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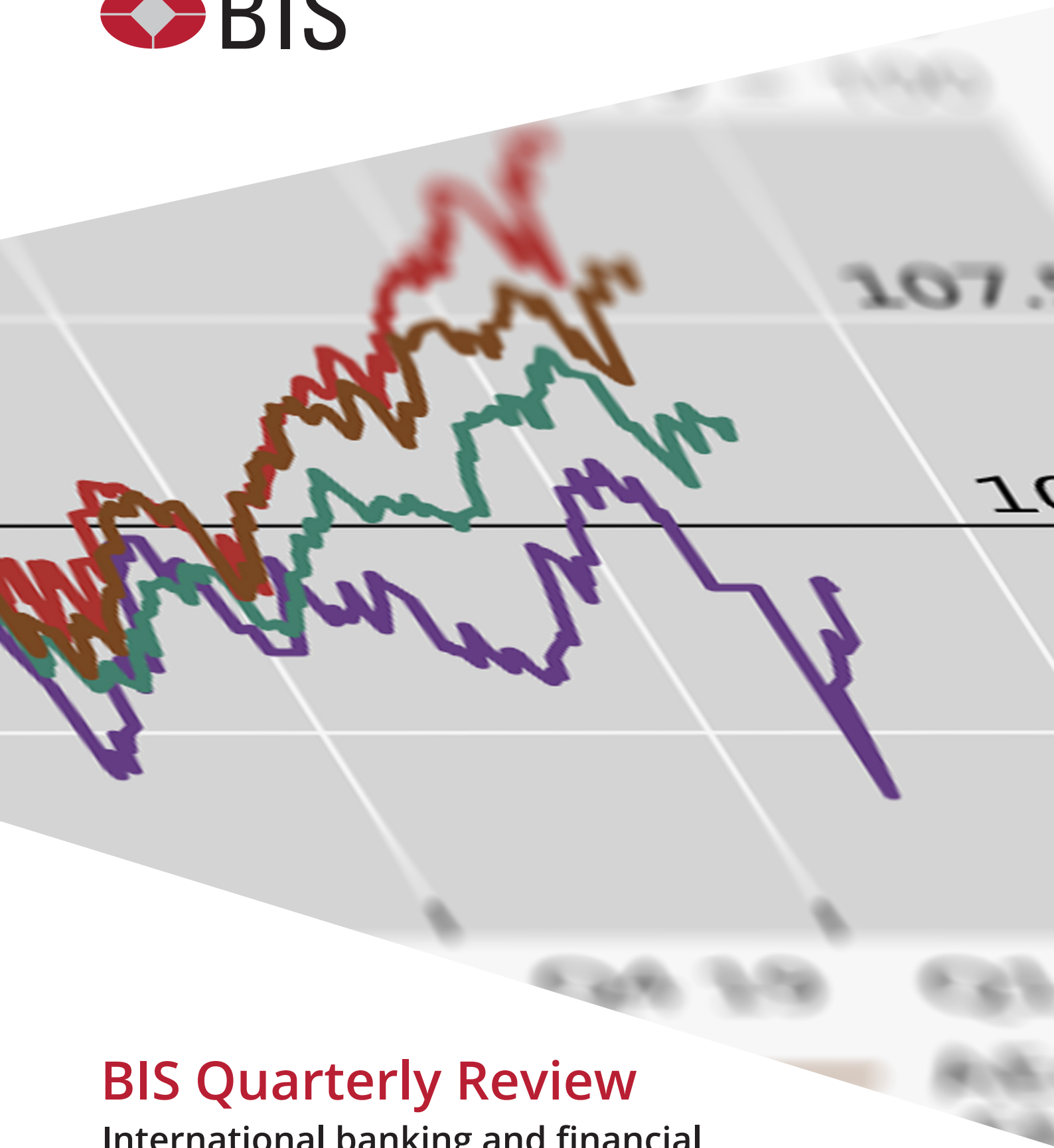

BIS Quarterly Review

International banking and financial market developments

March 2020

BIS Quarterly Review
Monetary and Economic Department

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Special features

Notations used in this Review

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

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

Glossary

This glossary summarises technical terms about payment systems used in the special features in this issue. For more details and additional terms, see the online glossary provided by the Committee on Payments and Market Infrastructures (www.bis.org/cpmi/publ/d00b.htm).

atomic settlement: The use of a smart contract to link two assets to ensure that the transfer of one asset occurs if and only if the transfer of the other asset also occurs (eg to achieve delivery versus payment in a securities transaction or payment versus payment in a foreign exchange transaction).

automated clearing house (ACH): Multilateral arrangement that facilitates the exchange of payment instructions between payment service providers.

back-end arrangement: Arrangement for clearing and settling payments. See also "front-end arrangement".

bearer security: Security issued as a paper certificate where the bearer is presumed to be the owner.

business-to-business (B2B) payment: Payment where both the payer and the payee are businesses (eg payment for raw materials).

central bank digital currency (CBDC): Digital form of central bank money that is different from balances in traditional reserve or settlement accounts (eg balances in accounts held by commercial banks at the central bank).

central counterparty (CCP): Entity that interposes itself between counterparties to contracts traded in one or more financial markets, becoming the buyer to every seller and the seller to every buyer and thereby ensuring the performance of open contracts.

central securities depository (CSD): Entity that provides securities accounts, central safekeeping services and asset services, which may include the administration of corporate actions and redemptions, and plays an important role in helping to ensure the integrity of securities issues (that is, ensure that securities are not accidentally or fraudulently created or destroyed or their details changed).

clearing: Process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement. If obligations are settled on a net basis, clearing can also involve the calculation of net positions for settlement.

closed loop: Payment system that provides services directly to both payers and payees. Sometimes known as an in-house or intragroup transfer system.

correspondent banking: Arrangement whereby one bank (correspondent) holds deposits owned by other banks (respondents) and provides those banks with payment and other services.

credit risk: Risk that a counterparty, whether a participant or other entity, will be unable to meet fully its financial obligations when due, or at any time in the future.

cross-border payment: Payment where the payer and the payee are located in different jurisdictions. Many cross-border payments are also cross-currency payments.

