intensive and raises scalability issues (Auer (2019)). Alternative blockchain designs have sought to overcome these problems by relying on consensus among a majority of the holders of a blockchain's exchange medium (proof-of-stake).

The growth of stablecoins has been exponential since mid-2020, when DeFi activities started to take off. As of late 2021, the value of the major stablecoins in circulation reached $120 billion (Graph 1, centre panel), as compared with the roughly $200 billion size of the largest money market fund. In particular, USD Tether has gained substantial scale as a "vehicle currency" for investors who seek to trade in and out of cryptoassets (right-hand panel). Being the first stablecoin, its growth has benefited from a user base built up early on, which has attracted new adopters seeking ease of trading (network externalities).

The mechanism for assuring a stable value varies across different designs.[5] The majority of stablecoins are CeFi – eg USD Tether – as they are managed off-chain. Others, such as DAI, are DeFi stablecoins that are managed on-chain. In the case of CeFi stablecoins, a designated intermediary manages issuance and redemption as well as the reserve assets backing the stablecoins. Some of these assets are bank deposits or their close substitutes. Other assets may comprise short-term securities – such as Treasury bills, certificates of deposit and commercial paper – as well as cryptoassets themselves. To the extent that DeFi relies on such stablecoins, it remains dependent on CeFi and traditional finance.

DeFi stablecoins record all transacting histories directly on-chain, without the involvement of centralised intermediaries. They rely on an overcollateralised pool of cryptoassets, ie the underlying assets are worth more than the stablecoins in circulation. Since crypto collateral has a very high price volatility, as measured in the reference fiat currency, DeFi stablecoins incentivise users to actively monitor the collateralisation ratio. To do so, the smart contracts behind these stablecoins allow any user to seize the collateral when the collateralisation ratio falls below a certain threshold (which is higher than 100%) and to redeem the stablecoins.[6] Such a design ensures that the value of stablecoins remains tied to the fiat currency. Other DeFi stablecoins have attempted to minimise their price volatility vis-à-vis a fiat currency by relying solely on algorithms (ie dispensing with collateral). They do so by adjusting the supply of stablecoins to match their demand. So far, no purely algorithmic stablecoin has been widely adopted.

In sum, stablecoin issuers receive assets (collateral) in exchange for their own liabilities (stablecoins). While this mechanism looks superficially similar to how banks operate, there are fundamental differences. Issuers lack public backstops, such as deposit insurance, and rely on private backstops (collateral) to ensure that stablecoins maintain a steady value and are suitable as mediums of exchange. As such, the expansion of the balance sheets of stablecoin issuers, at least currently, is driven more by the appetite of investors to hold the stablecoins than by any desire of the issuers to acquire more assets. In other words, this growth is liability-driven, while the expansion of bank balance sheets is commonly asset-driven (McLeay et al (2014)).[7]

5 See G7 Working Group on Stablecoins (2019), IMF (2021) and PWG (2021) for more details.

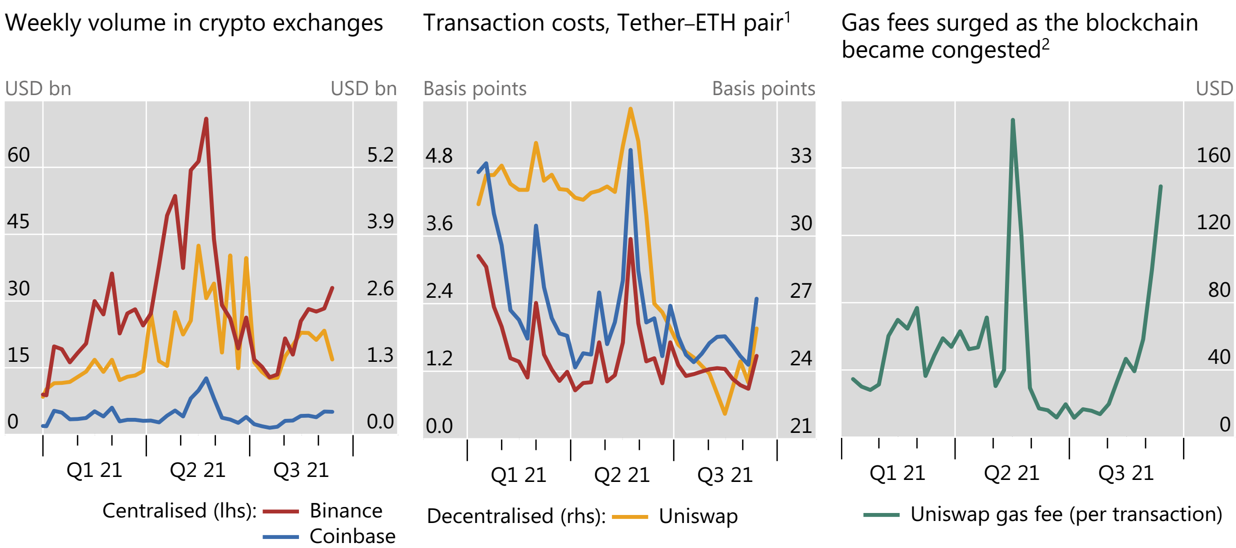
6 Given that the collateralisation ratio is still above 100%, users who seize the collateral and redeem the stablecoins would earn a profit as long as the collateral value remains above the stablecoin's.

7 At present, the "business model" of stablecoins implies that they are passive vehicles that issue liabilities only upon user demand. However, financial history shows that, when their liabilities become widely accepted as a means of payment, intermediaries usually tend to actively expand liability issuance to finance asset purchases, especially when a regulatory framework is lacking. See eg Frost et al (2020) comparing stablecoins with the Bank of Amsterdam (1609–1820). A key feature of the Bank of Amsterdam that eventually led to its collapse was that the shift towards a more opportunistic issuance of liabilities was unchecked by regulation and lacked a public backstop.

Trading of cryptoassets can take place on both **centralised exchanges (CEXs)** and **decentralised exchanges (DEXs**). The former are structured around the same principles as their conventional counterparts. CEXs maintain off-chain records of outstanding orders posted by traders – known as limit order books. By contrast, DEXs work in substantially different ways, by matching the counterparties in a transaction through so-called automated market-maker (AMM) protocols. AMMs follow mathematical formulas to determine prices based on transaction volumes. Box A discusses how AMMs incentivise liquidity provision; it also looks at their susceptibility to market manipulation. Both CEXs and DEXs have seen substantial growth since 2020, although the share of DEXs in the overall transaction volume on crypto exchanges has remained below 10% (Graph 2, left-hand panel).

At present, it seems to be costlier to trade on DEXs than on CEXs, especially for smaller transactions. For instance, the relative bid-ask spread for the Tether-ETH pair on a popular DEX has been up to 30 basis points wider than on a CEX (Graph 2, centre panel). In addition, trading on DEXs incurs execution costs when transactions are validated on the blockchain. These stem from so-called gas fees, which are designed to compensate validators. Gas fees increased markedly as cryptoassets gained popularity and blockchains such as Ethereum became more congested (compare left- and right-hand panels). Although transaction costs are higher in DEXs, some traders still prefer these platforms, in part due to their greater anonymity and interoperability with other DeFi applications (the so-called “DeFi Lego”).[8]

Centralised and decentralised exchanges: volumes and trading costs Graph 2



[1] Transaction costs are measured as the relative bid-ask spread, defined as 2*(ask price – bid price)/(ask price + bid price) for Tether-Ether in Coinbase, Binance and Uniswap. [2] Gas fees are payments made by users to compensate validators for the computing power required to process and validate transactions on the Ethereum blockchain. The time series is calculated for Tether-Ether in Uniswap.

Sources: Bitquery, Binance; CoinGecko; Coinbase Pro; authors’ calculations.

[8] A trader wishing to combine CEX trading with DeFi lending or investing would incur round-trip gas fees, first transferring cryptoassets off-chain and then moving them back on-chain after trading on the CEX. The combined fees would limit the appeal of CEXs that offer lower spreads.

Lending in DeFi tends to be overcollateralised. The reason is similar to that underpinning the overcollateralisation of DeFi stablecoins – the inherent lack of trust in anonymous transactions, together with the high volatility of the cryptoassets used as collateral. To protect the lender, loans can be automatically liquidated when the collateralisation ratio falls below a threshold. At present, the need for crypto collateral stands in the way of lending to households and businesses, eg for house purchases or productive investment. Nonetheless, outstanding loans on the major lending platforms have increased rapidly, to $20 billion in late 2021 (Graph 3, left-hand panel). Rudimentary forms of unsecured lending, known as "credit delegation", are available on some platforms. This often involves entities with established off-blockchain relationships, making collateral unnecessary.

DeFi lending platforms also offer a unique financial instrument, typically referred to as **flash loans.** These allow arbitrageurs to act without their own capital by taking out a loan for the entire arbitrage trade and then repaying the loan. Such loans are of zero duration and are essentially risk-free (requiring no collateral), as they are granted only if the arbitrage trade ensures the repayment of both principal and interest. Crucially, this is possible as all legs of the transaction can be attached to the same block (ie settled) simultaneously on the blockchain.[9] Flash loans have increased in popularity, with the largest platform granting a total of about $5.5 billion of such loans between their inception in mid-2020 and late 2021.

The growth of DeFi lending platforms has also encouraged the development of applications similar to investment funds in traditional finance. These **decentralised portfolios** follow pre-determined investing strategies, eg aggregating funds from investors and automatically shifting them across crypto lending platforms to profit from the best yields. As of late 2021, the funds held by two popular decentralised portfolios stood at around $10 billion (Graph 3, centre panel).

The "decentralisation illusion" in DeFi

DeFi purports to be decentralised. This is the case for both blockchains and the applications they support, which are designed to run autonomously – to the extent that outcomes cannot be altered, even if erroneous.[10]

But full decentralisation in DeFi is illusory. A key tenet of economic analysis is that enterprises are unable to devise contracts that cover all possible eventualities, eg in terms of interactions with staff or suppliers. Centralisation allows firms to deal with this "contract incompleteness" (Coase (1937) and Grossman and Hart (1986)). In DeFi, the equivalent concept is "algorithm incompleteness", whereby it is impossible to write code spelling out what actions to take in all contingencies.

This first-principles argument has crucial practical implications. All DeFi platforms have central governance frameworks outlining how to set strategic and operational

9 Besides facilitating arbitrage, flash loans open the door to market manipulation. Using a large volume of flash loans, an attacker can, for instance, manipulate the number of tokens in an AMM – which is a critical parameter in determining the prices of such tokens. In October 2020, the crypto trading platform Harvest was exploited by a flash loan attack, incurring losses of $27 million.

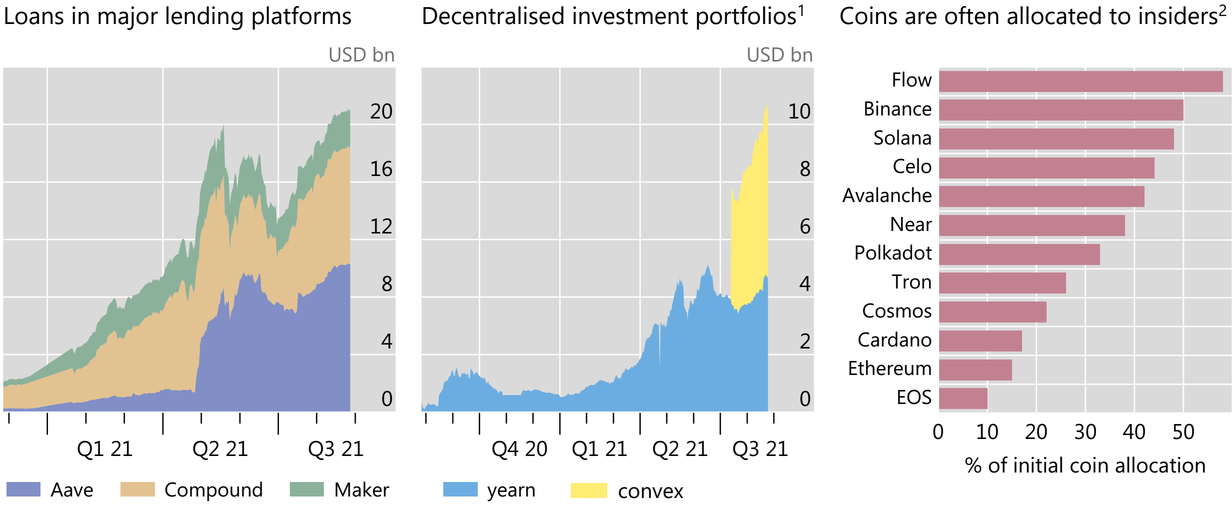
10 For instance, in October 2021, an update to the lending platform Compound introduced an error that incorrectly distributed rewards worth $90 million. The platform's founder posted on Twitter that "There are no administrative controls or community tools to disable the […] distribution" of rewards. In traditional finance, erroneous transfers can be challenged in court.

priorities, eg as regards new business lines.[11] Thus, all DeFi platforms have an element of centralisation, which typically revolves around holders of "governance tokens" (often platform developers) who vote on proposals, not unlike corporate shareholders. This element of centralisation can serve as the basis for recognising DeFi platforms as legal entities similar to corporations. While legal systems are in the early stages of adapting, decentralised autonomous organisations (DAOs), which govern many DeFi applications, have been allowed to register as limited liability companies in the US state of Wyoming since mid-2021.

In addition, certain features of DeFi blockchains favour the concentration of decision power in the hands of large coin-holders. Transaction validators need to receive compensation that is sufficient to incentivise them to participate without committing fraud. Blockchains based on proof-of-stake, which are expected to improve scalability, allow validators to stake more of their coins so that they have a higher chance of "winning" the next block and receiving compensation. Since the associated operational costs are mostly fixed, this setup naturally leads to concentration (Auer et al (2021)).[12] Many blockchains also allocate a substantial part of their initial coins to insiders, exacerbating concentration issues (Graph 3, right-hand panel).

Concentration can facilitate collusion and limit blockchain viability. It raises the risk that a small number of large validators can gain enough power to alter the blockchain for financial gain. Furthermore, large validators could congest the blockchain with artificial trades between their own wallets ("wash trades"), steeply raising the fees that other traders pay them. Another concern is that validators can

DeFi applications take off, while blockchain insiders are likely to reap the gains — Graph 3



[1] Size of capital pools in these DeFi investment portfolios. [2] Initial coin allocation to insiders for major public (ie permissionless) blockchains as of 9 May 2021. Insiders includes development teams as well as early investors such as venture capital.

Sources: Messari Report, Power and Wealth in Cryptoeconomies, May 2021; Skew.

[11] Walch (2019) reviews DeFi from a securities regulation perspective, focusing on how decentralised it is in practice. She finds elements of centralisation, particularly in governance protocols.

[12] The trade-off between the blockchains' ability to handle large transaction volumes, stakeholder concentration and blockchain security is known as Buterin's "scalability trilemma".

front-run large orders for higher trading profits (see Box A). Although front-running also occurs in traditional finance, it incurs punitive measures from regulators. These rent-seeking behaviours are detrimental to investors and may erode DeFi's appeal going forward.

Discussions about changes to governance protocols, in particular to rein in collusion, have gained momentum in the DeFi community.[13] However, adopting these changes would not alter the basic fact that some centralisation is unavoidable.

Vulnerabilities and spillover channels

While DeFi is still at a nascent stage, it offers services that are similar to those provided by traditional finance and suffers from familiar vulnerabilities. The basic mechanisms giving rise to these vulnerabilities – leverage, liquidity mismatches and their interaction through profit-seeking and risk-management practices – are all well known from the established financial system. Some features of DeFi could make them particularly destabilising, though. In this section, we focus first on the role of leverage and run-risk in stablecoins due to liquidity mismatches, before covering spillover channels to the conventional intermediaries.

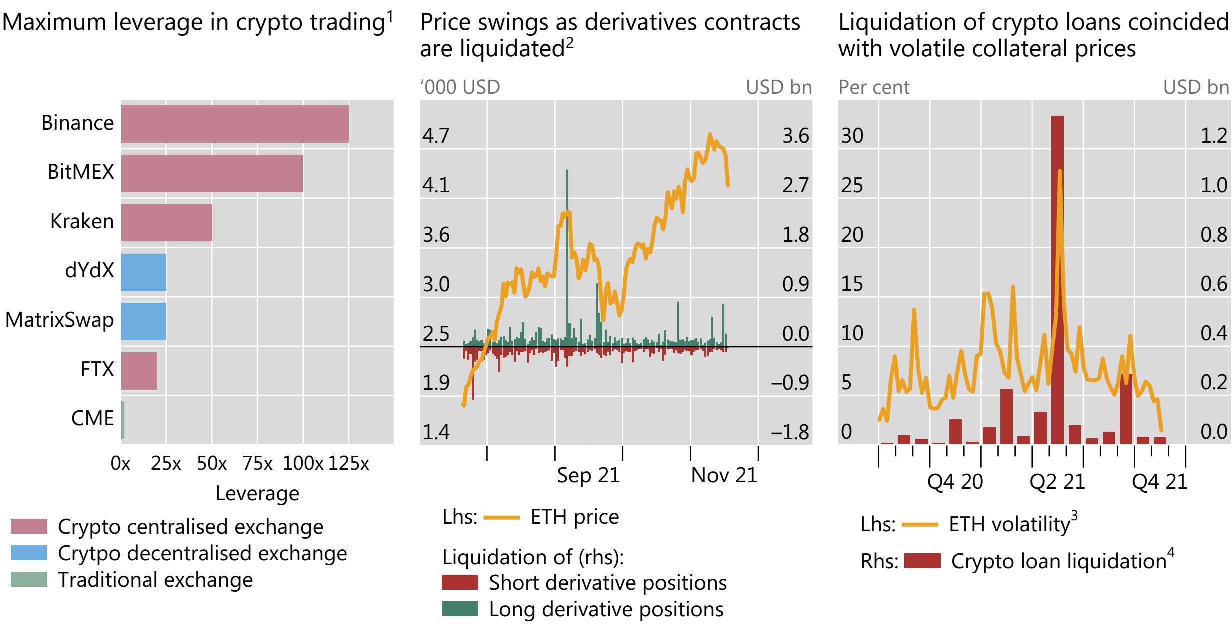
Leverage

DeFi is characterised by the high leverage that can be sourced from lending and trading platforms. While loans are typically overcollateralised, funds borrowed in one instance can be re-used to serve as collateral in other transactions, allowing investors to build increasingly large exposure for a given amount of collateral. Derivatives trading on DEXs also involves leverage, as the agreed payments take place only in the future. The maximum permitted margin in DEXs is higher than in regulated exchanges in the established financial system (Graph 4, left-hand panel). And unregulated crypto CEXs allow even higher leverage.

High leverage in crypto markets exacerbates procyclicality. Leverage allows more assets to be purchased for a given amount of initial capital deployed. But when debt eventually needs to be reduced, eg because of investment losses or depreciating collateral, investors are forced to shed assets, putting further downward pressure on prices. Such procyclicality can be amplified by the trading behaviour typical of markets at an early stage of development – eg the outsized role of momentum trading, which can add to price swings. In addition, the built-in interconnectedness among DeFi applications can also amplify distress, since the system's stability hinges on the weakest links.

[13] Proposals to overcome the issues associated with token voting include vote delegation to trusted members, which resembles proxy voting in traditional finance, and extending voting rights to all participants irrespective of their holdings of governance tokens, similar to firms organised as consumer cooperatives. See https://vitalik.ca/general/2021/08/16/voting3.html.

Leverage and procyclicality in crypto markets	Graph 4



[1] Maximum leverage for derivatives contracts as of 2021. For crypto exchanges, perpetual futures. For CME, standard futures. [2] Includes positions in the following crypto exchanges: Binance, Bitfinex, Bitmex, Bybit, Deribit, FTX, Huobi and Okex. [3] Volatility is defined as the weekly average of (highest price – lowest price)/close price at minute level. [4] Monthly liquidation volume in the largest DeFi lending protocols: Aave, Aave v2, bZx v2, Compound, Maker, Polygon Aave and Venus.

Sources: bybt; CoinGecko; CryptoCompare; The Block, www.theblockcrypto.com/data/decentralized-finance/cryptocurrency-lending; exchanges' websites; authors' calculations.

Financial intermediation in DeFi relies exclusively on private backstops, ie collateral, to mitigate risk and enable transactions when participants cannot trust each other. Thus, there are no shock absorbers in DeFi that can cut in during stress periods. By contrast, in traditional finance, banks are elastic nodes that can expand their balance sheets (extending loans or purchasing distressed assets) via the issuance of bank deposits, which are a widely accepted medium of exchange. The ability of banks to do so rests on their access to the central bank balance sheet (Borio (2019)).

The destabilising role of leverage came to the fore in the latest cryptoasset crash in September 2021. Forced liquidations of derivatives positions and loans on DeFi platforms accompanied sharp price falls and spikes in volatility (Graph 4, centre and right-hand panels).

Liquidity mismatches and run-risk in stablecoins

Stablecoins are inherently fragile. They are designed to target a fixed face value using various types of reserve asset. This arrangement gives rise to mismatches between the risk profiles of these assets (the underlying collateral) and the stablecoin liabilities. The vulnerability is similar to that of traditional intermediaries, such as money market funds, whose investors expect to be able to redeem in cash at par. Thus, contrary to what their name suggests, stablecoins are not money substitutes, since they lack a "no-questions asked" status (Gorton and Zhang (2021)).

The exact nature of stablecoins' vulnerabilities depends on their design. Coins backed by short-term securities with illiquid secondary markets, such as commercial paper, feature *liquidity* mismatches. Those backed by volatile collateral, such as cryptoassets, are exposed to *market risk*, because the value of these assets can quickly drop below the face value of stablecoins. Even though overcollateralisation generally offsets such risks, it can be exhausted when volatility spikes.[14]

Liquidity mismatches and exposure to market risk raise the possibility of investor runs. The viability of stablecoins hinges on investors' trust in the value of the underlying assets. Opaqueness and lack of regulation can easily erode this trust. If investors have doubts about the quality of the assets, they have an incentive to be the first to sell stablecoins or convert them to fiat currency. In turn, such a first-mover advantage can set off runs, leading to fire sales of the collateral.[15] Furthermore, an evaporation of trust in stablecoins could have wide repercussions for DeFi. Transfers of funds across investors and platforms would become more costly and cumbersome, impinging on the "networked liquidity" that is a key feature of DeFi.

Linkages with the traditional financial system

While DeFi is largely separate from the traditional financial system at present, connections could increase. This would raise the potential for spillovers, which would stem from linkages through both the asset and liability side of banks, as well as the activities of non-bank institutions that bridge the two systems.

A conservative regulatory approach has, so far, restricted banks' participation in the crypto ecosystem. On the asset side, banks' exposures are limited, in terms of both loans and equity investments (BCBS (2021)). The equity investments of large banks in crypto-related firms range from $150 million to $380 million in size as of late 2021, representing just a small fraction of their capital (Graph 5, left-hand panel).[16] On the liability side, some banks could receive funding from DeFi, since stablecoins might hold their certificates of deposit or commercial paper. As a result, runs on stablecoins could generate a funding shock for banks – akin to the familiar implications of a run on money market funds.

In addition, traditional non-bank investors are taking a growing interest in DeFi, as well as in the broader crypto markets. At present these investors include primarily family offices and hedge funds, which often receive credit from major dealer banks through prime brokerage. Funds with meaningful crypto exposure, some of which focus exclusively on DeFi while others are more diversified, have increased their assets from about $5 billion in 2018 to about $50 billion in 2021 (Graph 5, centre panel).

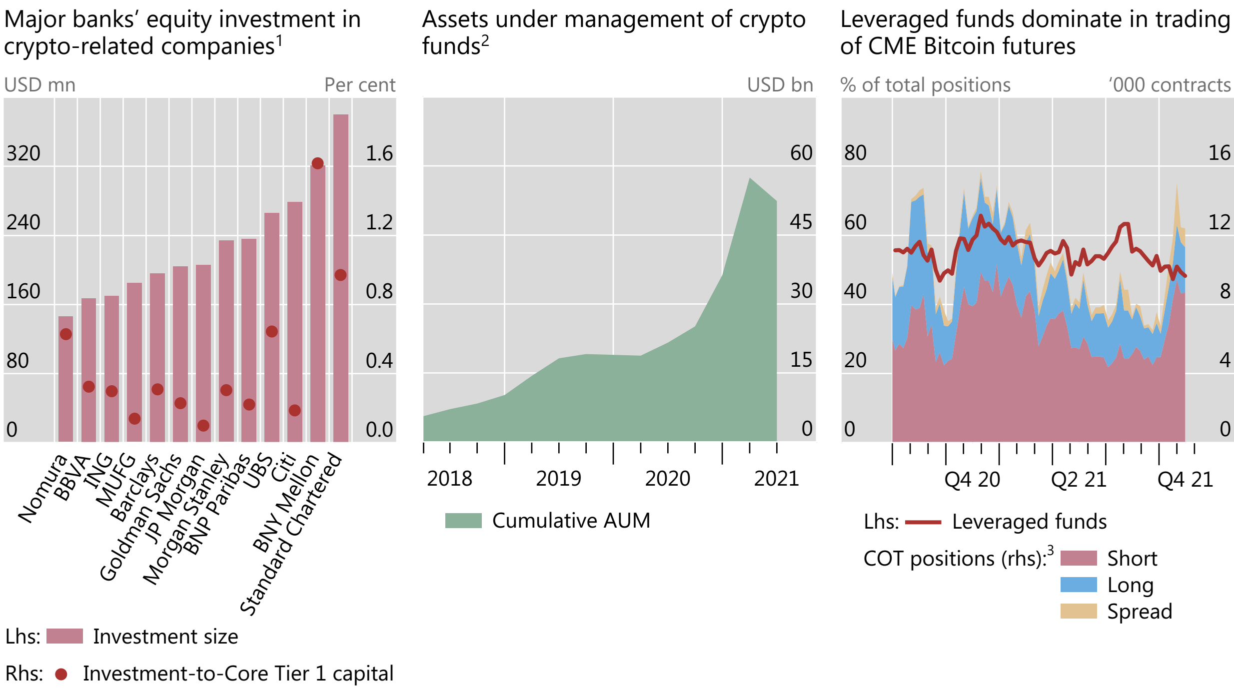
14 A recent example of losses on overcollateralised transactions relates to loans backed by the governance token of the most popular lending pool on the Binance smart chain (see https://blog.venus.io/venus-incident-report-xvs-liquidations-451be68bb08f).

