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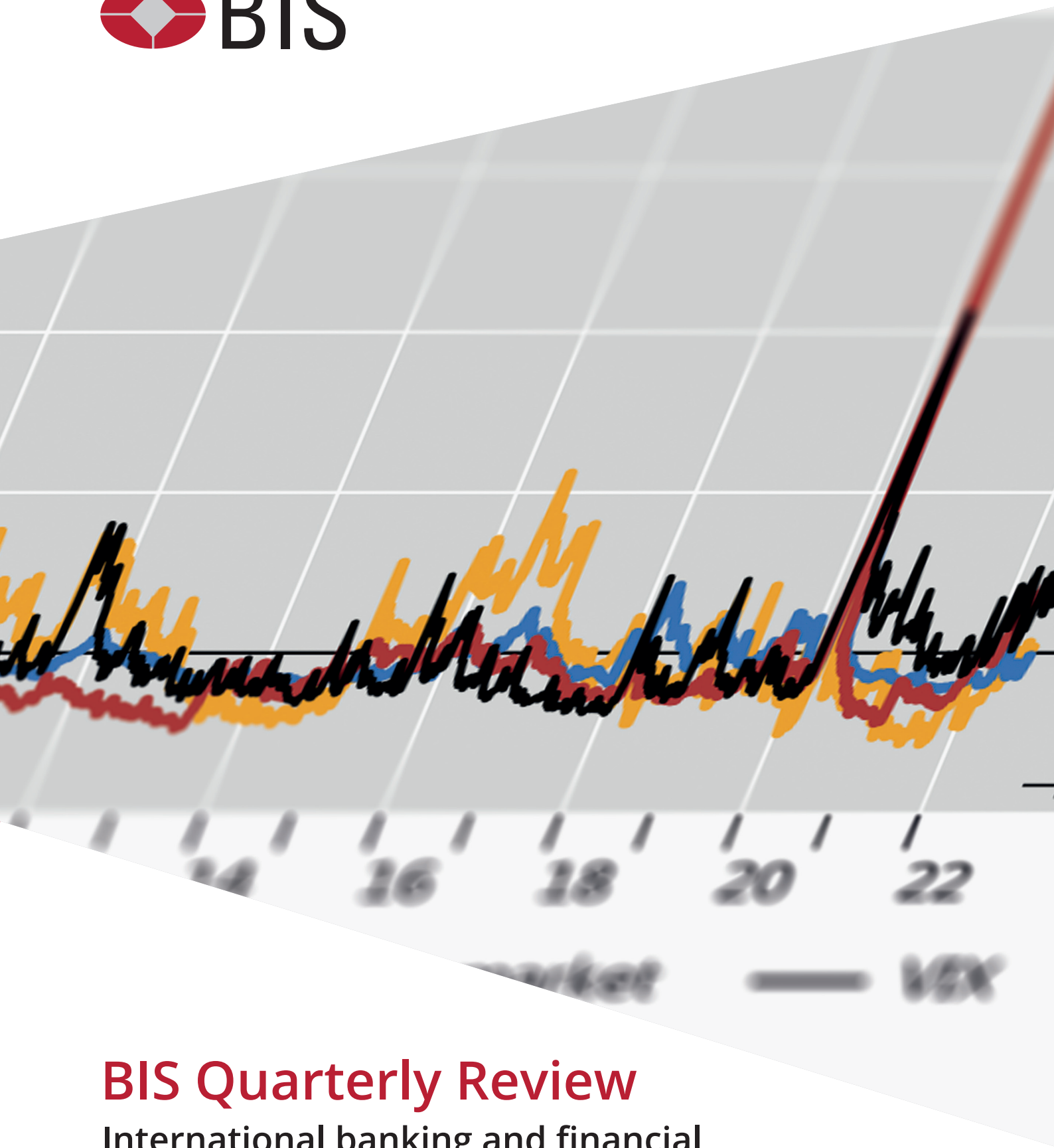

BIS Quarterly Review

International banking and financial market developments

September 2022

BIS Quarterly Review
Monetary and Economic Department

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This publication is available on the BIS website (http://www.bis.org/publ/qtrpdf/r_qt2209.htm).

ISSN 1683-0121 (print)
ISSN 1683-013X (online)

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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	Czechia
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

Markets swing on perceptions of the policy outlook

Worsening growth prospects and evolving perceptions of the monetary stance shaped financial markets during the review period.[1] Economic indicators deteriorated due to the fallout from the Ukraine war and weakness in China. Market-based expectations of inflation and policy rates fluctuated as monetary tightening quickened globally and energy disruptions intensified in Europe. All these factors swayed financial conditions and contributed to market volatility.

There were two turning points for risky assets and sovereign bonds. The first was in mid-June. After the Federal Reserve raised rates more than expected, investors anticipated falling inflation and a flattening of the policy rates' path. Financial conditions eased and corporate spreads compressed. A seeming paradox emerged from the markets for risky assets and sovereign bonds: while stock indices rallied with few exceptions, the yield curve inverted sharply in the United States – often a harbinger of recessions – and flattened in other jurisdictions. The second turning point was in August. As the policy response to inflation became more forceful and the energy crisis worsened in Europe, financial conditions tightened, risky assets retreated and core yields rose. On balance, investors seemed to anticipate a smooth resolution of the challenges posed by high inflation.

Commodity markets reflected the complex economic outlook. Metal prices continued the decline that had started in the second quarter, not least because of weakening activity in China. While oil prices started falling globally in mid-June, European natural gas prices surged to record highs on disruptions in Russian supplies, with substantial repercussions on industrial equities and electricity costs. The prices of natural gas and electricity remained highly volatile late in the review period, reflecting the confluence of geopolitical developments and possible speculative dynamics in a market with stressed intermediation capacity.

The US dollar appreciated broadly against advanced economy (AE) currencies. Due to previous US monetary tightening, as well as the ongoing European energy crisis, the dollar reached its highest level against the euro and the yen in more than two decades. The pace of dollar appreciation was also unusually quick.

Market developments diverged across emerging market economies (EMEs). Firmer monetary policy measures in the face of elevated inflation kept yields in Latin America considerably above those in Asia and put a cap on the depreciation of several currencies. At the same time, the weakness of the euro, yen and renminbi implied that trade-weighted exchange rates appreciated for several EMEs.

[1] The period under review extends from 1 June 2022 to 12 September 2022.

Key takeaways

- As economic prospects dimmed and the inflation outlook evolved, investors' changing perceptions of the central bank response swayed markets. The US dollar rose to multi-decade highs.
- In June, a risk-on phase went hand in hand with an inverted US yield curve – a seeming paradox. The easing of financial conditions partly reversed in August as the policy response to inflation firmed.
- Inflation was a key factor in EMEs: where it was entrenched, currencies depreciated steadily; where it met a more forceful policy stance, depreciations tapered off.

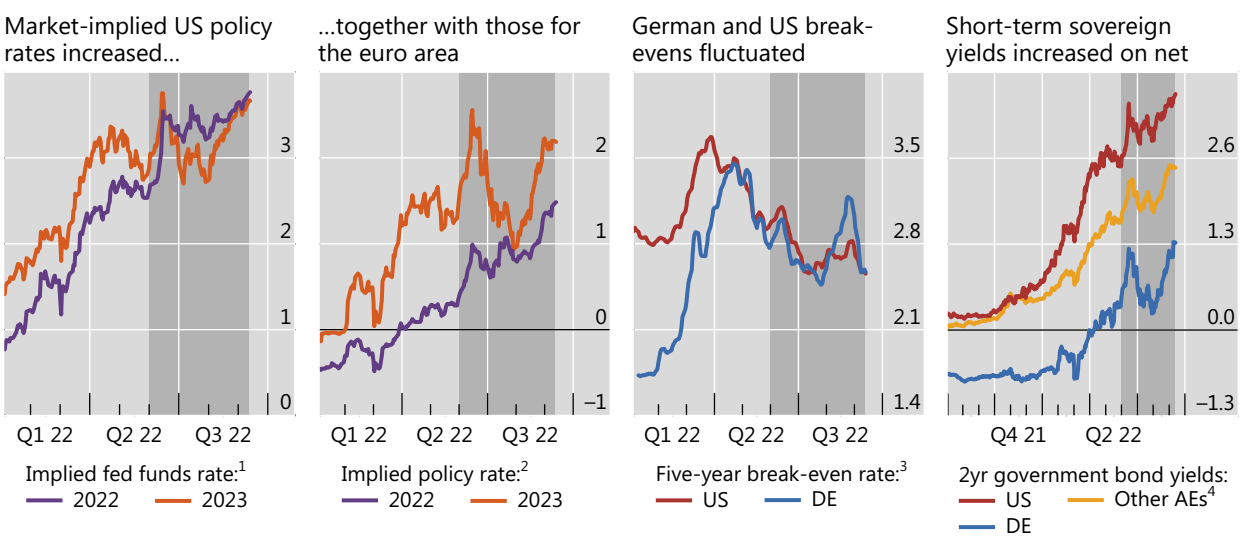
Core yields reflected the policy outlook and growth worries

Efforts to tackle inflation shaped the short end of the yield curve. Early in the review period, investors anticipated further tightening in major AEs on the back of elevated inflation (Graph 1, first and second panels). In mid-June, after the FOMC meeting raised rates more than foreseen, market-based inflation expectations fell (third panel) and the perceived pace of subsequent monetary tightening slowed, particularly for 2023. In August, investors anticipated rising inflation, chiefly due to intensifying energy disruptions in Europe and a buoyant US labour market. In addition, with central banks signalling further tightening, market-implied policy rates for 2023 began to climb again, supporting the rise in two-year sovereign yields (fourth panel).

Longer-term yields danced to the tune of the evolving outlooks for inflation, growth and the policy stance. They dropped alongside short-maturity ones for about six weeks starting in mid-June, when market-based inflation expectations fell

The front end of the yield curve reacted to the policy and inflation outlooks

In per cent — Graph 1



The shaded areas indicate 1 June–12 September 2022 (period under review).

[1] Federal funds rates implied by futures maturing in December 2022 and December 2023. [2] Rates implied by ESTR futures maturing in December 2022 and December 2023. [3] Five-day moving average. [4] AU, CA, DK, GB, JP, NZ and SE.

Sources: Bloomberg; Datastream; BIS calculations.

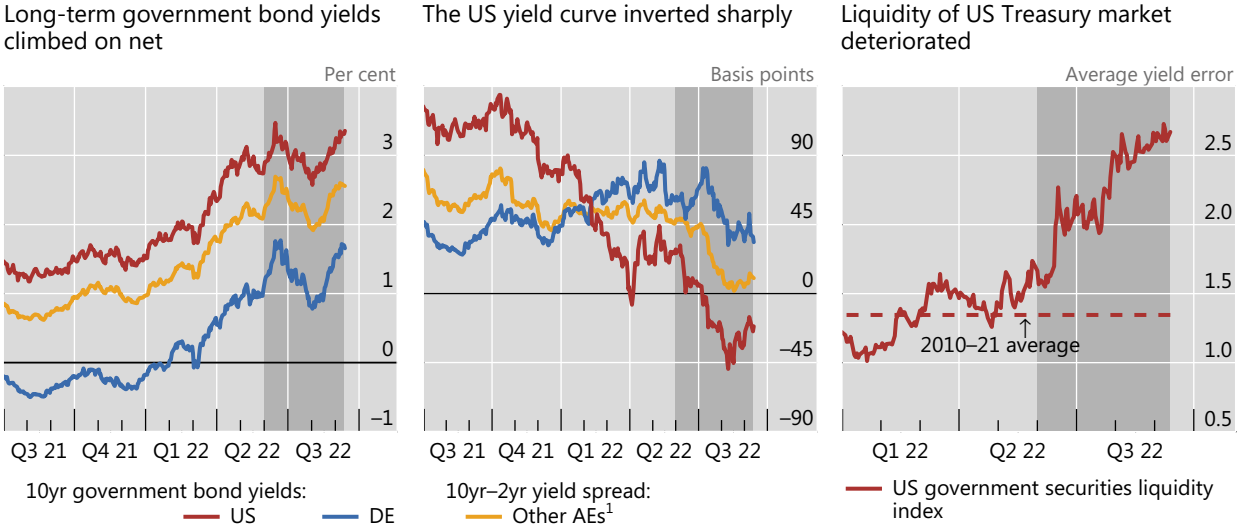
(Graph 2, left-hand panel). Worsening economic prospects also contributed to the decline, as probably did stronger Treasury demand from yield-insensitive traders. As a result, the US curve inverted sharply, in what is typically a harbinger of recessions (centre panel). In most other jurisdictions, curves flattened but largely remained positively sloped, a likely reflection of the less advanced policy cycles, especially in the euro area. In August, long-term yields rose, as investors anticipated increasing price pressures and policymakers reiterated their commitment to fighting inflation.

As sovereign yields fluctuated, liquidity in US Treasury markets deteriorated. It remained considerably worse than the post-2010 average (Graph 2, right-hand panel). In part, the deterioration stemmed from the Federal Reserve allowing its balance sheet to shrink, thus reducing liquidity support, especially for off-the-run bonds.[2]

The pronounced weakening of the economic outlook in Europe affected periphery spreads to German bunds as well as the euro exchange rate. Even as bund yields fell in mid-June and July, spreads for Greek and Italian bonds remained elevated (Graph 3, left-hand panel). They temporarily compressed on indications that the ECB would develop an instrument aimed at preventing pronounced divergence in euro area sovereign yields. This was eventually formalised in July as the Transmission Protection Instrument. In parallel, the euro continued its depreciation vis-à-vis the US dollar to a nadir last seen in 2002 (centre panel). In addition, the pace of depreciation over the review period was among the fastest in the last three decades.

AE yields were volatile and curves flattened, while US Treasury liquidity worsened

Graph 2



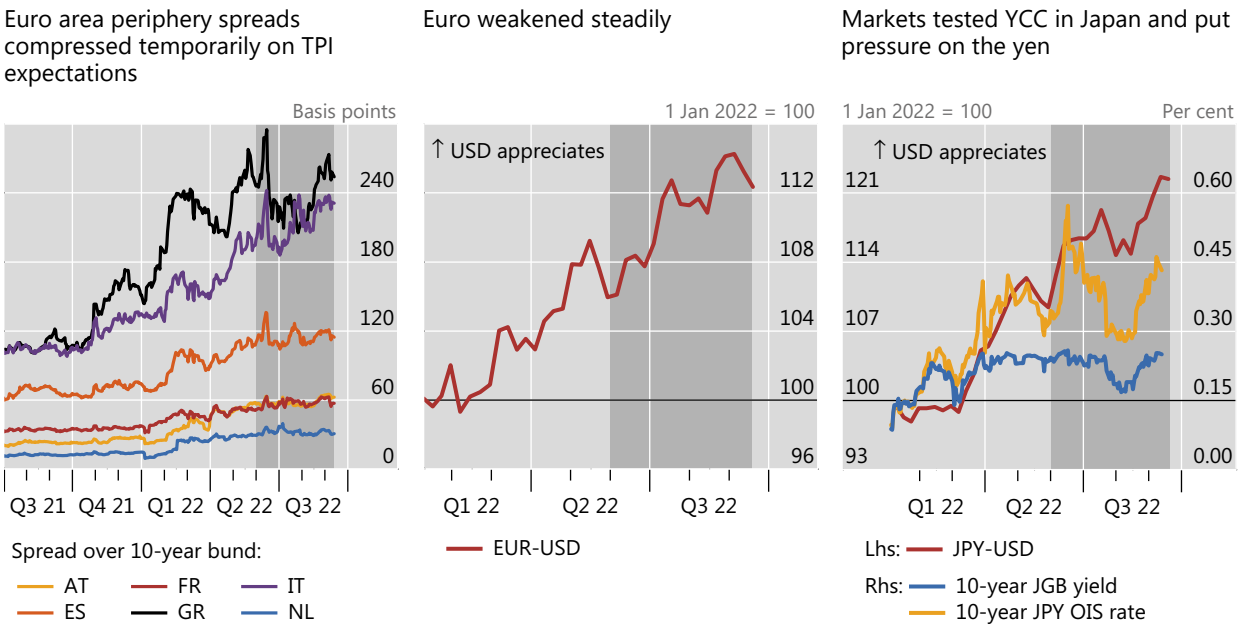
The shaded areas indicate 1 June–12 September 2022 (period under review).

[1] Simple average across AU, CA, DK, GB, JP, NZ and SE.

Sources: Bloomberg; BIS calculations.

[2] See the special feature by Aldasoro et al in this issue for new market conditions indicators, one of which is dedicated to the US Treasury market.

Euro area spreads pointed to persisting concerns; euro and yen depreciated Graph 3



JGB = Japanese government bond; OIS = overnight indexed swap; TPI = Transmission Protection Instrument; YCC = yield curve control policy.

The shaded areas indicate 1 June–12 September 2022 (period under review).

Sources: Bloomberg; BIS calculations.

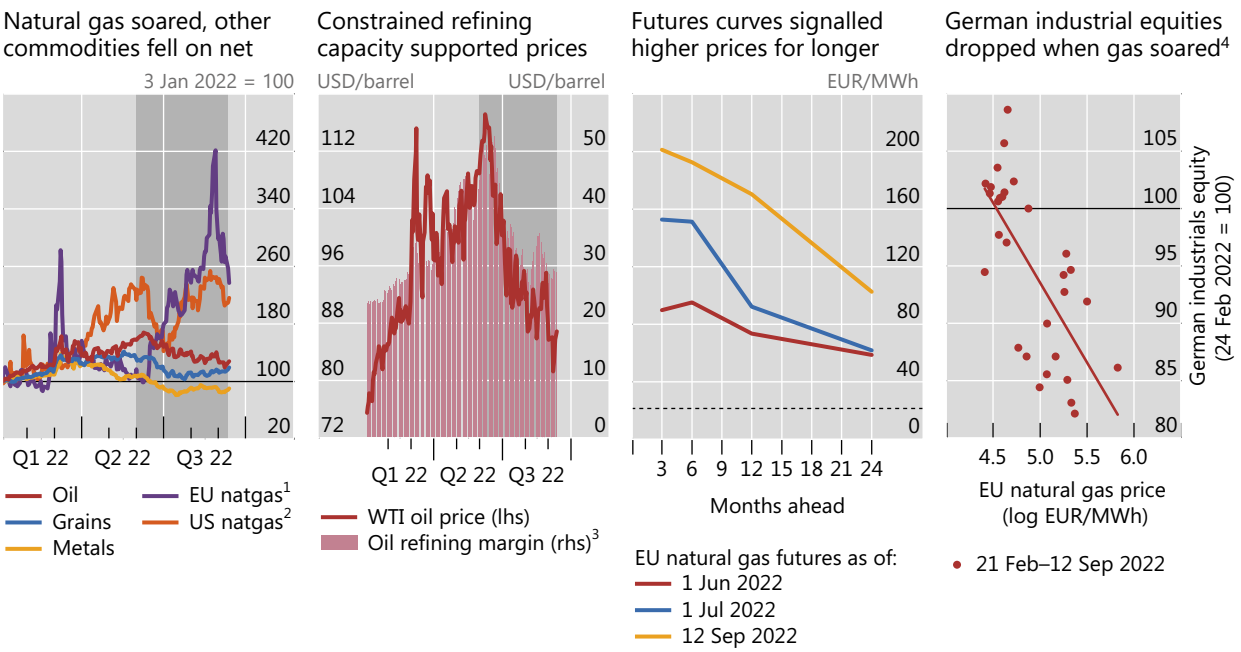
Japanese yields remained low, but upward pressure briefly tested policy. Even as 10-year rates rose before mid-June in other AEs, those of Japanese government bonds remained constrained by the yield curve control policy, which set a 25 basis point cap. Markets put this policy to the test as investors bet on increasing 10-year rates in derivatives markets. As a sign of this pressure, the gap between swap rates and cash yields widened rapidly in June (Graph 3, right-hand panel). However, the dimming economic outlook and perceptions that US inflation would fall lowered US yields and eased the upward pressure on Japanese ones, starting in mid-June. As a consequence, the swap-cash spread compressed markedly and the yen appreciated on the narrower US-yen yield differential. As long-term yields rose globally towards the end of the review period, this differential widened again and the yen's depreciation resumed.

Natural gas prices soared on supply disruptions

Except for natural gas, commodity prices remained, on net, below the high watermarks reached after the start of the Ukraine war (Graph 4, first panel). For grains, the decline partly reflected tentative agreements to resume dry bulk shipping from Ukraine. For industrial metals, the drop, which took prices below end-2021 levels, was driven by normalising supply chains and slowing activity in China. Oil prices were volatile but declined on balance. Snarled supply chains in the energy sector added to the prices of oil-derived products, such as diesel and gasoline (second panel).[3]

[3] See the special feature by Avalos and Huang in this issue for an in-depth discussion.

Markets anticipated lasting energy crisis in Europe, with broad repercussions Graph 4



The shaded areas in the first and second panels indicate 1 June–12 September 2022 (period under review). The dashed horizontal line in the third panel indicates the 2010–21 average price of one-month futures.

[1] Title Transfer Facility (TTF). [2] Henry Hub. [3] The chart shows the "3:2:1 crack spread", which is the difference between the price of a standard basket of refined products and the cost of crude oil. [4] TTF for natural gas and Germany-Datastream Industrials index for equity. End-of-week data.

Sources: Bloomberg; Datastream; BIS calculations.

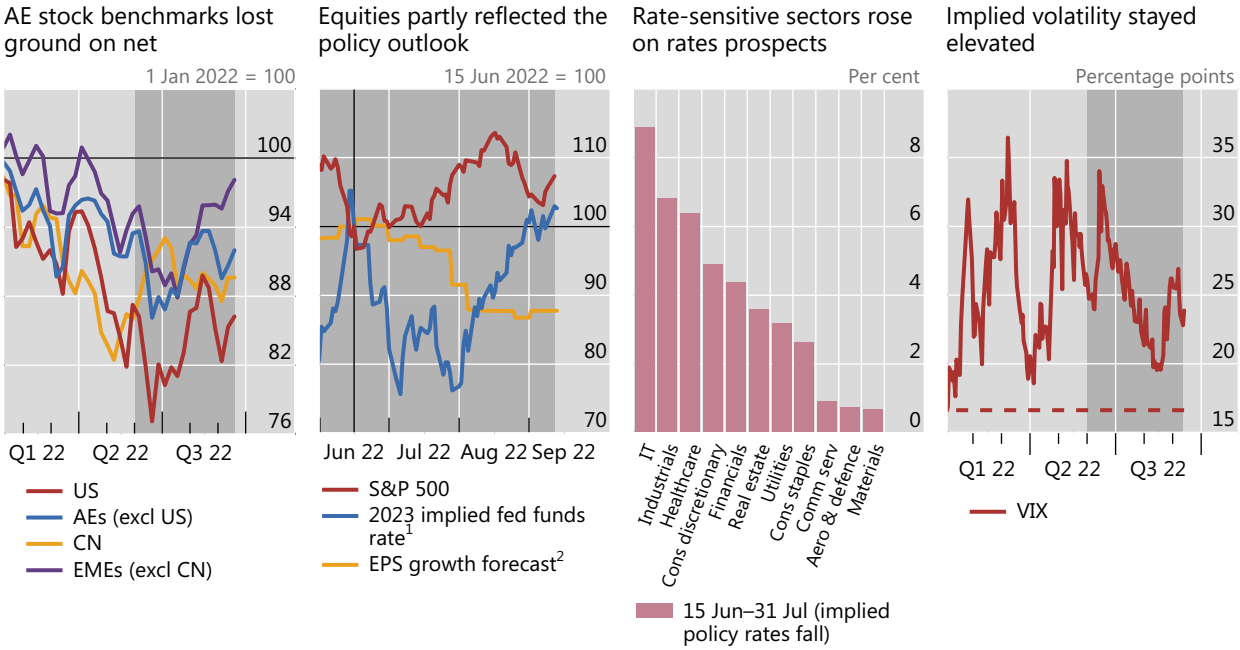
Disruptions in natural gas markets were widespread and threatened to be long-lasting. With sharp cuts in flows from Russia and efforts to fill storage ahead of the winter season, European gas prices soared and remained volatile even after a partial retracement. European gas futures signalled growing expectations that dislocations would be persistent, as prices at the two-year maturity rose over the period under review, to a level five times higher than the historical norm (Graph 4, third panel).

The increase in European natural gas prices had broad spillovers. First, attempts to replace gas delivered by pipeline to Europe with sea-borne shipments of liquified natural gas raised prices globally, despite the traditional geographical fragmentation of this market. Second, electricity prices for current and future delivery soared in countries more reliant on natural gas for power generation, reaching unprecedented heights. Prices remained very volatile, possibly indicating speculative dynamics in markets with reduced intermediation capacity. Third, energy-intensive sectors suffered. For instance, the stock prices of German industrial firms fell markedly when natural gas prices spiked (Graph 4, fourth panel). Similarly, those of firms for which natural gas is a key production input declined much more than broad equity indices.

Fight against inflation and growth woes drove risky assets

Equity markets were volatile as investors' perceptions of the policy outlook evolved. In mid-June, AE stocks began rising – even though earnings forecasts fell – as market-

The policy outlook influenced global stocks; perceived risks remained elevated Graph 5



The shaded areas in the first, second and fourth panels indicate 1 June–12 September 2022 (period under review). The vertical line in the second panel indicates 15 June (June 2022 FOMC meeting). The dashed horizontal line in the fourth panel indicates 2010–current median.

[1] Federal funds rates implied by futures maturing in December 2023. [2] Expected earnings per share growth between end-2021 and estimated end-2023.

Sources: Bloomberg; Datastream; BIS calculations.

based expectations of inflation and policy rates declined (Graph 5, first and second panels). Starting in August, however, equities reversed course, with energy disruptions putting pressure on prices in Europe and policymakers reiterating their commitment to fighting inflation globally, leading investors to anticipate higher future rates. Differences in returns across sectors confirmed that the interest rate outlook shaped equity markets. Indeed, the stocks of traditionally rate-sensitive industries, such as information technology, gained most as implied policy rates fell after mid-June (third panel). Throughout the review period, investors' concerns about downside risks were visible in option-implied equity volatility, which remained above its historical average (fourth panel).

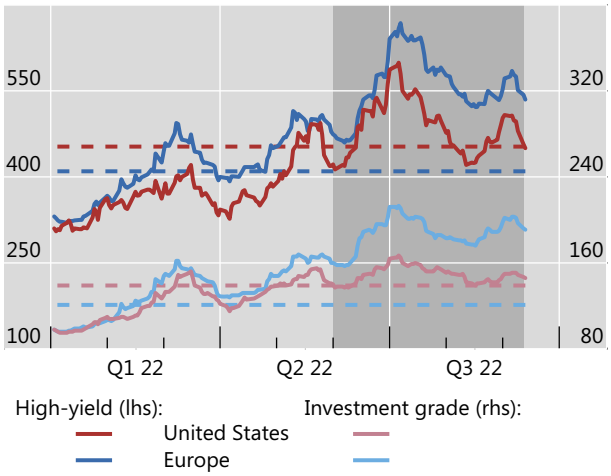
EME equities, except Chinese stocks, largely tracked AE benchmarks for most of the review period. EME stocks rose steadily through August and increased on net (Graph 5, first panel). Chinese indices diverged due to local factors, chiefly persistent problems in the real estate sector and recurring lockdowns to manage the lingering pandemic.

Corporate bond spreads broadly tracked equity market dynamics. In terms of levels, spreads remained mostly above historical averages in Europe but were in line with the long-run norm in the United States (Graph 6, left-hand panel). An upward trend in the gap between high-yield (HY) and IG spreads indicated stronger differentiation based on credit risk (right-hand panel). The long-term increase in the share of BBB bonds held by IG indices continued to bolster IG spreads (Box A).

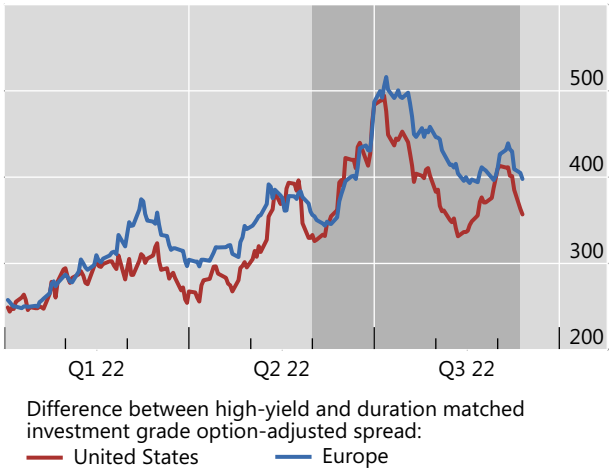
Credit spreads remained unusually wide in Europe

In basis points — Graph 6

IG spreads changed little on net in the United States



Wider HY-IG differentials hinted at lingering concerns about credit risk



HY = high-yield; IG = investment grade.

The shaded areas indicate 1 June–12 September 2022 (period under review). The dashed horizontal lines in the left-hand panel indicate 2005–current medians.

Sources: ICE BofAML; BIS calculations.