cross-currency payment: Payment where the amount debited to the payer is in a different currency than the amount credited to the payee, ie the payment involves a currency conversion along its route from payer to payee.

deferred net settlement: Net settlement mechanism which settles on a net basis at the end of a predefined settlement cycle.

delivery leg: One of two legs of a securities trade: the transferring of ownership of the securities from the seller to the buyer. See also "payment leg".

delivery versus payment (DvP): Securities settlement mechanism that links a securities transfer and a funds transfer in such a way as to ensure that delivery occurs if and only if the corresponding payment occurs.

dematerialisation: Elimination of physical certificates or documents of title that represent ownership of securities so that securities exist only as accounting records.

digital token: Digital representation of value that is not recorded in an account.

direct holding system: Arrangement for registering ownership of securities (or similar interests) whereby each and every final investor in the securities is registered with a single entity (for example, the issuer itself, a CSD or a registry). In some countries, the use of a direct holding system is required by law.

distributed ledger (DL): Record of transactions held across a network of computers (nodes) where each node has a synchronised copy. A DL usually relies on cryptography to allow nodes to securely propose, validate and record state changes (or updates) to the synchronised ledger without necessarily the need for a central authority.

domestic payment: Payment involving a payee and a payer that reside within the same jurisdiction and use the same currency.

DvP model 1: DvP model where securities and funds are settled on a gross and obligation-by-obligation basis, with final (irrevocable and unconditional) transfer of securities from the seller to the buyer (delivery) if and only if final transfer of funds from the buyer to the seller (payment) occurs.

DvP model 2: DvP model where securities are settled on a gross basis, with final transfer of securities from the seller to the buyer occurring throughout the processing cycle, but funds are settled on a net basis, with final transfer of funds from the buyer to the seller occurring at the end of the processing cycle.

DvP model 3: DvP model where both securities and funds are settled on a net basis, with final transfers of both securities and funds occurring at the end of the processing cycle.

fast-payment system (FPS): Retail payment system in which the payment message is transmitted and the final funds are made available to the payee in real time or near real time on as near to a 24/7 basis as possible.

final settlement: Legally defined moment when funds (or other assets) have been irrevocably and unconditionally transferred.

free of payment (FoP): Transfer of securities without a corresponding transfer of funds.

front-end arrangement: Arrangement for initiating payments. See also "back-end arrangement".

hash timelock contract (HTLC): Type of smart contract that combines a hashlock function with a timelock function to facilitate two-leg transfers across unconnected ledgers.

hierarchical DL: Distributed ledger where each node has a full copy of the ledger but some details are hidden using cryptography. Only one or more trusted third parties have a full view of the ledger.

hybrid settlement system: System that combines the characteristics of RTGS and deferred net settlement systems.

immobilisation: Act of concentrating the location of securities in a depository and transferring ownership by book entry.

indirect holding system: Multi-tiered arrangement for the custody and transfer of ownership of securities (or the transfer of similar interests therein) in which holders are identified only at the level of their custodian or intermediary.

infrastructure model: Back-end arrangement for cross-border payments involving a payment system or linked payment systems operating across borders.

interoperability: Technical or legal compatibility that enables a system or mechanism to be used in conjunction with other systems or mechanisms. Interoperability allows participants in different systems to conduct, clear and settle payments or financial transactions across systems without participating in multiple systems.

liquidity risk: Risk that a counterparty, whether a participant or other entity, will have insufficient funds to meet its financial obligations as and when expected, although it may be able to do so in the future.

liquidity saving mechanism (LSM): Mechanism that seeks to save liquidity, including through frequent netting or offsetting of transactions (payments and/or securities) in the course of the operating day. A typical approach is to hold transactions in a central queue and to net or offset those transactions on a bilateral or multilateral basis at frequent intervals.

money transfer operator (MTO): Non-deposit-taking payment service provider where the service involves payment per transfer (or possibly payment for a set or series of transfers) by the sender to the payment service provider (for example, by cash or bank transfer) – ie as opposed to a situation where the payment service provider debits an account held by the sender at the payment service provider.

multilateral netting: Offsetting of obligations between or among multiple participants to result in a single net position per participant.

offshore system: Financial market infrastructure for the processing of payments or securities denominated in a currency different from the one of the jurisdiction in which the FMI is located. It could also cover a CCP.

overlay system: System that provides innovative customer interfaces to initiate payments (ie front ends).

payment leg: One of two legs of a securities trade: the transferring of cash corresponding to the securities' price from the buyer to the seller. See also "delivery leg".

payment service provider (PSP): Entity that provides payment services, including remittances. Payment service providers include banks and other deposit-taking institutions, as well as specialised entities such as money transfer operators and e-money issuers.

payment system: Set of instruments, procedures and rules for the transfer of funds between or among participants. The system encompasses both the participants and the entity operating the arrangement.

payment versus payment (PvP): Settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place. PvP transfers can occur within a jurisdiction or across borders.

peer-to-peer arrangement: Arrangement that cuts out the financial intermediary payment service providers between the payer and payee.

permissioned DL: Distributed ledger that allows only trusted third parties to be involved in the updating process. Because validators are trusted, less computationally intensive mechanisms can be used to validate transactions.

person-to-business (P2B) payment: Payment where the payer is an individual and the payee is a business (eg bill payments). The reverse transaction is known as a business-to-person (B2P) payment (eg salary payments).

person-to-government (P2G) payment: Payment where the payer is an individual and the payee is a government (eg payment of taxes). The reverse transaction is known as a government-to-person (G2P) payment (eg welfare payments).

person-to-person (P2P) payment: Payment where both the payer and the payee are individuals (eg remittances). Also known as a peer-to-peer payment.

principal risk: Risk that a counterparty will lose the full value involved in a transaction – for example, the risk that a seller of a financial asset will irrevocably deliver the asset but not receive payment.

private DL: Distributed ledger that restricts who can initiate transactions. This is similar to an account-based system, where users must apply to open an account before they can use the system (or at least open an account at an intermediary that has access).

real-time gross settlement (RTGS): Real-time settlement of payments, transfer instructions or other obligations individually on a transaction-by-transaction basis.