15 Indeed, such a run on a DeFi stablecoin (IRON) took place in June 2021. See Iron post mortem: https://ironfinance.medium.com/iron-finance-post-mortem-17-june-2021-6a4e9ccf23f5.

16 In October 2021, Société Générale announced plans to borrow $20 million from MakerDAO – the issuer of the popular stablecoin DAI – using tokenised bonds as collateral.

Linkages between crypto and traditional financial systems

Graph 5



[1] Companies with a focus on cryptocurrencies technologies as of August 2021. The full list of the companies is available at www.blockdata.tech/blog/general/banks-investing-blockchain-companies. [2] Includes crypto hedge funds, venture funds, hybrid funds, private equity funds, fund of funds and passive funds. [3] Commitment of Traders (COT) positions from CME.

Sources: Sam Wouters, Top Banks Investing in Crypto & Blockchain Companies, Blockdata, October 2021; CME Group, Commitment of Traders; Crypto Fund Research, Crypto Fund Quarterly Report Q3 2020; Fitch Solutions; Statista; authors' calculations.

In a related sign of this increased involvement in crypto as an emerging asset class, leveraged investors, a category that includes hedge funds, are now a major participant in the trading of Bitcoin futures on the Chicago Mercantile Exchange (right-hand panel). Looking ahead, many intermediaries and infrastructures appear set to develop their business in crypto markets, including DeFi, alongside their traditional finance activities. This could potentially strengthen the links between the traditional and crypto systems. The recent popularity of a Bitcoin futures-based ETF is a tell-tale sign of this growing interest (see Todorov (2021) also in this issue).

Policy considerations and conclusions

Although it has grown rapidly, the DeFi ecosystem is still developing. At present, it is geared predominantly towards speculation, investing and arbitrage in crypto assets, rather than real-economy use cases. The limited application of anti-money laundering and know-your-customer (AML/KYC) provisions, together with transaction anonymity, exposes DeFi to illegal activities and market manipulation. On balance, DeFi's main premise – reducing the rents that accrue to centralised intermediaries – seems yet to be realised.

History shows that the early development of novel technologies often comes with bubbles and loss of market integrity, even while generating innovations that could potentially be of broader use down the road. With improvements to blockchain scalability, large-scale tokenisation of traditional assets, and most importantly, suitable regulation to ensure safeguards and enhance trust, DeFi could yet play an important role in the financial system.

The growth of DeFi poses financial stability concerns. One is leverage-driven procyclicality, which arises from changes in collateral value and fluctuations in the associated margins. Since collateral prices fall and margins rise at times of distress, downward price spirals often arise and may spread to the rest of the financial system. Due to the largely self-contained nature of DeFi, episodes of rapid deleveraging have thus far had little effect outside crypto markets.

Another concern applies more specifically to one of DeFi's main building blocks – stablecoins. If the attendant risks are not well managed, stablecoins are prone to runs, which would compromise their ability to transfer funds within the DeFi ecosystem. In addition, possible fire sales by a stablecoin of its reserve assets could generate funding shocks for corporates and banks, with a potentially severe impact on the broader financial system and the economy.[17] These risks are compounded by the fact that users treat stablecoins as a medium of exchange, although they are neither central bank money nor commercial bank money.

Since the main challenges in DeFi resemble those in traditional finance, established regulatory principles can serve as a compass. The basic tenet "same risks, same rules" should apply, not least to counter regulatory arbitrage. From a systemic perspective, policy measures should lead DeFi participants to internalise costs arising from the procyclicality of leverage. To address the run-risk in stablecoins and the associated possibility of wider contagion, policymakers can draw on precepts in bank regulation and supervision, on current initiatives in securities regulation about strengthening investment funds' prudential framework, and on international risk management standards for payment infrastructures.[18] Likewise, authorities focused on market integrity and illicit financial activities will need to expand their realm to cover DeFi.

The decentralised nature of DeFi raises the question of how to implement any policy provisions. We argue that full decentralisation in DeFi is an illusion. And indeed, platforms have groups of stakeholders that take and implement decisions, exercising managerial or ownership benefits. These groups, and the governance protocols on which their interactions are based, are the natural entry points for policymakers. These entry points should allow public authorities to contain DeFi-related issues before this ecosystem attains systemic importance. Regulatory safeguards would also help to ensure that the innovative potential of DeFi brings overall benefits to finance.

17 Also see Arner et al (2020). As a better substitute for stablecoins, which are privately issued, central bank digital currencies (CBDCs) could support fund transfers with greater efficiency and safety.

18 See BCBS (2021) and PWG (2021). Also see CPMI-IOSCO (2021) for proposed guidance on the use of stablecoins as a settlement asset by a stablecoin arrangement.

Box A

Trading in the DeFi era: automated market-makers

Sirio Aramonte, Wenqian Huang and Andreas Schrimpf[1]

Trading of cryptoassets in DeFi relies on new and unique matching mechanisms. One widely used mechanism in traditional finance is the centralised limit order book, which entails keeping electronic records of all outstanding orders. Likewise, crypto centralised exchanges (CEXs such as FTX, Binance or Kraken) rely on limit order books managed *off-chain*. But in DeFi, the sheer volume of orders would render the management of an *on-chain* limit order book very costly. Another mechanism in traditional finance – the dealership model, where dealers use inventories of assets in over-the-counter (OTC) trading – revolves around establishing trustworthy relationships with counterparties. Such intermediation is not feasible in DeFi due to the anonymity of transactions, and it also goes against the stated aim of building an intermediary-free ecosystem. To dispense with limit order books and the dealership model, decentralised exchanges (DEXs) resort to so-called *automated market-maker* (AMM) protocols.

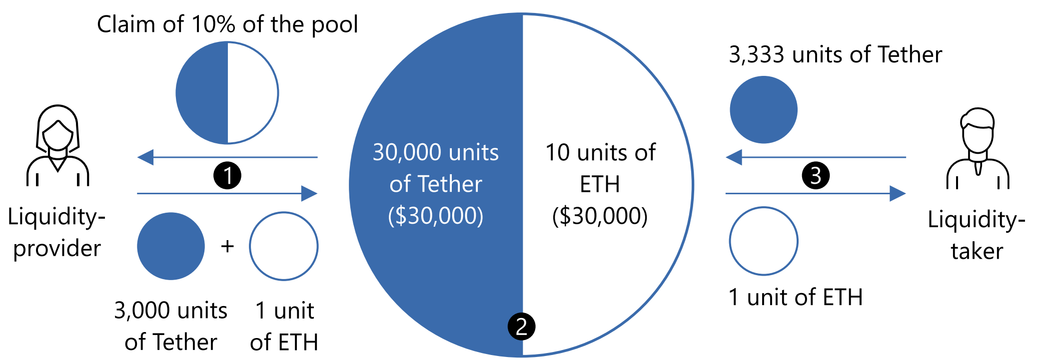
AMM protocols allow traders to exchange one cryptoasset for another automatically on a blockchain. They build on the idea that traders can become liquidity-providers by making their cryptoassets (eg ETH and Tether) available in liquidity pools. In turn, protocols allow other traders demanding liquidity (ie liquidity-takers) to buy or sell the cryptoassets in the pool, with relative prices set on the basis of quantities.[2] One popular type of AMM sets the liquidity-takers' exchange rate between token X and Y on the basis of the following *constant product function* that links relative prices and quantities (also known as the *bonding curve*):

*Amount of token X * Amount of token Y = constant.*

DEX – constant product function market-maker

Graph A

0 *Suppose 1 Tether = $1, 1 ETH = $3,000*
Initially, 27,000 units of Tether and 9 units of ETH, each worth $27,000



Transactions:

1 *A liquidity-provider "deposits" 3,000 units of Tether and 1 unit of ETH*

2 *After this deposit, the pool contains 30,000 units of Tether and 10 units of ETH*
*Following the bonding curve, the constant equals 300,000 (= 30,000 * 10)*
The liquidity-provider has a claim of 10% of the pool's crypto-assets

3 *A liquidity-taker wishes to buy 1 unit of ETH*
*The price for 1 ETH is (30,000 + x) * (10 – 1) = 300,000*
Thus, x = 3,333, which is the amount of Tether the taker pays for 1 ETH
End result: the pool contains 33,333 units of Tether and nine units of ETH

Liquidity-provider's value
(10% of the pool)

Before trade
3,000 units of Tether
+ 1 unit of ETH
= $6,000

After trade
3,333 units of Tether
+ 0.9 units of ETH
= $6,033

Source: Authors' elaboration.

Graph A illustrates this AMM with an example of a liquidity pool comprising Tether and Ether. When a trader wishes to provide liquidity, they need to deposit Tether and Ether in proportion to the two cryptoassets' dollar values in the pool (which is one at step ❶). The liquidity-provider's claim on the pool is proportional to its contribution.③

The AMM protocol incentivises liquidity provision in two ways. First liquidity-takers pay to the providers a fee that may range from a few basis points to several percentage points. Second, at each extraction of liquidity, the bonding curve generates an automatic transfer from the liquidity-taker to the providers. In the example in Graph A, the liquidity-taker pays a premium to acquire 1 ETH (equal to 333 units of Tether at step ❸). This makes the overall pool – and the claim of the liquidity-provider in particular – appreciate in value (bottom of right-hand panel).

That said, liquidity-providers can suffer losses if the relative price of the two cryptoassets on other exchanges diverges substantially from that implied by the bonding curve. The loss is realised when the liquidity-takers withdraw the cryptoasset that has increased in value, leaving the liquidity providers worse off than if they had kept their funds outside the pool. The transaction fees may not be high enough to offset this loss, which is commonly referred to as "impermanent loss".

Certain features of AMMs expose liquidity-takers to market manipulation on DEXs. The execution of trades in AMMs requires validations based on the blockchain's consensus protocol, ie buy and sell orders are stored in a public memory pool, so that validators (also known as "miners") can add them to the blockchain. When submitting orders, liquidity-takers are uncertain about the timing of their orders' execution and the execution prices, as these depend on the execution sequence. Importantly, the order quantities become public knowledge *before* their price impact has materialised – which is easily predictable from the bonding curve. This time lag opens the door to malicious activity, whereby a trader may try to place a buy and an offsetting sell order immediately before and after, respectively, the pre-announced buy order. When the latter order is large enough, the bonding curve implies that the malicious trader's sell order will be executed at a higher price than his buy order, thus generating a profit. Such front-running behaviour is particularly attractive to large validators because they have a higher chance to "win" the next block and time their front-running trades optimally. The profits sometimes are called "miner extractable value".

More and more analytical work on the pros and cons of AMMs is emerging. On the one hand, AMMs enable on-chain trading without intermediaries, improving interoperability with other DeFi platforms such as lending and investment platforms. Compared with a limit order book model, the bonding curve in AMMs also mitigates overcompetition between liquidity-providers on prices, potentially enhancing liquidity provision overall (Lehar and Parlour (2021)). On the other hand, the strict bonding curve in AMMs limits the flexibility of liquidity-providers and exposes them to impermanent losses, thus deterring traders from liquidity provision. The risk of being front-run may also push traders away from AMM protocols.

As the DeFi ecosystem remains in flux, AMM designs are still evolving. One emerging feature brings AMMs closer to the traditional limit order book model. Specifically, liquidity-providers can choose which range of the pricing curve they would like to provide liquidity to. When the transacted price falls within this range, the mechanics described above apply. Otherwise, the liquidity-providers' assets are removed from the active liquidity pool. In addition, the types of cryptoasset that can be traded via AMM protocols are also expanding, ranging from non-fungible tokens to tokenised equity shares.

① The views expressed in this box are those of the authors and do not necessarily reflect those of the BIS. ② The AMM trading mechanism shares similarities with the framework of Shapley and Shubik (1977), which ensures market-clearing. See L Shapley and M Shubik, "Trade using one commodity as a means of payment", *Journal of Political Economy*, vol 85, no 5, pp. 937–68, and H S Shin, "Comparing the robustness of trading systems to higher-order uncertainty", *Review of Economic Studies*, vol 63, no 1, pp. 39–59. ③ Decentralised trading is often fragmented. If there are multiple pools trading the same asset pair, one may use a smart order router for the best prices.

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Open-ended bond funds: systemic risks and policy implications[1]

Alongside other non-bank financial intermediaries, open-ended funds that invest in bonds ("bond OEFs") have grown rapidly over the past two decades. Besides their size, their business model and role in recent events suggest that bond OEFs can amplify stress in financial markets. The March 2020 market turmoil tested the effectiveness of bond OEFs' tools in dealing with large investor redemptions in the presence of liquidity mismatches. Their tools notwithstanding, bond OEFs had to liquidate assets on an elevated scale, thus collectively adding to bond market pressures. Without central bank interventions, broader fire sale dynamics could have been triggered. Regulation that takes a macroprudential perspective of the sector could support financial stability by ensuring that tools internalise the effect of spillovers arising from bond OEFs' actions.

JEL classification: G01, G23, G28, C72

The March 2020 market turmoil revived concerns about the amplification of financial stability risks by non-bank financial intermediaries, including open-ended bond funds ("bond OEFs"). A bond OEF pools capital to invest in fixed income instruments – corporate and other bonds – while typically granting its investors the right to redeem their shares for cash on a daily basis. Through this liquidity transformation, bond OEFs collectively can give rise to financial stability risks. During the early days of the Covid-19 pandemic, bond OEFs experienced intensive but short-lived outflows amid a significant decline in market liquidity and high valuation uncertainty. Conditions remained tense until major central banks stepped in to backstop bond markets.

This episode has sparked a discussion about bond OEFs' resilience, the comprehensiveness of their liquidity management tools, especially in times of stress, and the tools' adequacy for financial stability more broadly. Advocates of the current industry setup point to the swift market recovery and the reversal of fund outflows that followed the turmoil of March 2020. Critics, pointing to previous, similar episodes, question bond OEFs' ability to withstand large shocks without public sector support and call for these funds' regulation to be revisited.

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Key takeaways

- Open-ended bond funds, which have grown substantially since the Great Financial Crisis, have tools to manage investor redemptions, but these are not necessarily designed to support financial stability.
- During the March 2020 market turmoil, redemptions were elevated and led to procyclical asset sales that added to pressures on bond prices and liquidity conditions, even though liquidity management tools were widely used.
- New macroprudential measures, such as countercyclical liquidity buffers, and a comprehensive adjustment of existing tools could bolster the resilience of the bond fund sector.

In this special feature, we analyse redemption dynamics and bond OEFs' response during the March 2020 turmoil, asking whether funds' existing liquidity management tools are conducive to financial stability. Our focus is on actively managed high-yield, investment grade and general bond OEFs. Given their liquidity transformation, these OEFs employ several tools to manage the risk of large redemptions, such as holding liquidity buffers or using swing pricing. We find, however, that bond OEFs' lines of defence did not prevent spillovers across funds and procyclical asset sales.

The experience with bond OEFs during periods of financial turmoil and these funds' systemic importance call for revisiting the regulation of their liquidity management. Bond OEFs are exposed to the risk of concerted investor redemptions or strained market liquidity, which could lead to procyclical fire sales (ESRB (2021)). Macroprudential responses could include introducing new countercyclical tools and strengthening existing liquidity management tools.

We organise our analysis in three sections. In the first, we describe bond OEFs, outline their lines of defence against large investor redemptions and discuss how these mechanisms may or may not prevent shocks from propagating through the financial system. In the second, we review the March 2020 market turmoil, analyse how the drivers of fund flows during the turmoil differ from those in normal times, and study the effectiveness of bond OEFs' tools in mitigating large redemptions and related fire sales. In the final section, we discuss policy options, considering requirements for an effective macroprudential toolkit for bond OEFs.

Bond OEFs and liquidity risk management

Bond OEFs are collective investment vehicles that hold portfolios of debt securities. They complement bank lending by providing an additional source of funding to financial and non-financial corporates, allowing borrowers to diversify their funding mix. For investors, bond OEFs offer diversified exposures at comparatively low cost.

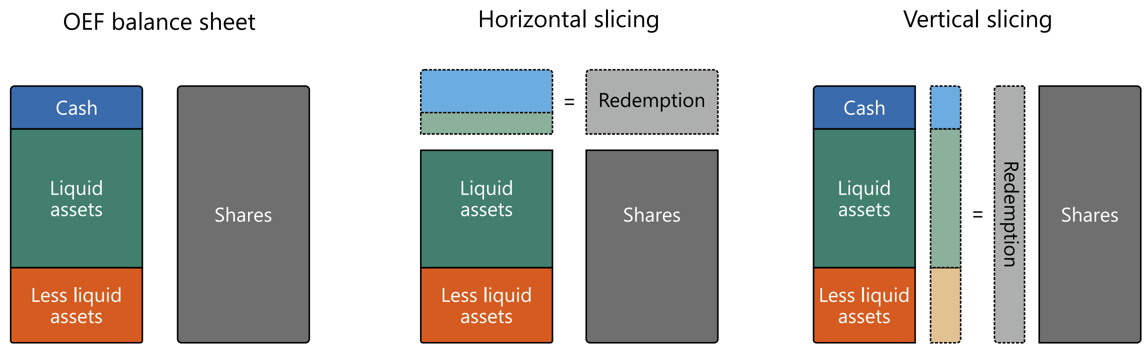
A bond OEF's liquidity mismatch drives its response to investor redemptions. Graph 1 provides a stylised illustration of this. In its simplest form, the balance sheet consists of cash and securities holdings on the asset side, with an equivalent amount of issued shares on the liability side (left-hand panel). Bond OEF shares can be redeemed at market value and at short notice, often daily. By contrast, the securities investments are less liquid, resulting in a mismatch. Unlike banks, which, in principle, can collectively expand their balance sheets and thus provide liquidity on demand to other sectors (McLeay et al (2014)), bond OEFs cannot elastically meet demand for cash because their shares are not a means of payment. And unlike exchange-traded funds (ETFs), bond OEFs typically do not "redeem in kind", ie pass on their assets to investors or dedicated financial intermediaries (Shim and Todorov (2021)), which would alleviate liquidity pressures. When net redemptions reduce the amount of outstanding shares, bond OEFs need to pay out in cash, either from an available buffer or after liquidating assets.

Given their liquidity mismatch, bond OEFs rely on a broad set of tools to manage large redemptions, some improving funds' redemption capacity and others reducing investors' redemption incentives. The first line of defence rests on cash and other liquid buffers. A fund's management choses the portfolio share that it holds as cash or invests in highly liquid securities (eg short-maturity sovereign bills and bonds) based on the bond OEF's characteristics (eg investment strategy and focus) and perceived redemption risks (eg investor composition and profiles). Clearly, in doing so, each fund faces a trade-off. While a high liquidity buffer reduces the need to sell less liquid assets in response to large redemptions, it also weighs on the fund's returns during normal times, thus putting the fund at a competitive disadvantage.

For a given liquidity buffer, the cash management styles used to address redemptions can be classified into two contrasting types: "horizontal slicing" (also referred to as the "waterfall approach") and "vertical slicing". Under horizontal slicing, the fund manager starts by using the existing cash and selling the most liquid assets (Graph 1, centre panel). Under vertical slicing, the fund manager sells assets in proportion to their corresponding weights in the fund's portfolio (right-hand panel).

Neither approach fully addresses redemption pressures since each can give rise to a first-mover advantage, although through different channels. While horizontal slicing helps contain selling of relatively illiquid assets in a possibly strained market, it exposes the investors remaining with the fund to increased liquidity risk. The anticipation of this approach may thus lead more investors to swiftly redeem their shares, reinforcing the redemption pressure on the bond OEF. In turn, vertical slicing leaves the average liquidity of the portfolio unchanged but may amount to selling less liquid assets into already strained markets. Unless the corresponding costs are charged to the redeeming investors, the expected dilution of the fund could prompt the remaining investors to redeem their shares ahead of others.

How open-ended funds (OEFs) can meet redemptions — Graph 1



This stylised example abstracts from bond OEFs' use of derivatives, repos or credit lines.

Source: Authors' elaboration.

Since the first-mover advantage is inherently destabilising, even for a single bond OEF, a second line of defence seeks to encourage redeeming investors to internalise the costs of their redemptions. It comprises price tools, such as swing pricing, anti-dilution levies and dual pricing, as well as quantity tools, such as redemption gates and the temporary suspension of redemptions (eg IOSCO (2018)).

Swing pricing is the most prevalent tool and has received the most attention.[2] While primarily designed as an anti-dilution mechanism, it enables the bond OEF to reduce the first-mover advantage by adjusting the redemption price according to the redemption size. If the fund exhibits net redemptions above a pre-defined threshold, the share price on that day is reduced by a swing factor set in advance by the management company.[3] If set high enough, the swing factor can reduce the first-mover advantage. However, since it is difficult to estimate the price impact and transaction costs of sales during episodes of market stress, swing factors typically rely on rough measures. In addition, swing factors and thresholds are typically not disclosed to investors on a regular basis. Given these various ambiguities, investors may still perceive a strong first-mover advantage, especially at times of unusual stress.

By preventing investors from redeeming their shares, quantity tools such as redemption gates or the temporary suspension of redemptions directly relieve pressure from the fund to raise cash. Yet the prospect of such restrictions could also set off self-reinforcing redemptions. Investors observing a decline in the fund's liquidity position could exit pre-emptively, as has been documented for money market funds (FSB (2021)). Moreover, failure to meet redemptions in full could be perceived as indicating fund weaknesses. This suggests that fund managers could refrain from deploying such tools in order to avoid reputational damage (IOSCO (2018)).

Their liquidity management tools notwithstanding, two factors raise concerns that bond OEFs may contribute to systemic risk.[4] One is the size of the industry. Bond OEF assets under management have outpaced even the strong growth in corporate issuance since the Great Financial Crisis. They now represent about 18% and 17% of the outstanding corporate bonds in the United States and euro area, respectively – up from 7% and 8% in 2008. A disruption of bond OEFs could thus result in a severe tightening of corporate funding conditions.

The second cause for concern is that, in the presence of large redemptions, inherent liquidity mismatches and the constraints imposed by the structure of bond OEF balance sheets can lead to destabilising behaviour and fire sale dynamics. The liquidity management tools are primarily geared towards managing risks at the fund level, with little weight given to broader market impact. Since the bond OEF sector is unable to generate liquidity, cash-raising in response to large redemptions can lead to a fire sale of assets (eg Goldstein et al (2017); Feroli et al (2014); Chen et al (2010)). Such fire sales could depress specific bonds' market valuations and thereby

2 Roughly 80% of the bond OEFs studied in this special feature reported that they could apply swing pricing. For research on swing pricing, see eg Jin et al (2021), Capponi et al (2020) and Lewrick and Schanz (2017)). For policy discussions, see eg IMF (2021) and FSB (2020).

3 Swing pricing is also applied to reduce the dilution that may result from large inflows. In this case, the price per share is raised by the swing factor if net subscriptions exceed a preset threshold.

4 Systemic risk can be broadly defined as the risk of widespread disruption to the provision of financial services due to an impairment of all or parts of the financial system, potentially resulting in severely adverse consequences for the real economy (eg IMF-BIS-FSB (2009)).

propagate shocks to other market participants with similar bond exposures (eg Jiang et al (2020); Manconi et al (2012)).[5]

Several factors increase the likelihood of fire sales and their impact. One stems from highly correlated holdings across funds – arising, for instance, from the targeting of common benchmarks – which would lead to the offloading of similar assets during stress. Another is the use of similar risk models and monitoring frameworks, making funds react similarly to market signals. Yet another factor is leverage via bond OEFs' use of derivatives, which can lead to concerted spikes in margin calls and hence cash needs during periods of high market volatility (eg Fache Rousová et al (2020)). A fourth factor is the reduction in dealers' intermediation capacity relative to the size of the market in recent years (eg Adrian et al (2017)), which implies that funds could face steeper discounts when trying to sell bonds en masse.

Bond OEFs during the March 2020 market turmoil

We revisit the market turmoil of March 2020 in order to assess the drivers of redemptions from actively managed bond OEFs and study these funds' use of liquidity management tools. Our analysis covers Undertakings for Collective Investments in Transferable Securities (UCITS) registered in Luxembourg, home to one of the largest OEF industries globally. We build on two data sets: a "broad" and a "survey" sample, which provide broader coverage and more detail, respectively.

The broad sample contains monthly data on fund characteristics from Refinitiv Lipper and daily flow data from Bloomberg. It is combined with semiannual supervisory information. Reporting funds have either more than €500 million of total net assets (TNA) or high leverage (above 2.5 times TNA, based on notional amounts). This sample comprises around 550 UCITS (henceforth, bond OEFs), with total TNA of around €690 billion in the run-up to the turmoil.[6] The OEFs are categorised in three broad classes: high-yield (HY), investment grade (IG) and general bond funds.

The survey sample originates from a supervisory data collection. It contains detailed daily information on up to 57 UCITS for the first half of 2020, including granular data on swing pricing and cash balances. Total TNA of the OEFs in the survey sample was about €77 billion just before the turmoil.

We start by documenting the scale and dynamics of redemptions in the broad sample. Up to the first week of March 2020, bond OEFs appeared broadly immune to the Covid-19-related uncertainty that had weighed on investor risk appetite earlier in the year (eg BIS (2020); FSB (2020)). Average net flows hovered around zero.

The second week of March, however, marked a sudden break. Daily outflows accelerated quickly amid fast declining returns (Graph 2, left-hand and centre panels). By 25 March, within just 16 days, cumulative net outflows had grown to about 6% of TNA. Some funds experienced daily outflows of more than 10% (right-hand

[5] OEFs can also spread risks to other market participants through financial interconnections. For instance, OEFs that manage their liquidity by investing in money market fund shares may opt to redeem these shares to raise cash during stressed market conditions, thereby transmitting the redemption pressure to money market funds.