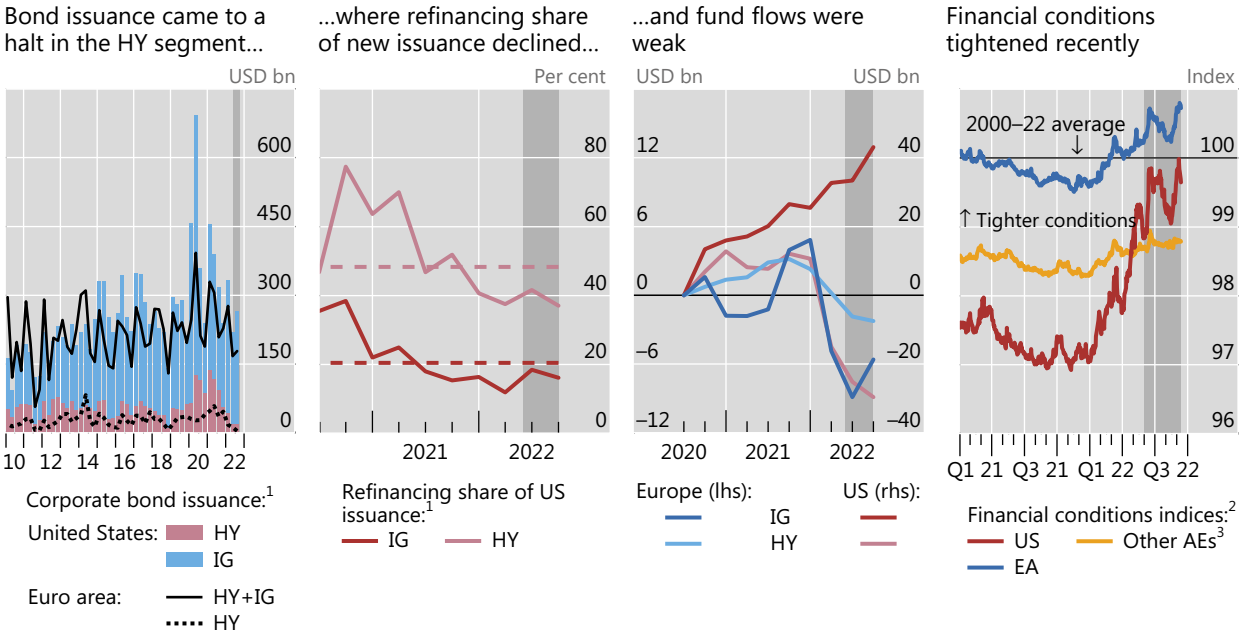
New credit issuance dropped during the review period. The drop was broad-based, but most pronounced in Europe and in the HY segment – where issuance came virtually to a halt (Graph 7, first panel). This occurred while bank credit was generally holding up, despite a tightening of credit standards. There were two factors behind patterns in bond issuance. First, from the perspective of borrowers, rising rates reduced the appeal of refinancing outstanding debt, especially in the HY space (second panel). Second, investor demand, as proxied by fund flows, remained weak in the HY segment (third panel).

Private credit and structured finance also saw declines in issuance. Private credit deals fell below 2021 levels, contracting after a decade of sustained growth.[4] The flow of collateralised loan obligations (CLOs) investing in new leveraged loans remained broadly stable, after dipping earlier in the year, partly due to losses on warehoused loans as the Ukraine war broke out. Just as with bonds, the issuance of "refinancing" CLOs came to a halt. Dynamics in the European CLO market suggested that investors might be underestimating tail risk (Box B).

Overall, financial conditions in AEs evolved in line with the markets for risky assets. They eased starting in mid-June, as equities rose and corporate spreads narrowed, and tightened in August. In terms of levels, conditions were somewhat less accommodative than the historical norm in the euro area but remained marginally loose in the United States and especially in other AEs (Graph 7, fourth panel). Real rates also remained below long-term averages in some countries.

[4] Occupying an opaque corner of financial markets, private credit funds deserve close monitoring. See S Aramonte, "Private credit: recent developments and long-term trends", *BIS Quarterly Review*, March 2020, pp 11–13, and S Aramonte and F Avalos, "The rise of private markets", *BIS Quarterly Review*, December 2021, pp 69–82.

Bond issuance dropped as financial conditions tightened on net — Graph 7



HY = high-yield; IG = investment grade.

The shaded areas indicate 1 June–12 September 2022 (period under review). The dashed lines in the second panel indicate 2010–current averages.

[1] For Q3 2022, issuance data up to 12 September 2022, extrapolated to full quarter. [2] Goldman Sachs Financial Conditions Index (FCI): a weighted average of country-specific risk-free interest rates, exchange rates, equity valuations and credit spreads, with weights that correspond to the estimated impact of each variable on GDP. A value of 100 indicates average conditions. A higher (lower) value indicates tighter (looser) conditions. [3] AU, CA, CH, GB, JP, NO, NZ and SE.

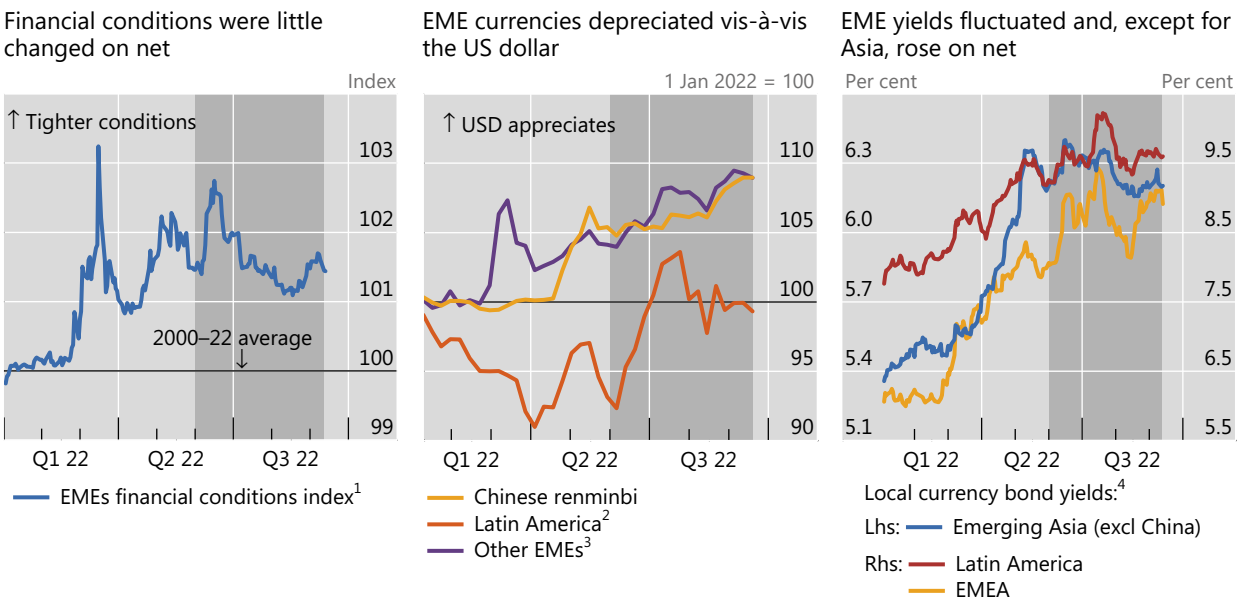
Sources: Bloomberg; Dealogic; EPFR; BIS calculations.

Inflation differences steered developments in EMEs

Financial conditions in EMEs fluctuated as the effect of depreciating currencies was partially offset by falling yields. After a marked tightening that followed the war in Ukraine, financial conditions eased starting in mid-June and ended the review period roughly unchanged (Graph 8, left-hand panel). The easing occurred even as the US dollar remained strong after appreciating markedly against EME currencies (centre panel). This easing hinged on decreasing US sovereign yields and, later, declining local currency bond yields (right-hand panel).

EME financial conditions were stable, despite a strengthening US dollar

Graph 8



The shaded areas indicate 1 June–12 September 2022 (period under review).

[1] Goldman Sachs Financial Conditions Index (FCI): a weighted average of country-specific risk-free interest rates, exchange rates, equity valuations and credit spreads, with weights that correspond to the estimated impact of each variable on GDP. A value of 100 indicates average conditions. A higher (lower) value indicates tighter (looser) conditions. [2] BR, CL, CO, MX and PE. [3] CZ, HK, HU, ID, IL, IN, KR, MY, PH, PL, RU, SA, SG, TH, TR, TW and ZA. [4] Simple averages of JPMorgan Chase GBI Global sub-indices, traded yields.

Sources: Bloomberg; JPMorgan Chase; BIS calculations.

Cross-country patterns in EME sovereign yields mostly reflected differences in inflation rates. On the back of a more aggressive monetary policy in EMEA[5] and Latin America, especially Brazil and Mexico – which had started tackling inflation already in 2021 – yields remained markedly higher in those regions than in Asia. In China, yields moved sideways as lockdowns and persistent pressures in the real estate sector clouded the economic outlook, thus spurring public support.

Yield differentials relative to the United States were important catalysts of EME capital flows. The effect was particularly pronounced for China, whose yield curve was below that of the United States. As such, outflows from Chinese bond funds continued after the large drawdown in May but tapered in the third quarter, as yield differentials to US Treasuries remained at slightly negative levels (Graph 9, left-hand panel). In contrast, outflows were muted for other EMEs, where pre-emptive monetary tightening contributed to positive yield differentials.

On the whole, EME currencies depreciated against the US dollar, but with notable differentiation across countries. A deteriorating current account deficit weighed on the Colombian peso, and persistently elevated inflation sapped the Argentine peso and Turkish lira (Graph 9, right-hand panel). In turn, dependence on expensive commodities was a headwind for some currencies, such as the Pakistan rupee. The dimming growth outlook in China, together with a negative differential relative to the US yield curve, contributed to a continued weakening of the renminbi. On the back

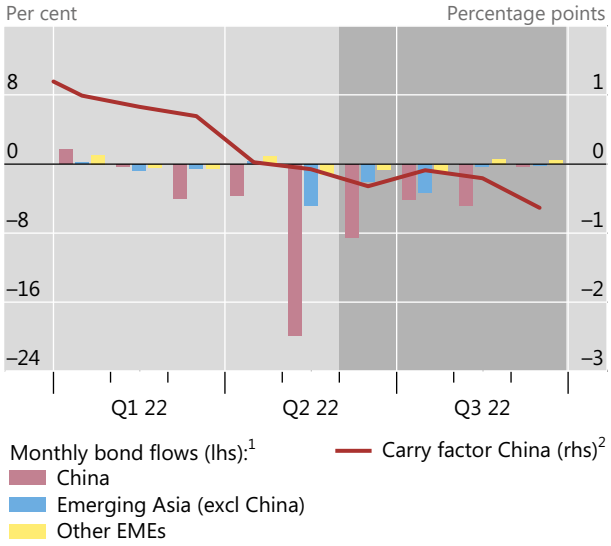
[5] Europe, the Middle East and Africa.

of an early tightening cycle and an attractive carry profile, some Latin American currencies proved more stable towards the end of the review period.

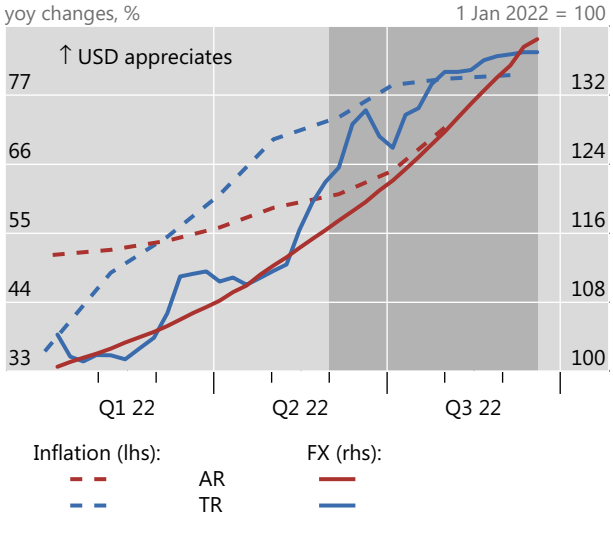
Bond fund outflows from China lingered; inflation weighed on some currencies

Graph 9

Chinese bond funds saw outflows as rate differentials turned negative



Accelerating inflation weighed on the Argentine peso and Turkish lira



The shaded areas indicate 1 June–12 September 2022 (period under review).

[1] Flows to local currency bond funds, scaled by previous month's assets. [2] The 10-year local currency sovereign bond yield minus the 10-year US Treasury yield; monthly average.

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

Box A

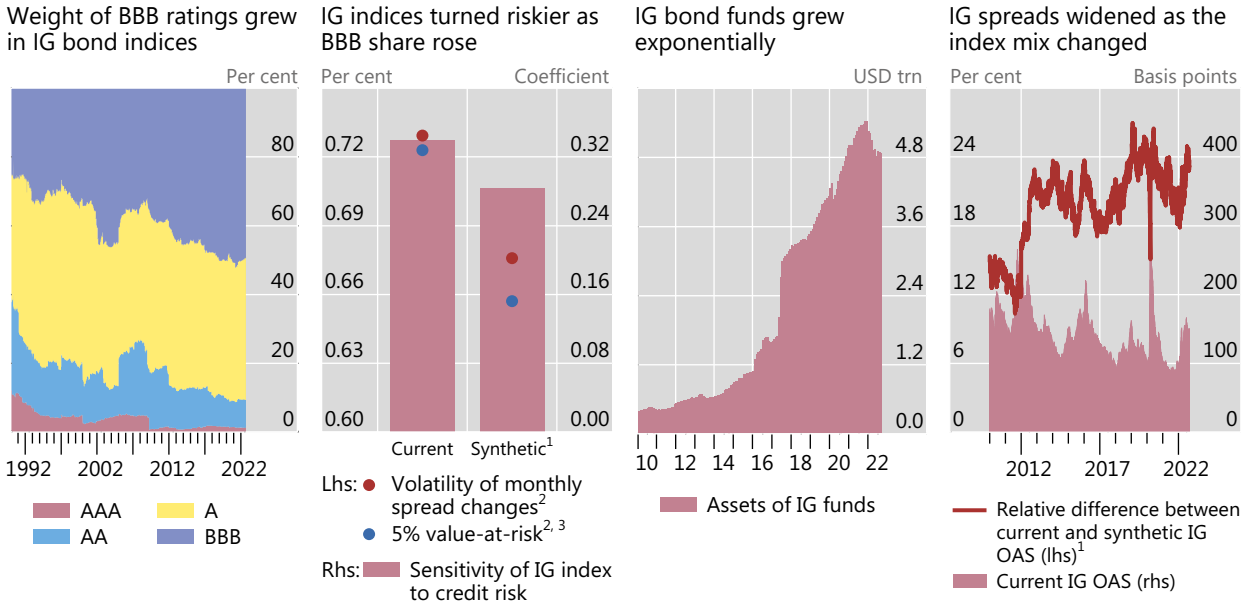
The increasing risk of investment grade indices: implications for investors

*Sirio Aramonte and Karamfil Todorov*①

Investment-grade (IG) corporate bond indices have grown riskier over time. The share of bonds rated BBB, the lowest rung of the IG segment, has been increasing for the past 30 years. At present, BBB bonds in one of the main US IG indices represent half of the total, up from 25% in 1990 (Graph A, first panel). The increase was mostly at the expense of bonds rated AA and above, whose current share is less than 10%, down from more than 35% 30 years ago. In this box, we explore the drivers of these changes and the implications for investors.

Investment grade indices have become riskier over the past 30 years

Graph A



IG = investment grade; OAS = option-adjusted spread.

[1] Weighted average of ratings-specific sub-indices, where the weights reflect the composition of the IG index at the start of 1990. [2] Annualised. [3] Displayed on an inverted scale.

Sources: Bloomberg; EPFR; ICE BofAML; BIS calculations.

The steady decline in the credit quality of IG indices reflects two broad trends in corporate markets. The first is search for yield in an environment of persistently low interest rates. Bonds rated BBB are particularly attractive to IG-focused investors that seek to earn higher yields, including many mutual funds.② The second broad trend is the general increase in issuance by BBB-rated firms, which accelerated with the launch of several central bank asset purchase programmes that further reduced these companies' cost of funding.③,④

The declining credit quality of IG indices has translated into a meaningfully higher risk of losses for investors. IG indices tend to be more sensitive to non-diversifiable credit risk than "synthetic" versions of these indices based on the rating composition in 1990 (Graph A, second panel, red bars). A moderate increase (one standard deviation) in credit risk would go hand in hand with an 11 basis points larger drop in current IG indices, as compared with synthetic ones. Given the present size of IG funds, this means that the change in the index's composition since 1990 would translate into an additional loss of $5 billion for investors. The higher risk is also visible in measures of tail risk (5% value-at-risk) and volatility (second panel, blue and red dots).

Understanding the implications of the increased riskiness of IG indices is particularly relevant for small investors. Funds benchmarked to IG indices have increased rapidly over the past decade and manage $4.8 trillion as of 2022 (Graph A, third panel). Investors in these funds are probably attracted by the increased income from riskier IG indices – their yield spread to Treasury bonds is currently 25% higher (35 basis points) than it would have been with 1990 rating shares (fourth panel). At the same time, small investors tend to rely on benchmarks to gauge the risk profile of funds⑤ and may not be fully aware that the riskiness of IG funds has increased, despite their unchanged IG label.

① The views expressed are those of the authors and do not necessarily reflect the views of the BIS. ② B Becker and V Ivashina, "Reaching for yield in the bond market", *Journal of Finance*, vol 70, no 5, October 2015. ③ For a recent study on the real economy implications of the demand for risky IG bonds, see V Acharya, R Banerjee, M Crosignani, T Eisert and R Spigt, "Exorbitant privilege? Quantitative easing and the bond market subsidy of prospective fallen angels", *BIS Working Papers*, no 1002, February 2022. ④ K Todorov, "Quantify the quantitative easing: impact on bonds and corporate debt issuance", *Journal of Financial Economics*, vol 135, no 2, 2020. ⑤ B Sensoy, "Performance evaluation and self-designated benchmark indexes in the mutual fund industry", *Journal of Financial Economics*, vol 92, no 1, 2009.

Box B

Are CLO investors underestimating tail risk in European markets?

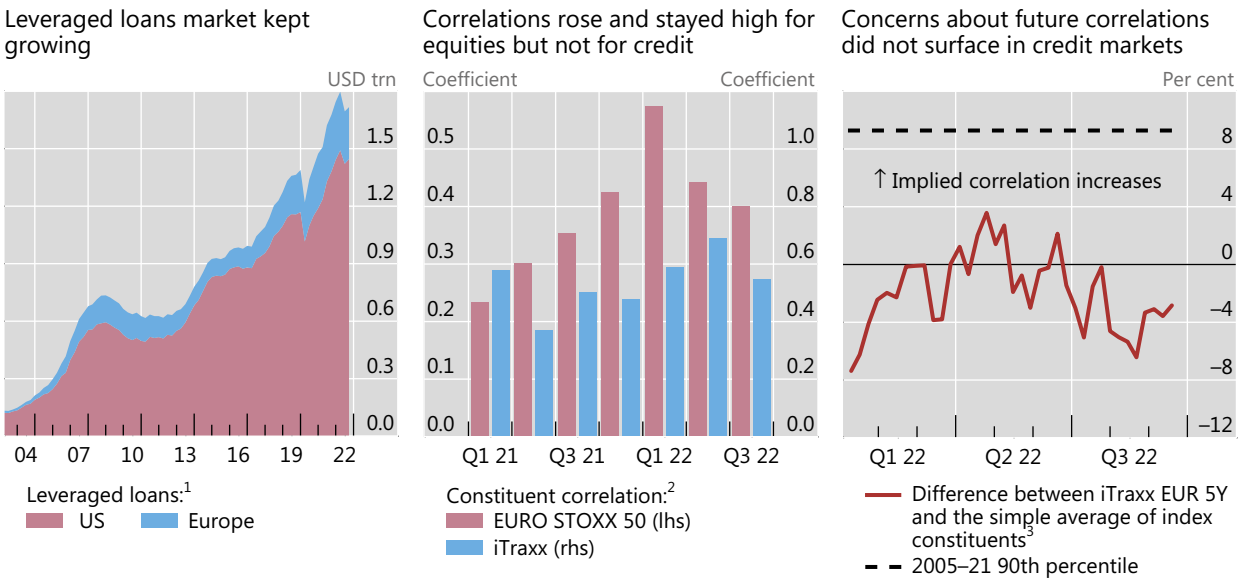
*Sirio Aramonte, Kirstin Detering and Karamfil Todorov*①

Collateralised loan obligations (CLOs) are among the largest holders of leveraged loans. CLOs are tranched securitisations, meaning that they invest in risky pools of leveraged loans using funds raised by issuing notes, or tranches, with different risk profiles. The most senior notes typically have AAA ratings because they are insulated by the junior tranches from all but the largest losses, which are more likely when defaults are highly correlated. CLOs are popular with ultimate investors for three main reasons. First, investors can fine-tune the desired risk exposure to a large market, as leveraged loans amount to more than $1.5 trillion overall in the United States and Europe (Graph B, left-hand panel). Second, CLOs' floating rates are appealing for investors seeking hedges against rising interest rates. Third, CLOs tend to engage in search for yield, enhancing the income stream.②

This box explores the potential implications of the energy crisis in Europe for AAA-rated CLO tranches, which are very sensitive to broad-based disruptions. Persistent issues with the supply of electricity or industrial inputs in Europe might worsen the outlook for many firms simultaneously, thus raising the risk of correlated defaults. Such a scenario could generate principal losses for AAA tranche investors, chiefly banks and insurers.③ Even in the absence of outright credit losses, price declines due to increased risk premia could generate mark-to-market losses.

European credit investors appeared unfazed that asset correlations could rise

Graph B



[1] For institutional leveraged loans, outstanding amounts are based on the S&P-LSTA leveraged loan index for the United States and the S&P European leveraged loan index for Europe (LSTA = Loan Syndications and Trading Association). From Q3 2018 onwards, outstanding amounts are based on JPMorgan leveraged loan indices. [2] Average stock return correlation for EURO STOXX 50 components and average correlation among relative CDS spread changes for iTraxx components. [3] The line shows the relative difference between the spread on a broad CDS index and the average spread of index constituents. This difference increases when investors perceive higher correlations among defaults.

Sources: Bloomberg; JPMorgan Chase; Thomson Reuters Loan Pricing; BIS calculations.

European CLO markets could be particularly exposed to correlated defaults. First, partly due to the smaller size of the European leveraged loan market relative to the US one, European CLOs have less diversified portfolios. Second, there is a higher overlap across the portfolio holdings of various European CLOs, which further limits investors' ability to diversify. Lastly, the European CLO market is relatively illiquid, which could amplify price swings in times of stress.④

Given the geopolitical forces at play and the structure of European CLO markets, it is noteworthy that market prices are sending divergent signals about default correlations. On the one hand, investors in equity markets have recognised that, due to the fallout of the Ukraine war, the outlooks for European companies are more intertwined than in the past. Indeed, realised correlations among stock returns rose sharply in Q1 2022 and remained somewhat elevated relative to the previous year. On the other hand, investors in European credit markets appear to see only a limited increase in default risk co-movement. This assessment rests on two observations. The first is that the correlations of changes in credit default swap (CDS) spreads increased only slightly after the Ukraine war and dipped below Q1 2021 levels by mid-year (Graph B, centre panel). The second is that a common market-based proxy for future default risk correlation rose after the war's outbreak but subsequently eased back to early 2022 levels (right-hand panel).

On balance, the jury is still out on whether defaults will be more correlated in the future. It is not unusual that equity and credit markets send divergent signals about correlations, which may reflect investor segmentation.⑤ However, if equity markets turn out to be correct in their assessment, the risk in AAA-rated CLO tranches is currently underpriced.

① The views expressed are those of the authors and do not necessarily reflect the views of the BIS. ② S Aramonte, S Lee and V Stebunovs, "Risk taking and low long-term interest rates: evidence from the US syndicated term loan market", *Journal of Banking & Finance*, vol 138, May 2022. ③ For a detailed discussion of possible spillovers from the CLO market, see S Aramonte and F Avalos, "Structured finance then and now: a comparison of CDOs and CLOs", *BIS Quarterly Review*, September 2019, pp 11–14. ④ M Wang and L Wang, "Global CLO market mid-year outlook", Citi Research, July 2022. ⑤ H Zhu and N Tarashev, "The pricing of portfolio credit risk", *BIS Working Papers*, no 214, September 2006.

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Commodity markets: shocks and spillovers[1]

Dislocations from the Russia-Ukraine war have buffeted commodity markets from both the financial and real sides. We argue that a substitution of Russian oil exports would be difficult, implying that restrictions on these exports may result in large and persistent price increases for oil-related products. Surging oil prices may be partly moderated by an increased use of biofuels, but this in turn could push up the prices of the staple crops that are biofuel feedstocks. In addition, persistently high prices for natural gas, key for electricity generation, could extend the recent electricity price hikes for final users – a strong headwind for all economic activity, especially industrial production.

JEL classification: Q02, Q43, G10.

Commodity markets seem to be undergoing sizeable transformations. The start of the Russia-Ukraine war gave rise to severe dislocations in many financialised commodity markets, which were followed by a sudden fragmentation of physical markets as Russian energy supply restrictions emerged. In this feature, we take stock of these developments in commodity markets and discuss their potential impact on the real economy as well as their financial market repercussions.

Current events are often compared with the 1970s oil shocks, but the global economy is very different today, with novel interactions in commodity markets. In contrast to 50 years ago, cleaner energy sources such as natural gas and renewables play a larger role in electricity generation, giving rise to new challenges. Biofuels – non-existent back then – have become an integral part of the fuel mix, leading to new interactions between oil and agricultural markets. Thus, understanding the potential consequences of the current developments requires fresh thinking, not least on the potential linkages across seemingly unrelated commodity market segments.

We argue that many economies will find it difficult to compensate for broad constraints on or withdrawal of Russian oil-related exports. For one, alternative producers do not seem to have enough idle capacity to fill the gap. In addition, investment in new production capacity appears to be subdued, particularly by advanced economy firms.

[1] The authors thank Claudio Borio, Julian Caballero, Stijn Claessens, Gong Cheng, Gabriela Nodari, Hyun Song Shin, Andreas Schrimpf, Vlad Sushko, Nikola Tarashev and Kevin Tracol for helpful comments and discussion, and Alessandro Barbera and Pietro Patelli 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.

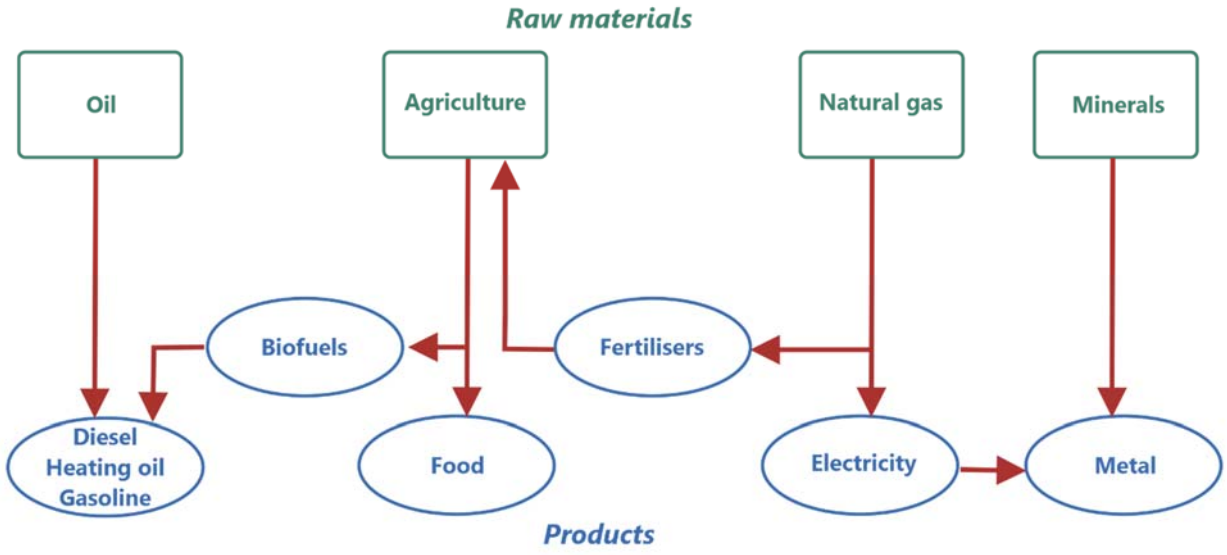
Key takeaways

- Replacing Russian oil output in global markets would be difficult, given limited spare capacity and subdued investment in new projects
- Persistently high oil prices may add upward pressure to the price of grains and oilseeds by boosting their use in the production of biofuels, such as ethanol and biodiesel.
- The recent outsize shock to natural gas prices could have a large and protracted impact on electricity prices for final users, which would be a major headwind to industrial production.

In discussing the spillovers of these shocks, we focus on a few key interactions in commodity markets (Graph 1). The direct effect of rising raw material prices would be to push up the prices of final products – eg from oil to gasoline/diesel, or from natural gas to electricity. Indirect effects are also important. For instance, enduringly high oil prices may add upward pressure to the price of corn and oilseeds, by increasing their use in the production of biofuels, such as ethanol and biodiesel. Shifts in the price of these crops, which are key livestock feedstuffs, could quickly propagate into other food prices.