remittance: Person-to-person payment of relatively low value. It can be domestic, but this term is generally used to refer a cross-border payment.

replacement cost risk: Risk of a trade failing to settle and having to be replaced at an unfavourable price.

retail payment: Payment associated with the purchase of goods and services by consumers and businesses. Each such payment tends to be for a relatively low value, but the volumes are large.

securities settlement: Transfer of ownership of securities in accordance with the terms of an underlying agreement.

securities settlement system (SSS): Entity that enables securities to be transferred and settled by book entry according to a set of predetermined multilateral rules. Such a system allows transfers of securities either free of payment or against payment.

settlement: Discharge of an obligation in accordance with the terms of the underlying contract.

smart contract: DLT protocol or code that self-executes when certain conditions are met.

stablecoin: Cryptoasset that seeks to stabilise its price by linking its value to that of an asset or pool of assets.

tokenisation: Process of converting assets into digital tokens.

transaction account: Account (including e-money and prepaid accounts) held with a bank or other authorised payment service provider, which can be used to make and receive payments and to store value.

wholesale payment: Payment between financial institutions – for example, payment to settle securities and foreign exchange trades, payment to and from central counterparties, and other interbank funding transactions. These are typically large-value payments that often need to settle on a particular day and sometimes by a particular time.

Abbreviations

Currencies

ALL	Albanian lek	MXN	Mexican peso
ARS	Argentine peso	MXV	Mexican unidad de inversión (UDI)
AUD	Australian dollar	MYR	Malaysian ringgit
BGN	Bulgarian lev	NAD	Namibian dollar
BHD	Bahraini dinar	NGN	Nigerian naira
BRL	Brazilian real	NOK	Norwegian krone
CAD	Canadian dollar	NZD	New Zealand dollar
CHF	Swiss franc	OTH	All other currencies
CLP	Chilean peso	PEN	Peruvian sol
CNY (RMB)	Chinese yuan (renminbi)	PHP	Philippine peso
COP	Colombian peso	PLN	Polish zloty
CZK	Czech koruna	RON	Romanian leu
DKK	Danish krone	RUB	Russian rouble
EUR	euro	SAR	Saudi riyal
GBP	pound sterling	SEK	Swedish krona
HKD	Hong Kong dollar	SGD	Singapore dollar
HUF	Hungarian forint	THB	Thai baht
IDR	Indonesian rupiah	TRY	Turkish lira
ILS	Israeli new shekel	TWD	New Taiwan dollar
INR	Indian rupee	USD	US dollar
ISK	Icelandic króna	VES	bolívar soberano
JPY	Japanese yen	VND	Vietnamese dong
KRW	Korean won	XOF	CFA franc (BCEAO)
MAD	Moroccan dirham	ZAR	South African rand

Countries

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

Countries (cont)

IL	Israel	MX	Mexico
IN	India	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	VC	St Vincent and the Grenadines
TO	Tonga	VE	Venezuela
TR	Turkey	VG	British Virgin Islands
TT	Trinidad and Tobago	VN	Vietnam
TW	Chinese Taipei	XM	euro area
TZ	Tanzania	ZA	South Africa
UA	Ukraine	ZM	Zambia
US	United States	1C	International organisations
UY	Uruguay	1Z	British West Indies
UZ	Uzbekistan		

A rude awakening for investors

Surging market sentiment faltered in mid-January with the worsening news on the new coronavirus (Covid-19) outbreak in China. The upswing in investor risk appetite sparked last October by easing trade tensions had gathered further momentum during the first half of the three-month period under review.[1] Starting in mid-January, however, concerns over the economic impact of the new epidemic in China dented investor confidence. The intensity of the ensuing risk-off episode, which had an uneven impact across asset classes and regions, fluctuated in response to news detailing the spread of the coronavirus across the globe. As of late February, jittery markets and abundant signs of investor caution indicated that the risk-off phase was not yet over.

The announcement on 13 December of a formal signing date for the phase-one trade deal between the United States and China breathed new life into a fading stock market rally. In early January, global equity valuations reached new highs amid incoming data suggesting that manufacturing activity was likely to have bottomed out at year-end. Among emerging market economies (EMEs), the stock markets of the countries more closely integrated in global value chains (GVCs) appeared to have benefited relatively more. The buoyant sentiment steepened yield curves and compressed corporate credit spreads in advanced economies (AEs), as well as sovereign and corporate spreads in EMEs. With a risk-on phase in full swing, stock market-implied volatilities fell back to recent lows. Consistent with the rise in risk appetite, the US dollar depreciated notably over this period.

First in mid-January, and then with even greater intensity in late February, the worsening news relating to the Covid-19 outbreak roiled markets. As investors fretted over the outbreak's economic fallout, commodity prices dropped, longer-term yields in AEs declined appreciably, and the mid-range of the US term structure inverted. Stock markets across the globe swung with news of the virus outbreak, relinquishing their earlier gains by late February. The US dollar appreciated, in particular against currencies of emerging Asian economies and commodity exporters. Although credit spreads widened somewhat, credit markets in AEs and fixed income markets in EMEs remained resilient, with portfolio inflows into EMEs continuing into February. All told, a stronger US dollar, depressed commodity prices, heightened stock market-implied volatilities and a deep inversion of the US term structure signalled a significantly more cautious mood by late February – the end of the review period.

Throughout, the central banks of major economies maintained an accommodative policy stance, while those of some large EMEs eased policy further. Overall, investors expected policy rates to stay unchanged in the short to medium run. That said, futures markets priced in some further easing by the Federal Reserve in the second half of this year.

[1] The period under review extends from 28 November 2019 to 25 February 2020.

Key takeaways

- The late 2019 upswing in market sentiment faltered in early 2020 amid unease over the impact of the Covid-19 outbreak.
- The sell-off was uneven across asset classes and regions, affecting countries with close geographical or economic links to China more than others.
- Direct lending by non-banks – private credit to riskier firms – is almost as large as and structurally similar to the better known leveraged loan market.