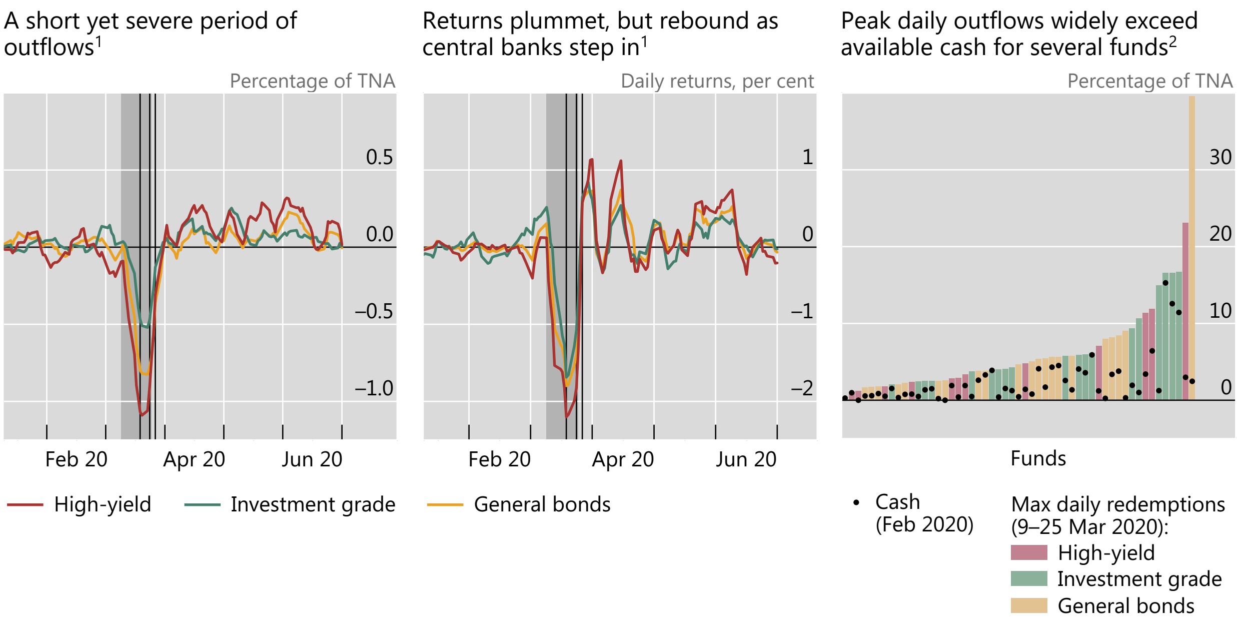
[6] This corresponds to about 18% of the total TNA of all UCITS registered in Luxembourg (ie equity and fixed income funds, including money market funds).

panel).[7] Stress was widespread, with developments closely mimicking the patterns observed for UK and US bond OEFs (eg Bank of England (2021), Falato et al (2021)).

The turmoil was short-lived, with markets rebounding in response to a series of central bank interventions. On 18 March, the ECB announced that, starting on 26 March, it would purchase up to €750 billion worth of bonds under its Pandemic Emergency Purchase Programme (€600 billion were added in June). On 23 March, the Federal Reserve announced the introduction of the Primary Market Corporate Credit Facility (PMCCF) and Secondary Market Corporate Credit Facility (SMCCF), specifying on 9 April that the combined size of the facilities would be up to $750 billion. These interventions, alongside other public sector support measures, not only provided backstops to markets where bonds in OEFs' portfolios were traded but also restored general investor confidence. Thus, they supported bond valuations more broadly and eased redemptions (eg Gilchrist et al (2021); Breckenfelder et al (2021)).

We find that bond OEF investors differentiate across funds according to several factors. Table 1 reports the coefficient estimates from multivariate regressions of monthly net fund inflows on several candidate explanatory variables, distinguishing between effects during normal market conditions and those in March 2020. For instance, the left-hand column shows that in normal times, all else equal, funds with a return that is one standard deviation below the sample mean (ie with an annualised monthly return of –0.7% as opposed to the sample mean's return of 0.9%) face extra

March 2020: severe stress followed by swift rebound as central banks step in — Graph 2



The vertical lines in the left-hand and centre panels indicate the following policy interventions in 2020: 18 March (ECB announces PEPP); 23 March (Federal Reserve announces PMCCF and SMCCF); 26 March (ECB begins purchases of corporate sector bonds under PEPP). The shaded area indicates 9–25 March (the period of elevated fund outflows).

[1] Based on 549 bond OEFs (broad sample). Five-day moving averages, weighted by total net assets (TNA). [2] The bars represent the highest daily redemption during the period 9–25 March (as a share of TNA) reported by 53 broad sample bond OEFs whose cash ratio fell short of the highest daily redemption in March. The dots represent the cash ratio (as a share of TNA) at end-February 2020.

Sources: Luxembourg CSSF; Bloomberg; Refinitiv Lipper; authors' calculations.

[7] According to Carpantier (2021), 18% of bond, equity and mixed Luxembourg UCITS exhibited daily outflows of more than 10% at least once during the period from March to December 2020.

net outflows of about 0.4 percentage points of TNA. In addition, older funds or those with larger TNA would typically experience smaller inflows.

In March 2020, bond OEF characteristics affected fund flows differently than during normal market conditions (Table 1, right-hand column). In that month, funds' lower returns made investors much more prone to redeem, consistent with the findings in Carpantier (2021). Whereas in normal times, lower asset liquidity matters little for net flows, it was of great concern to investors during the turmoil, leading to large outflows from funds with less liquid portfolios. Also different from normal times, bond OEFs with a larger share of institutional investors exhibited greater outflows in March 2020 than their peers. This is similar to dynamics observed for money market funds at the time (eg Avalos and Xia (2021)) and consistent with institutional investors monitoring conditions more closely than retail investors. At the same time, bond OEFs where few investors held a large share of the fund faced smaller outflows, suggesting that large investors internalise the effect of their redemptions more, consistent with prior research (eg Chen et al (2010)). Importantly, higher credit and market risks, as measured by value-at-risk, a larger share of lower-rated securities and greater exposures to emerging market economies (see also the box), were associated with larger net outflows (including within fund asset classes, eg HY vs IG). These last findings suggest that the prospect of asset illiquidity also contributed to investors' redemptions.

Bond OEF characteristics driving elevated redemptions[1]

Dependent variable: monthly net flows to an OEF as a percentage of its total net assets, 2012–20 — Table 1

	Normal	March 2020
Return (one-month, annualised)	0.393***	1.805***
Liquid asset ratio	–0.131*	1.200***
Total net assets	–0.346***	–0.794***
Years since launch of the fund	–0.660***	0.509***
Share of fund held by institutional investors	–0.075	–1.188***
Share of fund held by top 5 investors	–0.274***	0.908***
95% value-at-risk	0.079	–0.333***
Portfolio share below investment grade	–0.110	–1.815***
Investment focus on emerging markets (1, 0 variable)	–0.110	–5.507***
Excess flows of non-EME funds in March 2020 (1, 0 variable)		–3.598***
VIX	–0.372***	
Number of observations	37,246	
Adjusted R-squared	0.041	

*/**/*** indicates statistical significance at the 10/5/1% level based on robust standard errors clustered by OEF and month.

[1] OLS regression based on 427 bond OEFs. All regressors (except for the emerging market and excess flows dummies) are lagged by one period and standardised to z-scores. Coefficient estimates thus indicate the percentage point change in net flows (as a share of total net assets) that results from a one standard deviation increase in the corresponding regressor. Coefficients in the column labelled "normal" represent the regressors' effect during 2012–20, excluding March 2020; those in the column labelled "March 2020" represent the effect in March 2020. Excess flows indicate the additional outflows during March 2020 that are not explained by other regressors.

Sources: Luxembourg CSSF; Refinitiv Lipper; authors' calculations.

Box

EME funds during Covid-19

*Stijn Claessens and Ulf Lewrick*①

OEFs that invest in debt securities of emerging market economies ("EME funds") exhibited especially large investor outflows during the March 2020 market turmoil.② While the pace eased towards the end of March, inflows did not resume until later in the year. This contrasts with the swift rebound in fund subscriptions for many OEFs investing in advanced economy debt ("AE funds"), including those targeting high-yield securities (Graph A, left-hand panel).

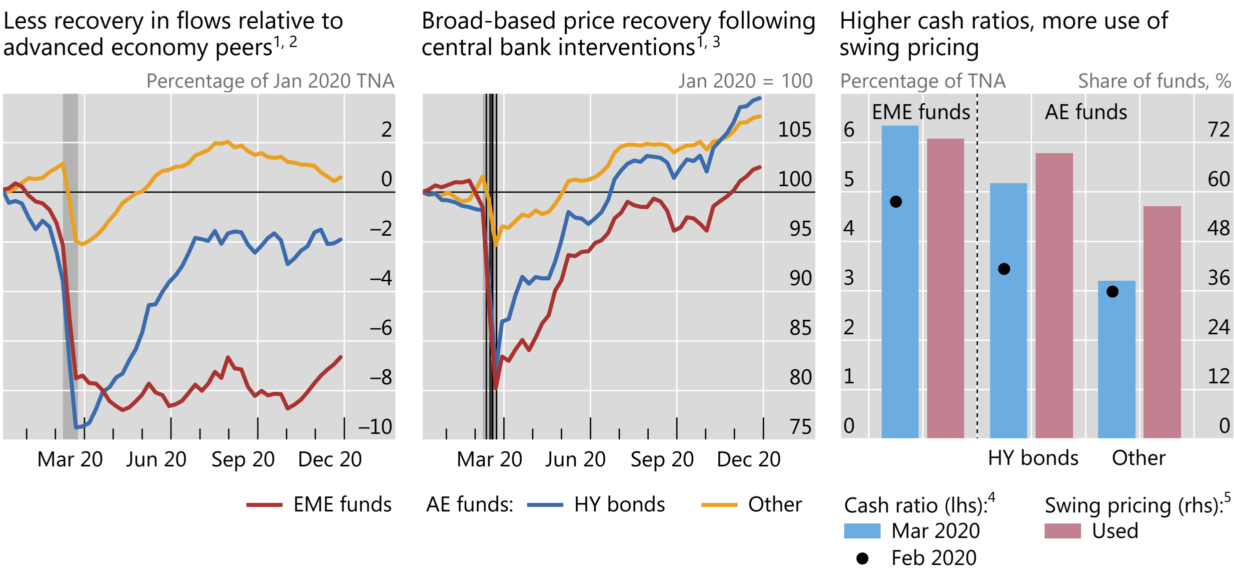
Differences between EMEs and advanced economies as regards the scope and scale of central bank interventions help explain the differences in flow dynamics. During the height of the turmoil, central banks in major AEs expanded their purchases of corporate bonds and other private assets or introduced new large-scale purchase programmes. The policy response of EME central banks, by comparison, relied less on asset purchases and focused more on foreign exchange, interest rate and reserve policies (Cantú et al (2021).

While the flows of EME funds evolved differently from those of AE funds, price-based measures exhibited similarities. The response of EME funds' net asset value (NAV) per share to the intervention by major AE central banks at end-March 2020 was similar to, although slower than, that of AE HY funds' NAV per share (Graph A, centre panel). This suggests that asset purchases supported the valuations not only of eligible bonds (ie primarily higher-rated AE debt), but also of ineligible bonds, albeit to a lesser extent and with some delay (eg Gilchrist et al (2021); Breckenfelder et al (2021)).

EME funds used some lines of defence more heavily than their AE peers. Although EME funds held more cash than their AE peers at the outset of the turmoil, they still increased their cash ratios during it. This resembled the behaviour of AE HY funds. EME funds, given their higher redemption risk, made heavy use of swing pricing, typically imposing higher swing factors and lower swing thresholds than their AE peers (Graph A, right-hand panel).

EME vs AE funds: similar, yet different

Graph A



The shaded area in the left-hand and centre panels indicates 9–25 March 2020 (the period of elevated fund outflows). The vertical lines in the centre panel indicate announcements of major asset purchases by central banks in major advanced economies.

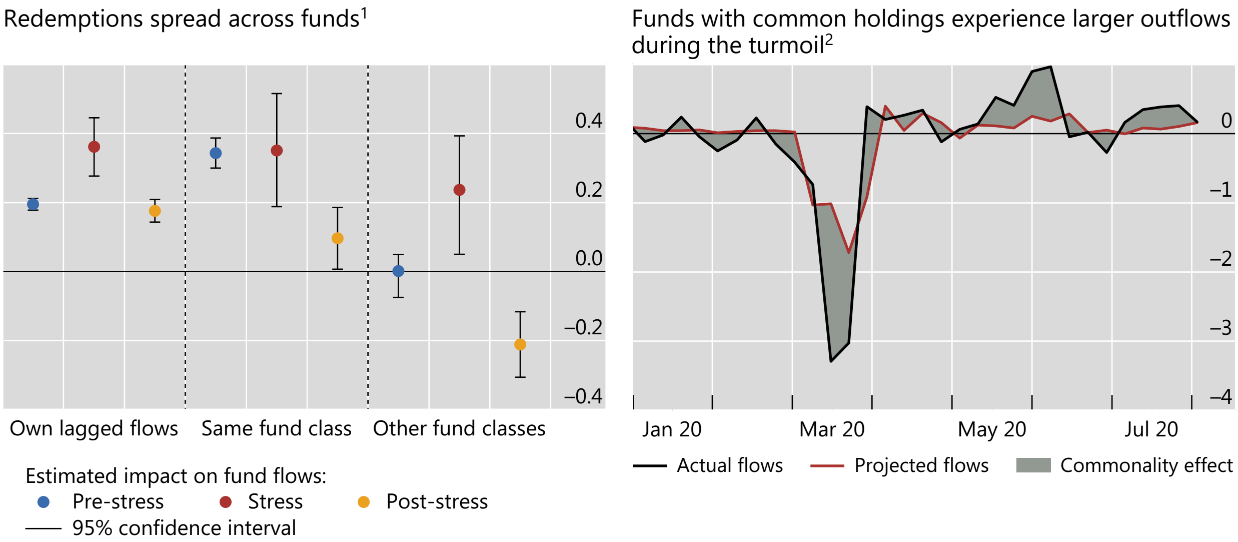
[1] Based on a balanced sample of 255 advanced economy (AE) bond OEFs and 79 emerging market economy (EME) bond OEFs (broad sample). [2] Cumulative weekly net fund flows as a share of aggregate total net assets (TNA) in January 2020. [3] Cumulative returns, TNA-weighted average. [4] TNA-weighted average cash to TNA ratio by fund class. [5] Share of funds reporting that they used swing pricing during the first half of 2020.

Sources: Luxembourg CSSF; Bloomberg; Refinitiv Lipper; authors' calculations.

① The views expressed in this box are those of the authors and do not necessarily reflect those of the BIS. ② For the purposes of this analysis, "EME funds" refers to UCITS that are registered in Luxembourg and invest predominantly in emerging market debt.

Spillovers and elevated redemptions due to common holdings

Percentage of TNA — Graph 3



[1] Coefficient estimates based on a panel regression of weekly fund flows (percentage of total net assets (TNA)) on lagged fund flows, lagged total flows in the same bond OEF class (excluding the fund's own flows), and lagged total flows in other bond OEF classes. Each flow variable is interacted with a binary variable that indicates the pre-stress period (Jan 2012–first week of March 2020), the stress period (second–fourth week of March 2020), and the post-stress period (April–December 2020). The regression also controls for lagged returns, fund size, cash holdings and fund fixed effects. [2] The lines depict the actual and projected weekly flows of *high* correlation funds, which are defined as bond OEFs with returns most correlated (in the top quartile) with the aggregate return of their asset class during the pre-stress period. The estimation of the projected flows proceeds in two steps: the weekly flows of *low* correlation funds (in the bottom quartile) are regressed on a set of fund characteristics and a dummy for the stress period; the resulting regression coefficients are then used to predict the weekly flows of *high* correlation funds. This approximates the counterfactual of flows for *high* correlation funds if their return correlation were low, with the difference reported as the commonality effect.

Sources: Luxembourg CSSF; Bloomberg; Refinitiv Lipper; authors' calculations.

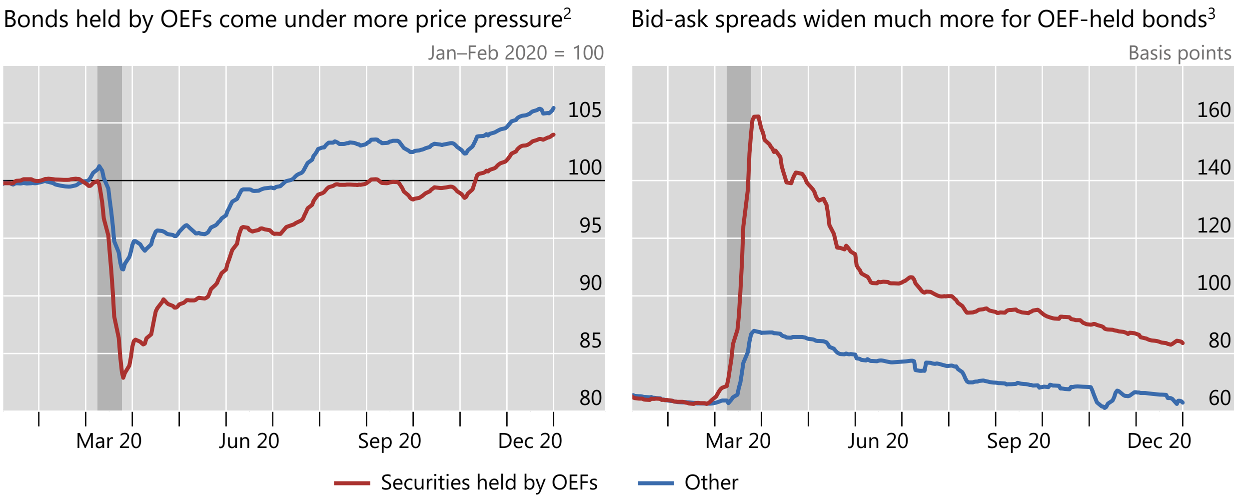
We find evidence of redemptions spreading across bond OEFs, including through asset price declines. Graph 3 (left-hand panel) depicts the relationship between fund redemptions and *preceding* flows to/from the same fund, other funds in the same class or funds in different classes. Examining this relationship over three distinct periods – pre-stress, stress and post-turmoil – suggests that the turmoil (red dots) stood out in terms of momentum in redemption activity (first triplet) and greater spillovers across similar funds and different fund classes (second and third triplets). This is consistent with spillovers throughout the bond OEF sector, as also documented for US bond OEFs during this period (Falato et al (2021)).

Similarity in funds' exposures seems to also have been a driver of redemption spillovers. Outflows were greater for bond OEFs whose returns co-move more strongly with the aggregate returns of funds in the same asset class (Graph 3, right-hand panel). This suggests that common holdings or benchmarking across funds added to redemption dynamics, with the attendant asset sales depressing the valuations of bonds. This could have spilled over to the returns of other funds.

Consistent with the notion of fund-driven fire sales, bonds owned by OEFs at the onset of the turmoil underperformed comparable bonds of the same issuers and displayed worse liquidity during the turmoil. For instance, prices of bonds held by HY bond OEFs declined by an additional 10 percentage points on average relative to those of comparable bonds during the period of elevated fund outflows

Bonds held by OEFs exhibit greater declines in price and liquidity[1]

Graph 4



The shaded area indicates 9–25 March 2020 (the period of elevated fund outflows).

[1] To maximise coverage, this graph uses an expanded sample of 179 high-yield Luxembourg bond OEFs for which monthly securities holdings data were available at end-February 2020. The sample comprises 34,497 USD- and EUR-denominated securities, of which 3,372 were held by these funds in February 2020. The sample was constructed by matching OEF-held securities with securities of the same issuers that had similar time to maturity but were not held by any of the bond OEFs. [2] Five-day moving average bond mid-prices. [3] Five-day moving average bid-ask spread measured as the difference between the ask and bid price, divided by half the sum of the ask and bid price.

Sources: Refinitiv Eikon; Refinitiv Lipper; authors' calculations.

(Graph 4, left-hand panel). Likewise, the bid-ask spreads for assets held by HY bond OEFs increased nearly twice as much as those observed for similar bonds at the height of the turmoil (right-hand panel). The differences in prices and spreads persisted for several months.

Using the detailed survey sample, we assess the performance of bond OEFs' first line of defence through the behaviour of two metrics. The first is the ratio of unencumbered cash to TNA ("cash ratio"), which provides a narrow measure of immediately available liquidity. The second is the "liquid assets ratio", which is the share of securities in the portfolio that can be liquidated within one day or less according to the fund manager's own classification.

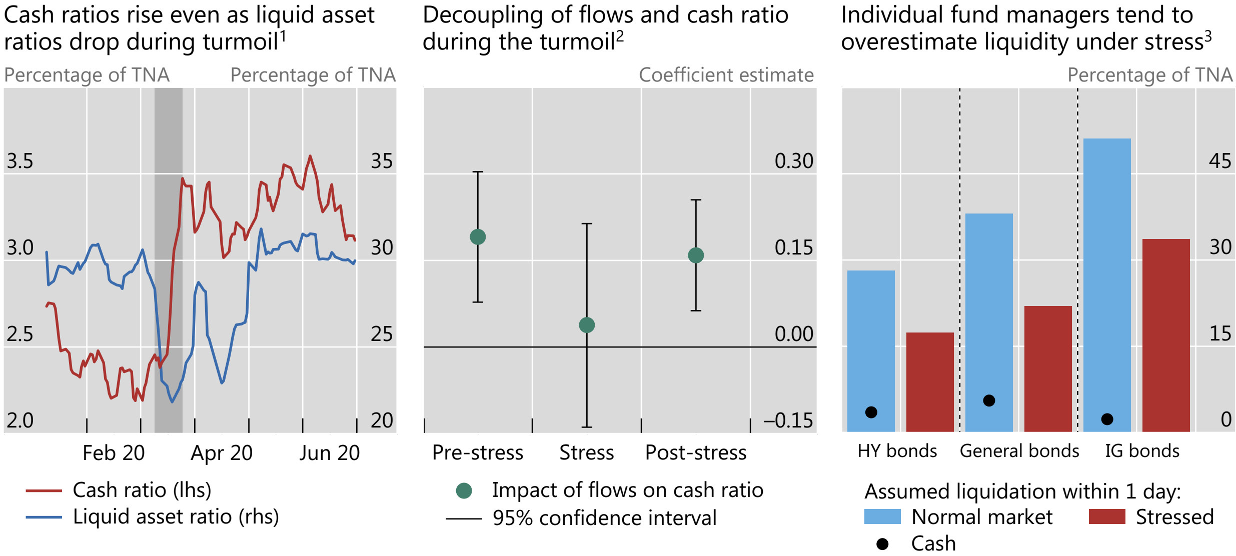
Despite the elevated redemptions in March 2020, bond OEFs actually raised their cash ratios (Graph 5, left-hand panel). This suggests that funds liquidated more assets than needed to meet the redemptions alone. Such procyclical behaviour is consistent with prior research on cash hoarding by fund managers during periods of stress (eg Schrimpf et al (2021); Morris et al (2017)). Indeed, the relationship between fund flows and cash ratios changed during the turmoil (centre panel).

By contrast, funds' (self-reported) liquid asset ratio declined in March 2020 (Graph 5, left-hand panel). This means that bond OEFs sold some of their non-cash liquid assets to boost their cash ratios, tallying with findings for US OEFs (Ma et al (2020)) and suggesting a horizontal slicing approach.[8]

[8] Consistent with the findings in Chernenko and Sunderam (2016), the bond OEFs in our analysis made little use of credit lines with banks – an additional source of cash – during the turmoil. Carpantier (2021) reports that only 2% (8%) of Luxembourg UCITS, including equity, bond and mixed funds, borrowed to meet daily (weekly) net redemptions that exceeded 10% (30%) of TNA.

Procyclical liquidity management

Graph 5



The shaded area in the left-hand panel indicates 9–25 March 2020 (the period of elevated fund outflows).

[1] Five-day moving averages of total net assets (TNA)-weighted means of the ratio of unencumbered cash to TNA and the ratio of liquid assets to TNA, respectively. Based on the survey sample, with data from 42 bond OEFs for which daily data on cash and liquid assets were available. [2] Estimated increase in the cash ratio in response to a 1 percentage point increase in net fund flows per TNA. Subsample multivariate regressions of daily changes in cash ratios on fund flows, lagged log TNA, the share of top five investor holdings and the VIX for the period 2 January–6 March 2020 (pre-stress), 9–25 March 2020 (stress) and 26 March–30 June 2020 (post-stress). Based on the survey sample. [3] Reported cash ratio (dots) and liquid asset ratio (bars) under normal conditions and under stressed market conditions. TNA-weighted averages based on a balanced sample of 165 bond OEFs from the broad sample. Data as of end-2019.

Sources: Luxembourg CSSF; Bloomberg; Refinitiv Lipper; authors' calculations.

In interpreting the above results, it is important to keep in mind that each individual bond OEF may overstate its assets' liquidity. Supervisory data of bond OEF reports during normal market conditions, and for some funds under a self-selected stress scenario, show that funds classify many bonds as highly liquid (Graph 5, right-hand panel). At end-2019, HY bond fund managers assumed that 28% of assets could be liquidated within one day or less, with this number remaining as high as 17% in a stress scenario. This corresponds to asset sales equivalent to €19 billion and €12 billion, respectively. For the broad sample, bond OEFs assumed that they could collectively sell more than €300 billion (or 45% of their TNA) within one day under normal conditions, suggesting strong reliance by funds on their first line of defence. But, as shown in March 2020, these assumptions underestimate the adverse effects of collective sales on market liquidity in times of stress.

Turning to the second line of defence, bond OEFs intensified their usage of swing pricing during the turmoil and adjusted swing pricing parameters to mitigate dilution. While the average swing factor for the survey sample hovered around zero before the turmoil, it increased by more than 100 basis points on average during the market stress (Graph 6, left-hand panel). Funds also lowered swing thresholds, on average from net outflows of 1% of TNA before the turmoil to less than 0.5% (centre panel).

Despite the adjustments in the swing factors and thresholds, we find no evidence of a dampening effect on investor redemptions in March (Graph 6, right-hand panel). The estimated effect of swing pricing on daily net outflows is insignificant in regressions that control for fund characteristics and market conditions. In fact, funds that apply swing pricing exhibited somewhat larger net outflows on a weekly basis.