The remainder of this article is organised as follows. The first section frames the discussion by reviewing recent market developments. The second considers the potential impact of a large withdrawal of Russian oil supply. We evaluate the prospects of other producers filling the gap and point out some indirect yet important interactions between oil and agricultural markets. The third section discusses the conditions that led to the current disarray in natural gas markets, the corresponding impact on electricity prices, and ultimately the potential fallout on economic activity, particularly industrial production. The final section concludes.

Some key connections in the commodity space — Graph 1



Source: Authors' elaboration.

An uneven shock to commodity prices

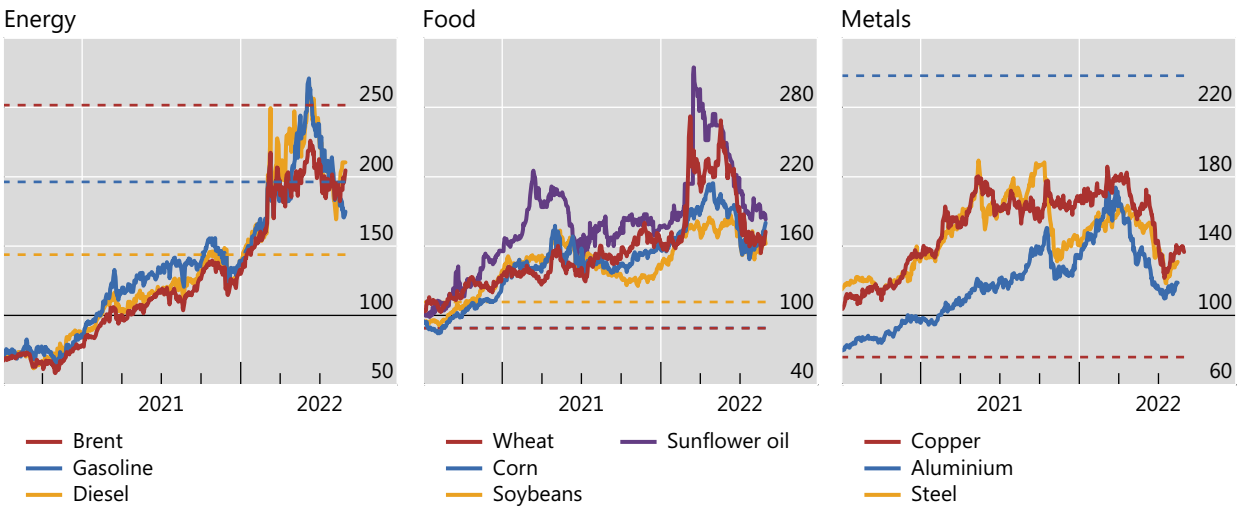
Key commodity prices have been on a pronounced upswing since early 2021. At first, the main driver was the rapid recovery of the global economy as the pandemic's effects began to ease. In 2022, the war in Ukraine added new momentum to price increases in some commodity markets, while disrupting the related financial markets.

The price surge following the beginning of the war in late February 2022 was particularly pronounced for energy and agricultural commodities, but less so for metals. While crude oil prices never broke through the peak recorded in the run-up to the Great Financial Crisis (GFC) (Graph 2, left-hand panel, solid and dashed red lines), the price of oil distillates (eg gasoline and diesel) reached all-time peaks, pointing to the existence of severe bottlenecks in the supply chain of refineries. Turning to key agricultural commodities, their prices have reached or surpassed the levels seen in the mid-2000s "supercycle".[2] Since February, price rises have been particularly strong for wheat and sunflower oil (Graph 2, centre panel), of which Ukraine and Russia are big exporters. Corn and soybean prices saw less of a jump, but market-specific factors had been driving them upwards since late 2020 (USDA (2022)). Industrial metals have seen relatively limited price increases. The persistent weakness of the Chinese economy has kept a lid on those prices (Graph 2, third panel).

The start of the Russia-Ukraine war led to a surge in volatilities and sudden changes in correlations across many commodity prices. These shifts threatened to destabilise the corresponding futures and option markets. One example is the surge in the volatility of natural gas prices, which quadrupled over H1 2022. In parallel, the

Commodity prices have trended upwards since 2021, setting many records

2015–19 average = 100 Graph 2



Horizontal dashed lines indicate pre-GFC maximum price levels.

Sources: Bloomberg; Datastream; authors' calculations.

[2] Steep increases in agricultural prices between 2004 and 2008 are attributed to natural catastrophes that reduced supply and to strong demand growth from emerging market economies (especially China). See for instance Erten and Ocampo (2012).

correlations of Brent prices with those of corn and soybean, which are low or even negative in normal times, jumped to more than 0.7. And while nickel traded on the London Metal Exchange (LME) saw the most conspicuous market disruption (Bloomberg (2022)), stress engulfed most markets (see Box A).

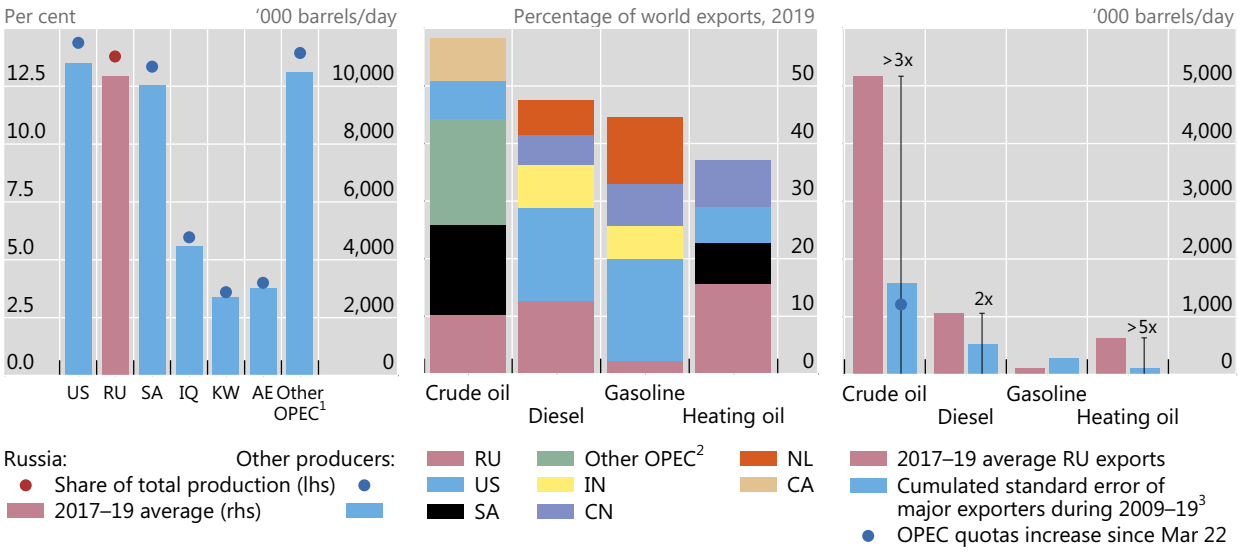
Oil markets: cascading down to agricultural markets?

The Russia-Ukraine war has led to a significant fragmentation of global oil markets, with Russian exports to some countries plummeting. Since further and broader oil supply shortages are possible down the road, it is important to gain an understanding of the potential to compensate for them and of how they may spill over to other commodity markets, eg via the links highlighted in Graph 1.

Finding new oil sources

Russian oil products have a massive footprint in global markets. As regards crude oil, Russia, Saudi Arabia and the United States are the only jurisdictions with daily output above 10 million barrels per day (bbl/d), each accounting for about 14% of global production, and vastly surpassing the output of any other producing country (Graph 3, left-hand panel). About half of Russian production is directly exported, representing 10% of global exports of crude oil. The rest is an input into the production of distillates, with Russian refiners accounting for about 15% of global exports of diesel oil and heating oil (centre panel). Thus, a material withdrawal of Russian oil products would be a major negative shock to the global economy.

The large footprint of Russian supply in oil-related markets — Graph 3



[1] AO, CD, DZ, IR, GA, GQ, LY, NG and VE. [2] AE, IQ and KW. [3] Standard errors of auto-regressive models of order one, for each country-commodity pair. Standard errors are the sum across countries for each commodity type, to gauge the variability of production patterns.

Sources: OPEC; UN Comtrade; JODI; national data; authors' calculations.

Current restrictions in Russian oil exports have led to fragmentation, with some consumers losing access to part of the market. Based on the available Comtrade data, US imports of Russian oil had fallen almost to zero by the second quarter of 2022, while the corresponding European Union (EU) purchases dropped by 29%. At the same time, the purchases of Russian crude oil by countries in Asia, Africa and Latin America have reportedly increased significantly (Reuters (2022a)). In the background, Russian oil production, after suffering a steep drop in April, gradually recovered to match 2021 levels in June, with some observers estimating that it will surpass 2021 levels by the end of the current year (OPEC (2022)).[3]

Looking forward, can the world easily compensate for effective restrictions on Russian oil supply? It seems unlikely that other producers currently have enough idle capacity to fill the gap that would be left by an extensive withdrawal of Russian oil products. Based on output levels during the pre-Covid decade, the typical variability of the exports of all OPEC members combined, including Saudi Arabia, is around 1.5 million bbl/d (Graph 3, right-hand panel). That is roughly the same as the production increases already agreed by members this year (blue dot).[4] Thus, for OPEC members, fully replacing Russian crude oil exports would represent more than three times the current effort. Turning to distillates such as diesel and heating oil, sectors which are also facing capacity challenges, the effort would be comparable if not greater.

In addition, substitution of Russian oil output may require investment. However, 2022 investment in the exploration and development of new sources (ie upstream investment) is set to fall short of pre-pandemic levels (Graph 4, left-hand panel, blue dots), even if it were to grow by 10% from 2021 (IEA (2022)). This relatively modest rise would be spearheaded by national oil companies (NOCs), particularly in the Middle East, the only producers that would exceed pre-pandemic upstream expenditure. Advanced economy (AE) energy companies, in contrast, are expected to see their upstream investment fall by an average of 30% vis-à-vis 2019. The retrenchment by AE energy firms is not a new phenomenon: it can be traced back at least to the middle of the 2010s (Deloitte (2015)). As of mid-2022, these firms' participation in the 50 largest oil and gas projects worldwide amounted to about 37% of these projects' value (centre panel). The corresponding share for projects controlled fully by AE energy firms is only 5%. Overall, despite recent increases in oil and gas prices, there are no signs of rebounding investment in oil production.

Weak sentiment towards energy companies, perhaps driven in part by climate policies, may be denting their incentives to invest. The excess stock return specific to AE energy producers has been increasing since 2017, and was positive for most of them in 2020 (Graph 4, left-hand panel, red line and area). This hints at an unfavourable market sentiment that lowers the valuation of these producers' stocks. Such an interpretation fits a general pattern that prevailed during the last decade: global upstream investment was weaker when there was a larger share of undervalued firms according to this measure (right-hand panel, red regression line). If the undervaluation has persisted, it can explain why some managers have preferred to repurchase their stocks rather than invest in real assets.[5]

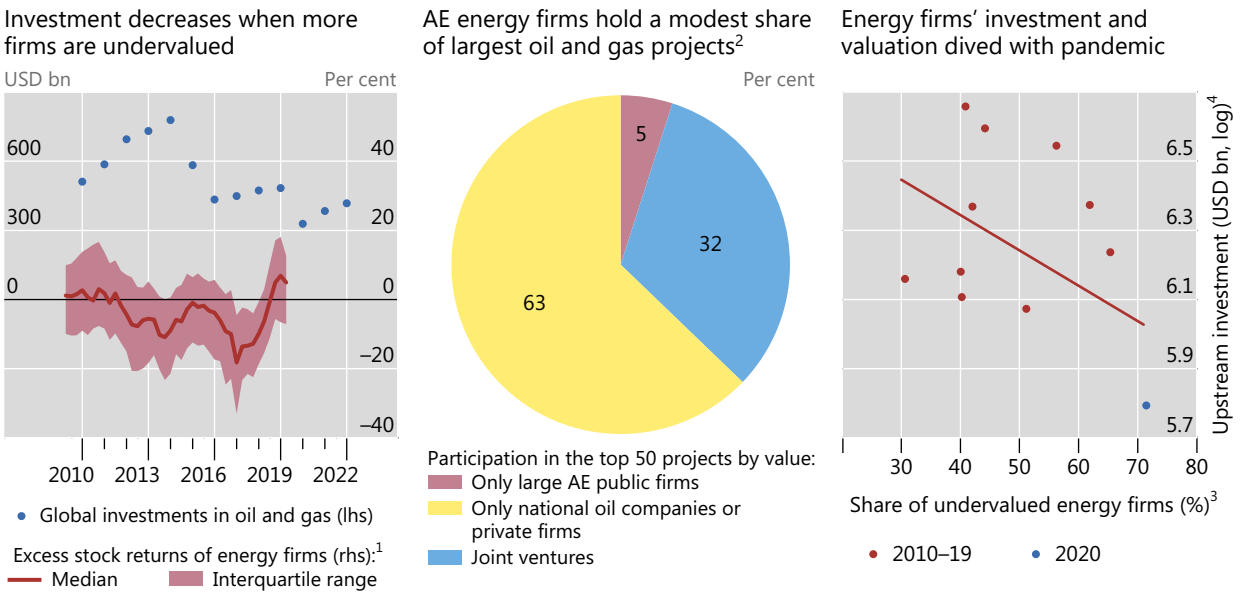
[3] As the supply disruptions began to ebb, weakening oil prices have led OPEC members to consider and implement cuts in production quotas.

[4] During the second quarter of 2022, Saudi Arabia has reportedly doubled its purchases of Russian fuel oil for power generation, in order to free up more crude oil for exporting (Reuters (2022b)).

[5] For instance, Glencore, BP, Exxon and Chevron spent more than $20 billion on buybacks in H1 2022.

Investment in new production capacity has been subdued

Graph 4



[1] Based on Fama-French regressions for S&P 500 companies and large global commodity producers with shares traded in US markets. [2] Share of the total value of the top 50 global oil and gas construction projects, by value as of July 2022. [3] Percentage of energy firms with positive excess stock returns. [4] Global investment in oil and gas.

Sources: K French, "US Research Returns Data", August 2022; Bloomberg; IEA; Offshore Technology; national data; authors' calculations.

Oil and agricultural prices: linked by biofuels

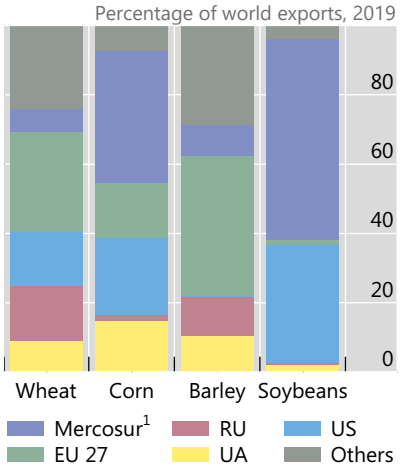
The Russia-Ukraine war has put upward pressure on the price of some agricultural commodities. In part, this pressure stemmed directly from supply restrictions, as the joint share of both countries in the global exports of key crops is substantial. There was also an indirect effect, from the increase in the price of crude oil and its distillates. In the short run, higher diesel and gasoline prices increase the costs of agricultural production and transportation. Large and persistent increases in oil prices may also result in a durable increase in the price of crops that are used as an input for the production of biofuels such as ethanol and biodiesel (Graph 1).

Russian and Ukrainian exports account for a large share of the global market of several food staples. Their share is particularly large in wheat, at roughly 25%, but also in barley and corn (Graph 5, left-hand panel). The surge in wheat prices was most pronounced after the start of the Russia-Ukraine war, as it was expected to disrupt the approaching harvest season for winter wheat (Graph 2, centre panel). The price reaction in other crops such as corn, however, was more limited, as major producers in this market were unaffected, particularly the United States, the crop's largest single producer and exporter.

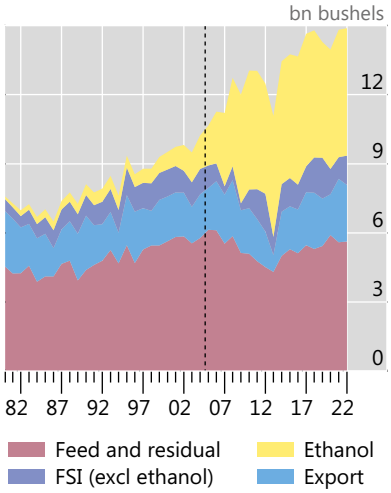
Interlinkages between oil and crops

Graph 5

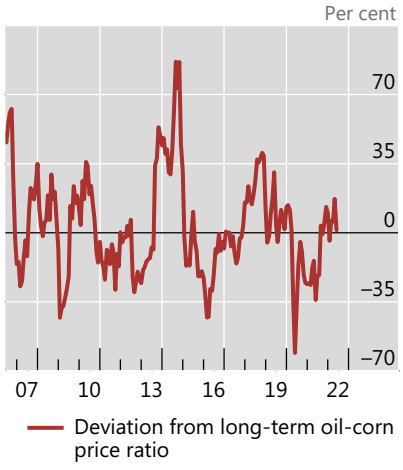
Global exports of grains and oilseeds



Uses of US corn production



Oil and corn prices move in tandem



FSI = food, seed and industrial. The vertical dashed line in the centre panel indicates 8 August 2005 (US Energy Policy Act).

[1] AR, BR, PY and UY.

Sources: UN Comtrade; national data; authors' calculations.

Corn is a major input in the production of ethanol, a biofuel commonly blended with gasoline.[6] In fact, ethanol production is the only use of corn that has materially increased during the last 20 years in the United States, having taken about 40% of the US harvest, on average, over the past five years (Graph 5, centre panel). The prices of corn and oil have thus moved in tandem since the mid-2000s, with occasional large deviations that eventually subside over time (right-hand panel).[7] Higher oil prices create incentives for gasoline blenders to increase the ethanol content in their product. Such a shift could moderate the oil price surge, but would also increase the demand for corn (alongside that for other ethanol feedstocks), pushing up its price.[8]

Shifts in corn prices could also spill over to other agricultural markets. As corn competes with soybeans for acreage, changes in corn prices usually are transmitted quickly to soybeans. Furthermore, both crops are used as livestock feedstuffs. In sum, persistent disruptions in global energy markets can spill over to raise the prices of a wide range of agricultural products through a variety of channels.

[6] Sugarcane and, to a lesser extent, also sugars from wheat, barley and sorghum are also common feedstocks for ethanol. Biodiesel has a much broader set of feedstocks, including oilseeds such as soybean, palm, rapeseed, canola and a variety of residual fats from animal and vegetable food processing. For an introduction, see US Energy Information Agency, "Biofuels explained": www.eia.gov/energyexplained/biofuels/.

[7] Avalos (2014) and Avalos and Lombardi (2015), among others, study the interactions between oil and agricultural prices after the passing of the US Energy Policy Act in 2005.

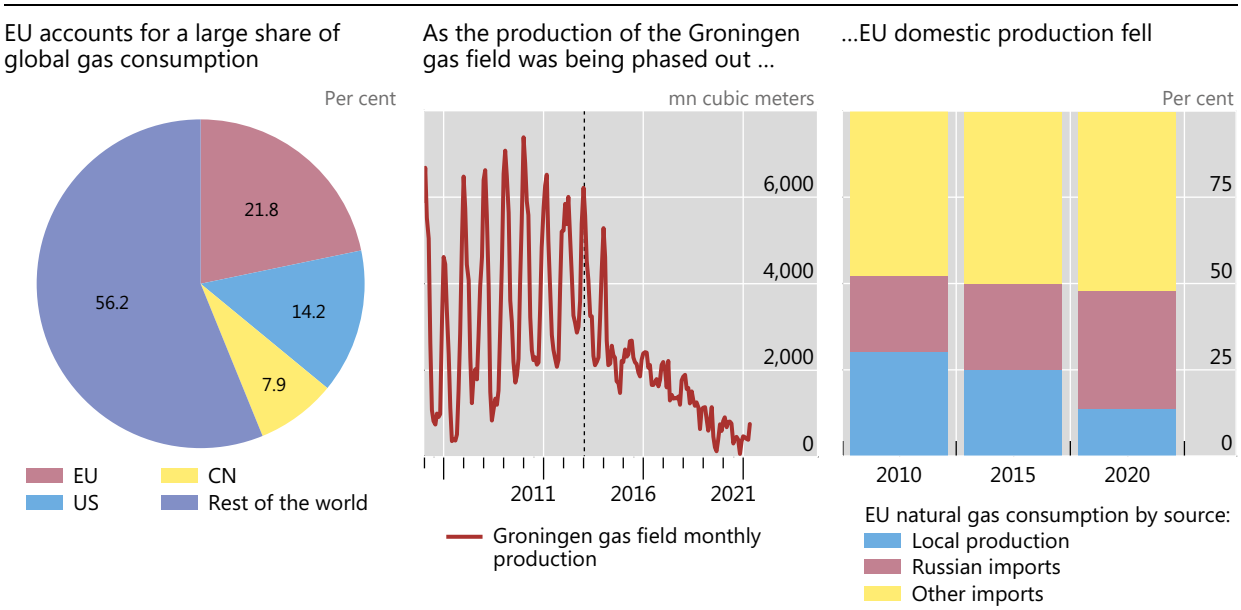
[8] In India, for instance, gasoline producers are currently offering substantial premiums over the government-mandated maximum prices of sugarcane ethanol (Reuters (2022c)).

Natural gas markets: the electricity connection

In contrast to the 1970s, oil now has a minimal footprint in electricity generation, as natural gas has risen in importance. The cleanest-burning fossil fuel among its peers (including oil and coal), gas has numerous industrial applications[9] and gas-fuelled generators are a key dispatchable[10] source of electricity (see Graph 1). Following many years of stability, gas prices have seen an extraordinary surge since mid-2021, in large part because of imbalances in EU markets. We now dig into the drivers of the surge and its potential impact on electricity prices and industrial production.

Global gas consumption has doubled in the last 30 years. The United States and the European Union are the two largest global consumers (Graph 6, left-hand panel). While the United States has become self-sufficient in the wake of the shale gas "revolution" (Stevens (2012)), the EU relies on a wide range of supply sources. For decades, a third or more of that supply used to come from domestic sources, underpinned by the massive Groningen gas field in the Netherlands. As late as 2013 its output, at 53 billion of cubic meters per year (bcm/year), represented 40% of the total EU natural gas production. The field was also important as it could accommodate large seasonal swings in demand (centre panel). With the phase-out

EU's gas consumption significantly exceeds domestic production — Graph 6



The dashed vertical line in the centre panel indicates January 2014 (first annual cap on Groningen production is announced).

Sources: European Commission; IEA; BP; NAM; national data; authors' calculations.

[9] Natural gas generates about 25% less carbon dioxide emissions than oil distillates, and it is a major input in the production of nitrogenated fertilisers (another connection between energy and food prices), plastics, batteries, clothing, solar panels and many more items. See, for instance, US Energy Information Agency, www.eia.gov/energyexplained/natural-gas/.

[10] Dispatchable sources of electricity are those that can be turned on and off at will, in response to current demand. This is the case for all fossil fuels, nuclear and usually hydropower. The main renewable sources, wind and solar power, are not dispatchable but "intermittent", since they can be used only when the right external conditions are present (the wind blows or the sun shines).

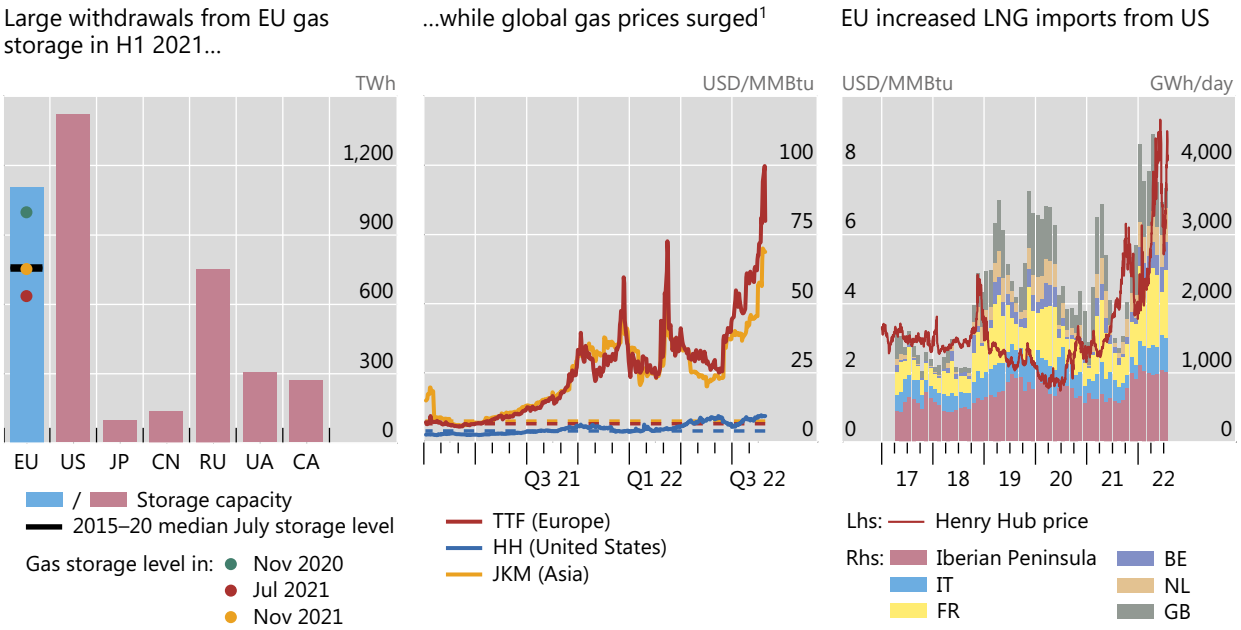
of Groningen starting in 2014, production within the EU declined quickly.[11] Instead, Russian supply took on a larger role, increasing its share of total EU gas consumption to almost 35% by 2020 (right-hand panel).

Gas markets have become globally interconnected in recent years. They were traditionally regional, with most of the trading based on regionally produced gas moving through pipelines. The construction of large liquifying/regasifying facilities in both producing and consuming countries has led to a sizeable global trade in liquified natural gas (LNG). The EU plays a pivotal role in this trade as it is one of the largest consumers and is tightly connected to regional and global markets through pipelines and LNG facilities. Typically, to counter supply-demand imbalances, the EU relies on its large storage capacity, second only to that of the United States (Graph 7, left hand panel, blue bar). In recent months, however, this practice has been put to the test.

As EU storage levels ebbed and flowed after the Covid outbreak, gas prices swayed. The sudden shutdown of the global economy in 2020 led to a glut of supply that drove prices to all-time troughs. Title Transfer Facility (TTF), the European benchmark, was trading at about $6 per million BTU in early 2021 (Graph 7, centre panel, red line). EU storage was replenished at low prices, reaching very high levels by late 2020 (left-hand panel, green dot). However, during the first half of 2021, a number of factors gradually tightened market conditions, mainly an unusually cold winter and the disconnection of several LNG hubs for technical reasons (Heather (2022)). EU gas reserves fell steadily to unexpected lows during the summer of 2021

Natural gas markets under stress

Graph 7



HH = Henry Hub; JKM = Japan-Korea Marker; TTF = Title Transfer Facility.

[1] The dashed lines indicate long-term medians starting from 2000 (subject to data availability).

Sources: AGSI; Bloomberg; Refinitiv Eikon; national data; authors' calculations.

[11] From early on, gas extraction from the field led to minor earthquakes, which became more frequent and intense from the mid-2000s. In 2014 the production of the field was capped for the first time, and a programme of gradual cuts that stretched out to 2030 was introduced. In October 2019, the government decided to accelerate the shutdown of Groningen to September 2022.