Trade deal spurs a rally in risk assets

Investor sentiment regained significant momentum early in the period under review. The boost to sentiment reflected the confluence of a marked reduction in global trade tensions and evidence that the downturn in manufacturing was bottoming out.

Trade-related concerns abated significantly late last year. On 13 December, the United States and China announced the formal signing date for their phase-one deal. Around the same time, the UK election dispelled uncertainty about the date and conditions of the United Kingdom's exit from the European Union. And in mid-January, the US Senate approved the US-Mexico-Canada Agreement (USMCA), removing an important roadblock to that deal.

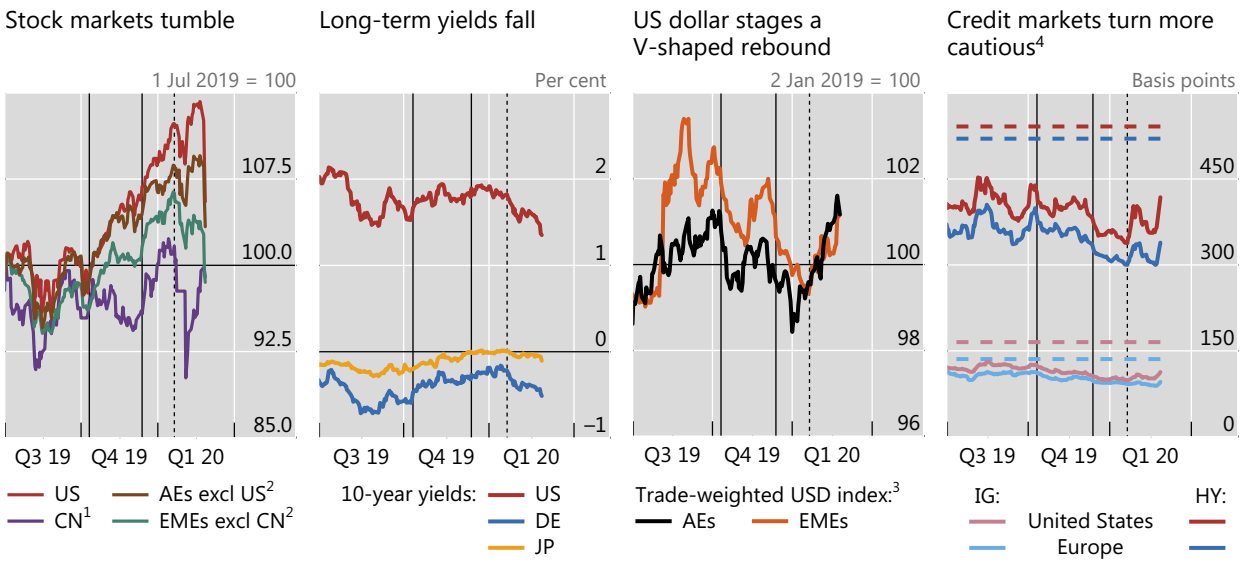
Incoming data during this period reinforced signs that the global economic outlook had turned. The improvement reflected continued healthy labour markets, which supported consumer spending in AEs. In the United States, the housing market was benefiting from the earlier Fed-induced decline in mortgage interest rates, and January survey data pointed to a firming of both consumer and business confidence. Surveys of purchasing managers' expectations (PMIs) released in early January indicated that, despite ongoing weakness in Germany, global manufacturing activity was likely to have bottomed out in December, and factory output was poised to expand. Services PMIs remained resilient to the end of 2019. In addition, corporate earnings announcements in the United States, which largely met or exceeded expectations, also contributed to growing optimism.

Risk assets reacted strongly to the improved economic environment and buoyant sentiment. In the United States the stock market had reached a record high by early January, whereas outside the United States the phase-one deal announcement revived a fading rally (Graph 1, first panel). Measures of compensation for bearing the risk of large declines in equity valuations plummeted, and option-implied volatilities hovered near multi-year lows. Long-term government yields in all major AEs continued on the upward trajectory that had started in October (second panel). Amid surging investor risk appetite, the US dollar depreciated broadly vis-à-vis most currencies, but especially against those of EMEs (third panel).

Corporate bond spreads also narrowed noticeably. In the investment grade segment, spreads declined by about 10 basis points in both the United States and the euro area (Graph 1, fourth panel, light lines). The increase in investor risk appetite was especially apparent in the high-yield segment, where spreads dropped more than 60 basis points in the United States and about 45 basis points in the euro area (Graph 1, third panel, dark lines). In fact, spreads in both segments of the corporate bond market broke through their respective lower bounds of the 2019 trading range and approached multi-year lows.

Sentiment falters on Covid-19 risk-off shock

Graph 1



The solid vertical lines indicate the trading day preceding 11 October 2019 (US announces that a phase-one trade deal with China has been agreed) and 13 December 2019 (US and China announce that the phase-one deal is to be signed the following month). The dashed vertical lines indicate 20 January 2020 (Chinese officials acknowledge that Covid-19 might be transmissible between humans).

The dashed horizontal lines in the fourth panel indicate 2005–current averages.

[1] Shanghai composite equity index. [2] GDP-weighted averages across regional economies. [3] For AEs: advanced foreign economies, goods and services; for EMEs: emerging market economies, goods and services. [4] Option-adjusted spreads.

Sources: Federal Reserve Bank of St Louis, FRED; Bloomberg; Datastream; ICE BofAML indices; BIS calculations.