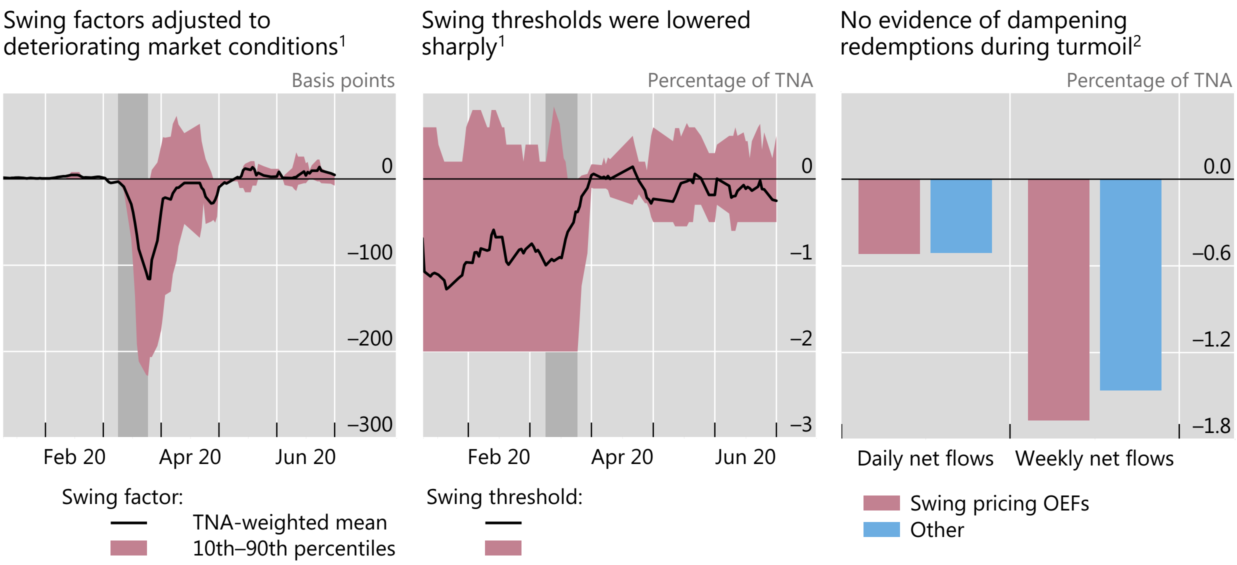
That said, these funds recouped roughly 0.06% of TNA on average from investors redeeming during the three weeks of elevated redemptions.

The swing factor might have been too modest to dissuade redemptions in this episode, in contrast to the dampening effect documented during more tranquil market conditions (Lewrick and Schanz (2017)). As liquidity in corporate bond markets evaporated, the pricing of bonds and the assessment of their liquidation costs became increasingly difficult. The swing factors may have thus fallen short of what investors perceived to be the true impact of liquidating assets on the funds' share price (Bank of England (2021)). The gap between the net asset value (NAV) per share and secondary market price of HY bond ETFs, for example, exceeded 800 basis points at the height of the turmoil, suggesting steep discounts on the underlying bonds (eg Shim and Todorov (2021); Aramonte and Avalos (2020)). Bonds' illiquidity may have also led to predictable declines in funds' share prices (Choi et al (2021)), many bond OEFs exhibited several days of consecutive price reductions during the height of the turmoil, which may have dominated the effect of the swing factor.

Lastly, the bond OEFs in our sample made relatively little use of quantity-based forms of defence. Only two management companies reported temporary suspensions of redemptions. In line with the findings in Grill et al (2021), these companies attributed their decision to the difficulty of pricing assets, which made it hard to have an objective basis for payouts, rather than to imminent redemption pressures.[9]

Swing pricing during the March 2020 turmoil

Graph 6



The shaded area in the left-hand and centre panels indicates 9–25 March 2020 (the period of elevated fund outflows).

[1] Five-day moving averages of the total net assets (TNA)-weighted mean swing factor and swing threshold across funds. Based on an unbalanced sample of 42 bond OEFs. [2] Estimated excess outflows as a share of TNA during the March 2020 market turmoil. Based on panel regressions using daily (weekly) observations to estimate the effect of the turmoil on net fund flows, while controlling for differences across funds with regard to performance, size, investor concentration, cash holdings and holdings of liquid assets. All control variables are lagged by one period. We allow the coefficients to differ for bond OEFs that apply swing pricing and those that do not.

Sources: Luxembourg CSSF; Bloomberg; Refinitiv Lipper; authors' calculations.

[9] Grill et al (2021) estimate that 68 bond OEFs in Europe suspended redemptions during the turmoil, on average for five days. These funds' TNA averaged €210 million (for a total of €14.3 billion), meaning that many of them did not meet the reporting thresholds for inclusion in our broad sample.

Conclusion: integrating a macroprudential perspective

The March 2020 episode revived concerns about the potential for OEFs to contribute to systemic risks. Even though it is notoriously difficult to disentangle the individual drivers of system-wide stress, the scale of fund redemptions indicated the pressure on OEFs to sell assets in increasingly illiquid markets. Decisive policy interventions to backstop bond markets quickly relieved pressure. At the same time, such interventions may nurture expectations of future policy support and provide the breeding ground for the build-up of new risks.

The turmoil raised questions about whether bond OEFs' own lines of defence can prevent the potential amplification of risks during periods of stress. Funds are more than a mere pass-through of investments: they provide liquidity to their investors. This liquidity provision hinges on a portfolio rebalancing, selling assets to raise cash. Large redemptions can then give rise to a first-mover advantage at the fund level: each fund benefits from selling ahead of the others. Since buyers are few in such a scenario, the liquidity of the underlying assets is impaired, with adverse spillovers.

Addressing this collective action problem calls for incorporating systemic considerations into bond OEFs' lines of defence. Adjusting existing tools could strengthen funds' resilience. Liquidity buffers could be expanded by a countercyclical add-on during times of ostensibly ample liquidity and released during periods of stress to provide leeway to OEFs. In addition, bond OEFs could be obliged to collectively move to redemption terms that are more closely aligned with the liquidity profile of their portfolio. This could, for example, include the introduction of notice periods that take account of negative externalities associated with large sales by individual funds and concerted selling by many funds under stress scenarios. For some bond OEFs, emulating ETF features, such as redemptions in kind supported by financial intermediaries to mitigate liquidity stresses, could be an alternative approach to enhance resilience. Swing pricing parameters, in turn, could be calibrated in a more comprehensive way to take account of the market-wide volume of potential sales. Notably, swing factors could be higher during periods of market stress to account for the impact of concerted selling.

Macroprudential tools would ideally be combined to meet several objectives. First, they would be stringent enough to help ensure liquidity mismatches are adequately managed and do not give rise to externalities. Second, they would help to identify and address systemic risks in the cross-section of bond OEFs. Third, they would materially support the liquidity of funds facing large redemptions. Finally, to serve as effective gatekeepers, the tools would be "usable" during episodes of stress both from a regulatory perspective and from the point of view of the fund manager and investors (Borio et al (2020)).

Policy efforts at the national and international level to strengthen the resilience of bond OEFs and other non-bank financial intermediaries are under way (eg Financial Stability Board (2020, 2021)). Clearly, expanding the macroprudential framework to fully integrate bond OEFs will raise implementation challenges and require cost-benefit considerations. Yet the important role that bond OEFs play in funding the economy suggests that enhancing their resilience would yield significant macroeconomic benefits.

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Outward portfolio investment and dollar funding in emerging Asia[1]

The growing heft of institutional investors and asset managers in several Asian economies has fuelled expansion in outward portfolio investment, mainly in US dollar-denominated assets. This investment is predominantly in long-term instruments but is hedged for currency risk mainly through short-term derivatives. The rollover risk in currency hedges exposes these non-bank investors to stress in dollar funding markets, as occurred in March 2020. Some Asian economies have since strengthened regulatory frameworks to address dollar funding-related vulnerabilities of resident institutional investors and asset managers.

JEL classification: F21, F34, G15, G23.

External vulnerabilities of emerging market economies (EMEs) traditionally revolved around their ability to service foreign currency debt. An accumulation of such debt, combined with local currency depreciation amid tightening global financial conditions, was at the heart of the Latin American debt crisis in the 1980s and the Asian financial crisis in the 1990s.

In recent decades, however, gross outward investment by residents of several Asian EMEs has been rising rapidly. Increasing wealth and population ageing has fuelled growth in the assets managed by institutional investors, such as pension funds and insurance companies, and other asset managers. This investor base is essential for developing domestic capital markets and makes EMEs less vulnerable to shifts in global financial conditions (CGFS (2019)). At the same time, the associated search for yield and duration in domestic securities markets which are still relatively shallow has driven booms in outward portfolio investment, mainly in securities denominated in US dollars. This has introduced new vulnerabilities in Asian EMEs' currency exposures that reflect their role as creditors rather than their traditional role as borrowers.

An institutional investor with a globally diversified portfolio of assets typically faces a currency mismatch between the assets it holds and its commitments to domestic stakeholders. For example, pension funds and insurance companies promise safe and stable returns in domestic currency to their beneficiaries and policyholders but invest in a portfolio that includes foreign currency assets. These

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Key takeaways

- The growing heft of institutional investors and asset managers in emerging Asian economies has fuelled expansion in outward portfolio investment in foreign currency assets, mainly in US dollars.
- Such non-bank investors rely on short-term foreign exchange (FX) hedging instruments provided by banks, which exposes them to rollover risk set off by disruptions in dollar funding markets.
- Market disruptions in March 2020 led to policy initiatives to enhance the resilience of FX hedging markets in Asia and to broaden prudential oversight of institutional investors and asset managers.

institutional investors thus use foreign exchange (FX) derivatives to hedge a large portion of the currency risk in their portfolios.

The rapid growth in Asian EMEs' outward portfolios has boosted demand for FX hedges and, thus, growth in local FX derivatives markets. The intermediaries in these markets are FX dealer banks, including the local affiliates of international banks that source dollars from their headquarters or from international capital markets. Dealer banks interpose themselves between the investors with hedging needs and the ultimate suppliers of dollars, both domestic and foreign. However, the hedging instruments' maturity is typically short-term, reflecting the bank funding model, which introduces a maturity mismatch between long-term dollar assets and short-term FX hedges. Korea, Malaysia and Thailand are among the EMEs exhibiting the most rapid growth in outward portfolio investment that has been accompanied by hedging for FX risk. Trading in FX derivatives contracts that reference one of these EMEs' currencies against the US dollar has more than doubled since 2013.

FX swaps are the most commonly used hedging instrument. In a typical FX swap, the investor – an Asian EME asset manager in our context – receives dollars from a bank and pledges local currency, with an agreement to repay the dollars at a pre-determined exchange rate at maturity. With the swap in place, changes in the value of dollar assets due to exchange rate movements are matched by changes in the value of dollar obligations. However, the investor faces rollover risk because FX swaps are overwhelmingly of shorter maturity than the attendant investments; if the contract cannot be rolled over, the investor must deliver dollars at maturity.

The dollar's pre-eminent role as a global currency means that the rollover risk is predominantly for dollar funding. As the dollar funding is provided by banks, it exhibits the well known procyclical property of expanding during tranquil times only to contract sharply during periods of financial stress. The need to hedge dollar portfolios thus exposes a wide range of financial institutions to stresses, as happened in March 2020 with the onset of the Covid-19 pandemic. During that episode, the cost of borrowing dollars spiked and liquidity dried up, as dealer banks were less able to accommodate investors' rollover needs in FX swap markets. The effects were felt especially keenly in those Asian EMEs with a fast-growing institutional investor base with sizeable hedging needs.

The lessons from the March 2020 turmoil have been incorporated into policy initiatives to improve the resilience of local FX markets and strengthen prudential oversight of institutional investors and asset managers. However, policy challenges remain. In most EMEs, current regulatory frameworks for FX management focus on banks and thus may not address the broader structural risks posed by non-banks. In addition, mechanisms to extend foreign currency liquidity beyond the banking sector are largely untested.

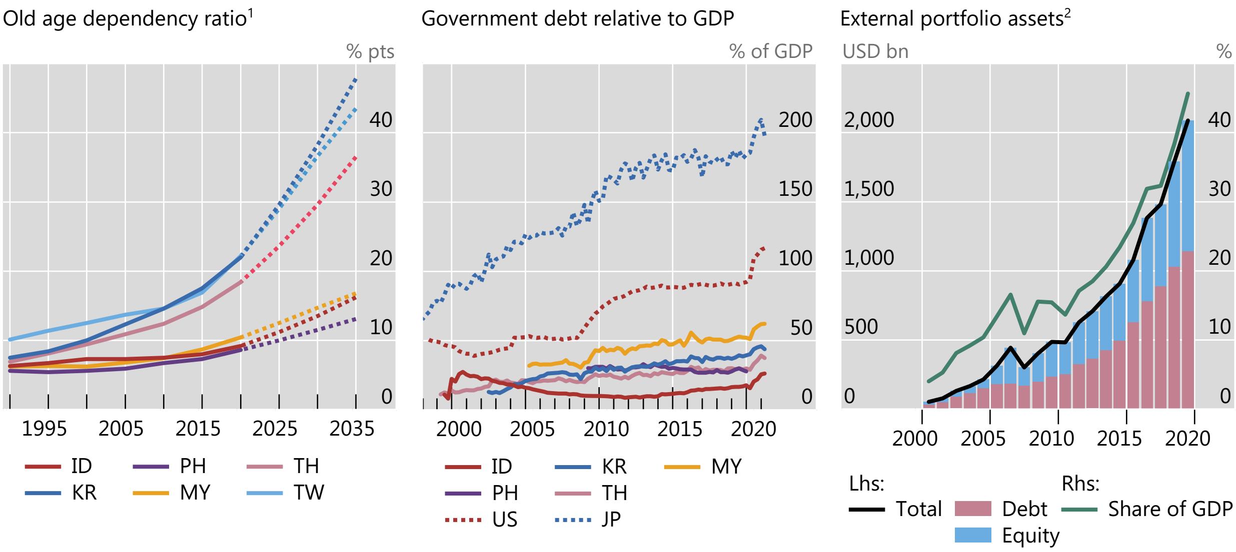
This feature proceeds as follows. The next section reviews demographic trends and the growing footprint of insurance companies and funded pension systems in Asian EMEs, which have fuelled expansion in outward portfolio investment. The following sections discuss their role in local FX markets and the hedging practices that make them vulnerable to stresses in dollar funding markets, as occurred in March 2020. The final section concludes with policy considerations.

Institutional investors' growing heft in external investment

In many economies, demographic trends towards an ageing population, together with the development of funded pension systems and the life insurance sector, have given institutional investors an increasingly important role in the financial system. While populations in many Asian EMEs are still relatively young, old age dependency ratios have risen sharply since 2015 and are projected to edge up further in the coming years, particularly in Chinese Taipei, Korea and Thailand (Graph 1, left-hand panel). Retirement savings managed by institutional investors have grown in parallel.

Asset managers that serve the funded pension system and insurance companies seek investments that correspond to the obligations to pension beneficiaries and life insurance policyholders. In so doing, they seek to acquire long-term assets with cash flow properties similar to institutional investors' longer-term liabilities, thereby mitigating duration risk.[2] However, scarcity of long-dated assets in many Asian EMEs, as evidenced, for instance, by relatively shallow local currency government bond

Demographics and scarcity of safe assets drive portfolio investment by Asian EMEs — Graph 1



[1] Share of population aged 65 or above. United Nations forecast from 2020 onwards. [2] Chinese Taipei, Indonesia, Korea, Malaysia, the Philippines and Thailand.

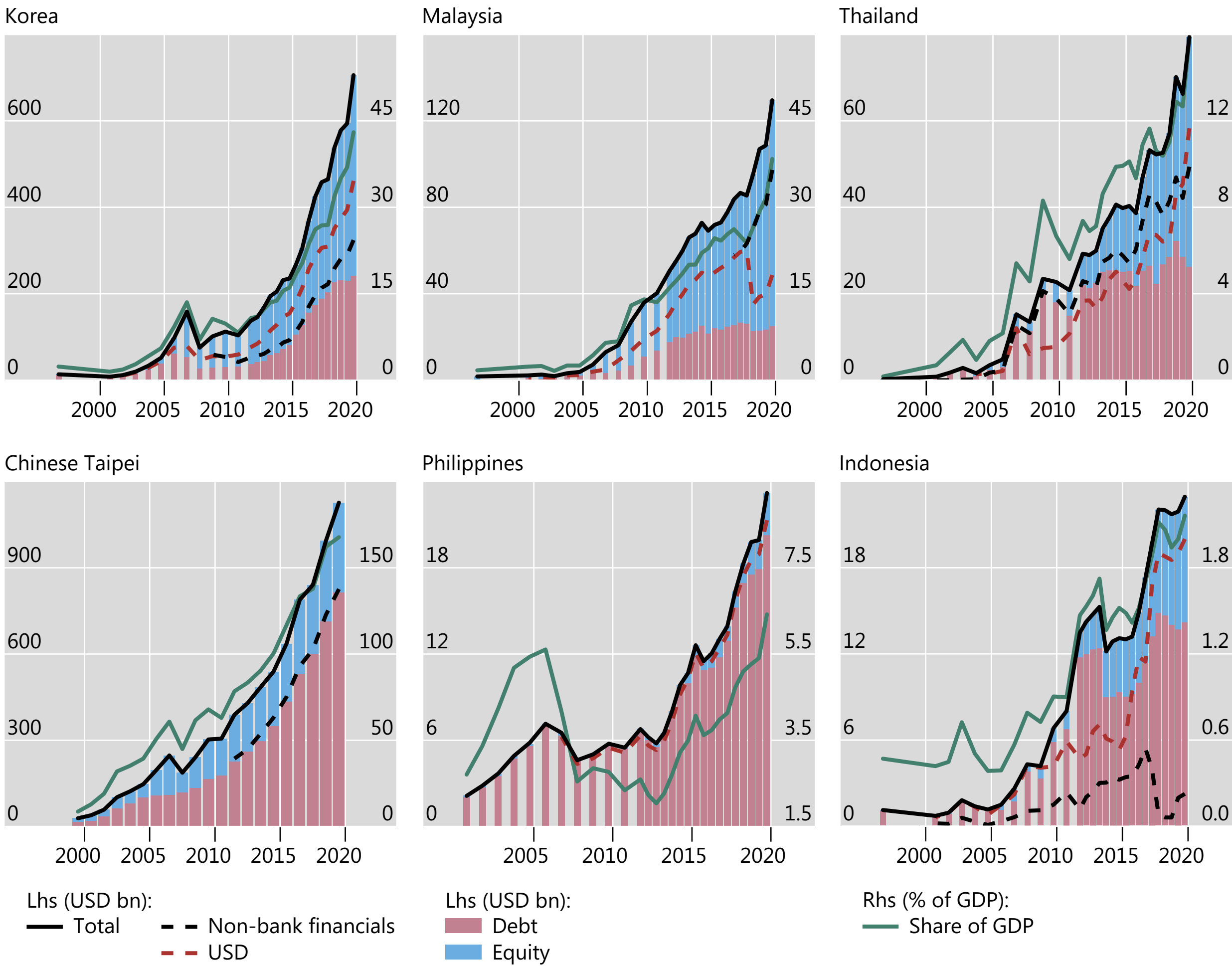
Sources: IMF, *Coordinated Portfolio Investment Survey*; United Nations, *World Population Prospects*, 2019; national data; BIS debt securities statistics; BIS calculations.

[2] Duration risk arises from a possible mismatch of valuation changes in assets and liabilities due to fluctuations in long-term interest rates.

markets (Graph 1, centre panel), has prompted resident investors to acquire foreign assets (IAR (2019)).[3] Their outward investment has at times been further spurred by an additional yield pickup even when hedging costs are factored in.

The "search for duration" has thus added to the traditional "search for yield" in fuelling the growth of external portfolio investment by Asian EMEs (Graph 1, right-hand panel). For Chinese Taipei and Korea, total investment has exceeded $900 billion and $700 billion, respectively, a near tripling in six years (Graph 2). The pace of the increases in Indonesia, Malaysia, the Philippines and Thailand was similar. In most of these economies, the accumulation of dollar-denominated assets (dashed red lines) by resident non-bank financial institutions (dashed black lines) drove this growth.[4]

Gross external portfolio assets of selected Asian economies[1] Graph 2



[1] Chinese Taipei does not report CPIS data, and figures for investment in US dollar-denominated assets are not available in national data. For the Philippines, which does report CPIS data, portfolio investment by non-bank financials is not available.

Sources: IMF, *Coordinated Portfolio Investment Survey* (CPIS); national data; BIS calculations.

[3] For comparison, in Japan other factors, such as the prolonged period of low yields and the large share of government bonds held on the central bank's balance sheet, have incentivised outward portfolio investment by institutional investors and asset managers.

[4] Authorities in some Asian EMEs impose limits on foreign investments by life insurance companies. For example, life insurers in Thailand cannot hold foreign assets in excess of 30% of their total assets. This limit is similar to that applied in China, but lower than that in Korea (50%). Life insurers in Thailand are also barred from investing in certain assets, such as US mortgage-backed securities.

Hedging practices of resident investors in emerging Asia

Demand for FX hedging services by investors based in emerging Asia has increased along with US dollar asset portfolios, not least because of regulations to curb currency risk. This has spurred growth in Asian FX derivatives markets, with the supply of hedging services provided by banks.

Institutional investors and asset managers typically hold foreign currency assets on a partially hedged basis, to mitigate the currency risk that arises from mismatch between these assets and domestic currency liabilities. In seeking to hedge currency risk, investors rely on banks to take the other side in FX derivatives. Due to the short-term nature of the bank funding model, the hedging instruments tend to be of shorter maturity than the assets, necessitating periodic renewal of the hedge. Hedging instruments include FX swaps and forwards, which are overwhelmingly short-term, and currency swaps, which have longer maturities.[5] Of these, FX swaps are the most liquid and widely used (BIS (2019)). They can be used to match the currency composition of assets and liabilities instead of borrowing and lending in the cash market. But unlike cash transactions, they do not appear on the balance sheet and therefore can be thought of as "missing" FX debt (Borio et al (2017)). As a result, foreign currency obligations stemming from FX derivatives positions of institutional investors and asset managers must be inferred from other indicators of banking sector exposures (see the next section).

In general, the degree to which currency risk is hedged depends on the type of asset and the type of investor. Equity portfolios are generally more volatile and have less predictable cash flows than fixed income portfolios, and so are preferred by investors willing to take on more risk in search of higher returns. Furthermore, the US dollar tends to appreciate precisely when US equity markets fall, thereby cushioning investment performance in local currency terms during risk-off episodes when the portfolio is unhedged. Across investor types, those that are more tightly regulated, like insurance companies, tend to have more conservative exposures than other types, such as pension funds and asset managers. Consider each in turn.

In many Asian EMEs, life insurance companies are subject to strict regulations on currency exposure, including some form of risk-based capital (RBC) requirement. Compared with other institutional investors, they allocate a greater proportion of their portfolios to fixed income assets and use FX derivatives to hedge.[6] Those in Korea and Thailand, for example, hedge close to 100% of their foreign currency bond portfolios to avoid additional capital charges.[7] By contrast, those in Chinese Taipei, where no strict requirements apply, hedge an estimated 50% of their foreign bond

5 In an FX swap, two parties exchange currencies at the prevailing spot rate and unwind the trade at a future date at a pre-agreed rate (the forward rate). A forward is a contract to exchange two currencies at a pre-agreed future date and price. Currency swaps are like FX swaps, except that the two parties agree to exchange both principal and interest payment streams over a longer term. The average maturity of FX forwards/swaps is about one month for contracts that reference the Malaysian ringgit, closer to two months for the Philippine peso and about three months for the Korean won and the New Taiwan dollar (BIS (2019)).

6 For instance, Malaysian and Thai life insurance companies invest 50% and 80% of their assets in sovereign and corporate bonds, respectively (Milliman (2019)).

7 Thailand's Office of Insurance Commission now allows insurance companies to have certain unhedged FX positions in proportion to the size of their solvency capital.

holdings.[8] As a benchmark, life insurance companies in Japan hedge approximately 50–70% of their bond portfolios.

Pension funds, which face fewer regulatory requirements, hold more equities in their portfolios and hedge currency risk to a lesser extent. Even with less hedging, however, the large size of their equity portfolios implies sizeable demand for dollar funding via FX derivatives. For example, pension funds in Chinese Taipei, Malaysia and Korea altogether held around $264 billion in foreign equities as of 2019 (Mercer (2021)). Hedging even 30% of this with one-month FX swaps would require rolling over more than $80 billion every month.

For their part, asset managers offering mutual funds or similar products that invest in foreign securities have an even greater share of equities in their portfolios. They too face few strict requirements but in practice tend to hedge in order to cater to investors' tolerance for currency risk. For example, investors in Thai mutual funds are known to have low tolerance for FX-related losses; hence these funds tend to hedge more than half of their holdings for currency risk.[9]

Growth in FX hedging markets and dollar supply

Trading in FX forwards and swaps in Asian EMEs' markets has grown in tandem with resident non-bank financial institutions' portfolio investment. By 2019, resident dealer banks reported close to $9.4 billion in daily trading with non-bank financial institutions, up from $4 billion in 2013 (Graph 3, left-hand panel). These transactions predominantly involved FX derivatives that referenced the US dollar. An estimate derived from the turnover data puts the outstanding amount of these hedges close to $545 billion in 2019 (centre panel, blue line), equivalent to roughly half of residents' portfolio investment in foreign currency debt securities (red bars).

Both the banks headquartered in the region and the local affiliates of global banks are active dealers in FX derivatives markets for Asian EME currencies. By June 2019, banks headquartered in Chinese Taipei, Indonesia, Korea, Malaysia or the Philippines reported a combined amount of almost $600 billion in outstanding FX swaps and forwards referencing their respective domestic currency, roughly double the amount reported in 2013 (Graph 4, left-hand panel, dashed red line).[10] Adding to this the positions reported by other banks, the estimated global total for these five currencies exceeded $1.3 trillion (solid red line) in 2019, indicating that foreign banks intermediate at least half of the total.

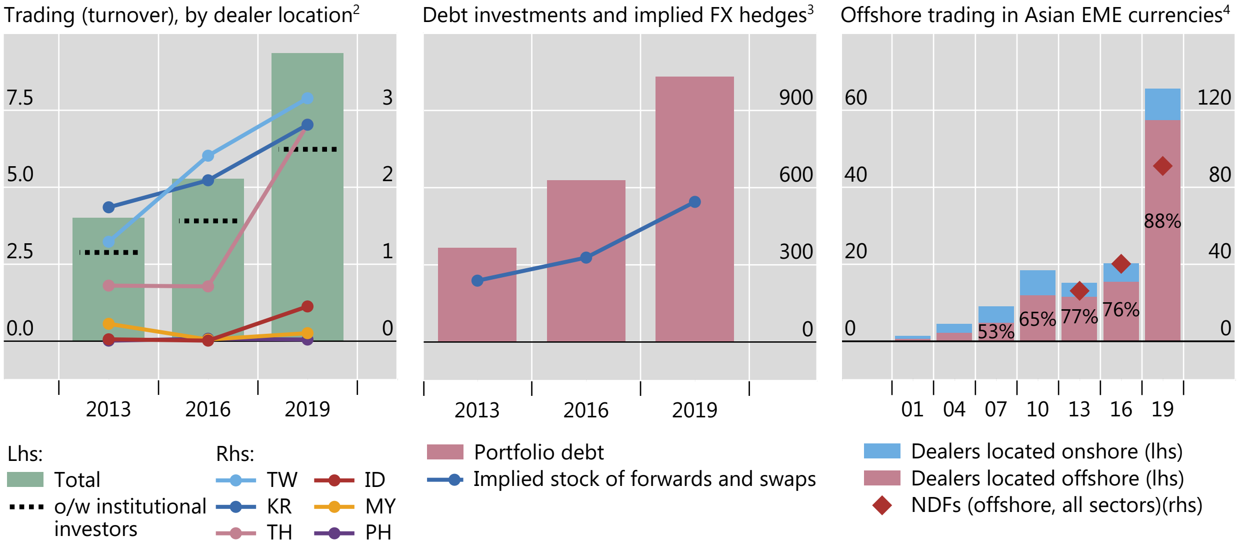
8 Setser and S T W (2019) show that the share of FX hedges by life insurance companies in Chinese Taipei declined from just under 80% in 2010 to just over 50% in 2019. However, the fivefold increase in foreign bond holdings over the same period implies strong growth in demand for FX hedges.