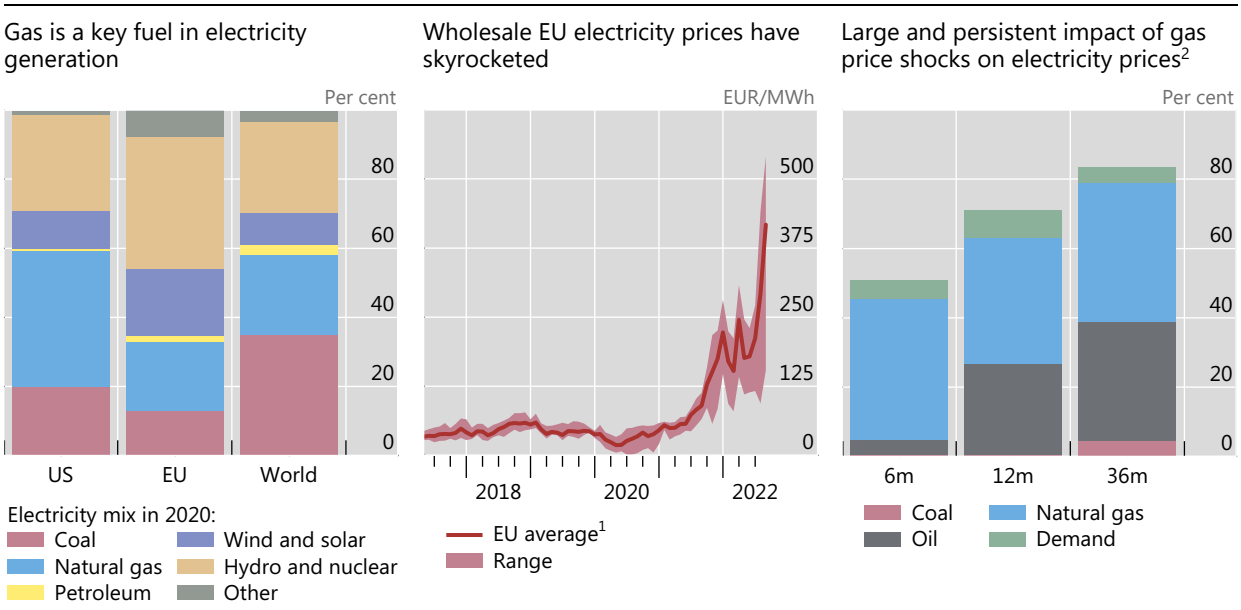
(red dot) and remained low until the beginning of the winter (yellow dot). By the end of 2021, TTF had surged to $60, eight times the average price of the previous 10 years (centre panel).[12] The stress spilled over to global markets, as indicated by the Japan Korea Marker (JKM), the Asian benchmark.

The stress in EU gas markets became even more acute with the war in Ukraine. With the Russian pipeline flow severely limited,[13] replenishing EU storage became complex and expensive, as it required substantial cuts in consumption (European Commission (2022)) or outbidding other LNG consumers. In fact, during 2022, the EU increased its LNG imports from the United States to all-time highs, thus contributing to the rise in the Henry Hub price, the US benchmark (Graph 7, right-hand panel). However, this rise has been moderate (centre panel), as the relatively limited US liquifying capacity insulates the local market from the surge in demand in the rest of the world.

Natural gas is a major input in electricity generation. It accounts for about 40% in the mix of US electricity sources, and about 20% in the EU (Graph 8, left-hand panel). The EU share is close to the world average and is surpassed in the region only by hydroelectric and nuclear power. Since nuclear generation in the EU dropped substantially in 2022, mainly due to a series of technical issues in France, the role of gas as a key dispatchable source of electricity gained further relevance just when its price was reaching historical peaks.

Gas price shocks have a large and persistent effect on electricity prices

Graph 8



[1] BE, BG, CZ, DK, ES, FR, HU, IT, NL, NO, Nordpool, PL, RO, SE and SI. [2] Variance decomposition for the electricity price over three time horizons, based on a VAR system with industrial demand, oil price, gas price, coal price and electricity price.

Sources: IEA; Our World in Data; Refinitiv Eikon; national data; authors' calculations.

[12] Translated into barrels of oil equivalent (boe), that price is about $350/boe, while Brent's all-time high was $147.50/bbl, recorded on 11 July 2008.

[13] According to Gazprom, sales to EU customers in the first seven months of 2022 fell by 35 billion cubic metres, which amounts to about 30% of the consumption over the same period in 2021.

Shocks to gas prices are bound to have a material effect on the price of electricity. Not surprisingly, the average wholesale electricity price in the EU has increased more than fivefold since mid-2021, while dispersion around the different regional trading hubs has also risen dramatically (Graph 8, centre panel). Such high and sustained wholesale electricity prices are unprecedented. Turning to the United States, an empirical analysis reveals that gas price shocks account for roughly 40% of the unexpected variation in industrial electricity prices over six months, with the share remaining stable for at least three years (Graph 8, right-hand panel). The impact of oil price shocks is initially small but increases materially over time. Since the footprint of oil is minimal in the electricity generation mix (left-hand panel), the estimated impact is likely the result of oil-indexing provisions in long-term contracts for the delivery of pipeline gas, which tend to kick in gradually over time.

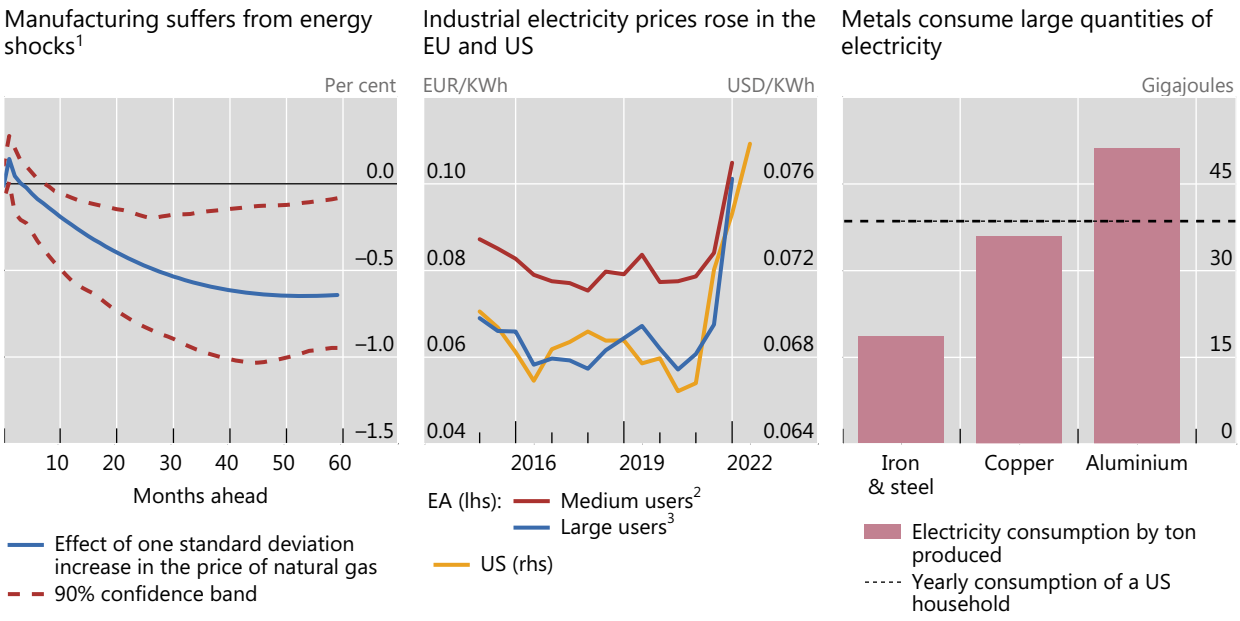
In general, the manufacturing sector is the main user of electricity, averaging more than 40% of total usage at the global level, according to IEA data. The share varies with country and economic specialisation. The electricity consumption of the EU manufacturing sector is in line with the global average, while in China manufacturing gobbles up 60% of total electricity usage. In the United States the share of manufacturing is only 20%, while the services sector accounts for about 35%, and residential consumption for about 40%.

The impact of gas supply disruptions on electricity prices is thus likely to affect global economic activity, particularly as a headwind for manufacturing. The results of an empirical investigation suggest that the effects build up slowly over time. In the United States, a one standard deviation increase in gas prices, transmitted through industrial electricity prices, starts affecting manufacturing production only a year after the onset (Graph 9, left-hand panel). And the negative effect continues to build up over time, reaching a maximum about 50 months after the shock. The delay probably reflects large consumers' cost hedges or long-term contracts with electricity generators or distributors. The impact of the shock grows as those hedges expire and contracts' indexation activates. With the current shocks still evolving, the empirical estimates are merely indicative. They do not account for potential non-linear repercussions of shocks larger than those observed historically.[14]

Industrial electricity prices are already on the rise in the United States and the EU (Graph 9, centre panel). A persistent rise in such prices would deal a particularly strong blow to sectors that use electricity intensively, such as metal production. For example, producing a ton of aluminium consumes more electricity than a US household does in a whole year, with copper a close runner-up (Graph 9, right-hand panel). Given the recent increase in electricity prices, there are already frequent reports of stoppages of metal production in the EU and other jurisdictions.

[14] A shut-off of natural gas in Europe could reduce Germany's GDP by an estimated 0.5–3% during 2022 (Lan et al (2022)). The most vulnerable countries in central and eastern Europe could face a GDP decline of up to 6% (Di Bella et al (2022)).

Shocks to electricity prices may be a substantial headwind for manufacturing Graph 9



[1] Based on a VAR model of industrial production index, consumer price index and the real electricity price, with gas shocks as an instrument. Bootstrapped confidence bands. [2] Average price for users with annual consumption of 500–20,000 MWh. [3] Average price for users with annual consumption of 20,000–150,000 MWh.

Sources: IEA; Refinitiv Eikon; national data; authors' calculations.

Conclusion

While it is hard to miss the immediate direct effects of a negative commodity supply shock on the broader economy, it is inherently difficult to gauge how these effects will play out down the road and in the relevant transmission channels. This article has argued that material restrictions on Russian energy exports will probably keep energy prices elevated. It has also pointed to two salient spillover mechanisms, from oil via biofuels to crops, and from natural gas via electricity to manufacturing. Some of these effects may still have not unfolded in full, due to structural delays in production chains, or may pick up steam if there are reversals in the recently subdued demand in key sectors (eg Chinese construction). That said, persistent disruptions to the markets for energy commodities may also accelerate the green transition, and in so doing reduce the global economy's dependence on fossil fuels and eventually lower their price. In the meantime, understanding the complex interlinkages across commodity sectors is essential for policymakers if they are to ward off the debilitating effects of energy and agricultural output reductions on economic activity.

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Box A

The financial implications of volatile commodity markets

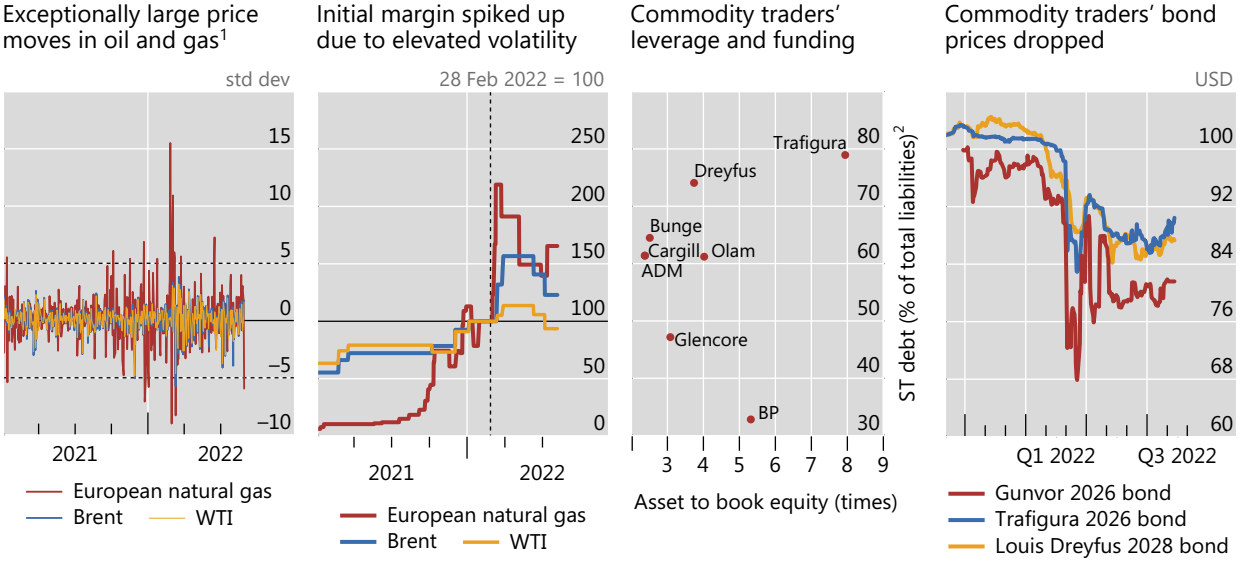
*Fernando Avalos and Wenqian Huang*①

The financialised commodities market – comprising mainly derivatives such as futures and options – is fairly concentrated, dominated by a few large commodity traders. These traders' main role is to intermediate between producers and consumers of commodities, taking advantage of arbitrage opportunities when they arise. This box discusses how recent developments in physical markets affected financial markets and the attendant vulnerabilities.

The Ukraine-Russia war led to large and frequent margin calls in financialised commodities markets. The exceptionally large price movements, in some cases equivalent to roughly a 15-sigma event (Graph A1 first panel), resulted in sizeable daily or even intraday variation margin (VM) calls as derivatives contracts were marked to market. The elevated volatility also prompted central counterparties (CCPs) to increase initial margin (IM) substantially. For instance, the IM requirement for European natural gas futures at Intercontinental Exchange (ICE) more than doubled right after the start of the war and then hovered at around 50% above pre-war levels (Graph A1, second panel).

Leveraged commodity traders faced large margin calls and high funding costs

Graph A1



Dotted horizontal lines in the first panel indicate plus and minus five standard deviations. The dashed vertical line in the second panel indicates 24 February 2022 (start of war in Ukraine).

[1] Daily returns, divided by their standard deviation calculated over 2000–21. [2] Liabilities due within one year.

Sources: IMF; Bloomberg; company filings; ICE (the data have been made available in accordance with the terms of use); S&P Capital IQ; Trafigura; authors' calculations.

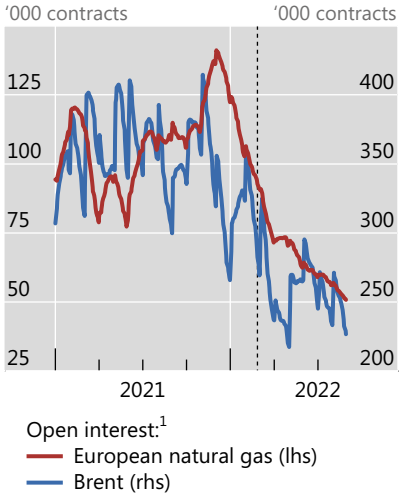
Higher IM requirements are costly for commodity traders. In order to maintain derivatives positions, they need to pledge more liquid assets as collateral. Furthermore, sizeable IM and VM calls can potentially drain the liquidity assets of commercial traders – possibly impairing their creditworthiness – as traders tend to be highly leveraged and reliant on short-term funding. For instance, one major trader in energy commodities has an asset-to-equity ratio of eight, while more than 75% of its liabilities are financed with short-term instruments of less than one year's maturity (Graph A1 third panel). Accordingly, bond prices for major commodity traders dropped by around 20% in the first half of 2022 (Graph A1, fourth panel). This has raised traders' funding costs, making it even more expensive to participate in commodities markets.

As the cost of trading on commodities derivatives markets increased in H1 2022, these markets became substantially thinner. After the war started, open interest in exchange-traded natural gas futures fell by more than 50%; and that in oil futures by almost 30% (Graph A2, left-hand panel). Trading volumes in both exchange markets and OTC markets also saw large declines and have remained at low levels ever since (Graph A2, centre panel).

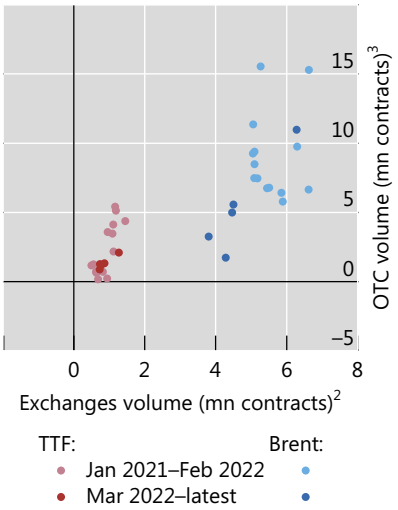
Commodity derivatives markets become thinner as activity dropped

Graph A2

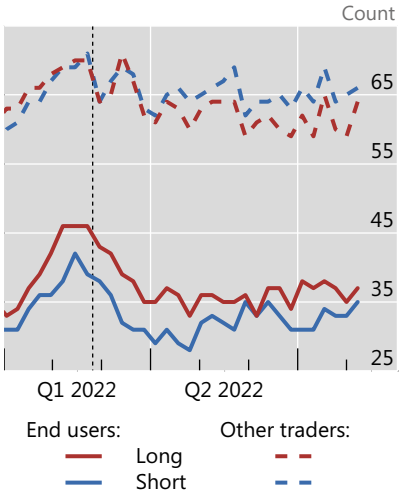
Exchanges' open interest saw sizeable declines



Volumes dropped on exchange and OTC markets



Biggest impact on end users[4]



The dashed vertical line in the left- and right-hand panels indicates 24 February 2022 (start of war in Ukraine).

[1] Monthly moving averages of open interest on ICE. [2] Numbers of futures contracts traded on ICE. [3] Monthly volumes of contracts traded over-the-counter (OTC) from DTCC SDR. Numbers of contracts based on the corresponding standard contract size on ICE. [4] Numbers of traders of WTI futures from CFTC commitment of traders reports.

Sources: Bloomberg; CFTC; DTCC; authors' calculations.

Setting aside their contribution to commodity price volatility, thinner derivatives markets are of particular concern if the reduction in open interest and trading volumes reflects declines in hedging rather than speculation activities. Indeed, US data on oil futures indicates that end users of commodities – such as producers, merchants and processors – were affected the most by the high trading costs.② The number of end users with long (short) positions in WTI oil futures dropped from 46 (36) in February 2022 to 33 (31) in May 2022, while the number of other types of user who are more likely to engage in speculation – eg money managers – remained relatively stable (Graph A2, right-hand panel). This suggests that some commodity end users tried to opt out of their usual hedging activities and to absorb price risks on their balance sheets. If they fail, there could be adverse consequences for commodity supply security.

① The views expressed are those of the authors and do not necessarily reflect the views of the BIS. ② US data from the CFTC commitment of traders report on WTI futures contracts.

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Under pressure: market conditions and stress[1]

When financial markets come under pressure, vital functions such as the efficient allocation of capital and price formation become impaired. It is therefore important to enhance the monitoring and analysis of market conditions, in particular events that may put pressure on authorities to intervene. We introduce market conditions indicators (MCIs) for each of three key market segments: the US Treasury and US money markets, and the foreign exchange market centred around the US dollar. Our daily MCIs reflect market volatility, illiquidity and deviations from standard no-arbitrage conditions. They capture well known episodes of market turmoil. We show that it is in some cases possible to identify conditions that point to a heightened risk of future market stress months ahead of the event.

JEL classification: G10, G17, G21, G23.

Since the Great Financial Crisis (GFC), structural changes in financial markets have significantly altered the nature of liquidity provision. For one, banks have adapted to a new regulatory environment that limits their ability to warehouse risks. At the same time, the heft of non-bank financial institutions (NBFIs) has risen markedly (Carstens (2021), Aramonte et al (2021)). In addition, technological improvements have facilitated high-speed trading on automated platforms (Markets Committee (2022)).

In this environment, episodes of market stress have become more frequent and widespread. We treat "stress" as a broad concept, covering periods of market dysfunction as well as periods when markets are functioning but amid liquidity that is low in historical terms.[2] Stress episodes are characterised by impairments to price formation and the breakdown of no-arbitrage relationships. From a policy perspective, it is important to monitor any deterioration of market conditions in real time and, in combination with leading indicators, to anticipate a potential need for intervention *before* stress has begun.

This special feature develops separate daily market conditions indicators (MCIs) for three key markets: the US Treasury market, US money markets and the foreign exchange (FX) market centred around the US dollar. These markets are key for

[1] The authors thank Claudio Borio, Stijn Claessens, Mathias Drehmann, Benoît Mojon, Andreas Schrimpf, Hyun Song Shin, Fabricius Somogyi, Vladyslav Sushko, Nikola Tarashev and Philip Wooldridge for valuable comments and suggestions, Pietro Patelli for excellent research assistance, and Azi Ben-Rephael and co-authors as well as Douglas Richardson from the Investment Company Institute for kindly sharing data. The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

[2] For a definition of market dysfunction, see Markets Committee (2022).

Key takeaways

- Newly developed daily market conditions indicators for three key segments – foreign exchange, US money and Treasury markets – capture known episodes of market stress over the past two decades.
- The new market-specific indicators co-move only loosely with the VIX – the most commonly used "fear gauge" – which is the key driver of alternative indices of financial conditions or stress.
- Variables capturing investor overextension and risk perceptions, liquidity conditions or intermediaries' market-making capacity can help detect a heightened probability of market stress.

monetary policy implementation and the fulfilment of central bank mandates. Furthermore, they are distinct yet intertwined, not least in the modern market-based financial system where money market funding of capital market lending supported by collateral plays a key role (Mehrling et al (2013)). We focus on the United States – and by extension the dollar – due to its central role in global financial markets.

We construct each MCI in two steps and use it to define stress episodes, focusing on one market at a time. First, we identify variables that capture market illiquidity or deviations from standard no-arbitrage conditions. Second, we equate an MCI with the factor that explains most of the variation across these variables. We define market stress as realisations of the MCI that fall in the upper tail of its historical distribution. The three MCIs spike concurrently when stress is pervasive, but also identify market-specific stress episodes. They co-move only loosely with the VIX, with which alternative indicators of financial conditions or stress are tightly linked.

Next, we examine the extent to which it is possible to anticipate MCI realisations that indicate stress. We are interested in uncovering leading indicators that signal market fragility and are associated with an elevated risk of future market stress, rather than in predicting the exact timing of stress episodes.[3] We consider two broad categories of variables that may signal fragilities: one capturing investors' overextension and risk perceptions, the other reflecting more structural features of markets such as intermediaries' market-making capacity and funding liquidity conditions. Our results suggest that it is possible in some cases to identify (in sample) a heightened probability of stress several months prior to the event.

The rest of this article is organised as follows. The first section briefly discusses conceptual issues around the measurement of market conditions and stress, contrasting our approach with the related literature. The second presents the construction of our three MCIs and discusses their properties. A third section assesses the probability of future stress. The final section concludes with policy considerations.

[3] This is in line with common practice in financial stability analysis: focus on assessing vulnerabilities, not triggers of stress episodes.

Financial conditions, vulnerabilities and stress

The GFC gave new impetus to the study of financial market conditions and stress, and their effect on the economy at large.[4] But as the adage goes, "not everything that can be counted counts, and not everything that counts can be counted". Market conditions certainly count, but are hard to "count": they are critical, yet not directly observable.

In practice, measurement difficulties have translated into a variety of financial stress (FSIs) and conditions indices (FCIs).[5] These have similarities, but also important differences in terms of both inputs and scope (Monin (2017)). Both FSIs and FCIs combine information from various financial variables into a single number. FSIs focus on identifying distress and dysfunction as they occur. They are often constructed with financial market prices only. By contrast, FCIs were originally designed to measure the impact of financial conditions on the economy and therefore tend to have a medium-term focus (Hatzius et al (2010), Adrian et al (2022)). Furthermore, FCIs tend to incorporate information on quantities in addition to financial market prices.

Our approach to measuring market conditions is close to the one underpinning FSIs. An important goal of our approach is to identify episodes of market stress as they occur, with stress broadly understood as poor market conditions. As such, we aim for coincident rather than early warning indicators. In addition, we use daily series with near real-time availability and hence focus almost exclusively on financial market prices as inputs.

That said, our approach also differs from that behind most FSIs in a number of dimensions, most notably regarding input variables. For one, we focus on disruptions to market liquidity, mispricing and the breakdown of standard arbitrage relations that are the tell-tale sign of impaired market functioning. Unlike FSIs, we do not consider variables from the equity market (eg valuations and volatility). Furthermore, our approach is more parsimonious than that of alternative indices. At a practical level, this simplifies collection and maintenance. At a conceptual level, it brings the virtue of greater transparency and greater scope for understanding the general state of market conditions. Finally, we also differ in our focus on *individual* key markets that are interwoven by the role of market-making and collateral to support leveraged strategies. Our approach thus aligns with the type of interventions central banks have made in recent times as dealers of last resort to backstop specific asset markets.

Measuring market conditions

We construct the MCIs in two steps. First, for each of the three markets, we collect variables capturing volatility, market (il-)liquidity and funding (il-)liquidity as well as impaired market-making more broadly. We aim to strike a balance between the coverage of different aspects of market conditions and availability of a reasonably lengthy daily time series. Guided by this trade-off, we start our analysis in 2003.

[4] Two related areas of work that saw a post-GFC resurgence are that of early warning indicators of banking crises (Borio and Drehmann (2009), Greenwood et al (2022)) and systemic risk measurement (Bisias et al (2012), Tarashev et al (2016)).

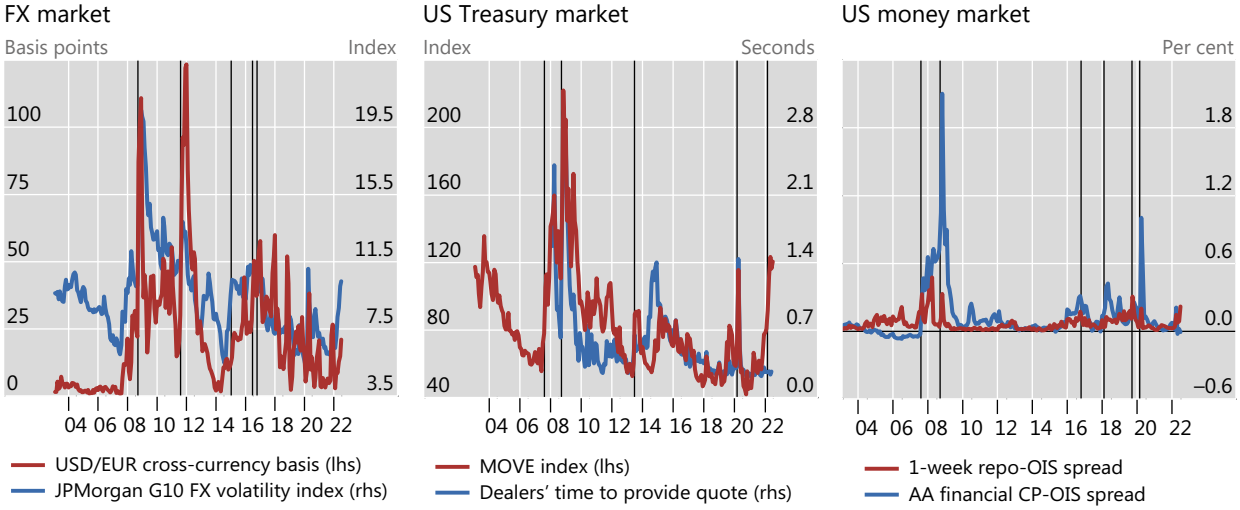
[5] See Hatzius et al (2010), Carlson et al (2014) and Kliesen et al (2012) for literature reviews.

The specific variables we consider are well known (online annex Table A). Those that capture market dislocation reflect the breakdown of no-arbitrage conditions. Examples include the cross-currency basis in FX markets,[6] or deviations of observed bond yields from a fitted smooth yield curve in the Treasury market. Measures of market liquidity, in turn, aim to capture the ease with which market participants can trade without significantly affecting prices. Examples include quoted bid-ask spreads for spot FX or the premium between on- and off-the-run Treasury securities. Finally, we incorporate measures of market uncertainty, such as the JPMorgan FX volatility indices and the MOVE index for the FX and Treasury markets, respectively.

The variables capture, to different degrees, known episodes of poor market conditions over the past two decades. For example, FX market volatility and dislocation measures, such as the JPMorgan FX volatility index or deviations from covered interest parity (CIP)[7] (Du et al (2018), Rime et al (2022)), signalled the European sovereign debt crisis in 2011–12, the 2015 de-pegging of the Swiss franc from the euro, Brexit and the US money market fund (MMF) reform (Graph 1, left-hand panel). In the Treasury market, measures of market liquidity (eg the time it takes dealers to provide quotes) and volatility (eg the MOVE index) rose around the GFC, taper tantrum, Covid-19 pandemic and the start of the war in Ukraine (centre panel). Similar measures also play a role in money markets. The spreads between repo and overnight index swap (OIS) rates (market dislocation) and between high-quality financial commercial paper and OIS rates (market liquidity) surged during the GFC, the US MMF reform, the VIX spike in early 2018, the September 2019 repo turmoil and the pandemic (right-hand panel).

Selected input variables for market conditions indicators

Graph 1



For better visibility, we plot all series as monthly averages. The vertical lines indicate, from left to right: Lehman Brothers' default, the European sovereign debt crisis, the Swiss franc de-peg, Brexit and the US MMF reform (left-hand panel); BNP's freezing of funds, Lehman Brothers' default, the taper tantrum, Covid-19 and the start of the war in Ukraine (centre panel); BNP's freezing of funds, Lehman Brothers' default, the US MMF reform, the 2018 VIX spike, the September 2019 repo stress and Covid-19 (right-hand panel).

Sources: Bloomberg; Tradeweb; authors' calculations.