Global health scare halts sentiment

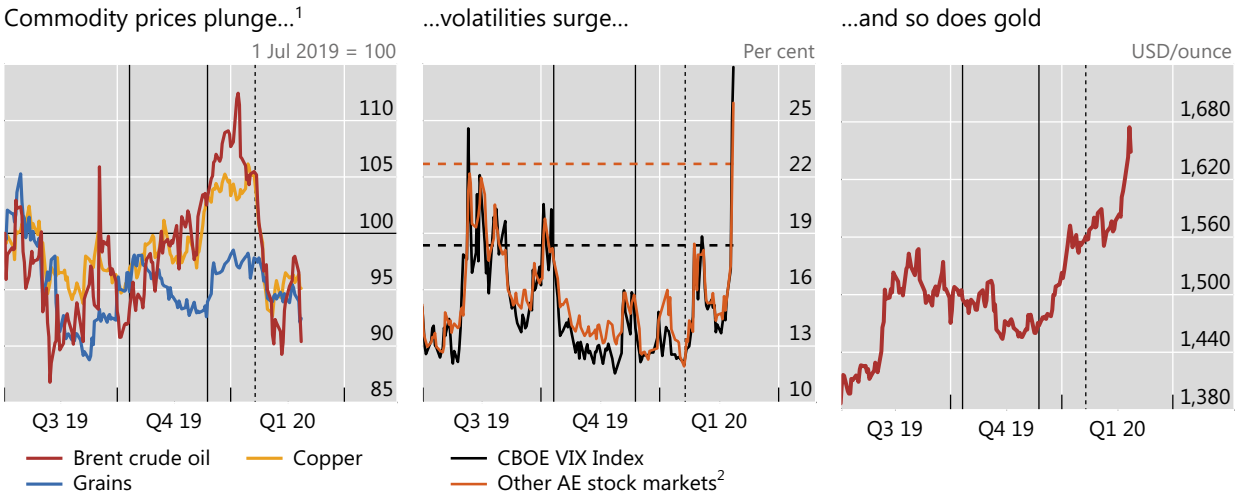
The risk-on phase came to an end in mid-January as concerns mounted over the economic fallout of the Covid-19 outbreak that started in China.[2] Global stock markets swung widely, eventually giving up the gains racked up during the trade-induced rally. Long-term government bond yields in AEs declined sharply, credit spreads widened somewhat, and the US dollar strengthened. As investors began to question the outlook for the global economy, the prices of commodities more closely related to energy, construction and manufacturing dived (Graph 2, left-hand panel).

On 27 January, worries that the outbreak could turn into a pandemic sent global stock indices sharply lower. The losses were large in EMEs and non-US AEs, all of which gave up a portion of the gains that had followed the US-China deal (Graph 1, first panel). In early February, when trading resumed in China after an extended lunar new year break, stock prices nosedived again. Market sentiment appeared to have stabilised in early February, and stock markets largely recouped their previous losses, although they stayed subdued in Asia. The interlude, however, was short-lived: a fresh wave of selling pressure swept across equity markets late in the period, following further evidence of the global spread of the coronavirus. Consistent with a pullback in risk-taking, stock market-implied volatilities jumped across jurisdictions, and the price of gold soared (Graph 2, centre and right-hand panels).

[2] On 20 January, news about the spread of the Covid-19 outbreak rattled markets, as Chinese health authorities acknowledged that there have been cases of human-to-human transmission. That same day, the Chinese leadership issued a directive instructing all levels of government to take actions to curb the spread of Covid-19.

The Covid-19 risk-off shock raises uncertainty

Graph 2



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The dashed horizontal lines in the centre panel indicate 2005–current averages.

[1] Bloomberg commodity indices. [2] Implied volatility of the EURO STOXX 50 and Nikkei 225 indices; weighted average based on market capitalisation.

Sources: Bloomberg; BIS calculations.

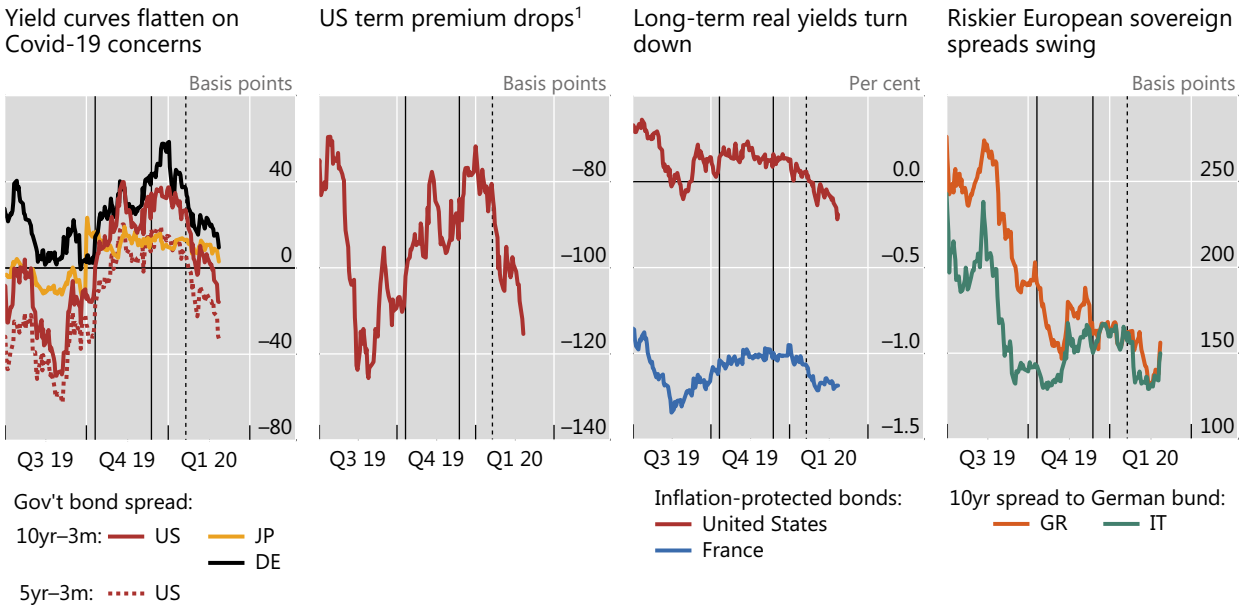
In fixed income markets, the yields of long-term government bonds in AEs declined significantly as investors fretted over the risks to the economic outlook (Graph 1, second panel). During the previous risk-on phase, growing risk appetite had gone hand in hand with steepening yield curves, particularly those of US Treasuries and German bunds (Graph 3, first panel). After being negative for most of 2019, the US 10yr-3m term spread had re-entered positive territory last October, mainly driven by increases in long-term yields. However, as news of the Covid-19 outbreak worsened, longer-dated US yields dropped, pushing the 10yr-3m term spread back into negative territory. The decline in the 10-year yield appeared to be due in large part to a significant drop in the term premium (Graph 3, second panel).