9 Under the Securities and Exchange Commission Thailand regulation, mutual funds in Thailand can hedge between 0 and 100% of their FX exposures and cannot over-hedge. The Bank of Thailand estimates that in 2018–20 the average hedge ratio for fixed income funds was around 96%, and that for equity funds 66%.

10 The BIS OTC derivatives statistics track the globally consolidated positions of banks headquartered in a particular country. About 80% of FX forward and FX swap positions reported by banks headquartered in the five Asian EMEs involved their own home currency.

Trading in FX swaps/forwards with non-bank financial institutions in Asian EMEs[1]

In billions of US dollars | Graph 3



[1] Trading by dealer banks located in Chinese Taipei, Indonesia, Korea, Malaysia, the Philippines and Thailand with non-bank financial institutions other than the official sector. [2] Daily average turnover volumes (notional amounts) in FX swaps/forwards (all currencies); excludes the Central Bank of Malaysia's dynamic hedging programme for institutional investors. [3] Implied stock of FX swaps/forwards derived by multiplying the average maturity (in days) by the average daily trading volume (blue dots); and countries' combined external portfolio debt investment (red bars, also in Graph 2). [4] Sum of average daily turnover of FX swaps/forwards with one leg denominated in IDR, KRW, MYR, PHP, THB or TWD. Dealers located onshore are those located in the currency-issuing country. Red diamonds are the sum of non-deliverable forwards (NDFs) (with all counterparty types) referencing the same currencies.

Sources: IMF, *Coordinated Portfolio Investment Survey*; BIS Triennial Survey; national data; BIS calculations.

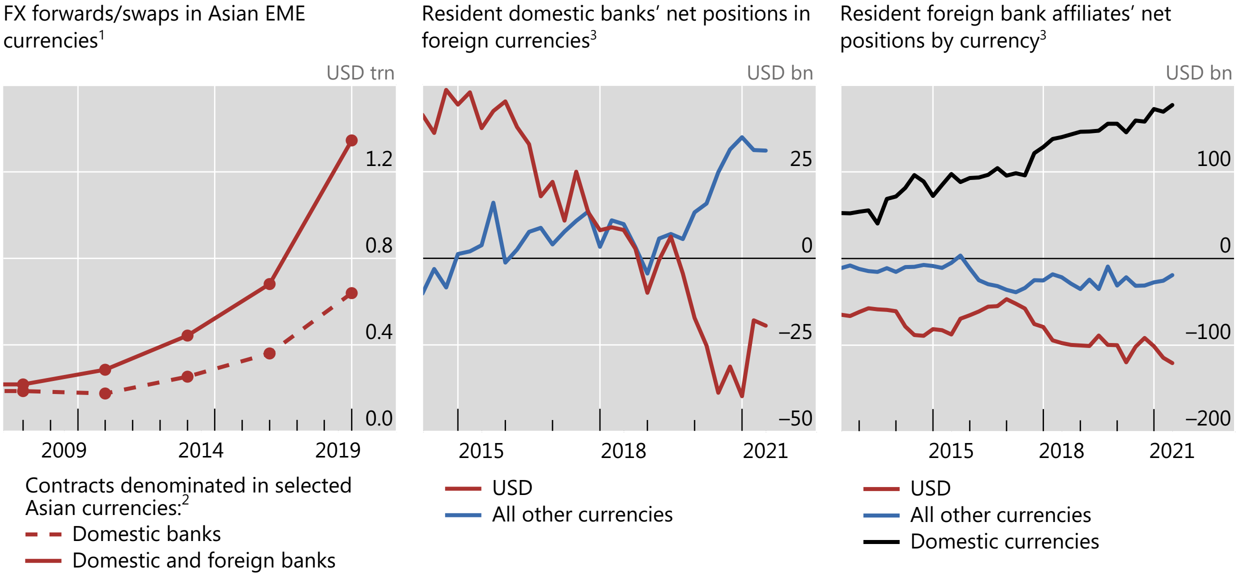
In their role as intermediaries, FX dealer banks meet the demand for dollars arising from resident institutional investors' FX hedging activities. Particularly important are the local affiliates of global banks, which source their dollars from capital markets or from their headquarters. Other potential sources of dollars in local FX hedging markets are resident corporates that hedge trade denominated in foreign currencies, and non-resident investors in local currency assets.

For resident bank offices, the approximate size of hedging positions can be pieced together with some detective work. The evidence is indirect but can be reasonably inferred from the apparent currency mismatches on their balance sheets, under the assumption that banks close this gap with off-balance sheet FX derivatives.[11] Combined, Asian EME domestic banks' home offices had more dollar liabilities than assets in mid-2020 (Graph 4, centre panel, red line), suggesting off-balance sheet net dollar lending of roughly $40 billion via FX derivatives. For their part, the local affiliates of foreign banks had an even larger and more persistent currency mismatch. Their net investment in local currency assets (right-hand panel, black line) neared $190 billion at end-2020, and was partly funded with net liabilities in US dollars ($120 billion, red line) and in other non-local currencies. These local currency investments make resident foreign banks natural suppliers of dollars to non-bank investors hedging their foreign currency investments.

[11] Regulation generally prevents dealer banks from running large open currency positions. Mismatches in their on-balance sheet positions are offset using off-balance sheet derivatives, and hence can be indicative of banks' net supply of or demand for a currency via FX derivatives. Moreover, as discussed below, restrictions on cross-border transactions in many Asian EMEs mean that resident banks' counterparties tend to be other residents.

Foreign and domestic banks in Asian EME FX hedging markets

Graph 4



[1] Reporting dealers' consolidated notional amounts outstanding with non-dealer financial institutions. The selected countries report only in the Triennial Survey (dashed red line). The BIS uses the Triennial data to supplement the semiannual data to arrive at a more accurate estimate of the size of OTC derivatives markets for all periods (solid red line). [2] IDR, KRW, MYR, PHP and TWD. [3] Combined on-balance sheet net positions (ie assets minus liabilities) of banks located in Chinese Taipei, Indonesia, Korea, Malaysia and the Philippines. Data for Q4 2017 and Q4 2018 have been partly adjusted due to a change in reporting practices by one of the countries.

Sources: BIS locational banking statistics and OTC derivatives statistics.

In addition to dollar funding from global capital markets and inter-office flows from banks' headquarters, resident non-financial corporates are also a source of dollars in local FX derivatives markets, although the amounts are comparatively small. Corporates issuing dollar debt in offshore bond markets supply dollars via swaps if they hedge their dollar liabilities into their home currency.[12] In addition, importers may hedge their future dollar payment obligations by buying dollars forward.

Finally, dollar-based non-resident investors who hold assets denominated in Asian EME currencies on a hedged basis may also supply dollars in local FX markets. For instance, non-residents account for a sizeable share of dollar supply into the FX swap market in Thailand. However, segmentation between onshore and offshore markets may inhibit this supply in other jurisdictions. Many Asian EMEs have in place some form of foreign exchange controls that result in residents trading onshore and non-residents trading offshore (Tsuyuguchi and Wooldridge (2008); Patel and Xia (2019)).[13] The implication is that dollars provided via FX derivatives by foreign investors hedging their EME currency assets may not be accessible in onshore markets. In other words, hedging related to portfolio *inflows* does not necessarily help meet the dollar demand from resident investors' hedging of their portfolio *outflows*.

Data on trading volumes of FX swaps and forwards in Asian EME currencies provide evidence for this market segmentation. In 2019, a full 88% of transactions

[12] EMEAP (2020) suggests that emerging Asian non-financial corporates do not hedge most of their foreign currency liabilities, but also highlights the lack of consistent information.

[13] Foreign exchange controls might take the form of requiring central bank approval for sales and purchases of foreign exchange or restrictions designed to suppress offshore trading because it is more difficult to monitor than onshore trading. This typically involves restricting the cross-border deliverability of a currency.

with non-bank financials were offshore (Graph 3, right-hand panel, red bars). Trading of non-deliverable forwards (NDFs), mainly contracts referencing the Korean won and New Taiwan dollar, has roughly tripled alongside offshore transactions since 2013 (red diamonds).[14]

The general trend among Asian EMEs is to relax FX controls to deepen FX hedging markets. For example, the Central Bank of Malaysia introduced its "dynamic hedging programme" in December 2016, which eased regulations on FX hedging by resident and non-resident institutional investors and allowed more flexibility in the management of FX risk exposures. Volumes in the onshore FX forward market have since doubled.[15] Similarly, the Bank of Thailand is introducing more hedging instruments, easing rules for overseas investment and allowing non-banks to provide FX services (Bank of Thailand (2020)). Finally, Bank Indonesia introduced a domestic NDF in November 2018 to promote the development of the domestic FX hedging market.[16]

US dollar funding stress in March 2020

Asian institutional investors and asset managers are exposed to disruptions in dollar funding markets through the maturity mismatch between the long-term nature of US dollar assets they hold and their use of short-term instruments supplied by banks for FX hedging. Dealer banks' balance sheet management conforms to the well documented, procyclical nature of dollar wholesale funding, which tends to expand during tranquil times only to contract sharply during periods of financial stress, especially when accompanied by a sharp appreciation of the dollar (Avdjiev et al (2019)).

This was evident most recently during the market turmoil of March 2020 due to the Covid-19 pandemic. The cost of borrowing dollars via FX swaps shot up relative to dollar interest rates in the money market – a violation of covered interest parity (CIP), as evidenced by a widening of the basis for multiple Asian EME currencies (Graph 5).[17] The impact differed across currencies in part depending on the depth of local FX swap markets and differences in hedging practices.

Most notable during the episode was the widening of Korean won FX swap basis vis-à-vis the US dollar (Avdjiev et al (2020)). Financial institutions' reliance on short-term hedges meant that the pressure in the market for three-month FX swaps was more acute than in that for one-year currency swaps (Graph 5). A spike in the demand

14 Historically, NDFs have been used to meet hedging demands involving currencies that are not fully convertible because they allow for payoffs related to a currency's performance without requiring funding in the underlying currency.

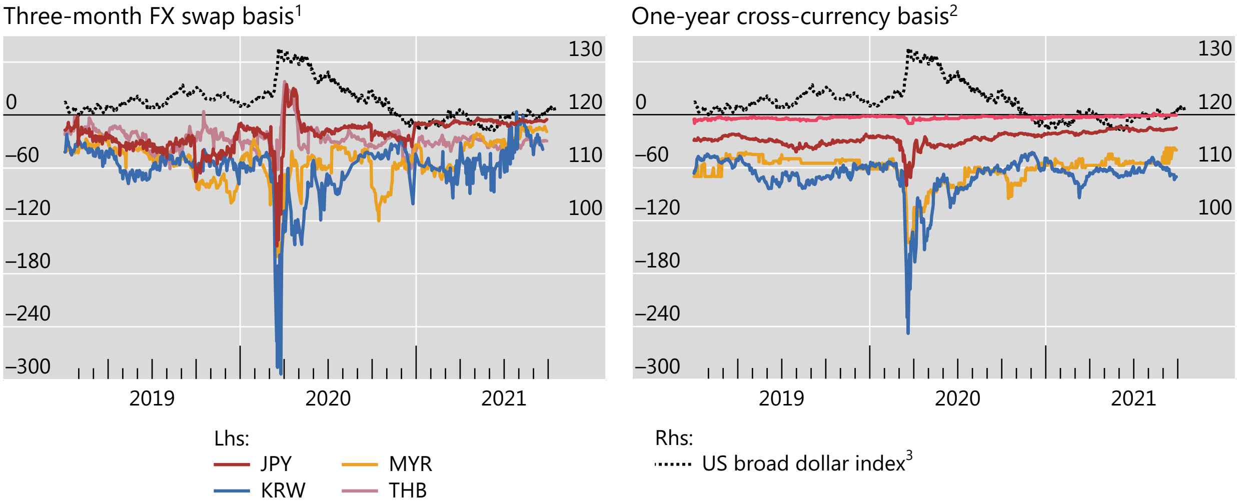
15 See www.bnm.gov.my/-/dynamic-hedging-programme-for-institutional-investors-1.

16 See www.bi.go.id/en/publikasi/peraturan/Documents/PBI_201018.pdf.

17 CIP is the textbook proposition that the dollar short-term interest rate in money markets and the implied dollar short-term interest rates embedded in the FX swap market should be equal, reinforced by arbitrage by market participants who borrow at the low dollar rate and lend at the high dollar rate. A negative basis means that borrowing dollars through FX swaps is more expensive than borrowing in the dollar money market. The FX basis tends to widen with a stronger US dollar, indicating tighter dollar funding conditions (Shin (2016); Avdjiev et al (2019)).

Currency hedging costs and the dollar exchange rate during the Covid-19 crisis

In basis points | Graph 5



[1] Based on the use of FX forwards and onshore money market rates: KRW CD rates; Central Bank of Malaysia Klibor and Bangkok Interbank Offered Rate, respectively. [2] Based on one-year cross-currency basis swap. [3] Trade-weighted nominal dollar index based on goods and services trade. Higher values indicate a stronger US dollar.

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

for dollars by securities firms in Korea, under pressure to meet margin calls on their futures and options contracts linked to foreign stock indices, further exacerbated dollar funding pressures (see box).[18]

On the supply side, banks in Korea may have been limited in their ability to accommodate the surge in demand for dollars by institutional investors and asset managers. First, banks themselves were in need of dollars during the turmoil. Second, in 2010 the Korean financial authorities introduced caps on banks' net FX forward positions relative to equity capital, to curb excessive FX borrowing. During the March 2020 market turbulence, domestic banks' caps were relaxed from 40% to 50%, and foreign bank branches' caps from 200% to 250%.

In contrast to the Korean won, movements in the Thai baht basis vis-à-vis the US dollar in March 2020 were short-lived and less severe. One possible reason is that outward portfolio investment from Thailand is much smaller, both in absolute amounts and relative to GDP (Graph 2). In addition, foreign investment funds in Thailand hedge flexibly. In March 2020, they allowed hedge ratios to temporarily fall by not rolling over existing hedges, thus alleviating price pressures in a countercyclical manner. Finally, the Bank of Thailand conducted open market operations in the local FX swap market (EMEAP (2020)), and so was well placed to ensure market depth.[19]

[18] Shin and Shin (2021) show that Korean securities firms faced a severe dollar shortage in March 2020 mainly due to margin calls on structured products linked to overseas stock markets and other assets (eg equity-linked securities, equity-linked bonds, derivatives-linked securities and derivatives-linked bonds). These auto-callable funds (or structured retail products) increased five-fold over the last decade, from KRW 22.4 trillion in 2010 to KRW 108.2 trillion in 2019 (Lee (2021)).

[19] The operations by the Bank of Thailand limited the impact of the pullback of dollar liquidity onshore and helped to restore market functioning. Similarly, Bank Indonesia increased the frequency of its FX swap auctions in March 2020 to improve dollar liquidity conditions.

Box

Korea's policy response to the March 2020 market turmoil

Patrick McGuire, Ilhyock Shim, Hyun Song Shin, Vladyslav Sushko[1]

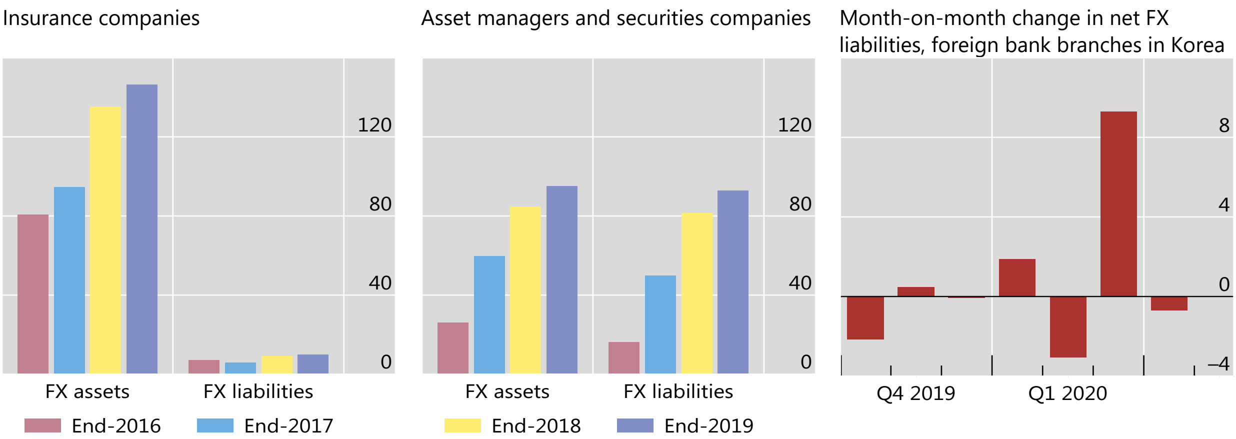
This box reviews the Korean experience with US dollar shortages during the March 2020 episode and the changes it triggered to the country's regulatory framework.

Strong demand for dollar funding in Korea originated from at least three sources. First, insurance companies were required to continue to roll over foreign currency (FX) hedges for their sizeable mismatches between FX assets and liabilities (Graph A, left-hand panel). Second, despite their smaller size, demand for dollars by asset managers and securities companies (centre panel) spiked during the market stress, as these investors struggled to meet margin calls on the roughly $11 billion in equity-linked securities (ELS) they had sold to Korean investors.[2] Third, non-resident investors sold local currency assets, resulting in the conversion of roughly $4.5 billion Korean won into US dollars in the spot market (Bank of Korea et al (2021)).

FX assets and liabilities of insurance companies and asset managers in Korea

In billions of US dollars

Graph A



Sources: Bank of Korea et al (2021); Korean Financial Analysis Information Retrieval System; BIS calculations.

Banks managed to continue to supply dollars via FX derivatives, albeit at a premium since they too needed to secure dollar funding. Domestic banks' FX borrowing grew by $4.5 billion in March 2020 and that of the branches of foreign banks by almost $10 billion, mostly via borrowing from their headquarters (Graph A, right-hand panel).

The experience highlighted two key vulnerabilities involving asset managers and institutional investors in Korea. First, their investment practices tended to exhibit herd behaviour and lacked diversity, thus amplifying systemic risk. In particular, the exposures in ELS issued by securities companies – which contributed to dollar shortages in March 2020 – were highly concentrated in only a few stock indices (eg the KOSPI 500, S&P 500, EURO STOXX 50 and the Hang Seng index). Second, these asset managers did not maintain sufficient dollar credit lines with banks before March 2020 and thus had to scramble for dollars exactly when banks became reluctant to lend to them.

In January 2021, the authorities announced a plan to address these weaknesses. It aims to enhance FX risk management capabilities of institutional investors and asset managers, strengthen monitoring of FX liquidity, close loopholes in FX prudential regulations, improve the FX macroprudential policy framework, and build a multi-layered supply chain to backstop FX liquidity for non-bank investors (Bank of Korea et al (2021)). By end-July 2021, indicators were in place to monitor the FX risks of insurance and asset management companies, and FX liquidity stress tests were conducted on a quarterly basis. In addition, the cap on insurance companies' open FX positions had been raised from 20% to 30% of solvency capital, so that they can hedge more flexibly. Finally, the FX Macroprudential Council was set up to enhance coordination among financial authorities. Additional measures are to be implemented by end-2021.

[1] The views expressed in this box are those of the authors and do not necessarily reflect those of the BIS. [2] Since their introduction in 2003, ELS and derivatives-linked securities have become the main indirect investment products in Korea. Their combined outstanding amount at end-2016 reached KRW 100 trillion, from KRW 18 trillion at end-2007 (Lee (2017)). ELS are classified as hybrid debt securities since they have domestic bonds as the underlying assets but also derivatives exposure to foreign equity indices.

The expansion of Federal Reserve swap lines with major advanced economy central banks, including the Bank of Japan, mitigated stresses in global dollar funding markets. And the reopening of swap lines with the Bank of Korea and the Monetary Authority of Singapore on 19 March 2020 further narrowed the swap basis in Asian EME currencies. However, even as funding rates recovered on the back of swift policy support, transaction volumes in domestic FX swap markets declined significantly and have been slow to return to pre-pandemic levels (EMEAP (2020)).

Policy considerations

The disruptions during March 2020 put the spotlight on a new element in dollar funding stresses and revealed gaps in traditional policy approaches to FX markets. The new element is institutional investors' and asset managers' need for dollar funding liquidity, which adds to the general scramble for dollar funding during periods of financial stress. These non-bank investors have traditionally been subject to less stringent FX liquidity regulation and risk management rules than banks, and financial authorities face challenges in monitoring their funding needs. Particularly thorny issues include strengthening the resilience of these investors in the face of disruptions in dollar funding markets, and integrating them into existing oversight frameworks through expanded coverage.

Monitoring systemic risk posed by non-bank financial institutions: Regulatory monitoring systems tend to be centred on the banking sector; there is a limited view of the activities of institutional investors and asset managers (Bank of Korea et al (2021)). Yet common exposures, dominant investors and interlinkages between banks and non-bank financial institutions can contribute to systemic risk (FSB (2020)). Similarly, the combination of banks' procyclical supply of wholesale dollar funding and the investment and margining practices of institutional investors and asset managers tends to amplify asset price cycles and swings in investment flows and exchange rates. Authorities need to better understand non-bank investors' role in those mechanisms that create or propagate systemic risk so that they can take the necessary policy actions to smooth out financial risk-taking over time.

Strengthening oversight of FX funding liquidity risks created by institutional investors and asset managers: In many EMEs, both resident banks and non-bank investors are exposed to disruptions in dollar funding markets. Yet oversight of these institutions, and of foreign exchange markets, is fragmented across the central bank and other regulators, making it difficult to effectively monitor developments and swiftly respond. Policymakers could benefit from a consolidated approach to oversight that encompasses the root causes of dollar funding problems created by institutional investors and asset managers in FX markets (Shin and Shin (2021)). The principle of "same risk, same regulation" would point to more disclosure of FX liquidity risk and enhancements to their FX liquidity regulation and risk management frameworks.[20]

Calibrating regulation of FX hedging: Many Asian EMEs have adopted risk-based capital (RBC) frameworks in their solvency regulation of insurance companies. To reduce procyclicality, such frameworks can be adjusted to allow for flexible hedging of currency risk in order to mitigate spikes in the demand for short-term

[20] Examples are the FX liquid asset/liability ratio, FX inflow/outflow ratio and FX maturity mismatch ratio.

dollars in times of stress. Similarly, adjustments that incentivise longer-term hedging (eg up to three years) could reduce reliance on short-term FX derivatives where rollover risk is concentrated.

The need for foreign currency liquidity beyond the banking sector: The March 2020 experience highlighted the importance of central bank swap lines for distributing dollar liquidity to the global banking sector. At the same time, it also illuminated the greater underlying demand for dollar funding from institutional investors and asset managers in EMEs, which is met by banks. Central banks in some Asian EMEs introduced new facilities in March 2020 to provide liquidity to institutional investors and asset managers via domestic banks.[21] But in many others, such mechanisms do not exist, reflecting concerns over moral hazard. In any case, the new facilities remain largely untested. Mechanisms to provide liquidity to institutional investors and asset managers during stress periods should be considered only with accompanying regulation, as in the case of banks. Otherwise, they may unleash more FX-related risk-taking during normal times and thus increase the intensity and likelihood of future stress episodes.

21 In June 2020, the Bank of Korea introduced a repo facility to provide US dollar liquidity to financial institutions (including insurance and securities companies) via auctions using US Treasuries as collateral. In March 2020, the Bank of Thailand expanded the scope of a special credit facility to provide liquidity to money market mutual funds and daily fixed income funds by allowing banks to repurchase the funds' investment units, government bonds and investment grade corporate bonds.

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The rise of private markets[1]

The last two decades have seen the growth and consolidation of private markets. These revolve around funds gathered from institutional investors by "alternative asset managers", typically private equity or venture capital firms that have subsequently expanded into credit. In an environment of light regulation, long investor horizons and low interest rates, the involvement of private market funds in firms' investment financing and restructuring has grown over time. The interactions of these increasingly important non-bank financial intermediaries with the wider economy and their response to monetary policy have not been fully explored. We find that, despite long investment horizons, private markets are as procyclical as public markets. As for monetary policy, its transmission differs according to the type of private market fund, exerting the strongest effect on private credit funds.

JEL classification: G15, G23, G32.

External financing is increasingly intermediated outside traditional channels. Banks and other institutions active in public capital markets, such as equity and corporate bond mutual funds, remain key financing sources for large and mature corporates. That said, "alternative asset managers" (AAMs) have become pivotal for smaller firms globally, including in emerging market economies (EMEs). Many AAMs were established as private equity firms that later expanded into credit, thus turning themselves into one-stop capital providers for firms less able or willing to access traditional sources.

Private markets have three features that distinguish them from public markets. First, there is limited liquidity transformation because investors commit capital for extended periods. Second, these investors tend to be large and sophisticated entities such as pension funds, whose focus on long-term returns enables target companies to confront significant earnings volatility. Third, the regulation of private market investment vehicles is relatively light, partly reflecting the lesser degree of liquidity mismatches and also the limited presence of retail investors.

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Key takeaways

- Private capital markets have become a major force in all aspects of firm financing and restructuring in advanced and also emerging economies, particularly in Asia.
- Financing is routed mainly through "alternative asset managers", which offer a suite of private equity, venture capital and private credit funding options across the life cycle of companies.
- Compared with public markets, the funding provided through private markets is just as procyclical, while sensitivity to monetary policy varies across business segments.

Private markets confer important benefits. They provide young and innovative firms with better access to finance, thus supporting long-term economic growth. AAMs also add value by advising entrepreneurs and introducing start-up firms to a wide network of industry contacts. This eases funding constraints, which may arise from a lack of tangible assets to post as collateral or from an inability to shoulder the compliance costs of mandatory disclosures in public markets.