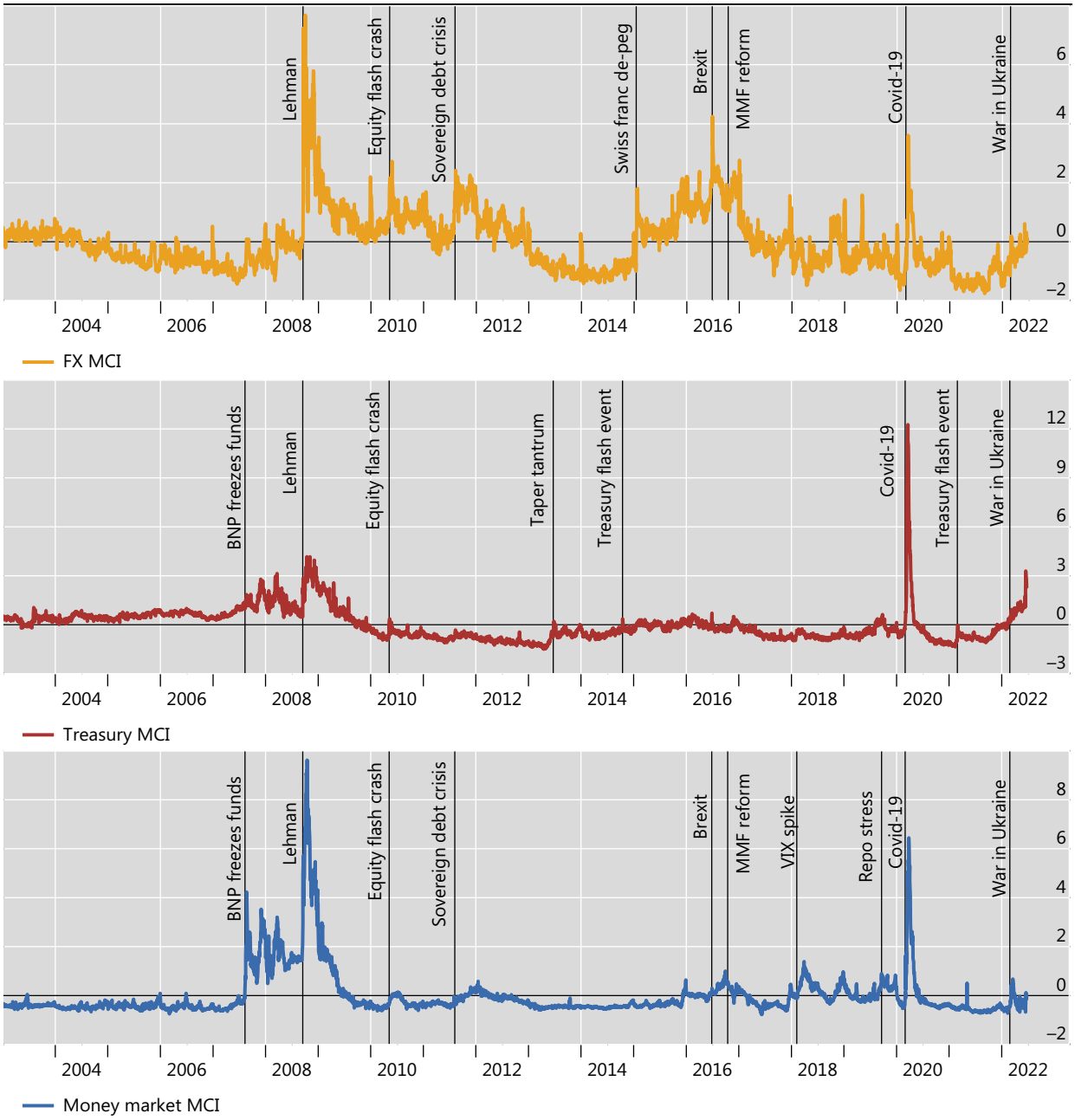
[6] The cross-currency basis denotes the difference between the interest paid to borrow one currency by swapping it against another and the cost of directly borrowing this currency in the cash market. A non-zero value indicates a violation of covered interest parity.

[7] These series also help illustrate the importance of the institutional environment. CIP deviations were non-existent before the GFC. Rising hedging demand and tighter limits to arbitrage post-GFC turned CIP deviations into a structural feature of financial markets (Borio et al (2016)).

In the second step, we build market-specific composite indicators. We express all variables so that higher values indicate worse market conditions and use principal component analysis (PCA) to extract a common factor from them.[8] The MCI for each market is defined as the first principal component, ie the linear combination of the underlying series that captures most of their variability. For ease of interpretation, we normalise the MCIs to have zero mean and unit standard deviation. Accordingly, positive values reflect tighter than average market conditions.

Market conditions indicators (MCIs)

Standard deviations — Graph 2



Source: Authors' calculations.

[8] Before performing the PCA analysis, we put all variables on an equal footing through a z-score transformation (ie subtracting the sample mean and dividing by the sample standard deviation).

Our MCIs capture both broad-based and market-specific episodes.[9] All three MCIs spiked (though to differing degrees) during the GFC and the Covid-19 crisis (Graph 2). But they also indicated material deterioration of market conditions outside these most severe episodes. For example, the FX MCI picked up during the European sovereign debt crisis in 2011–12 and from 2015 to 2016 following the Swiss franc de-peg, Brexit and the US MMF reform. The Treasury MCI, in turn, inched up slightly into positive territory following the taper tantrum in 2013 as well as during the flash events of 2014 and 2021.[10] It has been rising quickly since early 2022 (see below). Finally, the money market MCI remained largely subdued outside the GFC and the Covid-19 crisis. That said, it did exhibit moderate increases around some episodes, such as the MMF reform and the 2018 VIX spike.

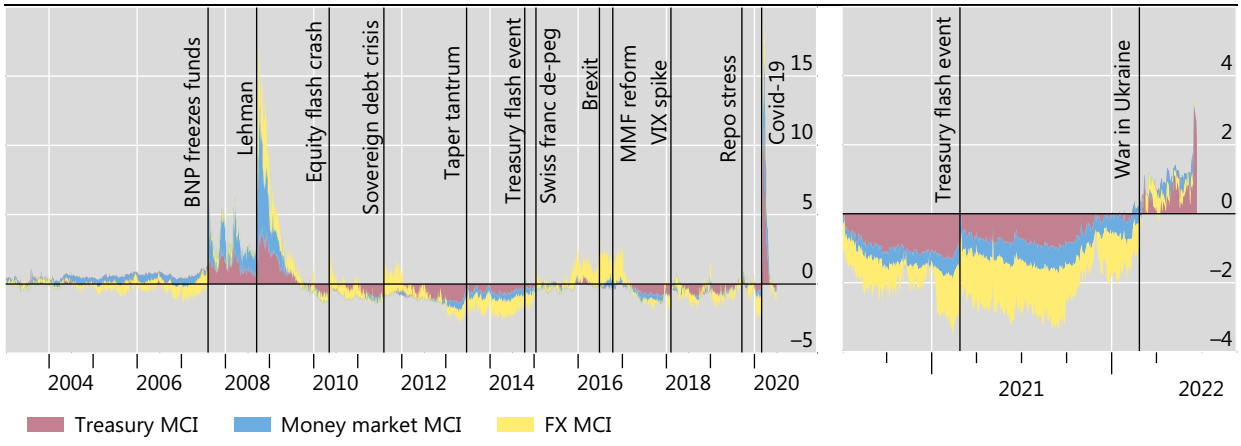
Comparing the three indicators can shed light on how conditions differed across markets at any given point in time (Graph 3).[11] Ahead of the Lehman collapse, for example, it was Treasury, and especially money market, turmoil that led the way, with FX market conditions sharply deteriorating only afterwards. In contrast, tighter than average FX market conditions dominated during the European sovereign debt crisis, Brexit and around the US MMF reform. More recently, tight market conditions were most visible in the Treasury market, with values approaching the levels seen during the GFC (though still well below the Covid-19 turmoil). This development is in line with recent commentary on declining Treasury market liquidity (Federal Reserve Board (2022), Scheicher and Schrimpf (2022)).

Importantly, our MCIs do not simply capture information already reflected by the VIX – as is the case for most FCIs/FSIs. While the MCIs are positively linked with the VIX, there are instances in which they convey distinct information (Graph 4, left-hand panel). One example is the already discussed rise in the FX MCI during 2015–16, a period that did not exhibit a commensurate increase in the VIX. Conversely, the VIX remained elevated in the aftermath of the Covid-19 turmoil, whereas all three MCIs

Conditions evolve differently across markets – Treasury market stands out in 2022

Standard deviations

Graph 3



Source: Authors' calculations.

[9] The first principal component that equals the FX MCI accounts for around 43% of the variance of the input series; the corresponding shares are 46% and 65% for the Treasury and money market MCIs.

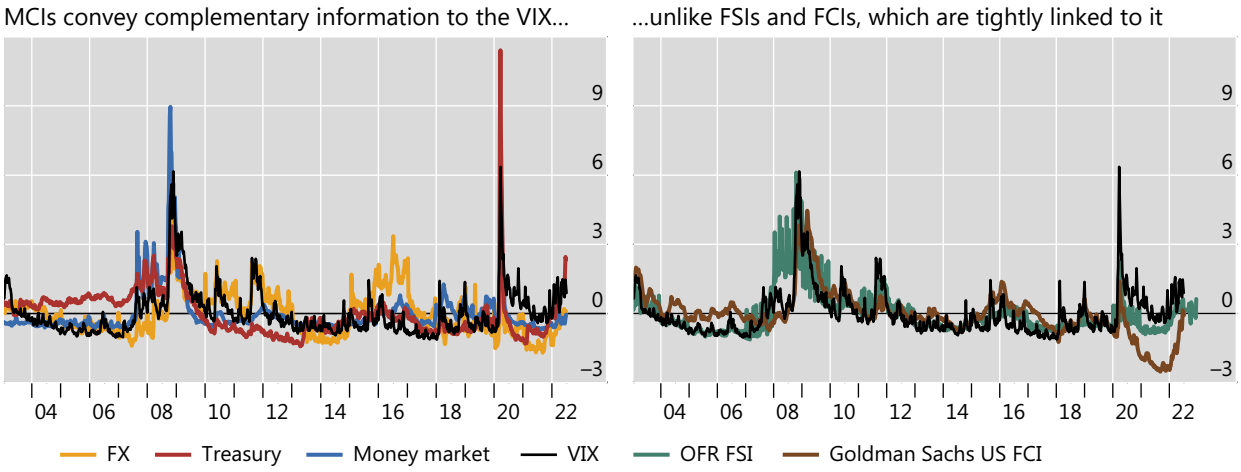
[10] Aronovich et al (2021) review the 2021 flash event and compare it with previous episodes.

[11] The MCIs are not additive. Hence, Graph 3 combines them for illustrative purposes only.

MCIs co-move only loosely with the VIX, itself a key driver of alternative FSIs/FCIs

Standard deviations

Graph 4



Financial stress indices (FSIs), financial conditions indices (FCIs), the VIX and the market conditions indicators (MCIs) are all normalised to have zero mean and unit standard deviation over the sample. Weekly averages are plotted for better visibility. The correlations with the VIX are as follows: FX MCI (0.50), money market MCI (0.66), Treasury MCI (0.53), OFR FSI (0.75), Goldman Sachs US FCI (0.52), St Louis Fed FSI (0.84) and Chicago Fed NFCI (0.77). Time series charts of the last two indices are not displayed for better visibility.

Sources: Office of Financial Research; Bloomberg; authors' calculations.

pointed to a swift reversal to benign market conditions. More broadly, the focus of the MCIs allows them to highlight different intensities in the deterioration of market conditions across markets and time.[12] In contrast, FSIs and FCIs are in general very tightly linked to the VIX (right-hand panel).[13] This is not surprising, since the VIX is an input in their construction. But as the VIX is only one among dozens of input variables, its tight link with FSIs and FCIs is striking.

All in all, our market-specific MCIs are related to, but distinct from, commonly used FSIs, FCIs and the VIX.

Measuring the probability of future stress

Given the importance of well functioning financial markets for the real economy, policymakers have an interest in understanding how stress risk builds up, and ideally in anticipating stress episodes. This is especially so since the severity of recent stress events has prompted authorities to backstop markets (Markets Committee (2022)).

However, any attempt to forecast episodes of market stress will face non-trivial challenges, especially over horizons long enough to allow for pre-emptive policy action. These range from difficulties in identifying leading indicators to structural

[12] Examples include a sharper rise in the money market and Treasury MCIs at the start of the GFC and a considerably larger increase in the Treasury MCI during Covid-19.

[13] For brevity, we focus on the most well known financial conditions and stress indicators, namely the FSI from the Office of Financial Research (OFR) and the FCI from Goldman Sachs. Alternative FSIs and FCIs deliver a very similar, and sometimes crisper, message. Goldman Sachs' FCI is strongly influenced by equity prices, which explains its divergence from the VIX and OFR FSI during the substantial equity rally that followed the Covid-19 market turmoil.

changes in markets that may affect such indicators' information content. Moreover, as is clear from our MCIs, there are several large spikes that correspond to inherently unpredictable events, such as Covid-19, the outbreak of war in Ukraine and various flash events (Graph 2). Predicting the exact timing of such shocks is simply impossible.

It may therefore be more fruitful to attempt to uncover conditions that signal an increased likelihood of future market stress by indicating market fragility. Information that broadly captures investor overextension (excessive search for yield, big changes in investor flows, atypically low levels of volatility etc) should be useful in revealing fertile ground for future stress. Using such information would be in the spirit of the literature on early warning indicators of banking crises (Borio and Drehmann (2009), Aldasoro et al (2018)).[14] Signals of investors' perceptions of elevated market risk would also be useful, as they speak *directly* to what we are interested in: the likelihood of a stress event. Such variables are typically tightly linked to, or may simply be mirror images of, those capturing overextension: a sudden withdrawal of investors in the face of unsustainable conditions would be a clear signal of heightened risk. We thus group all these variables into one category.

A second group of variables we consider is of a more structural nature. Here, we aim to capture information that need not be related to investor overextension or risk perceptions, but that still may have a bearing on future market stress. This includes information on the market-making capacity of intermediaries, as well as indicators measuring funding liquidity conditions in markets.

The time horizon matters for the information content of leading indicators. Specific signs of overextension would typically take time to surface as stress – or, alternatively, dissipate. At the same time, the explanatory power of any variable tends to vanish at long horizons. In turn, indicators of investor risk perceptions tend to be useful over shorter horizons. Information on liquidity conditions and market-making capacity may be informative over both short and long horizons, depending on how persistent the underlying drivers are. With this in mind, we focus on horizons between one month and one year when assessing future stress risk.[15]

Methodology

We use a logit model to examine the extent to which one can identify developments that signal a heightened risk of future market stress. In our setting, this amounts to modelling the odds of future "stress" relative to "no stress" as a function of a set of explanatory variables. Once we have estimated the parameters of the logit model, we calculate implied stress probabilities for each of the three markets we consider and compare them with actual stress episodes.

Our empirical model requires that we first construct a discrete variable that signals stress or no stress in the market. We do this by simply defining stress periods as the months when a given MCI is in the top 20% of its values over the sample

[14] We discuss a number of such variables in some detail in the following subsection.

[15] Such horizons are much shorter than those studied in the literature on financial crises, which is concerned with the slow build-up of fragility in the system that can accumulate over years. Market stress and the conditions leading to it, in contrast, are arguably of a shorter nature.

period.[16] The choice of a 20% cutoff involves a trade-off. It is sufficiently high to avoid a focus only on a few severe events, but still low enough to capture all periods with a meaningful degree of stress.

When selecting indicators that can help explain a rising risk of future stress, we focus on variables in the two categories discussed above: (i) those that point to investor overextension or that signal perceptions of higher risk in the market; and (ii) variables which are informative about liquidity conditions and market-making capacity.[17] Most variables are common to all three market segments, as they signal broad financial developments. Others have narrower informational content and are thus included only for some markets (online annex Table B).

Overextension / risk perception

Starting with variables that broadly capture investors' overextension and risk perceptions, we consider both quantity and price-based data. On the quantity side, we use information on exchange-traded fund (ETF) and investment fund flows. Strong flows to certain sectors or asset classes can point to shifts in investors' risk appetite. Insofar as the shifts are unsustainable, they may be helpful in signalling risks of sudden reversals and market stress further down the road. Conversely, sudden large outflows can point to perceptions of heightened market uncertainty.

We consider intra-family investor flow shifts from one type of mutual fund to another. An example is shifts towards high-yield bond mutual funds as suggested by Ben-Rephael et al (2021; BCG henceforth). BCG argue that such flow shifts are due to changes in investors' risk appetite. For our purposes, this may be useful information if increased risk-taking raises the likelihood of a future reversal and associated market stress. We also include a related measure by Ben-Rephael et al (2012; BKW henceforth), capturing investors' sentiment through shifts between bond and equity funds.[18] Finally, we consider total ETF inflows, which may capture similar information.

We include two price-based measures of investor overextension. One is the global financial cycle (GFCy) of Miranda-Agrippino and Rey (2020), which summarises fluctuations across hundreds of global asset prices and strongly interacts with monetary and financial conditions, including booms and busts.[19] The second measure is the US broad dollar index (DXY), which has been found to be tightly linked to funding and liquidity conditions as well as to the risk-taking behaviour of global banks (see, among others, Shin (2016) and Avdjiev et al (2019a,b)).

In turn, we consider two variables that may capture market participants' perceptions of higher market risk. The first one is the VIX, which incorporates investors' expectations of near-term equity market volatility. An elevated VIX could

[16] We aggregate the daily MCIs into monthly (non-overlapping) averages in order to avoid a focus on short-lived spikes. The use of a monthly frequency also allows us to extend the set of potential explanatory variables beyond high-frequency market prices.

[17] Table B in the online annex provides a summary of all explanatory variables considered.

[18] Inspired by Ben-Rephael et al (2012, 2021), we also use Investment Company Institute data to construct a measure of intra-family flow shifts into MMFs to capture potential investor overextension in money markets (referred to as "MM flow shifts" in online annex Tables B and C).

[19] The GFCy variable is only publicly available up to 2018. We therefore rely on the approximation suggested by Davis and Zlate (2022) and compute the first principal component of weekly equity returns for a sample of 48 countries (22 advanced and 26 emerging market economies). When aggregated at the monthly frequency, this measure has a correlation of 0.9 with Miranda-Agrippino and Rey's GFCy indicator.

point to possible market fragilities due to perceptions of higher risk. The second variable in this category is margin requirements, which tend to increase with market uncertainty and may therefore be useful in signalling stress. Specifically, we use CME initial margins on 10-year Treasury futures.[20] Importantly, the same indicators but at different values may signal the build-up of imbalances: prolonged periods when the VIX is low or margins are overly compressed may stem from increased risk-taking and leveraging-up.

Liquidity conditions / market-making capacity

Next, we consider variables reflecting liquidity conditions and intermediaries' market-making capacity. One such variable is the excess bond premium (EBP) of Gilchrist and Zakrajšek (2012) – a corporate credit spread shown to be informative about the risk-bearing capacity of the financial sector. A deterioration in risk-bearing capacity (signalled by a rise in the EBP) is likely to result in greater market fragility and a higher likelihood of future stress. We also include the net holdings of Treasury bonds by primary dealers. Du et al (2022) argue that in the post-GFC environment, when dealers maintained systematically net long Treasury positions, this variable served as a reliable indicator of dealers' balance sheet constraints. More constrained dealers have less room to arbitrage mispricings, potentially leaving markets more vulnerable to future stress. Having said that, a reduction in primary dealer Treasury holdings could also reflect a withdrawal from the market as a result of perceived greater uncertainty, which in turn could foreshadow stress in the Treasury market itself.[21]

We consider two additional variables that could affect liquidity conditions across market segments. The Federal Reserve's purchases of Treasuries may be important for conditions in both the Treasury and money markets. In particular, it is a key determinant for whether liquidity is ample or not. The total issuance of commercial paper (CP) can also affect conditions in funding markets by altering the portfolio composition of money market investors. A rise in CP issuance would, all else equal, reduce investments in other market segments, potentially reducing their liquidity.

Besides the above two categories of variables, we also include lagged values of the MCIs for the three markets we consider. By doing so, we hope to account for any persistence as well as possible spillovers and co-dependencies across market segments.

In the logit analysis, we successively narrow down the set of explanatory variables for each market segment by excluding those that are (mostly) statistically insignificant. The only variable that drops out from all three markets is, perhaps surprisingly, the VIX.[22] All other variables remain for at least one market segment.

Logit results: implied stress probabilities

Graph 5 displays the stress probabilities implied by the logit model estimates for each of the three market segments. These refer to the probability of stress occurring six

[20] This variable is thus specific to the Treasury market; unavailability of data precluded inclusion of margin information for the other market segments.

[21] This indicator could therefore potentially straddle both variable categories.

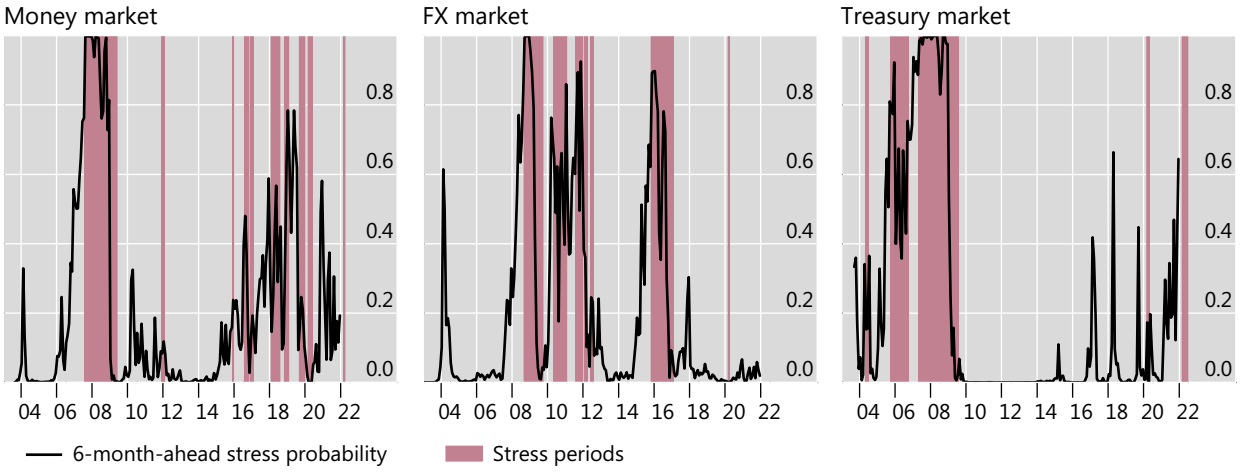
[22] The VIX is only significant at the very shortest horizons, ie one to two months, as a sudden rise in the VIX is often associated with already occurring market stress, which in turn has some near-term persistence. Over longer horizons, of greater policy relevance, it plays no significant role.

months ahead.[23, 24] The graph shows that the model can identify (in sample) a higher stress probability ahead of a number of stress episodes.[25]

Consider, for example, the run-up to the GFC-related stress in money markets. Our classification scheme dates the start of this stress episode as August 2007 (Graph 5, left-hand panel), when BNP Paribas froze three of its ABS investment funds and the dollar interbank market began seizing up. The model-implied stress probability rose quickly in the run-up to this episode: while the six-month-ahead stress probability stood at below 5% around mid-2006, it had risen to 50% six months before the episode started, and all the way to 75% by June 2007. Our estimates show that the main driver of this increase was a strong rise in the global financial cycle variable GFCy.[26, 27] A rising BGC indicator, measuring investor flow shifts towards high-yield bond mutual funds, contributed as well, even if to a lesser extent.[28] Both of these variables indicated increasingly aggressive risk-taking, which in turn signalled a rising risk of sudden reversal and attendant market stress.

Market stress episodes and six-month-ahead stress probabilities

Probability — Graph 5



Stress periods (shaded areas) are defined as months when the relevant MCI is in the top 20% of its distribution. The stress probabilities are calculated from a logit model. The estimated probabilities are shown for the dates at which they are calculated (ie a probability value at time *t* is based on information available (in sample) up to time *t*); the stress episodes are shown when they occur.

Source: Authors' calculations.

[23] We calculate implied stress probabilities up to 12 months ahead, but here focus on the six-month horizon for brevity. These results are broadly representative of those at other horizons. Online annex Tables C–E display our logit parameter estimates for the three-, six-, nine- and 12-month horizons.

[24] The last observation for the probabilities in Graph 5 is December 2021 (six months prior to the end of our sample), ie the last month for which we can evaluate the probabilities against an outcome.

[25] Across the 12 horizons we consider, the McFadden pseudo-R^2 values range from 44 to 63% for the money market, from 62 to 80% for the Treasury market, and from 25 to 69% for the FX market.

[26] The parameter estimates corresponding to this variable are positive across all horizons (and significant for three-month and longer horizons), in line with it conveying information about investor risk-taking, possible overextension and heightened risk of a reversal (see online annex Table C).

[27] Throughout, we judge the importance of the drivers based on the extent to which they raise the stress probability during the relevant episode (keeping everything else unchanged).

[28] While the coefficient for BCG is not statistically significant for the six-month horizon, it is significant (and consistently positive) for longer horizons (see online annex Table C).

A second example comes from the FX market, which saw stress concentrated in late 2015 and through much of 2016, preceded by a gradual rise in the estimated stress probability (Graph 5, centre panel). During this time, markets were unsettled as the Federal Reserve was preparing for its eventual December interest rate lift-off, while global growth prospects were deteriorating. In the FX MCI, this manifested itself through eg rising bid-ask spreads and widening CIP deviations.[29] Our classification method identifies November 2015 as the start of the stress episode. While the six-month-ahead stress probability had hovered around 5–10% at end-2014, it rose to 37% six months prior to the start of the stress episode, and to above 60% in the last months leading up to it. An increasing EBP credit spread was important in explaining the rise of the model-implied probability, suggesting that reduced financial sector risk-bearing capacity played an important role. Moreover, greater risk-taking and possible investor overextension seemed to also contribute to the build-up in the stress probability, as indicated by a general rise in BKW investment flow shifts and total ETF inflows prior to the episode.[30] Finally, a rise in lagged FX MCI values played an increasingly important role in the lead-up to the stress episode. This suggests that the build-up of stressed FX market conditions was gradual.

A more recent example is the Treasury market stress of 2022, which kicked off in March according to our classification. A key reason for the onset of stress was the start of the war in Ukraine in late February. In the face of already high inflation rates, the resulting commodity price spike contributed to an acceleration in planned quantitative tightening and other contractionary moves by the Fed.[31] While the exact timing of the stress event was unpredictable, the fact that our estimated stress probability began to rise months ahead points to pre-existing fragility (Graph 5, right-hand panel). The estimated six-month-ahead stress probability went from essentially zero at the start of 2021 to 47% six months prior to the stress episode and 64% three months before. Taken at face value, these results suggest that the market stress was in the making, and the war outbreak was the trigger that pinned down the timing.

Looking under the hood, we see that market participants' expectations of looming stress played an important role in the recent increase in Treasury market stress probability. The DXY dollar index contributed due to ongoing dollar strengthening at the time. This was largely linked to rising US bond yields that mean widespread bond market losses, greater market uncertainty and rising fragility. Linked to this, primary dealers were reducing their net holdings of Treasuries, possibly in anticipation of market stress.[32, 33] Moreover, initial margins on Treasury futures were

[29] The 2015 year-end was the first one after leverage ratio disclosure rules came into effect, which may have played a role. Bank balance sheet contractions at reporting periods (quarter-ends and especially year-ends) became frequent thereafter, with ripple effects across FX markets. In addition, the early implementation of the US MMF reform started in April 2016, adding pressure to FX and money markets through the final implementation date in October 2016.

[30] In line with our interpretation, the parameter estimates for EBP, BKW flow shifts and ETF inflows are all positive across every horizon (online annex Table D).

[31] This was also occurring against the backdrop of ongoing structural changes in liquidity provision in the Treasury market. Since 2020, the composition of the domestic investor base has changed: commercial banks have increased their presence while long-term investors such as insurers have pulled back (see the Overview).

[32] These two factors can also interact with each other. This occurs if the selling of Treasuries by central bank reserve managers – eg to lean against the wind of a strengthening dollar – increases the volume that comes to the market precisely when intermediation capacity is low.

[33] Interestingly, the logit parameter estimates for primary dealer holdings are negative (when significant) for the Treasury market, in line with our interpretation of the role this variable played for

rising, consistent with growing market uncertainty. In this increasingly fragile environment, CP issuance was also rising, thereby directing capital away from other segments, including the Treasury market.

Conclusion

The rising frequency and reach of market stress episodes call for enhancing authorities' ability to monitor market conditions and analyse stress risk in financial markets. We propose a new set of market conditions indicators for three key market segments and use them to define stress episodes.

From a policy perspective, it is key to have a warning when the risk of future stress increases. We examine whether variables capturing investor overextension and perceptions of risk, as well as indicators of funding liquidity conditions and market-making capacity, could be helpful in this regard. All in all, our results show that by exploiting the information captured by such variables, it is in some cases possible to anticipate increased market stress risk.

These results, however, should be interpreted with caution. Importantly, our findings are based on an in-sample exercise. Out-of-sample evaluations are beyond our scope, but represent an important topic for future research because they underpin real-time forecasts for policymaking. Further analyses could also delve more deeply into the information content of rising implied probabilities, not least by contrasting correct anticipation of stress with false alarms and missed stress episodes. More broadly, any set of results from a focused exercise, such as the one in this article, should be but one component in a holistic understanding of market developments.

the probability of Treasury stress (online annex Table E). Instead, for the other two markets the parameter estimates are positive, consistent with the original mechanism described in the "Methodology" section above (online annex Tables C and D).