More broadly, the shape of the US term structure suggested that investors were pricing in some additional and persistent monetary accommodation – "low for even longer". In mid-January, the spread between the five-year US Treasury yield and the three-month T-bill rate, a rough gauge of the expected policy path over the medium term, dropped back into the negative range. As news of the virus spreading around the globe roiled financial markets, the 5yr-3m term spread declined further, reaching a level last seen just before the easing of trade tensions in early October (Graph 3, first panel).

During the risk-off phase, a notable decline in estimates of real (inflation-adjusted) long-term yields in major AEs echoed investors' unease about the growth outlook (Graph 3, third panel). During the initial stage of the health scare in late January, the rush into government paper in the euro area did not stop at German bunds, as sovereigns on the periphery also saw their spreads vis-à-vis Germany trimmed (Graph 3, fourth panel). However, later reports of the virus spreading through northern Italy and Korea – in addition to sinking equity markets – sent periphery euro area sovereign spreads back to levels that had prevailed in early January.

With the outbreak, investors rush into government securities

Graph 3



The solid vertical lines indicate the trading day preceding 11 October 2019 (US announces that a phase-one trade deal with China has been agreed) and 13 December 2019 (US and China announce that the phase-one deal is to be signed the following month). The dashed vertical lines indicate 20 January 2020 (Chinese officials acknowledge that Covid-19 might be transmissible between humans).

[1] Ten-year term premium from T Adrian, R Crump and E Moench, "Pricing the term structure with linear regressions", *Journal of Financial Economics*, vol 110, no 1, 2013.

Sources: Federal Reserve Bank of New York; Bloomberg; BIS calculations.

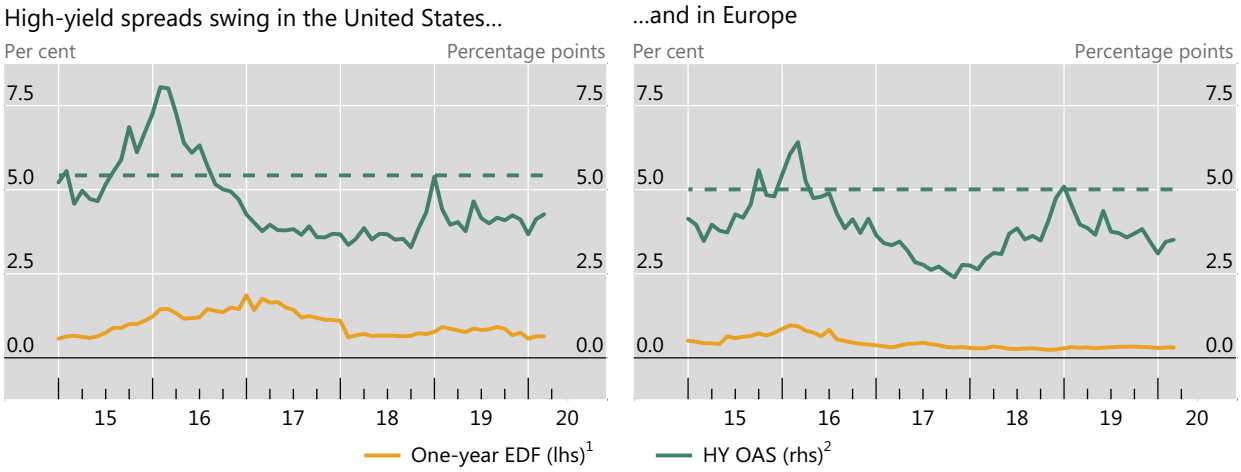
The central banks of major economies maintained a supportive policy stance, and some large EME central banks eased further. Sveriges Riksbank was an exception, as in December it ended its foray into negative policy rate territory. On balance, against a backdrop of still strengthening economic activity, subdued inflation and the monetary easing that had been in place since late 2018, major central banks signalled a pause in near-term policy adjustments. Nevertheless, forward rates in the United States suggested that investors were expecting further rate cuts in 2020, even before the virus outbreak.

Corporate credit markets appeared fairly resilient in the face of the large stock market correction. Both investment and speculative grade spreads widened somewhat in late January as investors started to pull away from risky assets. This momentum accelerated in late February, when fears over the impact of the Covid-19 outbreak sparked a sell-off in high-yield bonds. Swings in credit market sentiment can be assessed by the gap between the high-yield spread and the expected year-ahead default probability, a rough gauge of the credit risk premium. In early January, as high-yield spreads in both jurisdictions neared their recent lows, this premium approached the 30th percentile of its historical distribution in the United States (Graph 4, left-hand panel); in Europe, the same measure declined to around the 15th percentile of its historical distribution (Graph 4, right-hand panel). As sentiment soured late in the review period, the increase in risk aversion was relatively moderate: in the United States, the credit risk premium moved slightly above the 45th percentile of its historical distribution, whereas in Europe it returned to about the 30th percentile, levels that had prevailed before the onset of the risk-on phase.

Changes in risk appetite in bank-intermediated markets for business credit were mixed. According to the lending surveys released by the Federal Reserve and the ECB earlier this year, US and euro area banks did not change, on net, their lending

Credit market sentiment stirred, but not shaken

Graph 4



The dashed horizontal lines indicate 2005–current averages.