From a policy perspective, some aspects of private market functioning may deserve attention. We find procyclical risk-taking patterns, similar to those seen in public markets and stemming from search for yield and fund leverage. Separately, monetary policy transmission appears weak in some segments, but in private credit it is comparable with that in public markets. Further work on these and related issues would help to ensure that private markets do not become a blind spot for policymakers.

The rest of this special feature is organised as follows. The first section surveys the global growth of private markets, placing it in the context of evolving trends in public markets. The second presents the private market ecosystem. The third explores policy relevant issues, including procyclicality.

The global footprint of private markets

Private markets encompass a varied set of transaction types implemented through specialised funds. Some of these focus on providing equity capital by acquiring a minority stake in small start-up firms with high growth potential (venture capital, VC), or in somewhat more mature firms with good prospects or under restructuring (growth capital, GC). We refer to these collectively as VGC funds. In turn, so-called private equity (PE) funds specialise in mergers and acquisitions (M&A), aiming mainly to acquire controlling stakes in more established (often publicly traded) corporates, with the purpose of improving their value through restructuring for subsequent resale. By contrast, the assets of private credit (PC) funds typically consist of loans to small firms with high credit risk. Finally, there are funds that focus on "real assets", investing in infrastructure, real estate, commodities and other materials and resources. The box presents an overview of business segments and investment vehicles.

Box

Private markets: a primer

Sirio Aramonte and Fernando Avalos[1]

This box outlines the structural features of private markets. First, it highlights some key details of the main investment vehicles. Second, it reviews leverage sources. Third, it sketches the alignment of incentives between fund managers and investors. Fourth, it reviews the specialisations of the funds through which alternative asset managers (AAMs) provide corporate financing in private markets.

Closed-end funds are the most prevalent investment vehicles in private markets. These funds issue a fixed number of shares that cannot be redeemed before a scheduled wind-down, whose exact timing is decided largely by the fund managers. As such, liquidity transformation is limited in private markets. In many cases, shares rarely trade and are accessible only to large institutional investors. In others, they are listed on exchanges and can be traded by retail investors, which attracts more rigorous regulation. This is the case of US business development companies (BDCs), a vehicle commonly used to channel private loans, which have disclosure requirements similar to those of mutual funds.

There are three sources of leverage in private markets. The first is the often substantial debt of the target companies, taken to fund the asset acquisition and leverage up investment returns. The second is the debt that funds themselves may incur. For instance, BDCs can take debt equal to twice their net assets, compared with half of net assets for US mutual funds. The third comes in the form of "subscription credit lines" (SCLs), loans collateralised by capital that is committed by investors but not yet disbursed. This "dry powder" of the funds is periodically paid in by committed investors at the request of the fund manager, in so-called capital calls. SCLs are used to reduce the frequency of capital calls while retaining investment flexibility.

Alignment of incentives between investors and AAMs is promoted through co-investment. Fund managers are known as "general partners" (GPs). They take all decisions, from capital deployment to winding down the fund. They are also responsible for arranging the financing of the transaction, and undertake all the legal and business due diligence, whose costs and complexity are usually large. Besides receiving fees for portfolio management, GPs also typically co-invest their own capital in the funds they manage. Thus, the investors with no management rights (the "limited partners" or LPs) have some reassurance that the GPs' incentives are aligned with their own. The funds, however, remain legally separated from the GPs' balance sheet.

Recently, some large investors have also started to co-invest in specific projects with AAMs without committing capital to funds. These investors could be pension funds or insurance companies, or sometimes large corporations that set up in-house divisions to manage their own portfolio of private assets. Co-investment allows them to share in the returns of private capital investments without incurring the cost of fund management fees. In exchange, they assume a less diversified investment risk.

Broadly speaking, private markets consist of four business segments: private equity, venture capital, private credit and real assets, as presented below.

Private equity (PE), focused mostly on restructuring mature firms, sprung to life in the United States in the 1970s. The main business of PE firms is leveraged buyouts (LBOs), in which they acquire controlling stakes in firms, including listed companies, with the purpose of improving efficiency and raising enterprise value. LBOs belong to the category of mergers and acquisitions, making substantial use of debt in financing deals. In a typical LBO sponsored by a PE fund, a specially created shell company acquires the target company using mostly syndicated loans from banks and institutional investors but also equity from the PE fund. Subsequent issuance of high-yield corporate bonds by the acquired company repays part of the loans. Given the large amounts of debt involved, and the correspondingly high debt service costs, PE funds favour established companies with resilient cash flows and they become involved in managing the target company to facilitate restructuring. More recently, PE funds have also branched out into growth capital investment, taking minority equity stakes in mature firms and betting on their growth, as well as in turnaround majority investment in severely underperforming firms, and mezzanine lending to distressed firms, where the debt is convertible to common stock.

Modern venture capital (VC) traces its roots to the post-war United States. Previously, wealthy families were the main source of equity capital for start-up companies, in a similar way to today's "angel investors", who take limited stakes and refrain from day-to-day management. In contrast, VC investors are usually more proactive, partly because target companies have high growth potential but also elevated risks and few assets usable as collateral. Hence, close monitoring is key to investment performance. VC fund managers usually provide business expertise to the management of start-up companies, and further add value by providing access to a wide network of business relationships. Given this expertise, and the possibility of providing funding against little or no collateral, VC firms have traditionally focused on sectors with intangible assets, such as technology. As with private equity, venture capital funds aim to realise gains by selling their stakes to other private market investors in so-called secondary buyouts, or by listing target companies in public stock markets through initial public offerings.

Private credit refers to debt financing extended to small firms with a relatively high default risk. This sector grew as banks recalibrated their business models, partly in pursuit of operational efficiencies. Indeed, banks' direct involvement in this area is typically limited, even in credit origination. Most linkages between banks and private credit take the form of SCLs. BDCs provide a common entry point for retail investors. These entities hold mainly loans and other debt.②

Finally, a significant share of AAMs' funds focus on investment in real assets such as infrastructure, real estate, commodities and natural resources. These private funds are also organised as closed-end vehicles aimed at large institutional investors, unlike real estate investment trusts (REITs) that also tend to be closed-end but target retail investors and trade on public stock markets.

① The views expressed in this box are those of the authors and do not necessarily reflect those of the BIS. ② Also see Aramonte (2020).

The rise of private markets reflects in part structural shifts in financial intermediation that trace their roots to the 1980s. These shifts started in the United States and stemmed from changes in banks' business practices and the role of public markets.[2] Echoing their success in the United States, private markets began to develop in other parts of the world.

Private markets are largest in North America and Europe, and feature a different mix of specialisations in Asia. Of the nearly $10 trillion in global assets under management (AUM) – which compares with an estimated $40 trillion in non-government mutual funds – 56% are domiciled in North America, 24% in Europe and 18% in Asia (Table 1). The relative weight of the various fund specialisations is similar in North America and Europe, with PE and real assets representing about 40% and almost 30%, respectively, in both areas. In Asia, however, VGC encompasses half of the assets and PC is comparatively smaller.

In all jurisdictions, a substantial part of the funds raised are not immediately deployed. So-called "dry powder" represents commitments made by ultimate investors that have not been disbursed, typically because suitable deals have yet to be identified. Dry powder stood at about $3 trillion overall in early 2021 and represented about 40% of PE assets in North America and Europe, and approximately 30% of VGC assets in Asia (Table 1). These large, untapped capital commitments suggest a strong demand for exposure to private market assets.

[2] For the transformation of the US banking system, see Berger et al (1995), and references therein. For changes in global banking after the GFC see eg Cerutti and Claessens (2017). For changes in the US stock markets, see Doidge et al (2017).

Geographical distribution of assets under management, by specialisation

In billions of US dollars Table 1

	Private equity	Venture and growth capital	Private credit	Real assets	Total
North America	2,115	975	982	1,416	5,489
Dry powder	786	368	277	415	1,846
Europe	892	317	456	679	2,343
Dry powder	334	108	139	230	811
Asia	457	859	91	348	1,755
Dry powder	136	254	21	79	490
Rest of world	62	39	8	46	156
Dry powder	11	11	2	8	33
Total	3,526	2,190	1,537	2,489	9,742
Total dry powder	1,267	742	438	733	3,180

Dry powder is the amount of capital committed by investors, but still not invested by the funds.

Data as of 22 October 2021. For dry-powder capital, data as of 31 March 2021.

Sources: PitchBook Data Inc; authors' calculations.

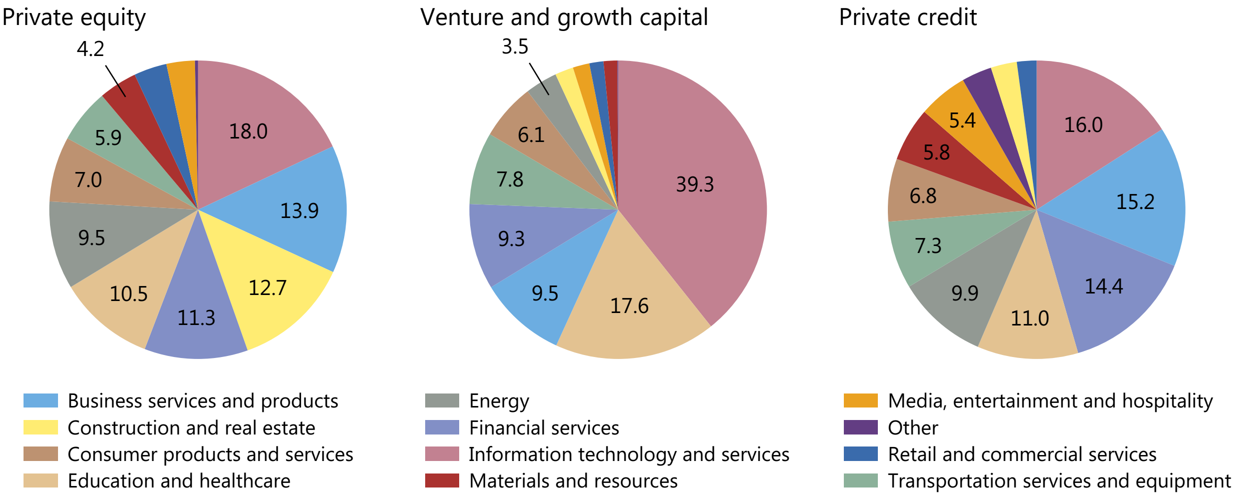
Private market funds with different specialisations tend to invest in different industries. We focus now on the fund types that are most closely linked to company funding: PE, VGC and PC, setting real assets aside. Given that it often involves highly leveraged transactions, PE has traditionally focused on less cyclical sectors with more resilient cash flows (Borio (1990)). At present, information technology, business services, education and healthcare, and financial services comprise more than half of the global portfolio of these funds, while construction, energy, and resources represent only about a quarter (Graph 1, left-hand panel). By contrast, VGC is heavily tilted towards the more innovative areas of the economy. Information technology is by far the main recipient of VGC financing, accounting for about 40% of the global portfolio. It is followed by education and healthcare, business services and financial services, including fintech, representing almost 30% (centre panel). PC's industry portfolio is diversified along much the same lines as that of PE, but with a noticeably smaller share of construction and real estate (right-hand panel).

In terms of activity flows, EME private markets have become comparable with the more traditional part of the financial system. Capital invested in EMEs through private markets rose markedly in the mid-2010s, targeting mostly emerging Asia (Graph 2, first panel, solid areas). Investment funds mobilised by private markets to and within EMEs have eclipsed portfolio flows to EME corporate assets (yellow line). Moreover, private investments have matched syndicated lending to EME corporates since the mid-2010s surge (green line), when they also started to approach the volumes of gross foreign direct investment flows (black line).[3]

[3] Private market funds with a regional focus raise capital both locally and internationally. To the extent that the capital deployed was committed by domestic limited partners, they will not show as FDI. If the funds have been committed by non-residents, there will be some overlap between FDI and private market flows. As portfolio flows are routed through public markets, their overlap with private market flows is less of an issue.

While private equity and credit are generally diversified, VGC targets innovation

In per cent | Graph 1



Based on data for 2021 up to 31 October 2021.

Sources: PitchBook Data Inc; authors' calculations.

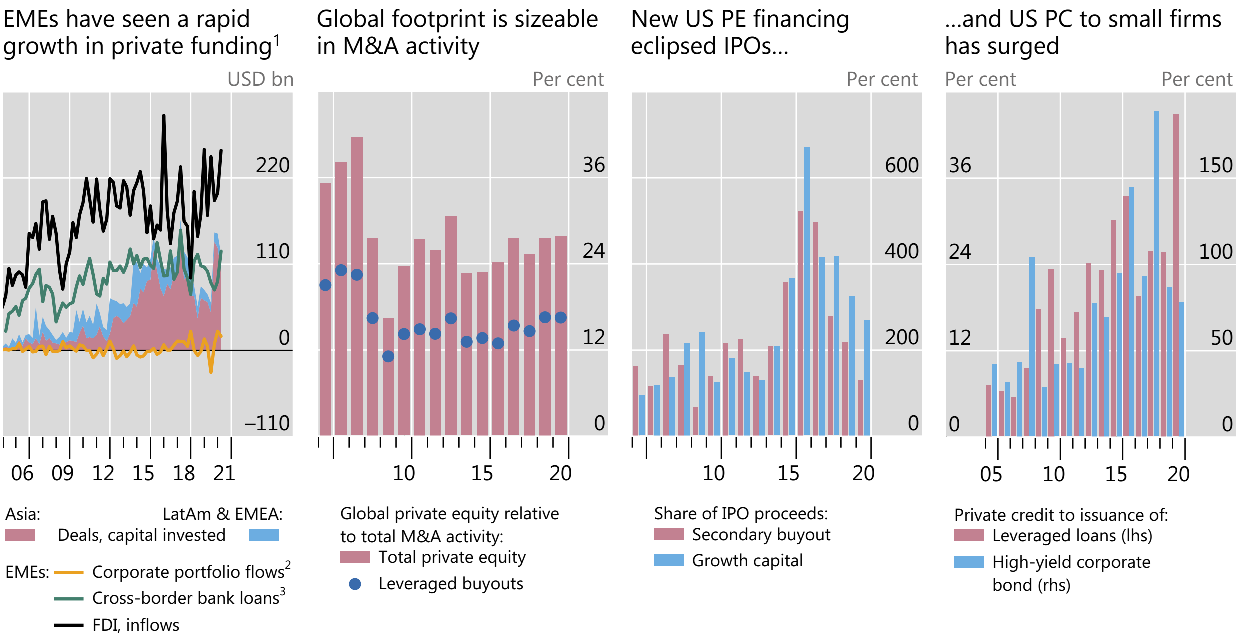
The footprint of private funds has become material in many market segments. Overall acquisition activity by global PE funds makes up about a quarter of global M&A volumes (Graph 2, second panel, red bars). This activity is based mainly on leveraged buyouts (LBOs), which have continued to represent about 15% of total global M&A since the Great Financial Crisis (GFC) (blue dots). In turn, the propensity of firms to remain private for longer than in the past, particularly in the United States, has boosted another PE business line – secondary buyouts. These deals consist in the acquisition of a private company, which is sponsored by a private market fund, by yet another private market fund. In recent years, secondary buyouts in the United States have often exceeded the volume of initial public offerings (IPOs), which have long been the main route for early investors who wish to liquidate their stakes (third panel, red bars).[4] The propensity of US companies to stay private is also behind the growth-capital segment of VGC outpacing IPOs for most of the last two decades (blue bars).[5] On the PC side, lending flows to small and risky firms have increased markedly, now amounting to a meaningful fraction of the leveraged loan and high-yield bond issuance by more established firms (fourth panel).

4 IPOs have traditionally been a way for early investors to exit their investment in private companies. The share of IPOs sponsored by private market funds, mainly PE or VC firms, has risen over time: from 46% during 1990–98 to 80% in 2019–21. This also speaks to the growing importance of private markets in early-stage corporate financing.

5 Growth capital transactions typically target private firms with high growth potential that are mature enough to go public through an IPO. IPOs have stagnated: in 2020, IPO proceeds were about the same as in 1999 in nominal terms, and the number of firms going public was about a fourth (see "IPO Statistics from 2020 and earlier years", https://site.warrington.ufl.edu/ritter/ipo-data/). As a result, listed companies are now older and more mature (see eg Doidge et al (2017)).

Private markets have become a global force in firm funding and restructuring

Graph 2



IPO = initial public offering.

[1] The sample includes BR, CL, CN, CO, CZ, HK, HU, ID, IN, KR, MX, MY, PE, PH, PL, RU, SG, TH, TR and ZA. [2] Includes equity and corporate bond net fund flows. [3] Includes investment grade, leveraged and highly leveraged syndicated loans.

Sources: J Ritter, "Initial Public Offerings: Underpricing", December 2020; IMF; SIFMA; Dealogic; PitchBook Data Inc; authors' calculations.

Key players in the private market ecosystem

Activity in private markets revolves around institutional investors, which provide nearly all the capital, and AAMs, which intermediate the funds.

The ultimate investors are typically large entities. Pension funds are the dominant players in PE and PC, with a share often exceeding 70% of capital commitments (Graph 3, left-hand panel). By contrast, economic development agencies – usually supranational or governmental entities – take the leading role in VGC. Insurance companies also have a relatively large participation in the safer business segments (PE and PC), while sovereign wealth funds focus more on PE and VGC. Finally, the limited activity of banks and corporations is tilted towards VGC.

Many AAMs grew organically by adding activities to their initial monoline focus. AAMs often trace their roots to private equity and/or venture capital and have used the expertise and relationships developed in these sectors to expand to other sectors, including credit. The overall expansion took place on the back of a relatively light regulatory regime for AAM funds. The main reasons for the light touch are the small involvement of retail investors and the limited degree of liquidity transformation, since private funds tend to be of the closed-end type.[6] Despite commonalities in their evolution, however, the relative weight of credit and equity instruments in asset

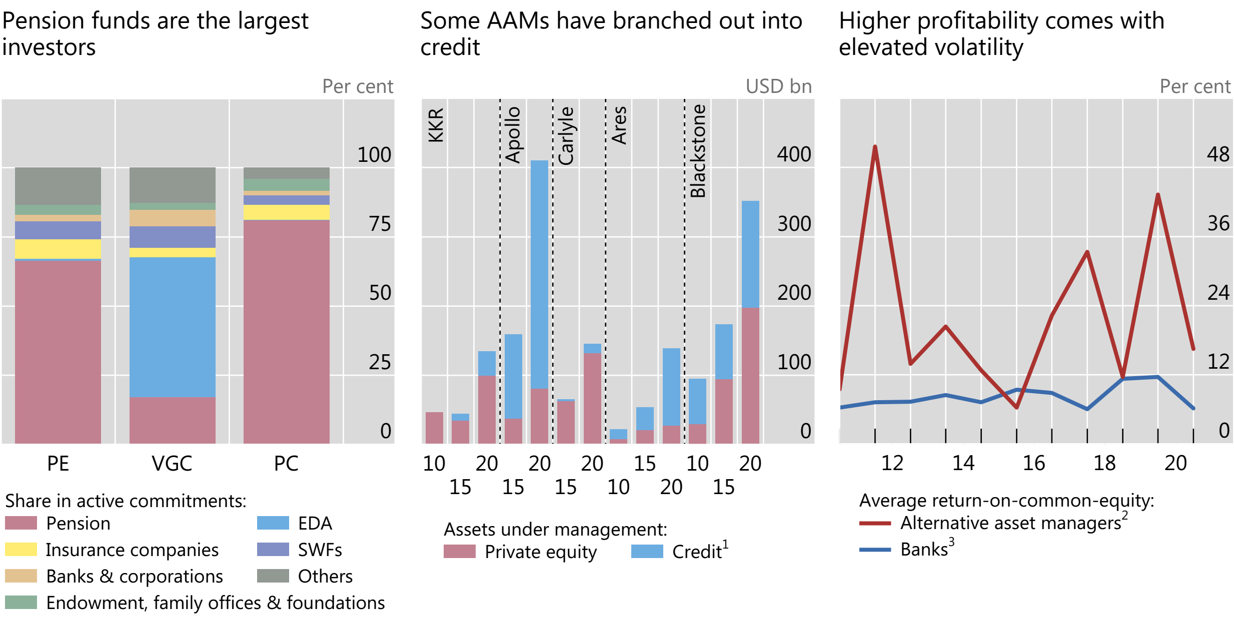
[6] Regulatory treatments can vary. For instance, certain US investment vehicles accessible to retail investors, known as business development companies, are subject to provisions similar to those applicable to mutual funds.

portfolios varies across the largest AAMs, which manage about 15% of global PE assets (Graph 3, centre panel).

The profitability of AAMs is higher but more volatile than that of banks. AAMs earn steady fees for asset allocation and ancillary services. They also invest their own capital in the funds they manage, thus taking on risk that manifests itself as large year-to-year swings in profitability (Graph 3, right-hand panel). Part of the additional return-on-equity obtained by these firms stems from liquidity risk (which earns a premium of about 3% a year; see Franzoni et al (2012)) and probably also reflects compensation for acquiring information about their target companies. These companies often lack established track records or face stern business or organisational challenges.

Banks have significant exposures to private markets. Besides subscription credit lines to funds (see Box), the main connection stems from PE transactions, particularly LBOs, which are funded largely with leveraged loans. Banks typically coordinate the origination of these loans and finance a share of them, maintaining a meaningful exposure until they ultimately offload most of it.[7] Banks' involvement then becomes indirect, through the credit they provide to entities such as hedge funds that invest in the ultimate buyers of leveraged loans, such as specialty funds and collateralised loan obligations.

Key players in private markets Graph 3



EDA = economic development agency; SWFs = sovereign wealth funds; PC = private credit; PE = private equity; VGC = venture and growth capital.

[1] Private credit when disclosed separately, overall credit otherwise. [2] Simple average of Apollo Global Management, Ares Management, Blackstone, Carlyle and KKR. [3] Simple average of Bank of America, Citigroup, JPMorgan Chase and Wells Fargo.

Sources: Bloomberg; PitchBook Data Inc; company filings; authors' calculations.

[7] See Aramonte et al (2019) for evidence based on US supervisory data.

Private markets, cyclicality and monetary policy

Studies indicate that private markets can benefit economic growth. Investors in these markets have long horizons and can tolerate temporary underperformance, thus helping more innovative firms reach maturity. Even during recessions, firms backed by private equity have better access to funding and can engage in capital investment. And in case of financial distress, AAMs contribute to a swifter resolution.[8]

Against this backdrop, we gather preliminary evidence on two policy-relevant issues worth exploring: the procyclicality of private markets and their response to monetary policy. The purpose is less to provide definitive answers than to motivate research. The empirical analysis that follows focuses on the United States, where the depth of financial markets allows us to obtain reliable price-based measures of risk profiles for private funds, despite the lack of detailed information on the underlying portfolios.[9]

While private markets feature final investors with long horizons, they appear every bit as procyclical as public markets. Capital deployment in PE, VGC and PC is positively correlated with stock market returns, ie more transactions are completed in bullish times (Graph 4, upper panels). In fact, the sensitivity of private market investment to stock market returns is almost identical to those of leveraged loans and equity public offerings, suggesting that a common factor drives all of them (lower panels). Academic studies connect increases in certain private market activities, chiefly LBOs, to the lower risk premia that accompany periods of high stock returns. These lower risk premia raise the present value of the future efficiency gains from corporate restructuring. Relatedly, some of these transactions require bridge financing or high-yield bond issuance, which are themselves procyclical.[10]

More generally, leverage can contribute to procyclicality. Fund managers can support more debt when their net asset value rises, thus expanding their balance sheets. Conversely, when this value falls in a downturn, they may need to cut their holdings in order to keep leverage within acceptable limits. The propensity to take leverage can vary across markets and investment vehicles. For instance, business development companies (BDCs), a type of private credit fund that can be bought by retail investors, can incur debt up to twice their net assets. This limit is substantially higher than for mutual funds, whose debt cannot exceed one half of net assets.

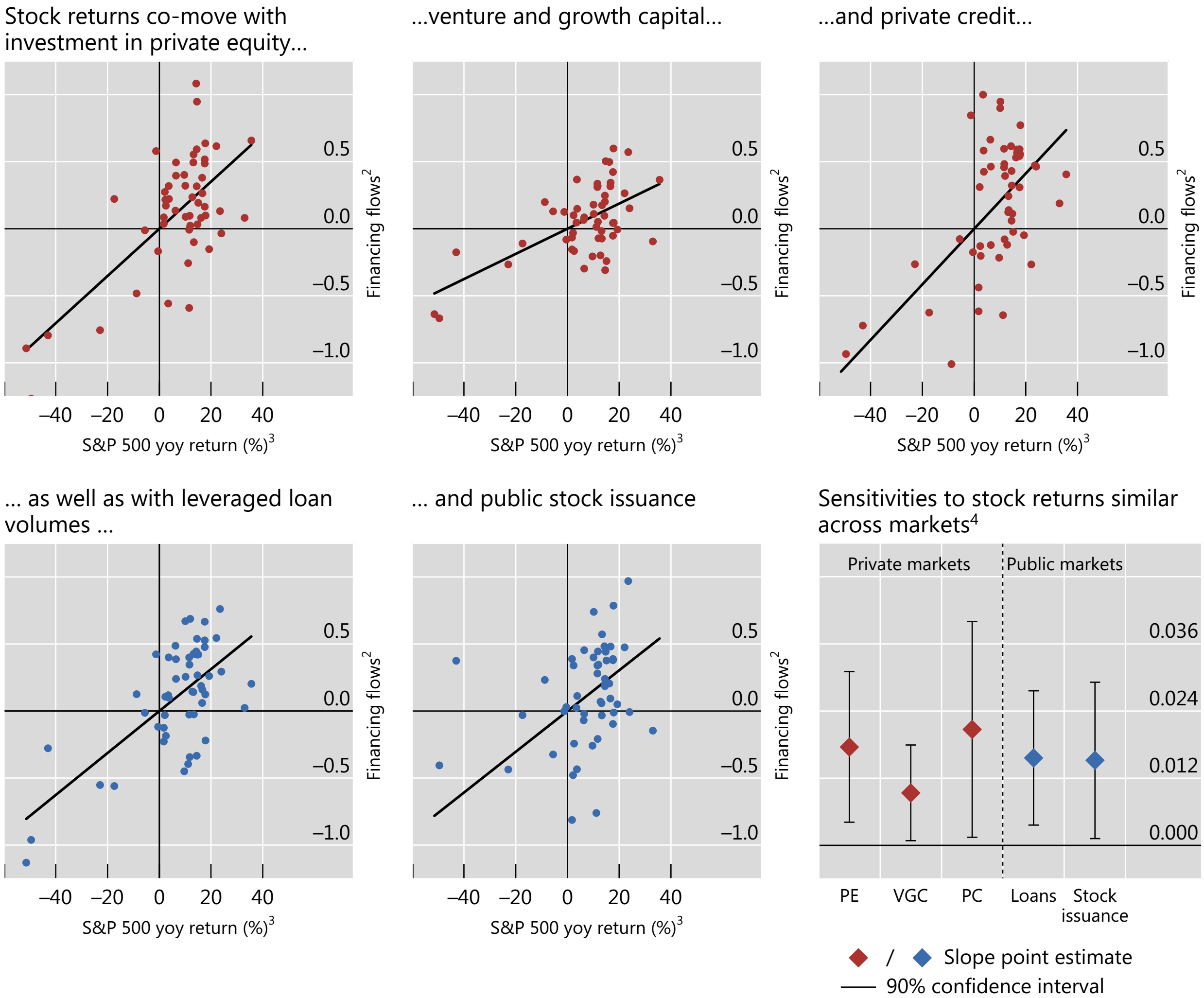
8 See: Boucly et al (2011) for the impact of LBOs on corporate profitability, growth and capital expenditures, Tian and Wang (2014) for the effect of investor tolerance of short-run underperformance by innovative firms; Bernstein et al (2019) for funding patterns of PE-backed firms during the GFC; Hotchkiss et al (2021) for the resolution of financial distress; Kortum and Lerner (2000) and Samila and Sorenson (2011) for the long-term benefits of venture capital for innovation and economic growth; and Davydiuk et al (2020) for the role of BDCs in offsetting reductions in bank financing.