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Sovereigns and sustainable bonds: challenges and new options[1]

The sustainable bond market, comprising green, social and sustainability (GSS) bonds, continues to develop rapidly. Until recently, sovereign issuers played only a minor role, due in part to tensions between the use-of-proceeds earmarking of GSS bonds and the fungibility requirements for many sovereigns. That said, sovereign GSS bond frameworks rely on stringent reporting and verification standards, thus setting goalposts for private issuers to aim for. Sustainability-linked bonds allow an unrestricted use of proceeds and – if based on contractual terms that sufficiently align issuers' incentives with sustainability objectives – can provide sovereigns with new options to make progress towards carbon emission reduction targets.

JEL classification: H63, O16, Q01, Q50.

The market for green, social and sustainability (GSS) bonds[2] has grown rapidly since its inception, to around $2.9 trillion outstanding by end-June 2022.[3] The funds raised for GSS bonds are earmarked for eligible projects: climate and environmental projects in the case of green bonds; projects related to health and education, affordable housing or food security for social bonds; and a mixture of green and social projects in the case of sustainability bonds. In contrast to conventional bond markets, sovereign issuers were latecomers to the GSS market, but have contributed notably to its growth more recently.

Exploiting the BIS sustainable bonds database, this feature analyses factors underlying sovereign GSS bond issuance. Sovereign issuers emerged late because of hurdles stemming from the fungibility requirements of public debt frameworks in many countries, which conflict with the use-of-proceeds earmarking of GSS bonds. That said, frameworks for sovereign GSS bond issuance have alleviated some of these difficulties and have set ambitious best practices for private issuers in terms of use-of-proceeds verification and sustainability impact reporting. We illustrate this by

[1] The authors thank Claudio Borio, Stijn Claessens, Ingo Fender, Kumar Jegarasasingam, Benoît Mojon, Hyun Song Shin, Nikola Tarashev and Dora Xia for helpful comments and discussion. We also thank Jimmy Shek and Jakub Demski for assistance with data. The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements or the International Monetary Fund.

[2] GSS bonds are part of the wider universe of ESG assets, or assets with environmental, social or governance benefits (see Scatigna et al (2021)). GSS refers to the bond asset class and the objectives that bond proceeds aim to finance, which do not include governance benefits. ESG applies to all types of financial securities, including bonds but also equities, derivatives and mutual fund shares.

[3] The data source is the BIS sustainable bonds database. Cutoff date is 30 June 2022.

Key takeaways

- The sustainable bond market has developed rapidly, reaching $2.9 trillion at end-June 2022, with sovereigns joining late but increasing their share from 4% to 7.5% over the past two and a half years.
- Tensions between sovereign green bonds' prescribed use of proceeds and the fungibility requirements of public debt can be partially overcome through refined reporting standards and external review.
- Sovereign sustainability-linked bonds with meaningful climate targets and penalties for non-compliance that are material in the public's eye could help sovereign issuers make progress towards carbon emission reduction targets.

focusing on sovereign green bond frameworks. In future, outcome-based instruments, such as sustainability-linked bonds (SLBs), could further lower the hurdles for sovereign issuers by offering more flexibility in the use of proceeds. Such instruments have attracted investors. Yet it is a challenge to set the key contractual terms so that they align the incentives for issuers with sustainability objectives.[4]

The roadmap for the rest of the feature is as follows. In the next section, we document the evolution and recent state of GSS bond finance, focusing in particular on differences between sovereign and other issuers. The following section highlights the challenges and the new options for financing sovereigns' climate ambitions: first, the tensions between green bond principles and the fungibility of government debt; second, the development of higher standards by sovereigns for green external review and impact assessment; and finally, SLBs as an option for overcoming the shortcomings of conventional green bonds.

Sustainable bond finance: sovereign vs other issuers

The BIS sustainable bonds database[5] indicates that the market for GSS bonds has been expanding rapidly. The amount of GSS bonds outstanding rose more than fourfold from January 2019, to stand at $2.9 trillion at the end of June 2022 (Graph 1, left-hand panel).

An unusual feature of the development of the GSS bond market is the late entry of sovereign issuers (Graph 1, centre panel). The first sovereign green bonds were issued by Poland and France as recently as early 2017 – more than nine years after the first green bonds were issued by two supranationals, in 2007–08.[6] Local

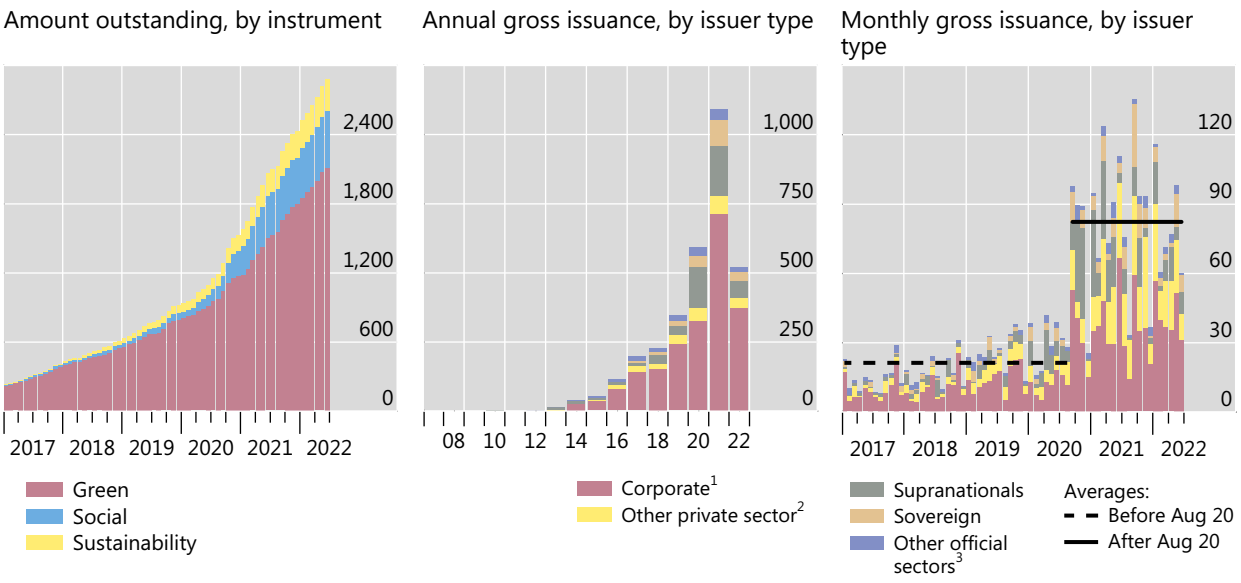
[4] There is a growing literature on how investors can provide incentives for issuers to support environmental sustainability and the greening of the financial system. Cheng et al (2022) in particular propose a strategy to build portfolios of sovereign securities with progressively declining carbon footprints.

[5] The BIS sustainable bonds database, developed to support the work of the central banking community, uses three distinct data sources for GSS bonds: Climate Bonds Initiative (CBI), Dealogic and Environmental Finance.

[6] In 2007, the European Investment Bank issued a Climate Awareness Bond, the world's first green bond. The World Bank's first green bond in November 2008 was the first to define project eligibility and to provide assurance, through a second-party opinion provider, that eligible projects would address climate change.

Green, social and sustainability (GSS) bond market: an overview

In billions of US dollars — Graph 1



[1] Both financial and non-financial corporations. [2] Asset-based securities and special purpose vehicles. [3] Local governments, development banks and public enterprises.

Sources: Climate Bonds Initiative, Dealogic, Environmental Finance Bond database, authors' calculations.

governments and public enterprises in advanced economies[7] issued GSS bonds in the early 2010s to fund specific environmentally friendly projects, for instance to improve water quality and energy efficiency or to support pollution clean-ups. Even non-financial corporations and banks started issuing green bonds before sovereigns, with the first issues by entities in France in 2013.

Sovereign issuance has, however, increased notably since the pandemic. At end-2019, the share of sovereign issuers in total outstanding GSS bonds was only 4.2%, but it increased to 7.5% by end-June 2022. By then, 38 sovereigns from five continents had brought out debut GSS issues, with the United States being noticeably absent. Several countries in Latin America (eg Chile and Mexico) have issued all three types of sustainable bond.

The 2020–21 period saw a particularly strong acceleration in the overall GSS bond market. Monthly gross issuance has averaged $88 billion since August 2020, compared with around $30 billion the previous three years (Graph 1, right-hand panel). Among the key drivers was the generous fiscal support in response to the Covid-19 pandemic as well as governments' expanding climate ambitions.

After the beginning of the pandemic, the relatively small social bond market received a boost from governments and government agencies (eg housing finance agencies in the United States) because of increased social needs, notably those related to the provision of healthcare services and equipment. As a result, the public sector accounted for about 80% of all social bonds issued in 2020–21. In the first half

[7] For instance, bonds issued by Kommunalbanken Norway (2010), Government of the Île-de-France region (2012), the City of Gothenburg, Sweden (2013) and the Commonwealth of Massachusetts (2013), to name but a few.

of 2022, gross issuance of social bonds declined by 40% year on year amidst the post-pandemic recovery in many countries.

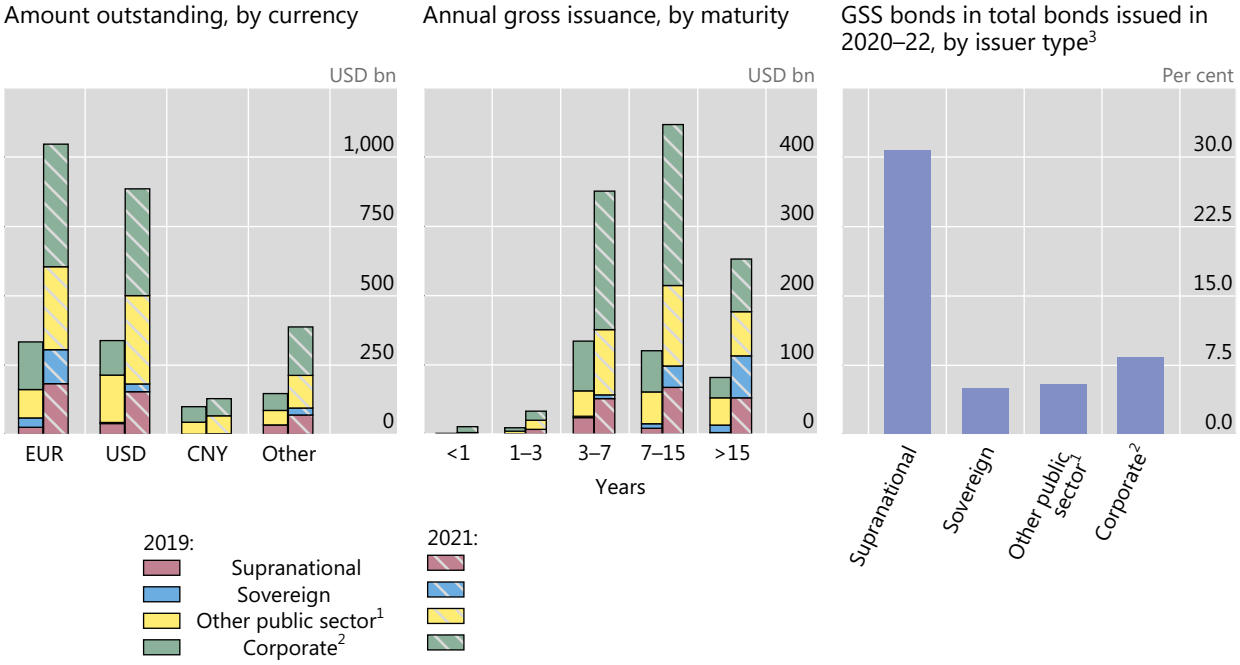
Sovereign green bond issuance has also increased since 2020. In particular, many countries, especially members of the European Union (EU), have committed themselves to using increased fiscal spending to accelerate green transition. Not only did several EU member states issue their inaugural sovereign green bonds during the pandemic (eg Sweden, German, Italy and Spain), but the EU also aimed at financing part of its pandemic response – for instance, 30% of NextGenerationEU funds – via green bonds.

The euro and the US dollar remain the key issuance currencies for GSS bonds, with euro denominations growing the fastest between 2019 and 2021, thanks to a strong contribution from sovereign issuers (Graph 2, left-hand panel). Not only did several EU member states enter the market, but many governments outside the euro area issued in euros to attract European institutional investors. The share of GSS bonds denominated in other currencies has also increased over time, mainly because other public sector and corporate issuers usually issue in the currencies of their jurisdiction.

Sovereign bonds tend to have the longest maturities within the GSS universe. Nearly two thirds of sovereign issues in 2021 are longer than 15 years (Graph 2, centre panel). The Monetary Authority of Singapore offered the latest example, with a 50-year inaugural green bond issued in August 2022 raising $2.4 billion, the longest-tenor green bond issued by a sovereign. By contrast, 41% of corporate GSS bonds have a maturity of less than seven years. Between 2019 and 2021, corporate issuers have also increased their issuance tenor.

GSS bonds: currency composition, maturity structure and relative sizes

Graph 2



[1] Local governments, development banks and public enterprises. [2] Both financial and non-financial corporations. [3] Issuance amount.

Sources: Climate Bonds Initiative, Dealogic, Environmental Finance Bond Database, Refinitiv, authors' calculations.

GSS instruments represent a rather small share of the overall bond issuance from 2020 to 2022, despite their rapid growth since the pandemic. Standing at around 5%, this share is lowest for the sovereign (central government) sector, with that of other public sector entities similarly low. In the case of corporations (both financial and non-financial), slightly more than 8% of their total bond issuance were green instruments (Graph 2, right-hand panel). International financial institutions (supranationals) are the exception, raising more than 30% of their total bond issues via green instruments.

Challenges and new options

While the momentum of sovereign GSS bond issuance has strengthened, structural challenges remain. At the same time, sovereign issuance can have a positive impact on general GSS bond market development by establishing best practices in verification and reporting. We now elaborate on these points, focusing on green bonds, given their dominant size within GSS instruments (Graph 1, left-hand panel). In addition, external review and impact reporting are most common for this bond class.

The fungibility of fiscal revenues

The fungibility of fiscal revenues is widely seen as one of the principles of public financial management. In some countries, it is written into the constitution or basic law (see OECD (2014)). This poses a challenge for many sovereign issuers of green bonds, who cannot legally commit themselves to using the proceeds of the bond for a specifically green purpose. While this is not the case for all sovereigns (Domínguez-Jiménez and Lehmann (2021)), public budgets are subject to frequent changes, and thus potentially to uses other than those envisaged for the proceeds of an existing green bond.

Relatedly, the framework for most sovereign green bonds does not guarantee that new green investments will be made using the bond proceeds. In many cases the funds can be used to refinance past expenditures (Kramer (2020)). Some sovereigns have tried to address this issue by committing some proportion – for example, at least 50% – of the proceeds for same-year expenditure, or for a combination of current and future expenditures.

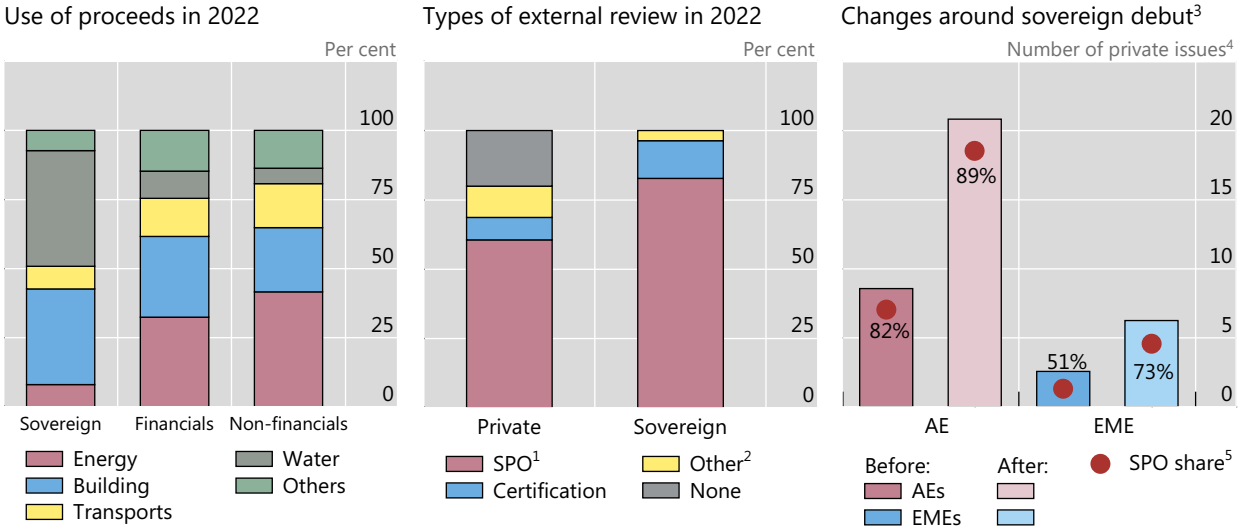
Sovereign bonds, green external review and impact assessment

Well formulated best practices in green bond markets have become increasingly important on the back of general concerns about greenwashing, or the tendency for issuers or brokers to misrepresent the environmental benefits of various types of security (Bolton et al (2022), Borio et al (2022)). There is thus great value in taxonomies and other forms of classification that aim to improve and standardise green definitions. That said, efforts are also needed to enhance the credibility of external reviews and reporting on both allocation and impact (Ehlers and Packer (2017), NGFS (2022)).

Despite their own challenges – and to address them in part – sovereigns have played a key role in promoting standards for green bond classifications and their

Sovereigns set an example for green bond documentation and verification

Graph 3



[1] Second-Party Opinion. [2] Assurance and ESG rating. In cases, where an issue has multiple forms of external review, only one is counted, in this order: SPO, certification, other. [3] This result is also corroborated by a panel regression which formally controls for a time trend and the behaviour of countries that have never issued sovereign green bonds. When the number of corporate green bond issues (and in separate regressions, the number of corporate green bond issues with SPOs) is regressed on a dummy that equals one in all periods during and after the sovereign debut, a quarterly time trend, and country fixed effects, the coefficient on the sovereign debut dummy is strongly significant. [4] Average number of green bonds per annum per jurisdiction issued by non-financial and financial corporations. [5] In the number of private issues.

Sources: Climate Bonds Initiative; authors' calculations.

verification. To date, all 38 central governments issuing sovereign green bonds have announced a green bond framework, all in line with International Capital Market Association (ICMA) principles.[8] Their issuance frameworks have set clear, publicly visible and ambitious examples. We discuss a few aspects of these frameworks in turn.

Sovereign green bond issues stand out in terms of their reliance on external reviews. Importantly, all sovereign issuers solicit a seal of approval from at least one, and often a variety of, specialised service provider(s). By contrast, as many as a fifth of corporate green bonds are self-labelled as green by the issuer without any external review (Graph 3, left-hand panel).

Beyond the verification of the use of proceeds, impact assessment provides another level of assurance that green bonds do achieve environmental benefits. All existing sovereign green bond frameworks require an environmental impact report.[9] With such reports, sovereigns seek to convey that sustainability objectives are a de facto priority, even in the presence of fungibility constraints. In comparison, impact reporting is still scant for corporate green bonds. So far, it has been only voluntary for corporate green bond issuers and, when it is conducted, reporting scopes and methodologies may differ considerably across issuers (NGFS (2022)).

[8] In 2014, the ICMA issued Green Bond Principles recommending a clear process and disclosure for issuers that ensure transparency, tracking and reporting of the use of green bond proceeds. The updated ICMA Green Bond Principles (2021 edition) recommend the use of both qualitative and quantitative indicators to show impact.

[9] In the case of France, for instance, an independent committee defines the specifications for the required impact report of green treasuries.

Sovereign issuers seem to have assumed a leadership role in promoting best practices in green bonds.[10] Indeed, the evidence suggests that the inaugural issue of sovereign green bonds tends to tighten standards for overall green issuance in that country. After such an issue, not only does the annual number of corporate issues tend to increase across jurisdictions, but so does the percentage of corporate issuance with second-party opinions. This tendency is apparent in both advanced and emerging market economies (Graph 3, right-hand panel).

Sustainability-linked bonds: a new "green" option for sovereigns

SLBs offer an option that sovereigns can explore to address challenges related to the issuance of existing green bonds (and other use-of-proceeds instruments).[11] SLBs are instruments with pre-defined sustainability performance targets that the issuer commits to meet by a given date ("penalty event date"). If the targets are not met, the issuer is subject to a penalty, a mechanism that is absent in the case of conventional green bonds.[12] Thus, in contrast to use-of-proceeds bonds, SLBs give issuers freedom as to how to use the proceeds of any specific issue, which enhances the compatibility of SLBs with the fungibility requirements of public debt.

The SLB market across all issuer types is still nascent but has been growing rapidly. Growth picked up markedly in 2021, involving both AE and EME issuance (Graph 4, left-hand panel).[13] The first (and thus far only) sovereign to issue an SLB was Chile, in March 2022.

Another advantage of SLBs, in particular for sovereigns, is the strong signalling[14] towards achieving high-level climate policy objectives such as the Paris Agreement. Conventional green bonds may not result in a material reduction of carbon emissions, even if the promised use of proceeds is met to the letter (Ehlers et al (2020)). SLBs, on the other hand, can be linked directly to reduced greenhouse gas emissions through the contractual choice of the key performance indicator (KPI) (Graph 4, centre panel). What is more, the target for greenhouse gas emission reduction can be aligned with the Paris Agreement by setting the contractual sustainability performance target (SPT) accordingly (eg a 50% reduction by 2030).

[10] In addition to sovereign issuers, public investors can also promote standards through their investment guidelines, which has been part of the rationale of the green bond funds that the BIS has launched for central bank reserve managers.

[11] The ECB has decided to accept SLBs as collateral for its refinancing operations to support "innovation in the area of sustainable finance".

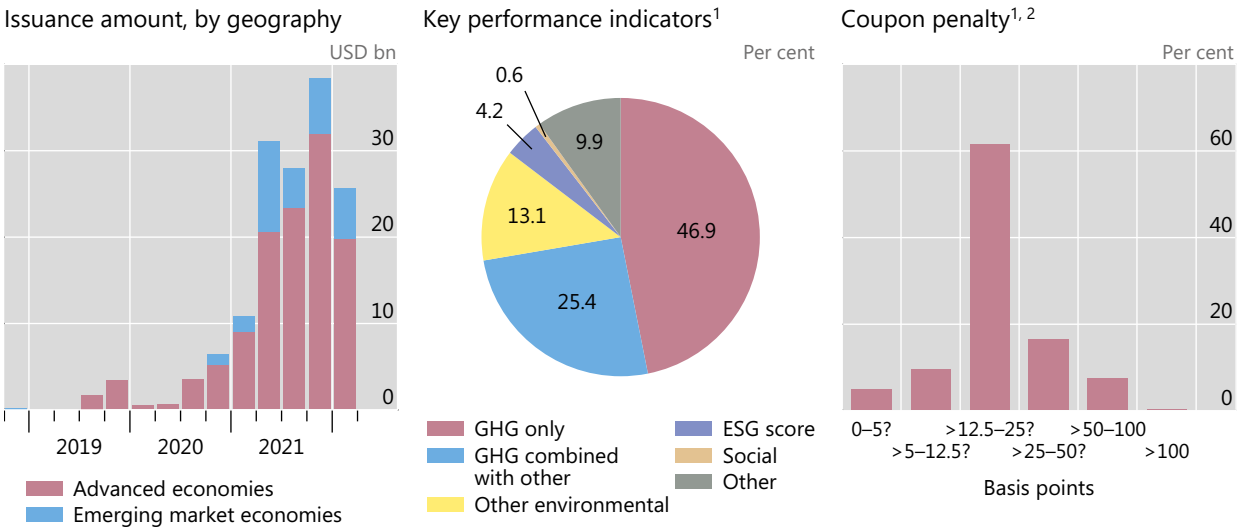
[12] There is no direct consequence for the issuer if the proceeds of a green bond are not used for green projects or if there are no resulting environmental benefits from using the proceeds as promised. Secondary effects, however, could include an exclusion from a green bond index or reputational costs that also influence the bond value, for instance through an elimination or reduction of any yield discount achieved by green bonds relative to conventional bonds of the same issuer ("greenium").

[13] See De la Orden and de Calonje (2022) for an in-depth discussion of how SLBs can be used to mobilise capital for sustainable investments in emerging markets.

[14] Unlike GDP-linked bonds, the contingent mechanism of SLBs is thus intended to penalise non-compliance with environmental goals, in sharp contrast to GDP-linked bonds, which instead reduce the burden on the issuer in the event of unforeseen shocks, which effectively offers insurance, raising moral hazard considerations (Borensztein and Mauro (2004)).

The market for SLBs has been growing rapidly, but penalties have been low

Graph 4



ESG = Environmental, social and governance; GHG = Greenhouse gas.

[1] Share calculated on the basis of aggregate gross issuances amounts over all countries and time periods. [2] Share calculated only for SLBs with a coupon step-up penalty (more than 70% of aggregate issuance amounts).

Sources: Bloomberg; authors' calculations.

For SLBs to gain market relevance and incentivise issuers to achieve the declared objectives, it is essential to set contractual parameters appropriately. This includes KPIs, the associated SPTs and the penalties when the SPTs are missed.

A key problem in the case of sovereigns is that, in practice, penalties cannot be set high enough to create material *financial* incentives for meeting sustainability targets.[15] The annual outlays necessary to achieve a national emission pathway consistent with the Paris Agreement for the energy sector alone amount to several percentage points of GDP. This dwarfs any penalty-related increases in bond service costs (IEA (2021)). Concretely, coupon step-ups in most cases have been 25 basis points or less (Graph 4, right-hand panel), including in the case of the Chile's SLB.[16].

To the extent that a financial penalty has an important signalling effect to investors, it can still serve as sovereigns' commitment device. Setting the penalty very low, as is arguably current market practice, may reduce the credibility of the commitment to achieving the set targets (Kölbel and Lambillon (2022)). Conversely, penalties high enough to be viewed as material by the public – coupled with the public's perception of the long-term benefits of meeting a sustainability target – could be seen as creating the appropriate incentives for the sovereign.

[15] In general, the penalty serves as an incentive mechanism for issuers. It is optimal for the issuer to achieve the sustainability target if the present value of the penalty is higher than the costs of achieving, say, a given degree of carbon emission reductions (Berrada et al (2022)).

[16] In the case of the Chilean sovereign SLB, the step-up is a maximum of 25 basis points if both SPTs (a greenhouse gas emission target and a renewable energy production target) are missed, or 12 basis points if one of the two targets is missed.

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Borrower vulnerabilities, their distribution and credit losses[1]

Central banks and other supervisory authorities have made significant efforts to collect borrower-level data on debt vulnerabilities. Do such data add to the information in aggregate measures? We find that statistics about household and non-financial corporate borrowers with low repayment capacity help to explain changes in non-performing loans and bankruptcies that aggregate measures would have missed. Borrower-level data could thus be useful for financial stability assessments.

JEL classification: E32, E44, G32, G33, G51.

Private non-financial sector debt has increased strongly in recent years (CGFS (2022)). As monetary policy tightens and economic conditions worsen, weaker borrowers could be pushed to the cusp of default or beyond. Thus, in addition to aggregate measures that represent the typical borrower, information about the distribution of vulnerabilities across borrowers may be informative about future credit losses.

To analyse the distribution of borrower vulnerabilities, granular information on individual borrowers is required. However, such data are often unavailable or, when they can be obtained, provide only limited historical information for many countries. Hence, the existing literature has focused mainly on how measures of aggregate repayment capacity can explain or predict credit losses or financial crises (eg Claessens et al (2012), Drehmann et al (2012), Schularick and Taylor (2012), Juselius and Tarashev (2022)). Much less is known about how borrower-level vulnerabilities might be used to inform financial stability assessments.

This special feature uses a unique cross-country data set to analyse whether information about the distribution of borrower-level repayment capacity helps to explain future credit losses. Collected from 20 central banks for the CGFS report on private sector debt and financial stability (CGFS (2022)), this data set contains summary statistics on the distribution of two common measures of repayment capacity: the debt-to-income and debt service-to-income ratios. These are available separately for the household and non-financial corporate (NFC) sectors. The summary

[1] The authors thank Claudio Borio, Stijn Claessens, Alessio de Vincenzo, Egemen Eren, Andreas Fuster, Ulf Lewrick, Benoît Mojon, Hyun Song Shin, Nikola Tarashev, Phillip Wooldridge and Egon Zakrajšek for helpful comments and discussions, and Daniel Heimgartner, Nicolas Lemercier and Oliver Surbek 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, the Bank of Italy and the Swiss National Bank.