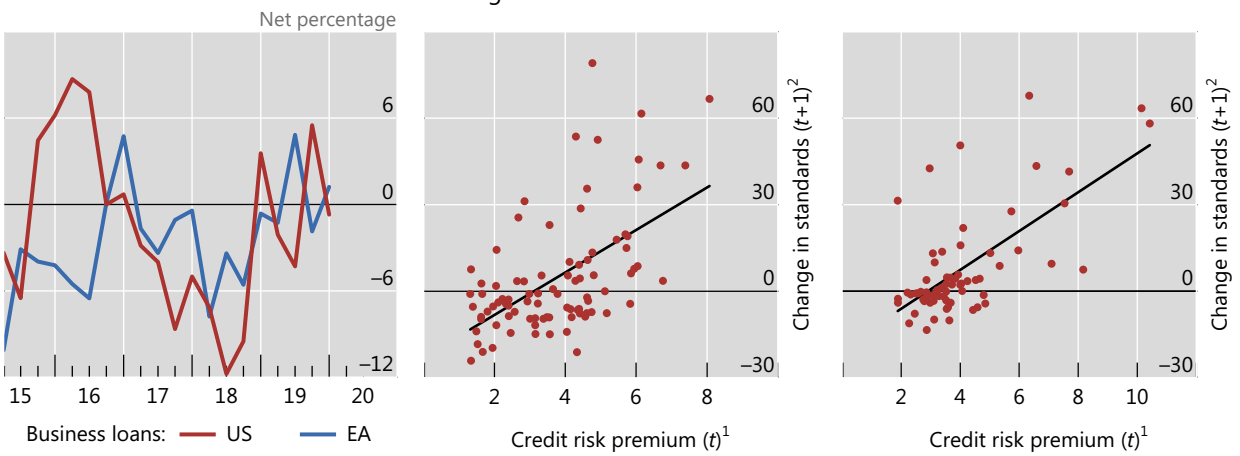
[1] Non-financial corporates, liability-weighted average; Europe = AT, BE, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, NL and PT. EDF = expected default frequency. [2] Option-adjusted spreads (OAS), non-financial corporates.

Sources: ICE BofAML indices; CreditEdge; BIS calculations.

standards on business loans during the fourth quarter of 2019 (Graph 5, left-hand panel). However, issuance of leveraged loans in the United States and Europe during January 2020 surged to twice the amount recorded in January 2019. From a longer-term perspective, buoyant risk appetite in corporate bond markets tends to be closely associated with subsequent easing of banks' lending standards (Graph 5, centre and right-hand panels). In light of the recent increase in credit risk premia in both the United States and Europe, bank lending standards are unlikely to loosen in the near term. In turn, that may lead to opportunities for non-bank financial intermediaries to further increase their footprint in the market for loans to small and medium-sized businesses (Box A).

Bank lending standards unlikely to ease

Graph 5



[1] Calculated as high-yield option-adjusted spreads minus one-year expected default frequency (EDF), in percentage points; European one-year EDF has been calculated across AT, BE, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, NL and PT non-financial corporates. Extreme observations for Q4 2008 and Q1 2009 have been excluded. [2] Net change in standards on business loans during quarter $t+1$, as a net percentage. For the United States, from the Fed Senior Loan Officer Opinion Survey on Bank Lending Practices (average of large, middle-market and small firms); for Europe, from the ECB Euro Area Bank Lending Survey.

Sources: ECB; Board of Governors of the Federal Reserve System; ICE BofAML indices; CreditEdge; BIS calculations.

Discerning investors in EMEs?

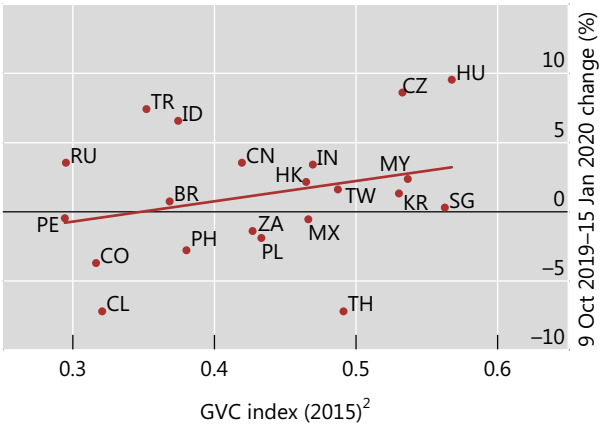
The Covid-19 outbreak had a differentiated impact on the prices of EME assets, as investors refrained from a wholesale sell-off during the period under review. During the trade-related risk-on phase, EME assets extended the rally triggered last October, and the stocks of countries more closely integrated in GVCs appeared to have benefited more. With mounting evidence of the increasing threat represented by the new viral infection, EME share prices and currencies pared their earlier gains, with the losses concentrated on countries closer to China geographically or economically.

Amid the significant reduction in trade tensions, investors appeared to have favoured the stock markets of countries more embedded in manufacturing GVCs. Once the overall effect of the appreciation of global stock markets during this period is taken into account, equity markets in GVC countries generally outperformed those of commodity producers (Graph 6, left-hand panel). This finding suggests that investors expected larger gains from those markets in which firms would benefit, directly or indirectly, from a resumption of "business as usual" in global manufacturing processes. Markets dominated by commodity producers, in contrast, may not see an improvement in business conditions until manufacturing production increases materially, and commodity inventories are wound down.

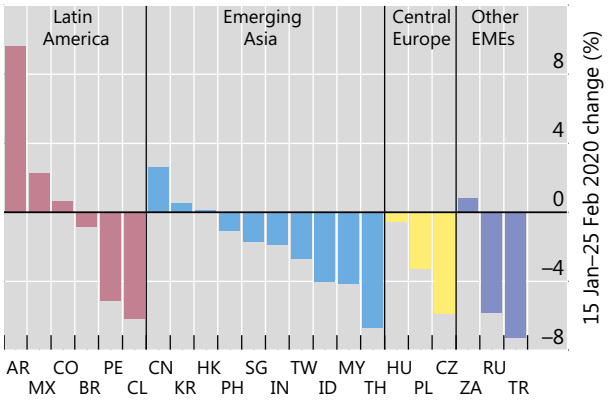
On net, those stock market gains largely evaporated as the health scare spooked global financial markets. While equity prices fell across the globe, once this general effect is accounted for, the declines were more pronounced in Asia. In contrast, the same measure of idiosyncratic stock market performance points to a better outcome in geographically distant Latin America, which is mostly linked to China through commodity exports (Graph 6, right-hand panel). In the case of Mexico, for instance, the relatively strong idiosyncratic stock market returns seemed connected to the positive news on the USMCA. Market commentary had drawn numerous comparisons with the 2003 outbreak of severe acute respiratory syndrome (SARS). Such comparisons, however, are inherently difficult, given the profound changes in the global economy and financial markets over the past 20 years. Box B provides an