9 This practice is common in academic studies of intermediaries with opaque portfolios (eg Agarwal and Naik (2004)).

10 For the role of the equity premium, see Haddad et al (2017). The fall in the equity risk premium reduces the expected return of common stock, an alternative asset allocation option for AAMs. This increases the relative value of illiquid investments with higher expected returns, such as buyouts. For the role of funding costs, see Axelson et al (2013).

Private and traditional capital markets can be equally procyclical[1]

Graph 4



PE = private equity; VGC = venture and growth capital; PC = private credit.

[1] The sample includes data for the period Q2 2007–Q2 2021. [2] Natural logarithm of the quarterly US dollar volume of the financing flows indicated in the panel title, after netting out the effect of the lagged volume, year-on-year returns of the iShares iBoxx $ High Yield Corporate Bond exchange-traded fund, and year-on-year growth in US nominal GDP, based on a regression that also includes the year-on-year return on the S&P 500, displayed in the horizontal axis. [3] Based on quarterly average of daily prices. [4] The point estimates represent the slopes of the fitted lines in the corresponding panels of this graph.

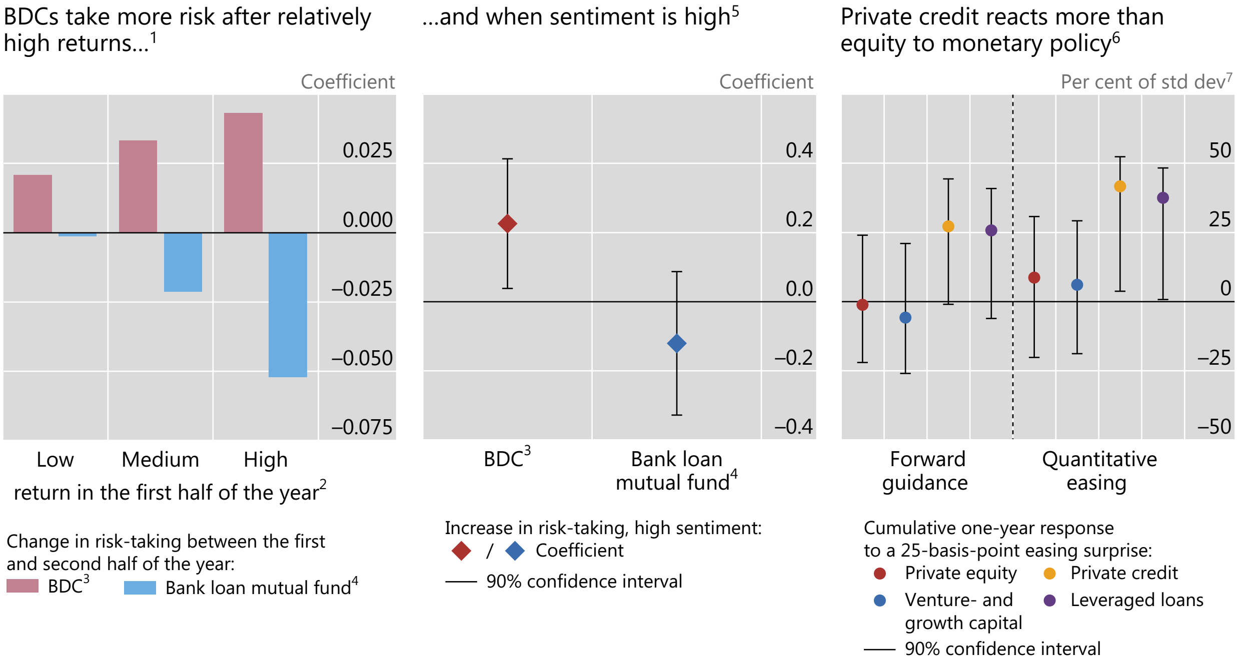
Sources: Bloomberg; Dealogic; PitchBook Data Inc; Refinitiv Eikon; national data; authors' calculations.

The effect of rising net asset values on risk-taking differs starkly between public and private market funds that invest in credit. In public markets, mutual fund managers that outperform their peers in the first half of the year take less risk in the rest of the year (Graph 5, left-hand panel, blue bars). They do so to mitigate the risk of large losses that would reverse the high returns achieved early on. Obtaining relatively high returns in the full calendar year is key for fund managers to maximise future inflows and fee income (Kempf et al (2009)). In private credit, however, the closed-end nature of investment vehicles eliminates flow-related incentives and drives managers to exploit the higher risk-taking capacity that comes on the back of outperformance. That is, rising net asset values beget risk-taking capacity. Consistent with this, BDCs tend to increase their exposure to credit risk after achieving relatively high returns early in the year, exactly contrary to what mutual funds invested in leveraged loans do (red bars).[11]

Search for yield characterises private markets, especially PC, on both the investor and manager side. Some of the largest investors, including pension funds, have explicit return targets and are thus attracted by the high coupons that prevail in private credit, exceeding 10% per year. Similarly attractive are rate floors that shield investors from falling rates. On the managers' side, BDCs appear to search for yield: their returns become more sensitive to changes in credit risk at times of strong market sentiment, ie when markets are buoyant and credit spreads compressed. This effect is somewhat stronger than in the case of actively managed mutual funds investing in leveraged loans (Graph 5, centre panel).

Risk-taking and monetary policy response of private market flows

Graph 5



BDC = business-development company.

[1] Sensitivities of BDC returns to changes in the US high-yield option-adjusted spread, netting out the effect of changes in the two-year US Treasury yields and the term spread (yields on 10-year minus two-year US Treasuries). The sample covers the period 2010–19. The coefficients have been multiplied by –1 to simplify interpretation. [2] Low/medium/high correspond to the terciles in the distribution of the returns realised in the first half of each year across all the entities in the relevant sample. [3] Includes 41 BDCs domiciled in the United States. [4] Includes 70 bank loan mutual funds domiciled in the United States. [5] The diamonds show the extra risk taken by BDCs and bank loan mutual funds when sentiment is high (top tercile). Extra risk is measured as the increase in the sensitivity of BDC returns to changes in the high-yield option-adjusted spreads. [6] Responses extracted from a vector autoregression including log dollar quarterly volume of each type of financing flow and a monetary policy indicator, corresponding to the yields of the three-year US Treasury note for forward guidance, and the 10-year US Treasury note for quantitative easing. Impulse responses computed as in Gertler and Karadi (2015). Event studies from Cieslak and Schrimpf (2019). Quarterly sample covers the period Q1 2005–Q4 2017. Bootstrapped confidence intervals, 100 samples. [7] Standard deviation of the natural logarithm of the quarterly dollar volume of the respective financing flows.

Sources: Bloomberg; Dealogic; PitchBook Data Inc; Refinitiv Eikon; authors' calculations.

[11] BDCs can fine-tune their risk exposure in several ways. While they invest mainly in loans, which are very illiquid, they also hold other securities, such as preferred stocks, that can be traded more easily. In addition, some BDCs disclose that they can use derivatives to hedge credit risk.

Monetary policy affects the real economy partly through credit availability. Thus, given the growing role of private markets as a financing source, it is useful to gauge how sensitive their activities might be to monetary policy surprises. We compute the cumulative response, within a year, of private financing flows to unexpected changes in forward guidance (FG) and quantitative easing (QE), two key post-GFC monetary policy tools (Graph 5, right-hand panel).[12] The responses appear to vary across funds with different specialisations. Funds focused on equity investments (PE and VGC) show minimal reaction to FG and QE news. On the other hand, PC funds appear more sensitive to both measures of policy surprises, on a par with the response of leveraged loans.

Conclusions

Private markets have become an important financing channel for the real economy, especially in North America and Europe. They also appear significant in EMEs, where their yearly transactions compare in volume with banks' syndicated loans. In Asia, the dominant private market activity is venture and growth capital, which tends to be most geared to fostering innovation. Private capital is typically deployed through closed-end funds with long-term commitments, thus limiting liquidity transformation. For the most part, this insulates fund managers from short-term pressures, facilitating investment in innovative companies or mature companies in need of restructuring. An investor base of highly sophisticated and professional investors, together with the limited liquidity mismatches, adds to the resilience of this type of funding.

In this feature we focus on two traditional issues that concern policymakers: procyclicality and the response of financing flows to monetary policy. We find that private market activities seem to exhibit relatively high procyclicality in risk-taking. This is possibly linked to leverage and search for yield, despite the long horizons of investors. Furthermore, the effectiveness of monetary policy appears to vary according to the type of fund, with funds specialised in equity investments showing minimal response, but those involved in private credit reacting more strongly. These are preliminary answers that invite further research, not least to monitor possible emerging vulnerabilities in this growing corner of the financial markets.

[12] We do not include reactions to unexpected changes in policy rates because they were few over the sample period we study.

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Achievements and challenges in ESG markets[1]

Financial markets can support the transition to a more sustainable and fairer economy by influencing firms' funding costs. To explore this mechanism, we study the extent to which investors respond to signals about the environmental or social benefits stemming from given projects or firms. We find evidence of a carbon risk premium: debt from entities with a higher carbon footprint trades at marginally higher yields, all else the same. We also document that investors are willing to pay a social premium – which we refer to as "socium" – when a firm issues a social rather than a conventional bond. The magnitudes of the carbon risk premium and socium are modest but non-negligible in some industrial sectors and market segments. Some obstacles – such as "ESG washing" – stand in the way of further ESG market deepening, limiting contributions to sustainable development.

JEL classification: Q01, Q5

Climate change and rising concerns over social issues have put the spotlight on the environmental costs and social disparities generated by economic activity. While climate-related concerns were first to come to the fore, the Covid pandemic has drawn attention to social considerations.

Financial markets – and in particular the markets for assets with environmental, social and governance (ESG) benefits – can play a key role in mitigating environmental externalities and social disparities. ESG markets have the potential to influence the allocation of economic resources by adjusting firms' funding costs. For this mechanism to work well, two conditions need to be met. First, there needs to be reliable information about the ESG benefits generated by projects and firms. Second, investors need to be responsive to this information.

Given such potential, policymakers have joined the general public in encouraging market participants to support the transition to a sustainable economy. For example, the Network for Greening the Financial System (NGFS) – representing 100 central banks and supervisory authorities – explicitly seeks to "mobilise capital for green and low-carbon investments in the broader context of environmentally sustainable development".

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Key takeaways

- Bonds from firms with higher carbon emissions tend to trade at marginally higher risk-adjusted yields, with the size of this carbon premium being larger for firms within energy-intensive sectors.
- Investors are willing to pay a premium at issuance for social rather than conventional bonds denominated in the US dollar or the euro: a "socium", which corresponds on average to more than a one-notch credit rating upgrade.
- Ensuring that ESG markets rest on robust foundations, which include reliable taxonomies, is essential for their contribution to sustainable development.

This special feature explores two questions related to financial markets' role in the transition to a more sustainable and fairer economy. Is there evidence that market participants respond to signals about the environmental and social benefits of projects or firms? What are the major roadblocks standing in the way of further ESG market development, and what are some possible solutions?

Our main contribution is novel empirical evidence on whether financial markets reward activity with perceived ESG benefits and penalise actions perceived to be harmful. In particular, we add to the fast-growing literature on climate risk in financial markets (see Giglio et al (2021) for a review) with evidence on the pricing of this risk in corporate bond markets. We are also among the first to shed light on whether bond markets pay attention to social issues.

We highlight three takeaways. First, we find that bonds issued by "browner" firms – those with higher carbon emissions – tend to trade at marginally higher yields on secondary markets after adjusting for credit risk. This probably reflects the preference of environmentally responsible investors. That said, the magnitude of the impact – the so-called carbon risk premium – is generally quite small and reaches non-negligible levels only for firms in energy-intensive sectors.

Second, we show that social bonds denominated in the US dollar or the euro have been issued at a price premium compared to standard bonds. There is thus a social premium – which we refer to as "socium" – in a market segment that grew more than fivefold between 2019 and 2021.[2] On average, the socium corresponds to a rating upgrade of more than one notch.

Third, we emphasise the importance of reliable information for ensuring that ESG markets rest on robust foundations. We review roadblocks undermining trust in ESG designations and possible solutions, including efforts already under way.

This special feature is organised as follows. We first provide an overview of ESG markets. We then discuss how investors respond to signals about projects' or firms' role in environmental and social issues. We conclude by highlighting the importance of reliable ESG information for ESG market development.

[2] While the carbon risk premium goes to the investor (compensation for bearing higher risk), the socium goes to the issuer (reward for being socially responsible).

ESG markets: an overview

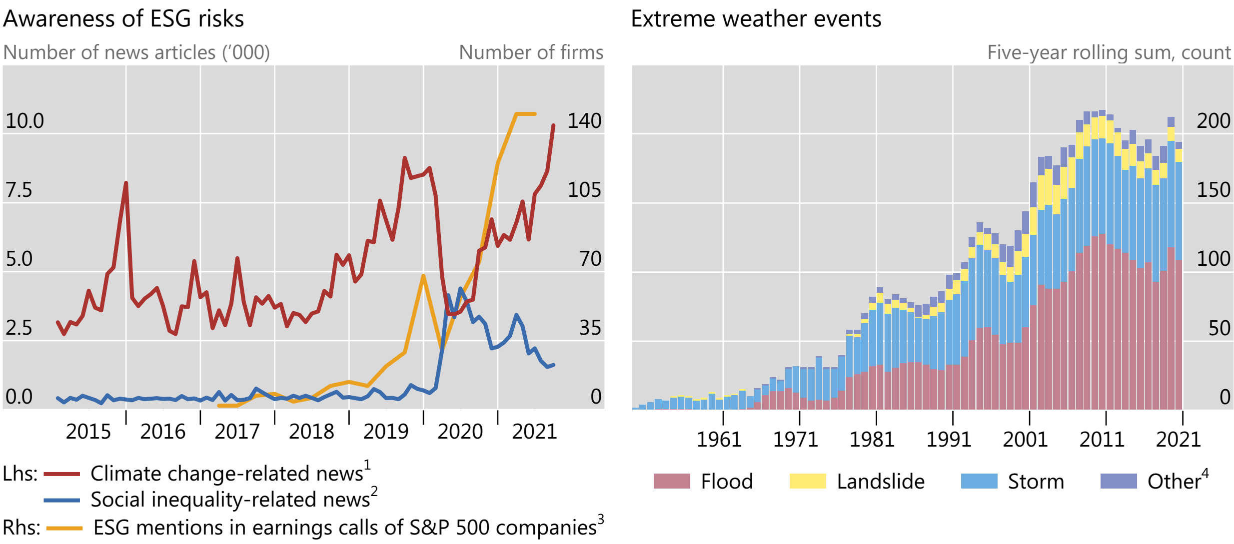
Awareness of environmental and social issues has been rising in recent years. Overall, the broad ESG topic has become more relevant for investors, with the term "ESG" increasingly mentioned in large companies' earnings calls (Graph 1, left-hand panel).

This partly reflects mounting environmental risks associated with climate change.[3] As a result of rising global temperatures, adverse weather events have become more frequent over the past three decades (Graph 1, right-hand panel). In addition to these physical risks, climate change also poses transition risks – which are related to regulatory measures, changes in consumer preferences or technology that may impair the viability of particular sectors.

At the same time, the Covid-19 pandemic has highlighted the pervasiveness of social disparities. For instance, firms receiving public support have come under scrutiny over their labour practices.[4] More generally, there is evidence that investors are paying increasing attention to social issues in the post-pandemic world.[5]

In parallel, a growing number of private and public initiatives have emerged to foster sustainable finance – investment products and services that intend to support the transition to a more sustainable and fairer economy. Many of these initiatives focus on improving investors' information about the ESG benefits generated by

ESG issues have become more relevant for investors as risks have increased Graph 1



[1] News coverage of climate change or global warming from 127 sources (in newspapers, radio and TV) across 59 countries in seven different regions around the world. [2] News mentioning the terms "social inequality" and "social unrest" in the Bloomberg news feed. [3] Number of companies in the S&P 500 citing ESG in earnings calls. [4] Includes extreme temperature, drought and wildfire events.

Sources: Bloomberg; Cooperative Institute for Research in Environmental Sciences; EM-DAT; FactSet; authors' calculations.

[3] We abstract from other sources of environmental risks, such as pollution, loss of biodiversity, etc.

[4] See Neilan et al (2020) and FT (2020) for a discussion.

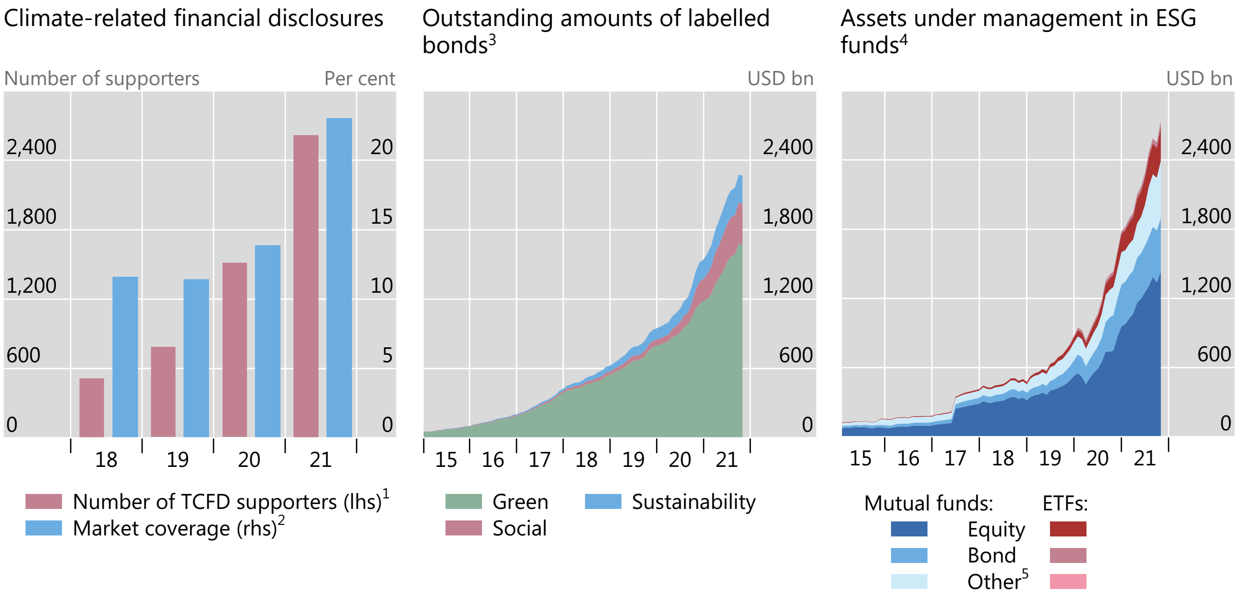
[5] According to a BNP Paribas survey, 70% of the investors responding after the pandemic's outbreak are concerned with social issues, compared to 50% pre-pandemic. See Basirov et al (2020).

projects and firms (see Box A for examples).[6] Some manifest themselves as a rising number of entities supporting climate-related risk disclosures: a fivefold increase since 2018 (Graph 2, left-hand panel). There are also efforts to mobilise private and public capital in support of broad ESG goals.

Against this backdrop, the markets for ESG assets are booming. The outstanding amount of "labelled" bonds – use-of-proceeds bonds to finance projects with environmental or social benefits – has risen more than tenfold over the past five years, and now stands at more than $2 trillion.[7] Green bonds account for the lion's share of this amount (Graph 2, centre panel). Assets under management (AUM) in funds that self-identify as having ESG mandates have also grown manyfold over the last five years, and now stand at about $2.4 trillion (right-hand panel). ESG mutual funds hold mostly equities (more than 60% of AUM), followed by bonds (around 20%).

ESG markets are booming

Graph 2



[1] Number of organisations pledging support for the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). [2] Firms' share in global equity market capitalisation. [3] Bonds are classified according to ICMA criteria: green = raise funds for projects with environmental (E) benefits; social = raise funds for projects with social (S) benefits; sustainability = raise funds for projects with a mix of E and S benefits. [4] Includes funds with socially responsible investment (SRI) mandates, an older designation. ESG = environmental, social and governance. ETFs = exchange-traded funds. [5] Includes multi-asset, money market and alternative funds.

Sources: FSB Task Force on Climate-related Financial Disclosures; World Bank; Climate Bonds Initiative; Dealogic; Environmental Finance Bond Database; EPFR; authors' calculations; BIS calculations.

[6] The Basel Committee on Banking Supervision (BCBS) is also active in this area. The BCBS has recently published a set of guidance principles for banks on the issue of management of climate-related risks: see BCBS (2021).

[7] Issuers typically follow market-based guidelines (eg ICMA principles) to label their bonds, depending on the use of proceeds. Securities issued to finance projects with explicit environmental benefits (eg retrofitting an existing building for energy efficiency) can be labelled as green. Bonds raising funds for projects with specific social benefits (eg providing social housing, delivering affordable basic infrastructure like electricity or sanitation or essential services like access to healthcare or education, supporting employment) can be labelled as social. Sustainable bonds finance projects with a mix of environmental and social benefits. Third-party verification is not required. What is required in addition to disclosing use of proceeds, however, is that the proceeds be ring-fenced for the specific project that the security was issued to finance. Importantly, labelled bonds differ from so-called project bonds in that the cash flows of the former are backed by the entire revenue stream of the issuer.

The footprint of retail investors in the ESG fund segment is rising, as indicated by the growing AUM of passive funds (ETFs). Like mutual funds, ESG ETFs also focus primarily on equities.

Market developments also reflect the increased prominence of social issues since the outbreak of the Covid-19 pandemic. Social bond issuance has surged recently, with outstanding amounts growing more than fivefold between 2019 and 2021 (Graph 2, centre panel). Such securities tend to be issued by supranationals (33% of total amounts outstanding), sovereigns, government agencies and development banks (46%), as well as corporates (21%). Most social bonds are issued in either the euro (67%) or the US dollar (15%).

In interpreting these market developments, it is necessary to keep in mind that the term "ESG assets" covers a wide range of investment products, with a universally accepted, standardised classification yet to emerge. For instance, the ESG designation can be self-attributed by the very firms issuing securities (eg labelled bonds) or by asset managers marketing their investment products.[8] Alternatively, the designation may be assigned by a specialised provider of ESG ratings, with firms' voluntary disclosures providing a key input. When it comes to exposures to climate-related transition risks, such providers and investors seem to be converging on disclosed carbon emissions as a reasonable proxy.[9] But there is no similar metric when social aspects are involved.

ESG preferences and the cost of debt

ESG markets have the potential to reallocate resources to economic activities that generate fewer environmental externalities and social disparities. A precondition for this mechanism to work is that market participants respond to information about the extent to which a given asset is associated with such activities. Part of this response may have to do with the information's relevance for assessing the asset's riskiness, ie if assets yielding such benefits are perceived as less risky, *all else equal*. In addition, the response may work through a preference channel. Investors committed to supporting sustainability goals might have a preference, all else the same, for assets that they perceive as helping to achieve those goals.[10]

We look for empirical evidence that the preference channel matters – over and above any risk considerations – for the costs of debt finance in two ESG market segments. In E space, we study the impact of a *firm's* carbon footprint on its borrowing costs, which we approximate with secondary market bond yields. In S space, we examine how the "social bond" label affects a *bond's* yield at issuance (primary market).

8 In selecting their investment portfolios, some asset managers follow the UN Principles for Responsible Investment.

9 Physical risks are harder to quantify, not least because they depend in complex ways on firms' geospatial characteristics. Existing literature seems to suggest that physical climate risks are not priced in correctly; see Hong et al (2019) and Murfin and Spiegel (2020) for examples.