Key takeaways

- Data collected from 20 central banks reveal information about differences in borrowers' capacity to repay debt, and how these have evolved from 2006 to 2021, within both the household and corporate sectors.
- The repayment capacity of the most vulnerable borrowers can evolve quite differently from trends in aggregate measures that represent the typical borrower.
- Data on borrowers with the lowest repayment capacity are useful for financial stability assessments because they help to predict future credit losses that would be missed by aggregate data.

statistics capture information about borrowers in the "tail of concern" – ie those with the lowest repayment capacity.

Can information about the tail of concern be used to complement aggregate measures for the prediction of credit losses? To answer this question, we start by constructing two metrics of borrower vulnerabilities in this tail. The first reflects the extent to which the vulnerability of the typical borrower within the tail of concern is greater than that of the typical borrower overall (ie the median borrower) – the *tail length*. The second conveys information about the extent to which the group of borrowers with the lowest repayment capacity is more vulnerable than the typical borrower in the tail of concern – the *tail thickness*. We then assess whether these two metrics help to explain credit losses, after accounting for the aggregate repayment capacity as well as that of the median borrower.

Our analysis produces two main findings.

First, the two metrics of borrowers' repayment capacity from the tail of concern – length and thickness – have evolved quite differently from the corresponding aggregate measure over our sample (2006–21). This provides a first indication that borrower-level data – be it about households or NFCs – could contribute information that is not contained in aggregate data.

Second, information about the tail of concern helps to explain future credit losses. After taking aggregate vulnerabilities into account, both the tail length and tail thickness appear useful in explaining banking sector non-performing loans (NPLs) and business bankruptcies over the next three years. Thus, despite being parsimonious, the two metrics appear useful for financial stability analysis.

The remainder of this special feature is organised as follows. The first section briefly surveys the literature on how the distribution of borrower vulnerabilities can help to inform financial stability assessments. The second describes the data set and explains how we capture information about the tail of concern. The third examines whether shifts in this tail reflect changes in borrower vulnerabilities that do not surface in aggregate statistics. The fourth analyses the extent to which the tail of concern helps predict future credit losses. Finally, we conclude with policy takeaways.

Financial stability implications of debt distribution: the literature

There is a growing awareness that the distribution of borrower vulnerabilities matters for credit losses. Central banks and banking supervisors use granular data on the repayment capacity of vulnerable borrowers in their stress tests (eg Anderson et al (2014), Bilston et al (2015), Finansinspektionen (2022)). Fuster et al (2018) discuss the importance of accounting for the vulnerabilities of the riskiest borrowers when assessing potential losses under adverse shocks. Adelino et al (2016) use FICO scores to show that the share of delinquencies among high-income borrowers increased particularly sharply after the Great Financial Crisis (GFC) in areas that experienced the strongest run-up in house prices before the GFC.

Yet data scarcity has constrained research linking the distribution of borrower vulnerabilities to actual credit losses or financial crises. The lack of long and comprehensive historical data series has limited analysis largely to specific episodes or big firms. For example, Greenwood and Hanson (2013) show that, among listed firms, a higher concentration of debt growth in the riskier firms is associated with weaker GDP growth, downside risks to economic activity and a higher probability of financial crises. Brandao-Marques et al (2019) find similar results using a cross-country panel of listed firms. Gourinchas et al (2020) project non-performing loan (NPLs) that could materialise in the wake of the Covid-19 shock using firm-level data on debt in a sample of large and small firms. However, their NPL projections are based not on any historical pattern but on an assumed relationship between stressed cash flows and subsequent defaults.

Characterising the distribution of borrower vulnerabilities

This special feature uses a unique cross-country data set on borrower-level vulnerabilities at an annual frequency over the period 2006–21. These data, provided by 20 central banks, consist of summary statistics about the distribution of common measures of repayment capacity, separately for the household and NFC sectors.[2] The specific statistics collected were the median, and the 75th and 90th percentiles of the debt-to-income and debt service-to-income distributions across borrowers.[3] To take the 90th percentile as an example, it is equal to a ratio that is exceeded by exactly 10% of the borrowers. Thus, the summary statistics in the data set capture information about the vulnerabilities of the median borrower as well as those in the "tail of concern" from a financial stability perspective.

We complement this data set in two ways. First, we include aggregate – ie country-level debt-to-income and debt service-to-income ratios for the same time period. Second, we also add country-level data on bank NPLs, business bankruptcies and GDP growth.

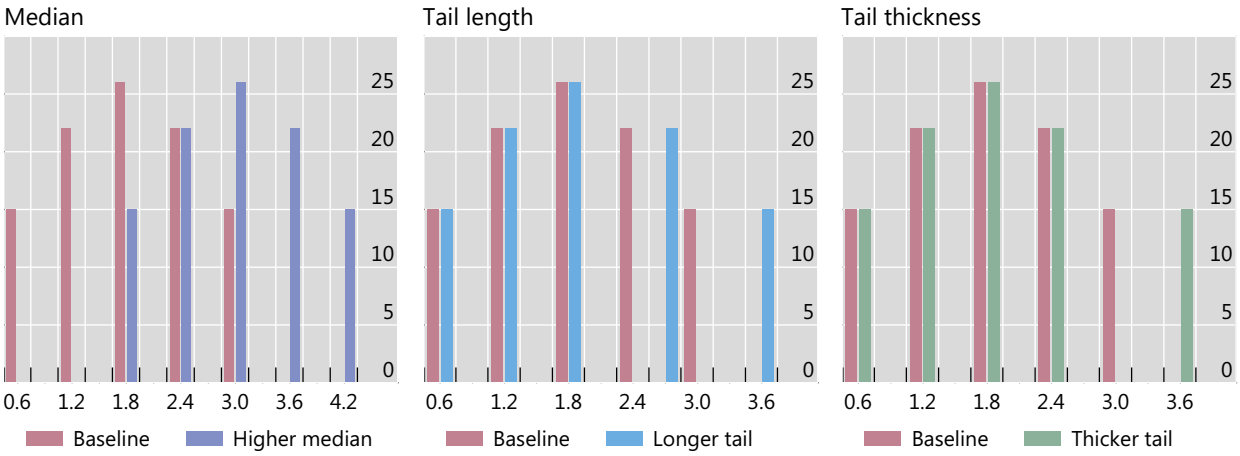
[2] The data set consists of data from central banks in AU, BE, BR, CH, DE, ECB, ES, FR, GB, HK, IN, IT, KR, LU, MX, NL, RU, SA, TH and US.

[3] For the NFC sector, the summary statistics are based on transformations of raw data on the income-to-debt and interest rate coverage ratios.

Illustrative changes to the tails and centre of the distribution

Density in percent

Graph 1



Source: Authors' calculations.

Our analysis starts by characterising the distribution of borrower vulnerabilities with three metrics. The first captures the repayment capacity of the "average" (or typical) borrower with the median of the distribution. An increase in the median corresponds to a rightwards shift of the whole distribution, all else equal (Graph 1, left-hand panel). We expect this metric to capture information similar to that contained in the corresponding aggregate measure of vulnerability.

The second metric captures the extent to which the vulnerability of the typical borrower within the tail of concern differs from that of the median borrower. It is equal to the distance between the 75th percentile and the median – the *tail length*. An increase in the tail length indicates that repayment capacity has deteriorated particularly strongly in the tail of concern (Graph 1, centre panel).

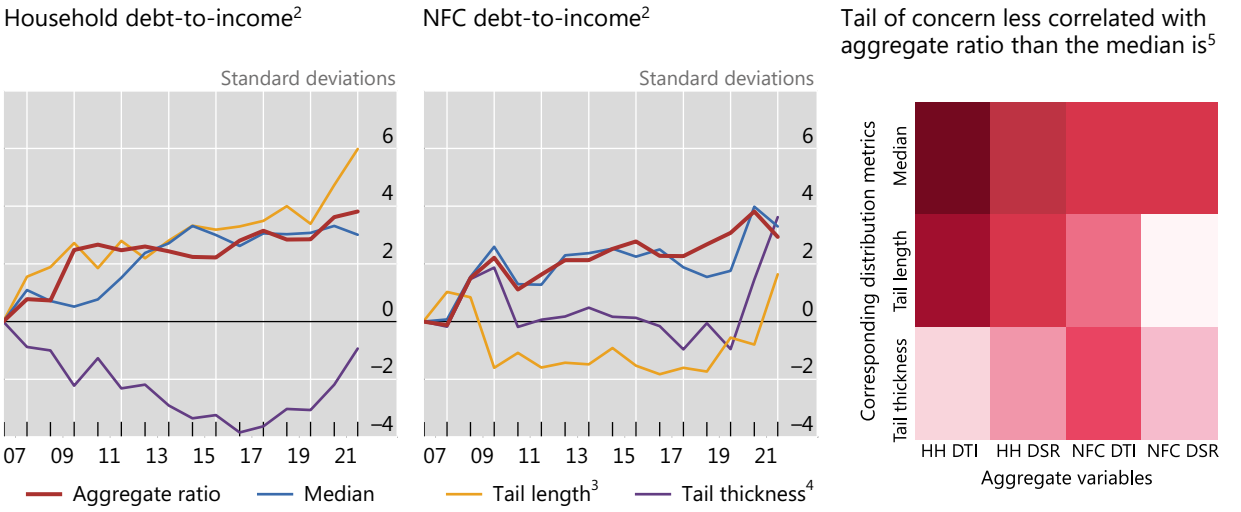
The third metric conveys information about the extent to which the riskiest group of borrowers is more vulnerable than the typical borrower in the tail of concern. It is equal to the ratio of the distance between the 90th and 75th percentiles to that between the 75th percentile and the median – the *tail thickness*. An increase in the tail thickness indicates that repayment capacity has deteriorated in particular among the riskiest borrowers (Graph 1, right-hand panel).

Information in the distribution vs the aggregate

Do the metrics capturing the tail of concern contain information that is different from that in the corresponding aggregate measure? If so, one would expect that the tail will evolve differently from the rest of the distribution.

First, we record that, as expected, the medians tend to co-move closely with aggregate ratios that capture repayment capacities at the country level. For example, averaging across countries, we see that the median household debt-to-income ratio increased steadily alongside the aggregate ratio between 2006 and 2021 (Graph 2, left-hand panel). A similar picture is evident in terms of NFC debt-to-income (centre

Trends in the tail evolved differently from the centre and aggregate[1] Graph 2



HH DTI = household debt-to-income ratio; HH DSR = household debt-service ratio; NFC DTI = non-financial corporate debt-to-income ratio; NFC DSR = non-financial corporate debt-service ratio.

[1] Higher values indicate greater debt vulnerabilities. [2] Average across countries. Each series is standardised to start at zero in 2006 and have a unit standard deviation. [3] Difference between the 75th percentile and the median. [4] Ratio of the difference between the 90th and the 75th percentiles and the difference between the 75th percentile and the median. [5] Darker colours indicate higher correlations. Correlations computed on the pooled sample after subtracting the within-country means of each series.

Sources: CGFS Working Group on Private Sector Debt and Financial Stability; Fitch; national data; authors' calculations.

panel). Correlation coefficients, based on within country variation, point in the same direction (right-hand panel, top row).

By contrast, the time series profiles (Graph 2, left-hand and centre panels) and correlations (right-hand panel) reveal substantial differences between the tail length and thickness, on the one hand, and the aggregate measures on the other. For example, even though the aggregate household debt-to-income ratio rose across countries after the GFC, the corresponding tail thickness decreased as the most vulnerable households repaired their balance sheets more than others and financial intermediaries cut back on their riskier lending. After 2017, the tail thickened again, alongside a general rise in mortgage growth and rising house prices. Turning to the Covid-19 shock, its impact on the most vulnerable NFCs was reflected in a surge in both tail length and thickness, as firms in customer-facing sectors borrowed to fill a cashflow gap (Banerjee et al (2021)). In parallel, aggregate and median NFC vulnerabilities declined, possibly on the back of blanket fiscal support schemes.

Distribution of borrower vulnerabilities and credit losses

We next investigate the information value of the tail metrics for explaining future credit losses. We do so by estimating the following predictive regressions for the household and NFC sector separately, using one measure of repayment capacity at a time – debt-to-income or debt service-to-income:

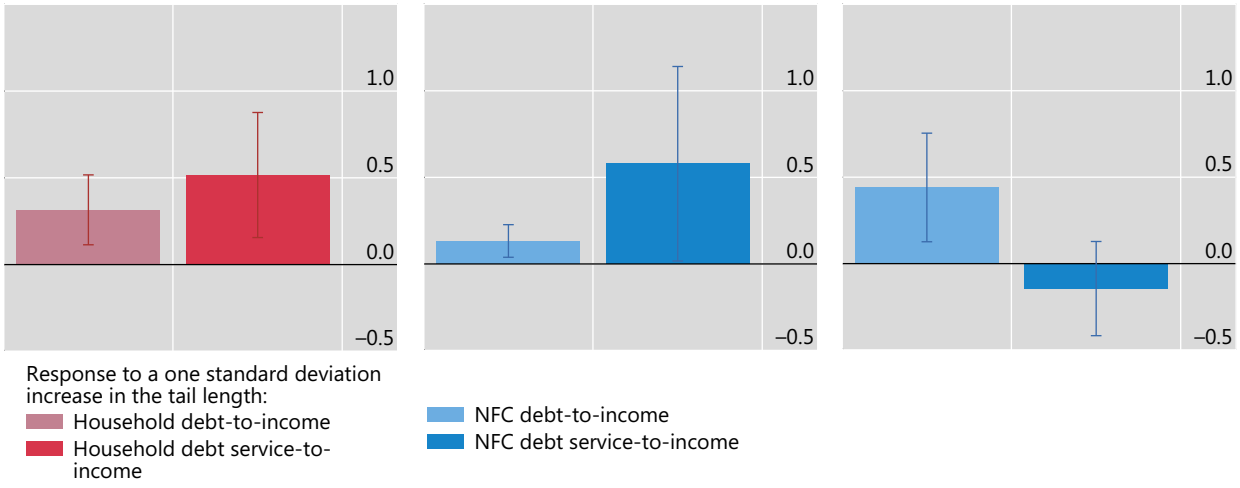
$$Outcome_{it+h} = \beta_1^h Tail\ length_{it} + \beta_2^h Tail\ fatness_{it} + \beta_3^h Median_{it} + \beta_4^h Aggregate\ ratio_{it} + \gamma^h X_{it} + \alpha_i + \varepsilon_{it}, \quad h=1,\ldots,3 \qquad (1)$$

where *i*, is the country and *t* stands for the year. The longest horizon, *h* is equal to three years, a time span that is often used to test the signalling quality of early warning indicators for financial distress.[4] The variable $Outcome_{it+h}$ for country i in year $t+h$ is equal to the change in total new NPLs in the banking sector between period *t-1* and $t+h$ as a share of total loans in year *t-1*[5] or the log change in business bankruptcies between $t+h$ and *t-1*. Our key explanatory variables are $Tail\ length_{it}$, and $Tail\ fatness_{it}$, which seek to establish if information about the tail of concern helps to predict credit losses. We include the corresponding $Aggregate\ ratio_{it}$ and $Median_{it}$, to control for their influence on the outcome variable. In addition, we include controls dated in period *t* or earlier. These include real GDP growth in period *t* to control for general economic activity, an indicator variable taking on the value of one during 2020 and 2021 to account for the Covid-19 shock, and country fixed effects, α_i, to control for time-invariant unobserved country characteristics. It is important to note that, due to the short time series of our data, the analysis is in-sample. This means that our estimations capture the co-movement of variables but does not necessary imply that they also forecast credit losses out-of-sample.

Information about the tail length does appear to help explain credit losses that aggregate data and the median metric alone would miss. Our estimates indicate that a one standard deviation increase in the tail length of either the household debt-to-income or the debt service-to-income distribution is associated with a 0.6 to 1 percentage point (0.3 to 0.5 standard deviation) rise in the share of new NPLs in total loans after two to three years (Graph 3, left-hand panel). NPLs increase by between

Peak response of NPLs and bankruptcies to shifts in the tail length[1]

Standard deviations — Graph 3



[1] Over a three-year horizon. Based on a panel regression of the variable in the panel title on the tail length, tail thickness, median and, aggregate measure of the repayment capacity metric in the legend. Tail length is defined as the difference between the 75th percentile and the median of the distribution. Tail thickness is defined as the ratio of the difference between the 90th and 75th percentiles and the difference between the 75th percentile and the median. Additional control variables include GDP growth and a Covid-19 indicator variable taking on the value of one in 2020 and 2021. Whiskers indicate 90% confidence intervals. Driscoll-Kraay standard errors.

Sources: CGFS Working Group on Private Sector Debt and Financial Stability; Fitch; national data; authors' calculations.

[4] For example, Drehmann and Tsatsaronis (2014).

[5] New NPLs are defined as total NPLs at the end of the period minus total NPLs at the start of the period plus net charge-offs over the period of observation.

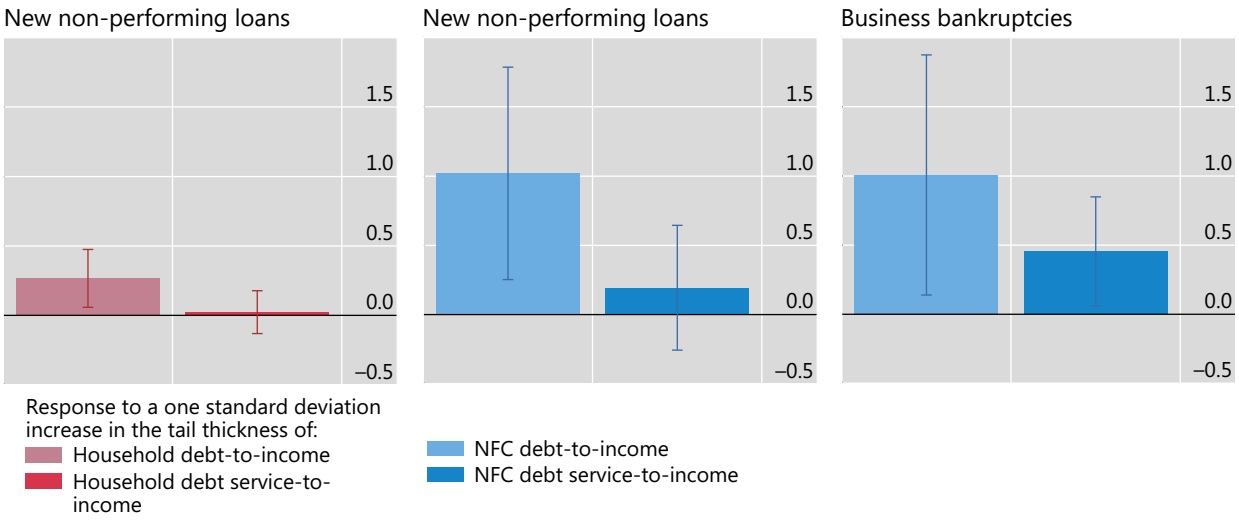
0.3 to 1.2 percentage points (0.1 to 0.6 standard deviations) following similar-sized increases in NFC tail length (centre panel), while the annual growth rate in business bankruptcies would go from –8% (sample average) to +16% (a 0.4 standard deviation rise) (right-hand panel).

An increase in tail thickness is also associated with a rise in credit losses. For example, a one standard deviation increase in the tail thickness of the household debt-to-income distribution is associated with a 0.5 percentage point (0.3 standard deviation) increase in NPLs (Graph 4, left-hand panel). A similar-sized increase in the tail thickness of the NFC debt-to-income distribution is associated with a one standard deviation increase in NPLs and business bankruptcies (centre and right-hand panels). Turning to the debt service-to-income ratio, an increase in tail thickness has significant predictive power only for business bankruptcies.[6]

Accounting for the tail of concern helps to explain a material portion of the variability in credit losses. For example, including such metrics from the household debt-to-income distribution in regression specification (1) raises the explained portion of new NPL variability (adjusted R^2) three years in the future by around 8 percentage points. Similarly, including tail metrics stemming from NFC debt-to-income distributions raises the explained portion of new NPL variability by around 6 percentage points. The increase in explanatory power for business bankruptcies rises from around 3% to 13%. Overall, our results suggest that information about borrowers in the tail of concern adds value in explaining future credit losses.

Peak response of NPLs and bankruptcies to shifts in the tail thickness[1]

Standard deviations — Graph 4



[1] Over a three-year horizon. Based on a panel regression of the variable in the panel title on the tail length, tail thickness, median and, aggregate measure of the repayment capacity metric in the legend. Tail length is defined as the difference between the 75th percentile and the median of the distribution. Tail thickness is defined as the ratio of the difference between the 90th and 75th percentiles and the difference between the 75th percentile and the median. Additional control variables include GDP growth and a Covid-19 indicator variable taking on the value of one during 2020 and 2021. Whiskers indicate 90% confidence intervals. Driscoll-Kraay standard errors..

Sources: CGFS Working Group on Private Sector Debt and Financial Stability; Fitch; national data; authors' calculations.

[6] We ran several additional tests to confirm the robustness of our results. Our broad findings do not materially change if we include lags of the dependent variable as additional control variables in the regression. Similarly, our results are robust to excluding the indicator variable for the Covid-19 shock and either the median or aggregate ratio from our regression specification.

Takeaways for policymakers

The added informational value of granular data should be set against the costs of collecting it. CGFS (2022) highlights the significant efforts central banks have made to gather such data as well as the related privacy issues. This special feature has underscored that, when it comes to predicting credit losses, it is important to track the repayment capacity of the most vulnerable borrowers. In addition, it has shown that parsimonious summary statistics – which may help to overcome privacy concerns – can complement aggregate measures in explaining credit losses.

Our results should be interpreted with caution because of the short underlying time series. Although the coverage of 20 countries helps to mitigate this deficiency by increasing the number of observations, it is important to note that our sample covers only one financial cycle, with one episode of distress. Future research based on longer time series could shed useful additional light on the value of information about the most vulnerable borrowers for predicting credit losses. Importantly, it should also seek to clarify whether such information improves the real-time (ie "out of sample") forecasts on which policymakers would need to rely when taking action.

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Bank funding: evolution, stability and the role of foreign offices[1]

The Covid-19 pandemic and the war in Ukraine have furthered a sustained retreat from global banking. The funding sources of local banking systems have shifted from cross-border to local and, within cross-border, from inter-office to unrelated sources. An increased share from local sources could improve the stability of funding, but greater cross-border funding from unrelated sources could be detrimental, as it is more sensitive to global shocks than is inter-office funding. The shift in the funding mix reflects salient differences between the funding models of domestic banking offices, which have been gaining in importance, and foreign banking offices – ie subsidiaries and branches with foreign parents. Furthermore, as individual foreign bank affiliates have withdrawn, the effect has been to increase the nationality concentration in local banking systems, which historically has correlated with higher funding volatility.

JEL classification: F34, G15, G21.

The Covid-19 pandemic and the war in Ukraine have given further impetus to a generalised retreat from global banking that began in the aftermath of the Great Financial Crisis (GFC). A retrenchment of foreign bank offices (FBOs) – subsidiaries or branches whose parent is in another country – changes the structure of a local banking system, not least because their funding models differ from those of domestic bank offices (DBOs). In this article, we document changes in the funding sources of local banking systems, trace the effects to the relative evolution of FBOs and DBOs and draw implications for funding stability.

Our analysis uses the BIS international banking statistics. We define a local banking system to comprise all banks located within a given jurisdiction (Graph 1). Thus, such a system includes both FBOs (eg French banks operating in Brazil) and DBOs (eg Brazilian banks operating in Brazil). We group bank funding sources into three broad categories: local funding (from residents), cross-border inter-office funding (from related banks), and other cross-border funding (from unrelated sources, eg banks, non-bank financial entities or non-financial corporates). We cannot include in most of the analysis countries that do not report local positions in the BIS international banking statistics, such as China and the United States.[2]

[1] We thank Claudio Borio, Stijn Claessens, Patrick McGuire, Hyun Song Shin, Nikola Tarashev and Goetz von Peter for useful comments. Mert Onen, Swapan-Kumar Pradhan and Jhuvesh Sobrun provided excellent research assistance. All errors are our own. The views expressed in this article are those of the authors and not necessarily those of the Bank for International Settlements.

[2] We also exclude offshore financial centres (OFCs), where positions are largely unconnected with the jurisdiction's funding needs.

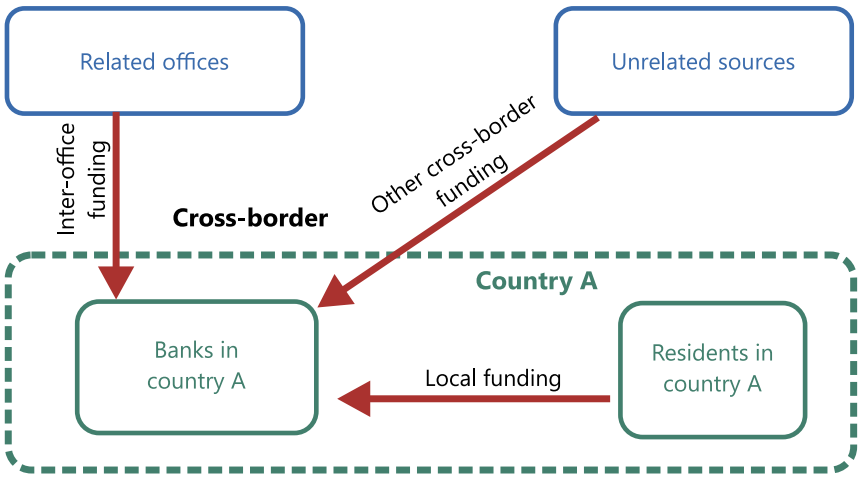
Key takeaways

- Bank funding sources have been shifting: from cross-border to local funding, which enhances stability, and, within cross-border funding, from inter-office to unrelated sources, increasing volatility.
- Shifts in the funding mix of local banking systems stem from the declining share of foreign banking offices, which rely more heavily than domestic offices on cross-border and inter-office funding.
- The retreat of foreign banking offices has increased the concentration of nationalities in local banking systems, which is associated with heightened funding volatility.

There are four key findings. First, the mix of local banking systems' funding sources has been shifting in recent years, from cross-border to local and, within cross-border, from inter-office (ie from related banks) to unrelated sources. Second, this shift has implications for funding stability, as local funding is typically more stable, but unrelated cross-border funding is more sensitive to international shocks than is inter-office funding. In particular, we show that inter-office funding was the more resilient part of cross-border funding during the GFC and in the face of fluctuations in global financial conditions. Third, the shift in funding mix over the past five years is driven primarily by a relative retreat of FBOs, which rely more than DBOs do on funding from cross-border sources. This is consistent with a generalised retreat from global banking business models, as banking groups have started operating more out of their home offices rather than via their foreign affiliates. Fourth, the retreat of individual foreign offices drives an increasing concentration of FBO nationalities in local banking systems, which has historically been connected with more volatility in cross-border funding.

This article builds on two strands of international banking research. The first is the literature on the stability of foreign bank funding and lending (eg Claessens and van Horen (2013), McGuire and von Peter (2016)). We contribute to it by highlighting the importance of inter-office flows for cross-border funding stability and studying sensitivities to global shocks across cross-border funding sources. The second is the literature on banks' international business models (eg Cetorelli and Goldberg (2012), CGFS (2010), McCauley et al (2010)). We bring aspects of these studies up to date by

Bank funding sources — Graph 1



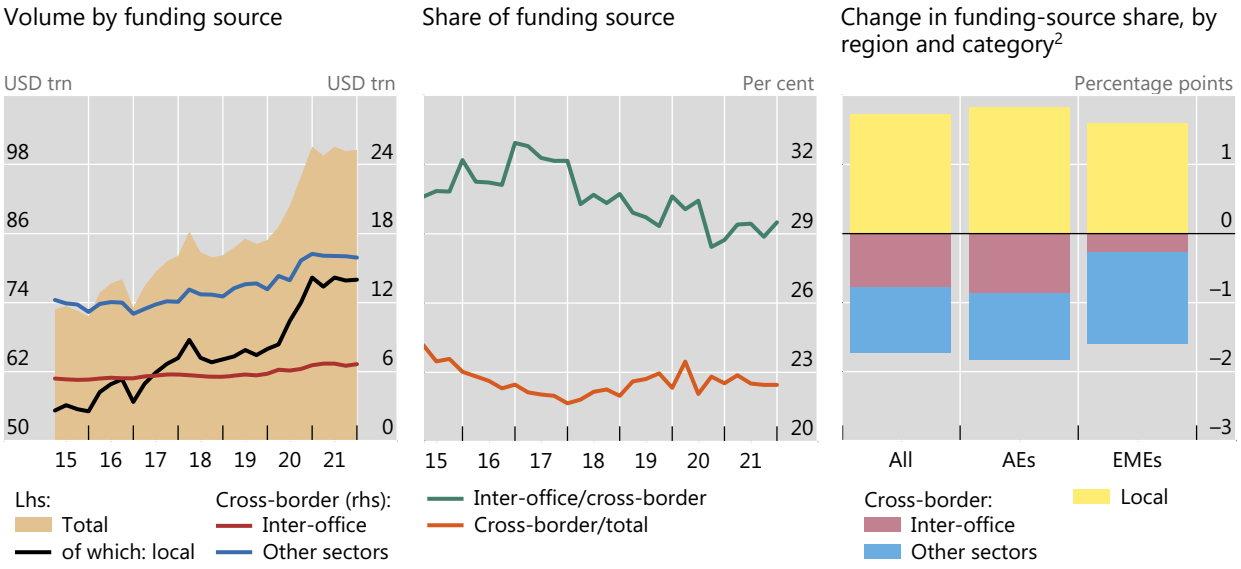
showing how the funding profiles and the relative size of FBOs and DBOs have evolved in recent years.