10 In the language of Pedersen et al (2021), the preference channel corresponds to "ESG-motivated" investors.

Box A

Public support for ESG markets: an Asian perspective

*Michela Scatigna, Dora Xia, Anna Zabai and Omar Zulaica*①

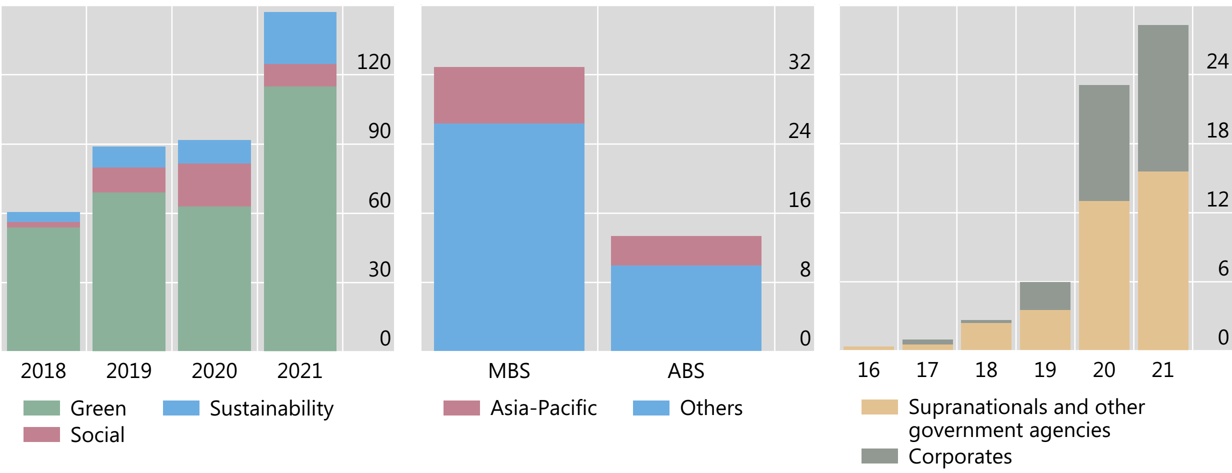
Environmental and social issues are particularly acute in the Asia-Pacific region. The region has experienced about 40% of all global climate disasters over the last three decades. Moreover, it was hard hit by the pandemic, which exacerbated social disparities. Against this backdrop, policy authorities in the region have stepped up their efforts to address environmental and social issues. This box takes stock of recent developments in Asian ESG markets and provides an overview of policy efforts to foster such markets.

The development of ESG markets in the Asia-Pacific region is well under way. The region accounts for about 20% of global outstanding amounts of labelled bonds.② The year to date has seen strong issuance, up 66% compared to 2020 (Graph A1, left-hand panel). The region is also well represented in the nascent ESG securitisation markets, with a 20% share (centre panel).③

Asia-Pacific ESG bond markets are booming on the back of official support

In billions of US dollars — Graph A1

Issuance of labelled bond, by type[1] — Securitisation[2] — Social bonds outstanding, by sector[1]



[1] For 2021, up to September. Bonds are classified according to ICMA criteria: green = raise funds for projects with environmental (E) benefits; social = raise funds for projects with social (S) benefits; sustainability = raise funds for projects with a mix of E and S benefits. [2] Based on ICMA definitions, cumulative issuance of green, social and sustainability securitised assets from 2015 to September 2021.

Sources: Bloomberg; Climate Bonds Initiative; Dealogic; Environmental Finance Bond Database; authors' calculations; BIS calculations.

Several regional authorities are deploying a wide range of measures to actively foster ESG markets.④ The People's Bank of China (PBoC) has taken the lead in the development of taxonomies, issuing the Green Bonds Catalogue and joining forces with the EU to standardise taxonomies across different regions. New Zealand has made climate risk disclosures mandatory for banks and insurers. Hong Kong SAR has announced that climate-related disclosures will be mandatory for listed firms and various financial institutions no later than 2025. In addition, climate stress tests are under way or have been planned in several jurisdictions, including Australia, China, Hong Kong, Japan and Singapore. The Hong Kong Monetary Authority and the Monetary Authority of Singapore subsidise the issuance costs of green bonds and loans. Central banks in the region are also integrating ESG principles into monetary policy and reserve management operations. Green bonds have become eligible collateral for the PBoC's lending facilities. The PBoC, the Bank of Japan and the Central Bank of Malaysia (BNM) have announced facilities to subsidise loans to commercial banks that either support decarbonisation sectors (PBoC and BNM) or purchase green bonds or extend green loans (Bank of Japan).

In addition, regional and multilateral development banks have been playing an especially active role in deepening ESG markets, particularly the labelled bonds segments. On the supply side of these markets, the Asian Development Bank (ADB) and various government agencies in Korea and Japan have issued the bulk of social bonds in the region (Graph A1, right-hand panel). Agencies and multilateral development banks are also helping support demand for new ESG assets by mobilising private and public capital. The Asian Infrastructure Investment Bank (AIIB), for example, has provided anchor capital for a fund dedicated to climate bonds. In collaboration with the development financing community, the BIS is establishing an Asian Green Bond Fund, to channel global central bank reserves to green projects in the Asia-Pacific region.⑤

① The views expressed in this box are those of the authors and do not necessarily reflect those of the BIS. ② Based on data from Bloomberg, as of end-November 2021. ③ The ESG structured products segment is still small overall. At about $10 billion, ABS backed by green and social bonds correspond to less than 1% of the outstanding stock of the underlying securities. ④ For a full review, see De la Serve, M-E, D Revelin and K Triki, "Green finance in the Asia-Pacific region: mobilisation spearheaded by central banks and supervisory authorities", *Banque de France Bulletins*, no 237, article 4, September 2021. ⑤ For more details, see S Tiwari, "Greening Asia for the long haul: What can central banks do?", *Brookings Institute Future Development Blog*, October 2021.

The preference channel and the relative cost of debt in E space

Is there a carbon risk premium in corporate bond markets – one of the main sources of firm financing? In other words, do investors demand a higher yield when trading bonds issued by corporations with heavier carbon footprints? To answer this question, we measure a firm's carbon footprint through its carbon emissions[11] and use secondary market corporate bond yields to gauge investors' response.[12] We then analyse the relationship between the two while controlling for credit risk and other bond characteristics.

Our data set is as follows. We gather data on both direct and indirect carbon emissions from Trucost. Direct emissions refer to emissions from production (also known as "scope 1"). Indirect emissions refer to those coming from the consumption of purchased electricity, heat or steam ("scope 2").[13] For bond pricing, we use secondary market quotes of option-adjusted spreads, provided by Refinitiv. We assume that estimates of five-year probabilities of default (PD), provided by Bloomberg, capture investors' perceptions of credit risk. We thus use these estimates to abstract from the risk channel and focus on the preference channel. Our analysis focuses on US and EU companies and bonds issued by them. Box B provides further detail on our empirical setup and reports additional results.

Considering firms in all sectors, we find that bonds issued by those with more carbon emissions ("browner" firms) tend to have statistically higher risk-adjusted spreads, even though the difference is economically negligible (Graph 3, left-hand panel). Through the preference channel, a 10% increase in direct carbon emissions

11 We use carbon emissions in tonnes of CO_2 instead of carbon intensities (calculated as the ratio of emissions to revenue in USD millions). From an intuitive standpoint, a reduction in emissions intensity may not be consistent with a decrease in total emissions, the ultimate environmental goal. Our choice is consistent with the literature: see Bolton and Kacperczyk (2021) for an example.

12 Even though primary markets provide a more direct gauge of funding costs, secondary markets reflect investors' preferences at a higher frequency. To the extent that there is a reasonable alignment between the two markets (a standard assumption in the related literature), our choice allows us to work with richer information on funding costs.

13 Trucost also provides data on indirect emissions from the production of purchased materials, product use, waste disposal, outsourced activities, etc ("scope 3"). We abstract from scope 3 data because of concerns with the reliability of the underlying reporting.

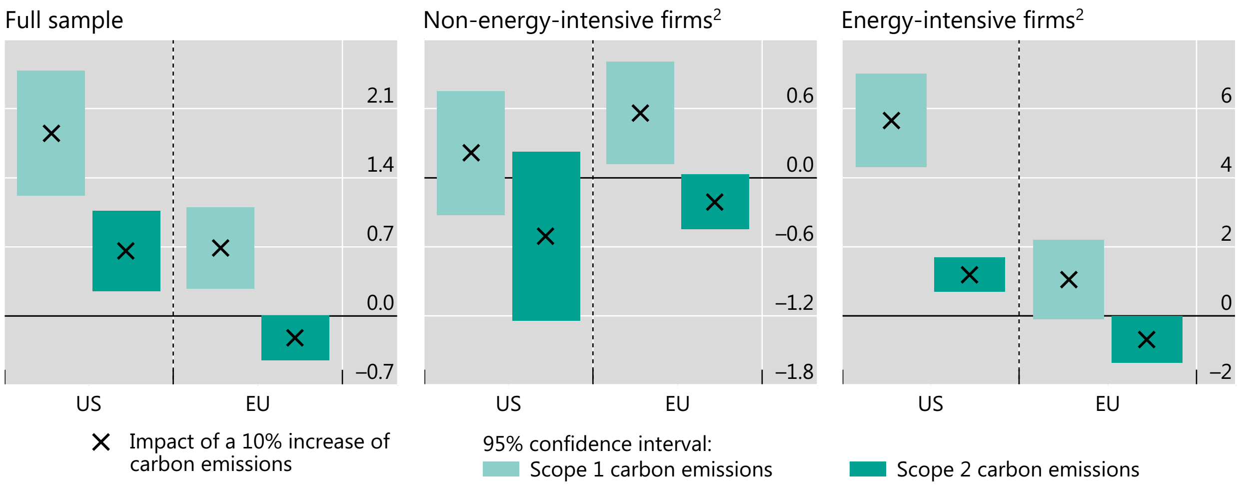
would lead to an increase of 2 basis points in corporate bond spreads for US bonds and 0.7 basis points for EU bonds (Graph 3, left-hand panel). These results are orders of magnitude smaller than the median spread in our sample, at 115 basis points. The impact of indirect emissions is even smaller, at 0.7 basis points and effectively zero for US and EU bonds, respectively.

That said, zooming in on firms in energy-intensive sectors – which we define as energy, materials and utilities – reveals more material effects through the preference channel. Indeed, the overall results are heavily influenced by other firms, whose carbon emissions do not have a significant impact on their risk-adjusted spreads (Graph 3, centre panel). By contrast, the impact within the set of energy-intensive firms is not only statistically significant but also of non-negligible economic importance (right-hand panel). In the case of US bonds in particular, a 10% increase in direct carbon emissions would translate to a 6 basis point increase in spreads, which corresponds to a rating deterioration of 0.3 notches.[14] The differentiated impact across industries probably reflects investors' greater scrutiny of firms traditionally viewed as brown.

Taken together, we find some evidence supporting the presence of a preference channel in E space. However, the economic impact is rather small. This could be because the supply-demand imbalances arising from investors' preferences are not large enough to offset arbitrage forces that reflect purely financial considerations.

Browner firms face marginally higher risk-adjusted debt financing costs[1]

Option-adjusted spread change, in basis points — Graph 3



[1] The impact is calculated through a panel regression of option-adjusted bond spreads on carbon emissions, controlling for the five-year probability of default, other bond-specific characteristics and time, firm and currency fixed effects. Monthly sample from 2016 to 2020. Standard errors are clustered at the bond level. See Box B for further details. [2] Firms classified as energy-intensive are those from the energy, materials and utilities sectors. The rest are non-energy-intensive firms.

Sources: Bloomberg; Refinitiv Eikon; S&P Global Trucost; authors' calculations.

[14] A one-notch rating change corresponds to a change to an adjacent rating, eg from A+ to A. Our result is the average of individual notch changes across all bonds. To estimate each individual notch change, we divide the 6 basis point impact by the difference between two (mean) spreads: that in the bond's credit rating and that in the adjacent rating, one notch below. Our sample is comprised of bonds with ratings ranging from AAA to C on the Fitch scale.

Box B

Estimating the role of carbon emissions in corporate bond spreads

We employ two panel regressions to examine the role of carbon emissions in corporate bond spreads. The first provides our estimate of the preference channel and the second that of the risk channel.

To gauge the impact via the preference channel, we estimate the following equation:

$$OAS_{i,j,t} = \beta_{PD} \times \widetilde{PD}_{j,t} + \beta_{P,carbon} \times ln(CarbonEmissions_{j,t-12}) + \gamma' Z_{i,t} + FE + \epsilon_{ijt},$$

where $OAS_{i,j,t}$ is the option-adjusted spread for bond i issued by firm j at month t; $\widetilde{PD}_{j,t}$ is the natural logarithm of the five-year probability of default (PD) odds ratio for firm j at month t; $CarbonEmissions_{j,t-12}$ are the one-year lagged carbon emissions from firm j (we use scopes 1 and 2 in separate regressions); $Z_{i,t}$ is a set of contemporaneous bond-level control variables, including: duration, age, coupon rate, logarithm of amount outstanding, bid-ask spread (a proxy for liquidity) and a dummy indicating whether a bond is callable or not; FE represents a vector of time, firm and currency fixed effects.① In this specification, the coefficient $\beta_{P,carbon}$ corresponds to the impact of carbon emissions through the preference channel.

To assess the impact via the risk channel, we examine how carbon emissions affect $\widetilde{PD}_{j,t}$ estimates while filtering out the impact of other firm characteristics:

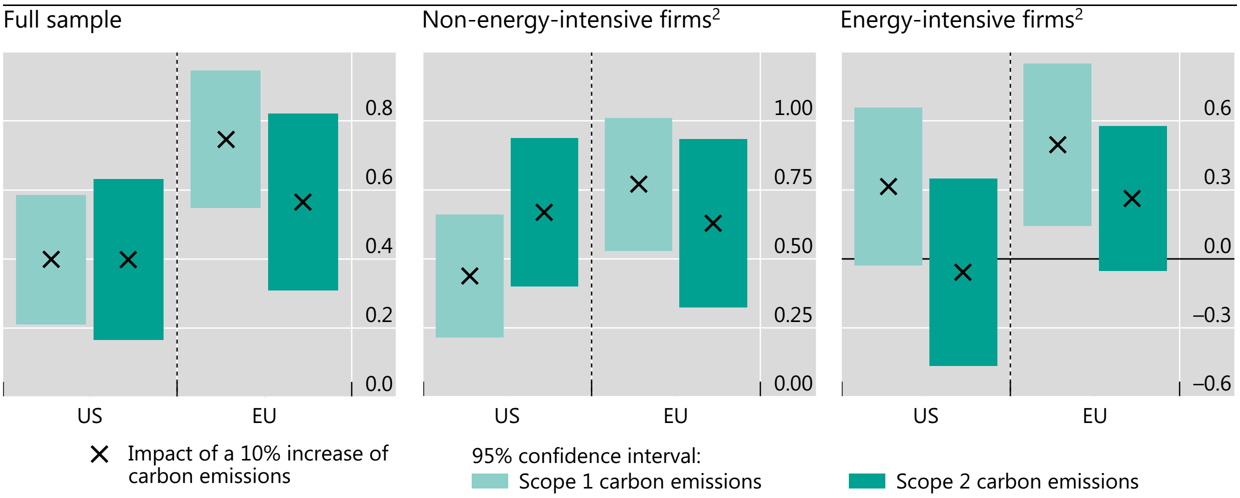
$$\widetilde{PD}_{j,t} = \beta_{R,carbon} \times ln(CarbonEmissions_{j,t-12}) + \delta' X_{j,t} + FE + \epsilon_{ijt},$$

where $X_{j,t}$ is a set of firm-level control variables, including: size of assets, return on assets, debt/asset ratio, retained earnings/asset ratio and capital/asset ratio, and FE represents a vector of time and sector fixed effects.

In estimating the regressions, we implement different sample splits. We estimate the two specifications separately for US and EU firms (and bonds issued by them). In each case, we conduct one estimate with all industrial sectors in the sample and then we split the sample in two by grouping firms in energy, materials and utilities into an "energy-intensive" category and all the other firms into a separate category. Our estimates of $\beta_{P,carbon}$ for the preference channel are shown in Graph 3 and discussed in the main text. Our estimates of $\beta_{R,carbon}$ for the risk channel are presented in Graph B1.

Browner firms are perceived as slightly riskier

Default odds ratio change,[1] in per cent — Graph B1



[1] The impact is calculated through a panel regression where the dependent variable is the natural logarithm of the default odds ratio. The default odds ratio is defined as $PD/(1-PD)$, where PD is the annualised five-year default probability estimate. Independent variables are carbon emissions, firm-specific variables and time, firm and currency fixed effects. Monthly sample from 2016 to 2020. Standard errors are clustered at the firm level. [2] Firms classified as energy-intensive are those from the energy, materials and utilities sectors. The rest are non-energy-intensive firms.

Sources: Bloomberg; Refinitiv Eikon; S&P Global Trucost; authors' calculations.

The results suggest that higher carbon emissions are linked to higher credit risk (Graph B1, left-hand panel). The impact is slightly larger for EU firms and for direct carbon emissions. Furthermore, the risk channel effect is not limited to energy-intensive sectors (Graph B1, centre and right-hand panels). Despite the statistical significance of some of the results, the economic significance is very low. For instance, a 10% increase in US firms' direct or indirect emissions would lead to a 0.13 basis point increase in their bond spread. ② The numbers are comparable for EU firms.

① We use option-adjusted spreads to account for the optionality embedded in callable bonds, which account for 60% of our sample. The logit transformation is a standard approach to account for the fact that default probabilities are bounded by 0 and 1 and are likely to depend on firm characteristics in a non-linear fashion. We use default probability estimates generated by Bloomberg, reflecting firm fundamentals (eg financial ratios) and asset prices (eg stock and CDS prices). We lag carbon emissions by one year to reflect Trucost's one-year release lag of carbon emissions data. We choose the bond-level control variables that are standard in the literature; see, for example, S Gilchrist and E Zakrajšek, "Credit spreads and business cycle fluctuations", *American Economic Review*, vol 102, no 4, June 2012, pp 1692–720. We do not include oil prices in our set of control variables. While they influence corporate bond spreads, especially in the energy sector, their impact is absorbed in the time fixed effect. There are also fixed effects at the country level in the case of the European Union. Our carbon emissions data span the period from 2016 to 2020. Trucost does not cover a comprehensive list of firms before 2016. ② We obtain the impact of carbon emissions on corporate bond spreads through the risk channel by multiplying $\beta_{R,carbon}$ and β_{PD}.

The preference channel and the relative cost of debt in S space

Might investors value the social label enough to pay a premium for holding social rather than conventional bonds? In other words, is there a socium?

To answer this question, we match social bonds issued by banks and corporates between 2016 and 2021 with conventional securities that share similar risk characteristics.[15] For each matched pair, we compute the socium as the yield spread between the social and conventional bond at issuance (that is, on primary markets). We carry out the analysis at the security level because there is no equivalent to carbon emissions in S space: market participants have not yet converged on a set of metrics capturing the social benefits generated at the firm level.[16]

In matching bonds, we use several criteria in the spirit of Larcker and Watts (2020) and Flammer (2021). We first try to match the social bond with a conventional bond that is issued *by the same firm*. Within that firm, we look for a bond with the same rating as and a similar remaining maturity to the social bond at the time of data retrieval. If several such bonds exist, we pick the one whose issuance date is closest to the social bond's. Conversely, if no such bond exists, we look for a security that is issued *by a firm in the same sector* as the social bond issuer and has similar characteristics to the social bond (again, credit rating and maturity).

We find that investors are indeed willing to pay a socium. That is, social bond yields at issuance are systematically lower than the yields on conventional bonds (Graph 4, left-hand panel). The mean socium in the full sample is statistically significant, at approximately 12 basis points. To gauge the economic significance of this estimate, we express it in "rating-notch equivalents" following Baker et al (2018).[17]

15 Only 10 of the bonds in our sample were issued before 2019.

16 Others have studied the response of corporate bond yields at issuance to the *green* label with mixed results. Examples include Ehlers and Packer (2017), who find a green issuance premium ("greenium") of 18 basis points, and Flammer (2021), who finds no evidence of a greenium.

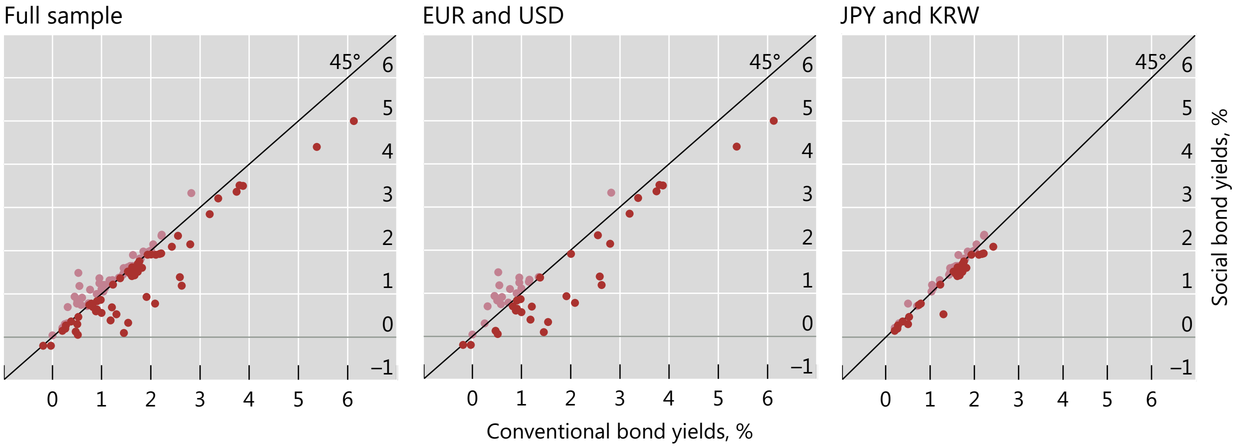
17 For each matched pair, we computed the yield spread at issuance between the social and the conventional bond and recorded the credit rating of the conventional bond (based on Bloomberg's

We find that the average socium corresponds to a rating upgrade of about 1 to 1.5 notches. The results are in line with market intelligence reporting that social bond issues are oversubscribed (Bloomberg (2021)) – enough investors have a preference for these assets to affect their issuance price.

We next investigate whether the socium is currency-specific. To date, most corporate social bonds have been issued in euros (41% of amount outstanding), followed by US dollars (23%), Japanese yen (16%) and Korean won (10%). Corporate issuance in euros is associated with companies domiciled in the European Union (95%), whereas about a third of dollar-denominated issuance has taken place outside the United States. We split the sample by currency: one subsample includes bonds issued in euros and dollars, the other in yen and won.[18] For the first subsample, we find the same average socium as in the overall sample: 21 basis points (Graph 4, centre panel). By contrast, there is no socium for securities denominated in won or yen (right-hand panel).

Taken together, our results in E and S space suggest that investors do respond to signals stemming from carbon footprint data and bond labels. While some of the effects are extremely small at present, ESG markets hold the potential to influence the allocation of economic resources.

Issuing social bonds is less costly[1] Graph 4



[1] Each dot represents yields at issuance on a matched bond pair. There are 24 bonds denominated in euros, 24 in US dollars,13 in Japanese yen and 42 in Korean won. A difference-in-means test for the variable on the horizontal axis versus that on the vertical axis reveals statistical significance at the 1% level in the left-hand and centre panels but no statistical significance at conventional significance levels in the right-hand panel.

Sources: Bloomberg; authors' calculations.

composite credit rating) on the coarse scale AAA/AA/A/BBB/BB. When the spread was negative (positive), we divided it by the average yield difference between: (i) an index of bonds with the same rating as the conventional bond; and (ii) an index of bonds with a one-grade higher (lower) rating on the coarse scale. Multiplying this ratio by three (since there are three notches between adjacent grades on the coarse scale) delivers an estimate of the rating upgrade (downgrade) implicit in the social bond's relative yield. The numbers reported in the text are based on averages across the pair-specific estimates of up-/downgrades. The underlying bond index data are from the ICE BofA Global Corporate Index family and cover the past 10 years.

[18] We aggregate by relevance of currency denomination in the corporate social bonds market. The euro and the US dollar account for 64% of outstanding amounts. If we split the sample further to isolate bonds issued in euros and dollars we still find evidence of a socium significantly different from zero at the 1% level, but the two subsamples are very small (24 bonds each).

Concluding observations

For ESG markets to support the transition to a more sustainable and fairer economy, it is not enough that investors respond to environmental and social signals. Another prerequisite is that these signals provide accurate ESG information.

Whether booming ESG markets rest on solid foundations remains an open question, not least because of growing concerns about "ESG washing" – that is, a misleading attribution of the ESG designation. These concerns are stoked by the absence of universal taxonomies and standardised, mandatory disclosures. For instance, ESG ratings are provided by a small group of agencies, which disagree as to how to interpret firms' voluntary ESG disclosures (Berg et al (2019)).[19] This indicates uncertainty about the ESG benefits reaped by retail investors piling into ETFs that rely on specific ESG ratings (Graph 2, right-hand panel). Similar concerns apply to the nascent ESG derivatives market, and in particular its index segment.[20]

Another issue is that the current ESG designation system might fail to align incentives with broad environmental goals at the level where decisions are made – the firm. This is particularly relevant when the designation is at the level of a security (ie labelled bonds). Green bond labels are a case in point. For these labels to imply emission reductions,[21] the attendant projects would have to have a radical impact on the activities of the bond issuer. However, issuance of green bonds does not necessarily indicate a material reduction in carbon intensities at the firm level over time (Ehlers et al (2020)).

Any ESG designation needs to rest on a reliable taxonomy. Accordingly, some jurisdictions, notably China and the European Union, have already developed and adopted sustainable finance taxonomies, while others are taking steps in that direction (eg Canada, the United Kingdom). Classification systems have also emerged from the private sector (eg the Climate Bonds Taxonomy). The emerging consensus (G20 (2021)) is that, in an effective classification system, ESG assets will be those whose environmental and social benefits are material and consistent with broader sustainability goals (eg as set out in the Paris Agreement or the UN Sustainable Development Goals).

It is also important to standardise ESG taxonomies and make them comparable across countries. This is high on the policy agenda, as indicated by the G20's Sustainable Finance Roadmap and by the priorities of COP 26. Some progress has already been made on this front. The European Commission and the People's Bank of China recently released their Common Ground Taxonomy, which identifies a set of economic activities recognised as environmentally sustainable by both the EU's and China's own classification systems.

19 Examples of ESG rating agencies include ASSET4 (Refinitiv), , ISS (Deutsche Börse Group), KLD (MSCI Stats), MSCI, RobecoSAM (S&P Global), Sustainalytics, and Vigeo Eiris (Moody's).

20 Global stock exchanges, including Eurex, Intercontinental Exchange (ICE), CME Group, Nasdaq, Chicago Board Options Exchange (CBOE), Euronext and Japan Exchange Group, have introduced equity index futures and options contracts tied to ESG benchmarks (see ISDA (2021)).

21 Green bond labels can signal other environmental benefits than reducing carbon emissions (eg promoting biodiversity or fostering processes that reduce consumption of natural resources).

Reliable taxonomies rest on reliable and informative metrics, which are still in the making. The metrics employed to quantify ESG benefits should be science-based (for environmental benefits) or fact-based and verifiable (for social and other benefits). While carbon emissions may be a reasonable proxy for the environmental benefits associated with firms, open questions remain concerning carbon accounting for sovereign or supranational issuers. Importantly, investors have not yet agreed on how to quantify social benefits (ADB (2021)). Given the multifaceted nature of social issues, it is likely that the quantification process will have to rely on a menu of (possibly ad hoc) metrics rather than a single indicator.

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