The rest of the article is organised as follows. The first section documents changes to banks' funding mix and sets out the implications for funding stability. The second section looks under the hood, showing that these trends are driven by the evolution of FBOs and DBOs and their differences in terms of funding models. The third section documents an increase in FBO nationality concentration, which also has implications for funding stability. The final section concludes.

Funding sources: recent shifts and relative stability

The mix of funding sources for local banking systems has been shifting in recent years. Following a post-GFC retrenchment, total liabilities grew by 39%, from $70 trillion in Q1 2015 to $101 trillion[3] in Q4 2021 (Graph 2, left-hand panel). However, the share of funds obtained from cross-border sources showed some decline, falling from 24% to 22% over the same period (centre panel). Within the cross-border segment, funding shifted away from inter-office, falling from 31% of cross-border liabilities to 29%. Overall, local banking systems have replaced cross-border funds, especially inter-office funds for banks in advanced economies (AEs), with local funding (right-hand panel). While these shifts seem small in percentage terms, the decline in the cross-border funding share represents a $1.7 trillion reallocation of the global aggregate.

Funding mix of local banking systems[1] Graph 2



[1] Based on a constant sample of 27 reporting countries comprising 20 AEs and seven EMEs, excluding offshore financial centres and those that do not report inter-office and local liabilities since Q1 2015 (eg the United States, China). The sample generally comprises more than 75% of aggregate balances reported in the BIS international banking statistics. [2] Change in share of total liabilities between Q1 2015 and Q4 2021.

Sources: BIS locational banking statistics; authors' calculations.

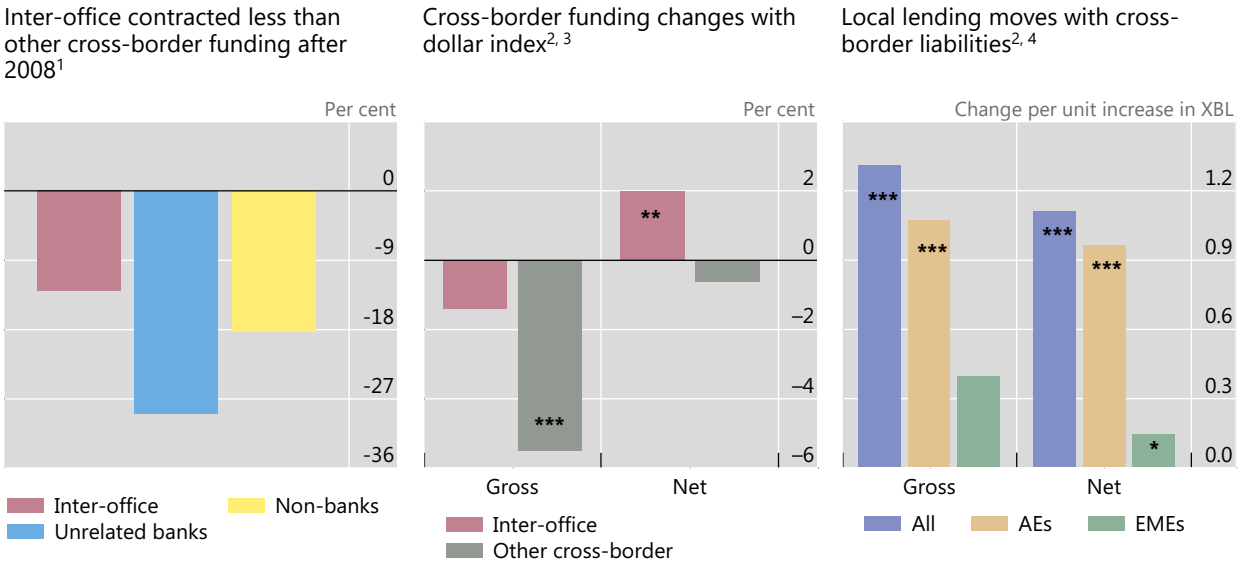
[3] These figures are based on a constant sample of reporting countries, and so do not match the global aggregates published on the BIS website, which include all available data.

Previous research points to a stability hierarchy among funding sources, particularly in the face of international shocks. Most stable is local funding, especially deposits (Ongena et al (2015)). Within cross-border funding, inter-office funding has been shown to be the most stable (Reinhardt and Riddiough (2015)),[4] probably as a result of the pursuit of banking group-wide objectives (De Haas and Van Lelyveld (2010)). Cross-border funding from unaffiliated sources is generally the least stable.

Consistent with these stylised facts, we find that inter-office funding was the most stable part of banks' cross-border funding during the GFC. Overall, cross-border funding plunged from its peak in Q1 2008 through Q1 2009, but inter-office cross-border liabilities declined by only 13% in aggregate, while liabilities sourced from unrelated banks and non-banks, declined by 29% and 18% respectively (Graph 3, left-hand panel).[5,6]

Cross-border funding stability

Graph 3



[1] Values represent percentage change in amount outstanding between Q1 2008 and Q1 2009. The sample of 29 reporting countries, including the United States. [2] Net funding equals cross-border liabilities minus cross-border claims. ***/**/* indicates statistical significance at the 1/5/10% level. [3] The reported effects result from a one standard deviation movement in the dollar index and are expressed as percent of average gross cross-border liabilities for the given funding segment. Based on a regression of aggregate cross-border changes on lagged changes in the real broad dollar index (BDI) over Q1 2005–Q4 2021. Sample consists of 22 countries with full coverage of inter-office liabilities over the sample period, excluding the United States (results similar when not excluded). [4] XBL = Cross-border liabilities. Coefficients from a regression of the change in aggregate local claims on the change in aggregate local liabilities and either the change in aggregate gross cross-border liabilities and gross cross-border claims or net cross-border liabilities (cross-border liabilities minus cross-border claims) over Q4 2014–Q4 2021. Sample consists of 30 countries that have coverage of local claims over the sample period, comprising 21 AEs and 9 EMEs (excluding the United States and China).

Sources: BIS locational banking statistics; authors' calculations.

[4] This need not always be the case. During the Covid-19 pandemic, inter-office positions jumped considerably, along with other positions (Aldasoro et al (2021)).

[5] Local liabilities were likely the most stable funding source, but low data reporting over this period prevents a direct comparison. Local claims in local currency (obtained from the BIS consolidated banking statistics), typically funded by local liabilities and shown to be relatively stable through the GFC (McGuire and von Peter (2016)), declined by 14% over the same period.

[6] Following the GFC, foreign banks in the United States saw a reversal in their inter-office positions, switching from being a net creditor to their parents to a net borrower (Bruno and Shin (2014)). This development reflects attractive interest rates on reserves at the Federal Reserve, which were due to quantitative easing in the United States, leading banks to keep more funds in their Federal Reserve accounts (McCauley and McGuire (2014)). When banks located in the United States are excluded, inter-office liabilities still see a much smaller decline than those to unrelated sources.

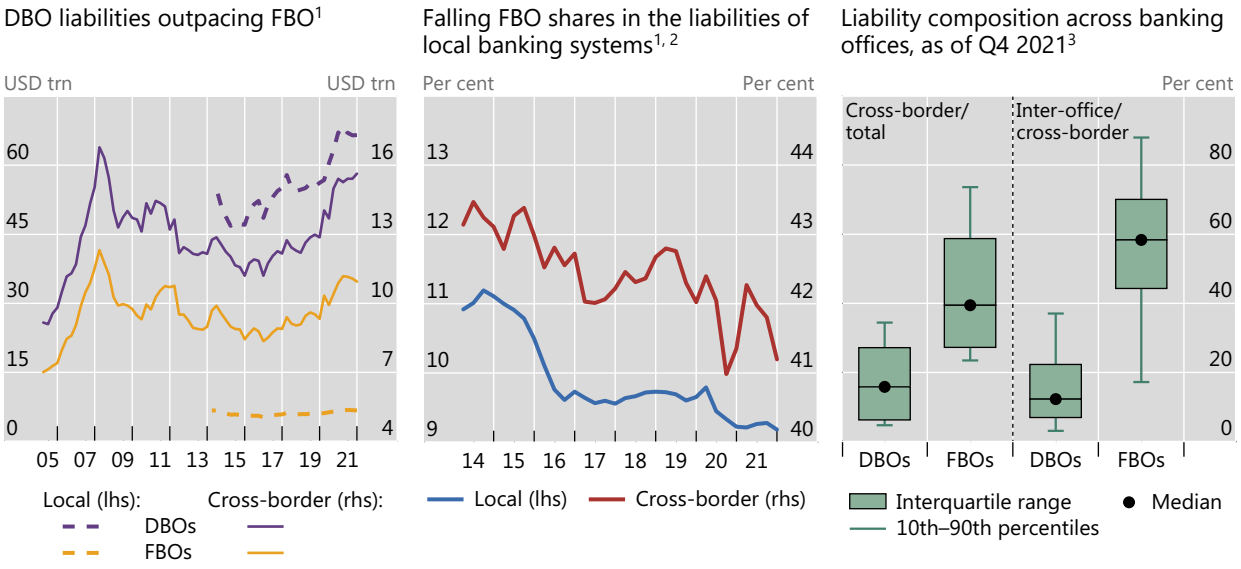
In line with previous studies, we also find that inter-office funding is less sensitive to global financing conditions, as proxied by the broad dollar index (Graph 3, centre panel).[7] For a one standard deviation change in the dollar index (a roughly 8% appreciation), cross-border liabilities fall by less than 1.5% for inter-office but by 5.5% for other sources (for an overall decline of around 4%). Net changes (whereby cross-border claims are subtracted from liabilities) suggest that inter-office sources actually compensate for the retrenchment of unrelated entities.

Swings in a local banking system's cross-border funding go hand in hand with similar swings in domestic lending. We obtain this result from an empirical analysis, that considers both gross and net cross-border liabilities. In particular, we find that, when such liabilities decline, so do local claims, by an equal amount for AEs and by 40% of the gross cross-border liability decline for emerging markets (EMEs) (Graph 3, right-hand panel).

Underlying foreign and domestic banking office trends

The shifts in global funding mix indicated above reflect the confluence of three factors: the declining share of foreign banking offices (FBOs) relative to domestic banking offices (DBOs); the differences between the FBO and DBO funding models; and changes in liability structures within these groups, particularly among DBOs. We discuss these factors in turn.

Changing footprint of FBOs — Graph 4



[1] Cross-border and local liabilities are based on a balanced panel of 27 reporting countries. The sample compositions for local and cross-border liabilities are different due to reporting practices. Local liabilities exclude the United States. [2] Share of FBOs in total cross-border and local liabilities. [3] The sample comprises 29 countries, excluding countries without coverage for both inter-office and local liabilities (eg the United States).

Sources: BIS locational banking statistics; authors' calculations.

[7] An increase in the broad dollar index is indicative of a tightening of global financial conditions and is associated with a contraction in international banking (Avdjiev et al (2019)).

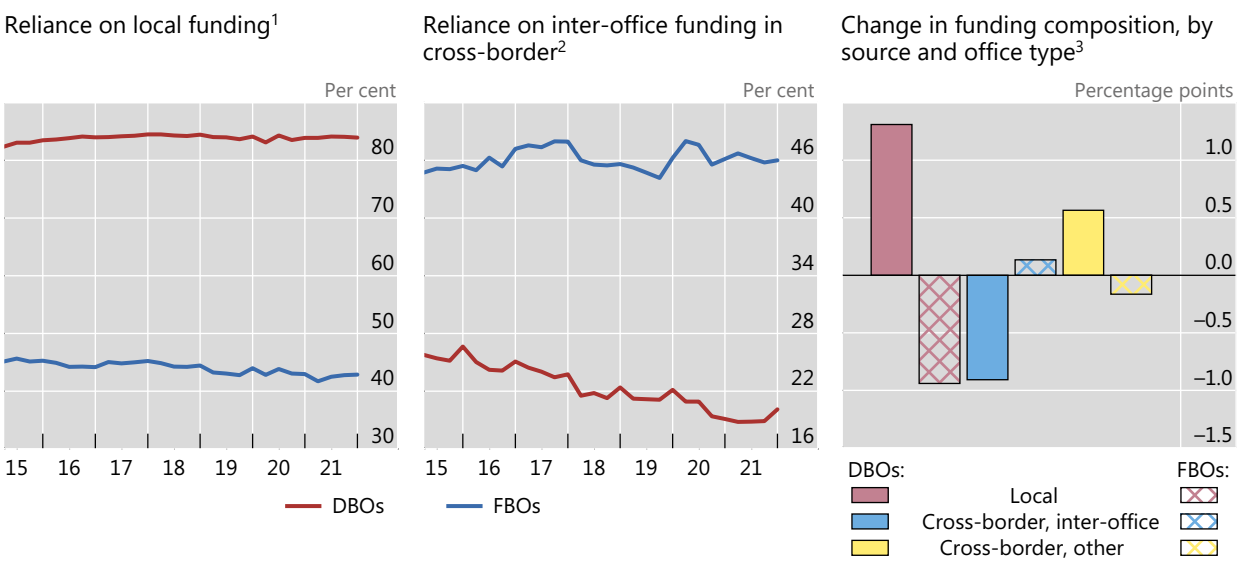
Following the post-GFC retrenchment in international banking, FBOs' liabilities grew from around 2016, but by less than those of DBOs did (Graph 4, left-hand panel). As a result, FBOs' share in local banking system liabilities declined, from 43% in Q1 2015 to 41% in Q4 2021 for those sourced cross-border. In the case of local liabilities, the corresponding decline was from 11% to 9% for local liabilities (centre panel).

FBOs' funding models differ from those of DBOs in several respects. Cross-border positions account for a far higher proportion of FBOs' balance sheets, reflecting these offices' generally greater international focus (Graph 4, right-hand panel).[8] In addition, FBOs are nodes in global banks' international intermediation networks, and part of their function is to help manage flows of liquidity within global banks. This naturally generates a higher proportion of inter-office positions. FBOs also utilise much more US dollar funding (Box A). These differences across FBOs and DBOs would affect the funding structure of local banking systems, as the share of FBOs declines.

Within the aggregate FBO and DBO groups, the funding mix has been mostly stable over the past five years, with a few notable shifts. For both FBOs and DBOs, the share of funding from local sources remained largely unchanged between Q1 2015 and Q4 2021 (Graph 5, left-hand panel). However, DBOs have reduced the use of inter-office sources, from 26% to 20% of cross-border liabilities over the same period (centre panel).

Funding composition changes across FBOs and DBOs

Graph 5



[1] Local liabilities as a share in the total liabilities. The sample comprises 28 reporting countries, excluding OFCs as well as those that do not report local positions (eg the United States, China). [2] Cross-border inter-office liabilities as a share of total cross-border liabilities. The sample comprises 28 countries including the United States, excluding OFCs and those that do not report inter-office liabilities. [3] Changes in shares between Q4 2015 and Q4 2021. Based on a balanced sample of 24 reporting countries in which DBOs and FBOs report both cross-border inter-office and local liabilities throughout the period.

Sources: BIS locational banking statistics; authors' calculations.

[8] FBOs vary considerably in their funding composition, ranging from those that obtain nearly all their funding from cross-border sources to those that obtain less than a quarter (see also Fender and McGuire (2010)). This reflects differences among parent banks' international business models (McCauley et al (2010)). Nevertheless, the majority of FBOs have significant cross-border positions in their balance sheets.

Box A

US dollar funding and foreign banking offices outside the United States

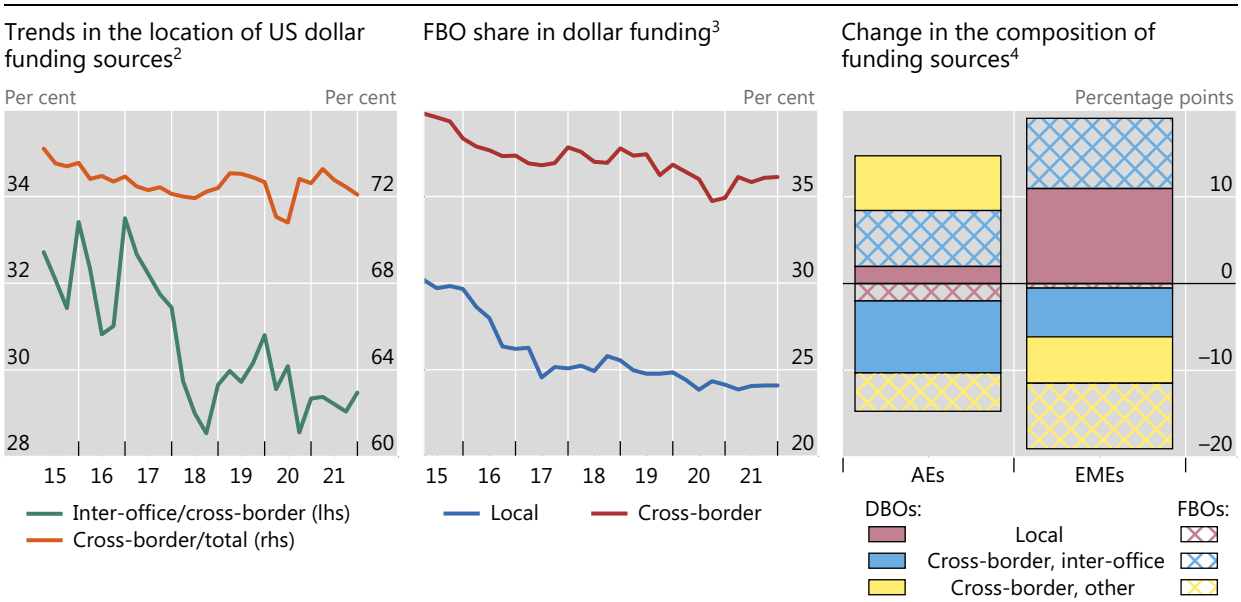
*John Caparusso and Bryan Hardy*①

With US dollar funding central to much of the international banking system, dollar funding shortages can be destabilising for banks (Barajas et al (2020)). As the pattern of funding sources has been changing for banks outside the United States, their susceptibility to dollar funding shocks may also have undergone changes. This box highlights how the role of cross-border and inter-office (ie from related banks) funding in US dollars has changed for banks outside the United States. It also relates such changes to the relative presence of foreign banking offices (FBOs, subsidiaries or branches whose parent is in another country) and domestic banking offices (DBOs, those located in their country of headquarters).

There is a distinct change in the location of banks' US dollar funding sources. The share of cross-border sources fell from 74% in Q1 2015 to 72% in Q4 2021 (Graph A, left-hand panel). Over the same period, the share of cross-border US dollar funds that banks sourced inter-office fell from 33% to 29%.

US dollar positions[1]

Graph A



[1] For USD-denominated liabilities only. Excludes banks located in the United States and OFCs. Includes balanced panels of countries that report positions continuously over the specified time period. [2] Based on a sample of 28 reporting countries. [3] Both lines represent a balanced panel of 31 reporting countries. [4] Difference in shares of total liabilities between Q4 2015 and Q4 2021. Sample of 26 reporting countries.

Sources: BIS locational banking statistics; authors' calculations.

A relative retreat of FBOs from local banking systems has driven these developments. With the decline in global banking as a business model, banking groups do more business from their home office rather than through their foreign affiliates (Aldasoro and Ehlers (2018)). A number of consequences follow from such structural shifts. FBOs typically obtain a higher proportion of funding from cross-border, especially inter-office, sources than do DBOs. However, the share of FBOs in the US dollar funding of local banking systems has been falling, from 40% in Q1 2015 to 36% in Q4 2021 for cross-border sources and from 30% to 24% over the same period for local sources (Graph A, centre panel). This shifted the US dollar funding mix of the local banking system, reallocating it away from DBOs' inter-office sources and FBOs' unrelated cross-border funding sources (right-hand panel). In advanced economies, this was compensated for largely by DBOs' borrowing from unrelated sources; in emerging market economies, by local DBO funding.

① The views expressed are those of the authors and not necessarily those of the Bank for International Settlements.

In sum, the decline in FBOs' liabilities relative to those of DBOs, the differences in these offices' funding structure, and changes in the funding mix within each group have delivered the following shift at the level of local banking systems: from cross-border inter-office to other cross-border and local funding. (Graph 5, right-hand panel). The underlying reshuffling of DBO funding sources is consistent with the generalised retreat of global banking: banking groups have reduced the role of their foreign affiliates to do more business directly from their home offices.

The impact of a shift away from FBOs on funding stability is a priori unclear. Granted, there is evidence that foreign banks tend to be more vulnerable to international shocks than domestic banks are (McGuire and von Peter (2016)). However, such stylised facts reflect foreign banks' greater use of non-deposit funding, especially cross-border funding, whereas FBOs and DBOs that fund themselves similarly are similarly stable.[9] In addition, FBOs tend to have more stable *cross-border* funding because their parents support them in times of stress, probably as part of an overall optimisation for the banking group (Eguren-Martin et al (2022), De Haas and Van Lelyveld (2006, 2010), Barba-Navaretti et al (2010)). A decline in FBOs' share of the local banking system's cross-border liabilities reduces the reach of these inter-office networks. In the light of the discussion in the previous section, this could impair local banking systems' funding stability, all else equal.

Impact of FBO closures

Many global banks have recently announced sales or closures of their foreign affiliates (either subsidiaries or branches) across host countries.[10] This is yet another facet of a general retreat from global banking business models. To investigate this phenomenon in a systematic way, we drill down to the level of individual foreign banking offices – branches and subsidiaries – that contribute the data underlying the BIS banking statistics.[11]

Exits of individual foreign affiliates – through closure or divestiture – have contributed to the relative retrenchment of FBOs studied above. The number of individual foreign offices has declined over the past five years by about 8% in both advanced and emerging markets and by about 17% in OFCs (Graph 6, left-hand panel, bars).

Because FBOs' and DBOs' funding models differ, exits of individual foreign affiliates are likely to affect the overall funding mix of a local banking system.

[9] For instance, Ongena et al (2015) and Claessens and van Horen (2013) show that foreign banks funded locally behave in a similar way to domestic banking offices (DBOs) funded locally. Moreover, internationally funded FBOs do not generally respond to funding shocks more negatively than DBOs with a similar reliance on foreign funding (Ongena et al (2015)). The type of credit and how it is funded matters more than the ownership of the bank (Ehlers and McGuire (2017)), but foreign ownership is notable as it typically indicates a different funding mix.

[10] For instance, since 2021 (in addition to planned exits from Russia): Citi announced its intention to exit retail business in at least 15 emerging market economies; Commerzbank said it would leave Hong Kong SAR, Hungary and Luxembourg; HSBC sold assets in France and Greece and announced sales in Saudi Arabia, Turkey and the United States; Standard Chartered announced exits from at least seven countries in Africa and two in the Middle East; and a few non-US G-SIBs have announced, planned or consummated divestitures of large US subsidiaries

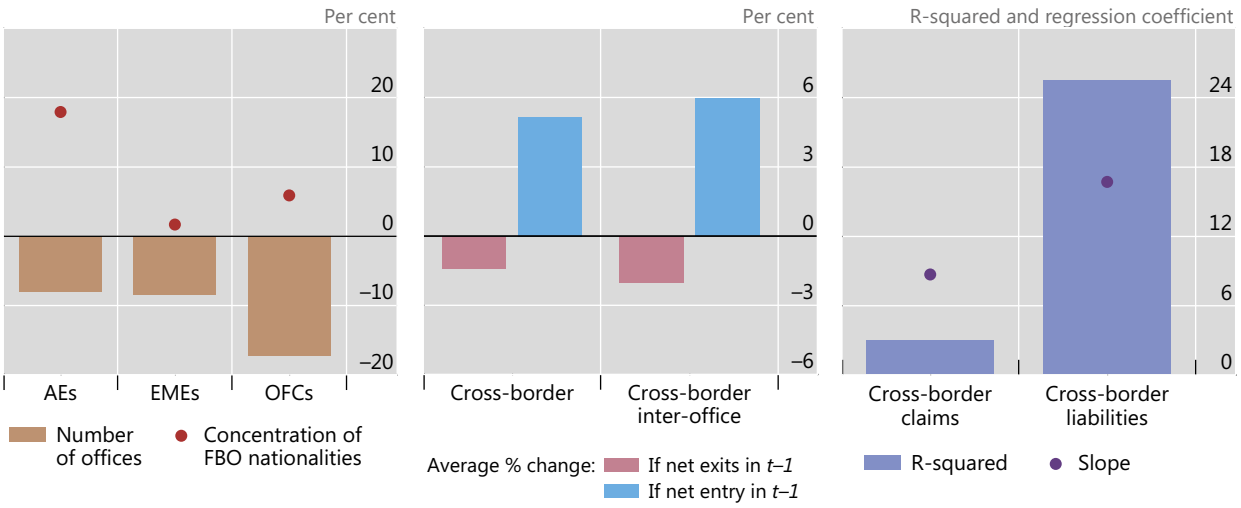
[11] The BIS records on a yearly basis the number of banks (head offices, subsidiaries and branch networks) that constitute the reporting population of the BIS locational statistics.

Consistent with this, we see that over the 2016–21 period, declines in the number of foreign bank affiliates[12] were followed on average by a 1.4% decline in the total cross-border funding of local banking systems. This compares with an average 5% increase after the net entry of foreign bank affiliates. The effect of changes in the number of FBOs on the growth of inter-office funding is more striking (Graph 6, centre panel).

More generally, an individual office's exit reduces the presence of one nationality and opens the door to banks from other – typically, already present – nationalities to step in (either by purchasing the exiting affiliate or expanding to take over market share). This can raise the concentration of nationalities in the local banking system (Graph 6, left-hand panel, dots). Increasing concentration reduces the diversification of ultimate funding sources, which makes overall funding more vulnerable to financial stress in individual home countries and thus more volatile (Peek and Rosengren (2000)). Over the past 10 years, we find a material relationship between the nationality concentration in a local banking system and the volatility of its cross-border liabilities, but not with that of its cross-border claims. Concretely, changes in such concentration explain roughly 25% of the variability in a system's total cross border liabilities (right-hand panel, bars).

FBO intermediation and stability of cross-border liabilities

Graph 6



[1] Based on counts of banking entities that are located in BIS reporting countries and have parents in another country. Bars report the change in median FBO nationality concentration across 47 jurisdictions. Concentration in each jurisdiction is measured as the Herfindahl-Hirschman Index (HHI) of cross-border liabilities of banks of each nationality in the given location. [2] Median across 41 countries of the average year-on-year change in local banking system cross-border liabilities in the year after a net FBO entry and exit, respectively. Net exit is identified by decline in both the number of foreign affiliates and number of nationalities (to filter out potential consolidation effects); net entry is identified only by an increase in the number of foreign affiliates. Based on annual data spanning 2010–2021. [3] R-squared and slope from a simple linear regression of each country's standard deviation of quarter-on-quarter changes in outstanding position, against each country's average Herfindahl index of liabilities across FBO nationalities, computed for 47 countries over the period Q2 2012–Q4 2021.

Sources: BIS locational banking statistics; authors' calculations.

[12] A decline in foreign affiliates is flagged when both the number of banking affiliates and the number of bank nationalities decline. This conservative measure accounts for the possibility that the number of affiliates fall because of a consolidation rather than a true exit. The trend is similar if we use only a decline in the number of affiliates. An entry is flagged when the number of affiliates increases.

Conclusion

This article has highlighted changes in the mix of three funding sources for local banking systems – local, cross-border inter-office, and other cross-border. These sources differ in their stability. Local funding is most stable, in part because its major component is deposits. Inter-office funding provides access to cross-border (and foreign currency) funding through a channel that remains relatively resilient during periods of stress. While the focus above was on international shocks, inter-office networks are also an important source of diversification following domestic shocks (Reinhardt and Riddiough (2015), D'Avino (2015)).

Since 2015, a shift toward local funding, which benefits stability, has been counteracted by a decline in the share of inter-office in cross-border funding, which has the opposite effect. These shifts in a local banking system's funding mix stem from a retrenchment of foreign bank offices, which have ceded funding share to domestic bank offices with weaker cross-border inter-office channels.

The importance of cross-border sources for funding stability is most relevant for economies that cannot readily substitute for such sources locally. For example, foreign currency funds typically need to be sourced cross-border. Thus, the ongoing retreat of foreign banking offices makes central bank swap lines more relevant as a tool to ensure access to foreign currency funding after a shock.[13]

While this article has emphasised the resilience of foreign bank offices' cross-border funding, the activities of such offices can also be destabilising. Global banks with extensive networks of foreign affiliates can become increasingly complex, which increases their riskiness (Aldasoro et al (2022)). Further, at times of stress in their home country, FBOs may be drawn upon to help support the parent. This could be at the expense of the local banking system and may syphon liquidity away from the host economy (Cetorelli and Goldberg (2012)).

[13] Access to insured FX retail deposits can similarly cushion banks and stabilise their lending supply (Ivashina et al (2015)).

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