EME stock markets reflect differential reactions to shocks[1] Graph 6

Easing of trade tension favoured stocks of countries more integrated in GVCs…



…and Covid-19 losses mounted for countries with closer economic ties to China



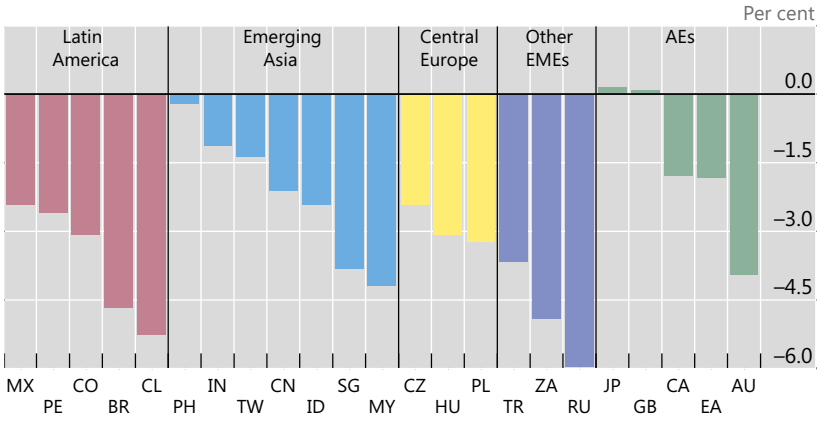
[1] Cumulative idiosyncratic returns over the specified periods. [2] The GVC index is the ratio (for each respective country) of the sum of foreign value added content of gross exports and gross imports of intermediate goods to the sum of total gross imports and total gross exports. A value closer to 1 (0) indicates a greater (lesser) inclusion in GVCs. Data from 2015.

Sources: OECD; Datastream; BIS calculations.

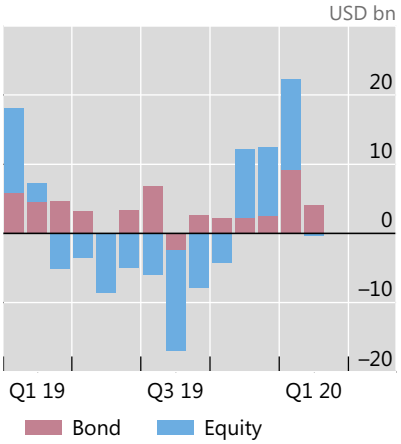
Dollar appreciates against EME currencies, yet inflows remain resilient

Graph 7

Dollar appreciates after Covid-19 outbreak[1]



Portfolio flows to EMEs surge in January[2]



[1] Change between 19 January 2020 and 25 February 2020. A negative value indicates USD appreciation. [2] Monthly sums of weekly data up to 19 February 2020; excluding AR.

Sources: Bloomberg; EPFR; BIS calculations.

additional perspective on this comparison based on the reaction of stock markets now and then.

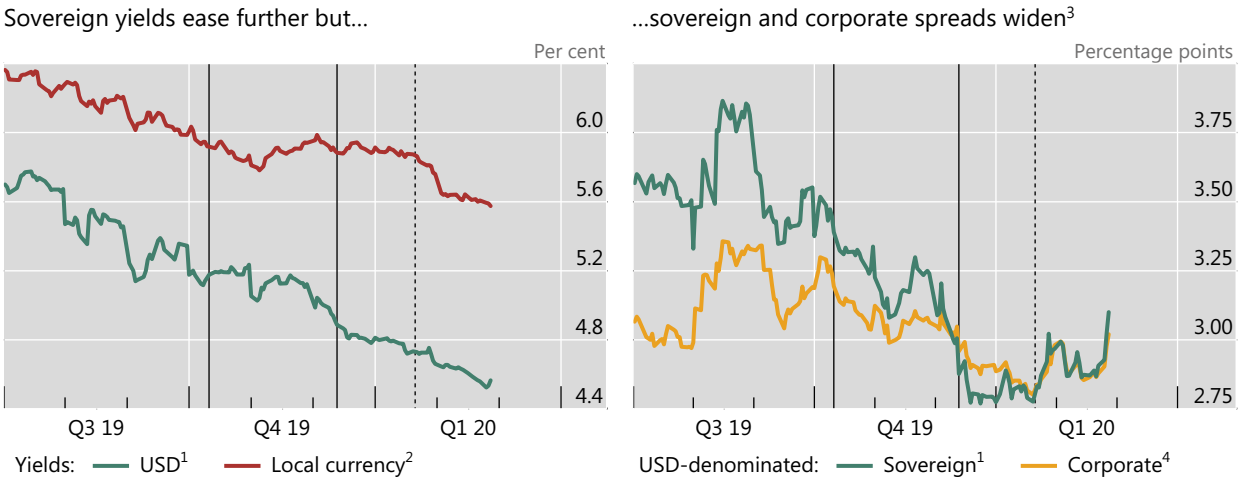
Swings in FX markets were similar to those in stock markets. On balance, EME currencies strengthened significantly against the US dollar during the period under review (Graph 1, third panel, orange line). In trade-weighted terms, EME currencies had hit a trough in early September 2019, after the breakdown in US-China trade negotiations, and rallied thereafter. The appreciation picked up pace after the signing of the phase-one deal. To be sure, the dollar strengthened materially with the onset of the virus risk-off episode. But within each geographical region, including AEs, large commodity exporters and countries with close economic links to China saw a stronger depreciation (Graph 7, left-hand panel).

As was the case in AEs, price reactions in EME fixed income markets were more restrained than those of other asset classes. Yields of US dollar-denominated sovereign debt continued to trend lower throughout the last quarter of 2019 and into late February (Graph 8, left-hand panel, green line). The decline in EME yields throughout this period reflected, in part, robust capital flows into EME bond and equity investment funds (Graph 7, right-hand panel). An index of local currency sovereign yields also eased during the period under review, mainly driven by declines in the yields of Brazil and Turkey (Graph 8, left-hand panel, red line).

The appetite for US dollar-denominated EME corporate debt remained robust amid swings in investor sentiment. During the risk-on phase, the spreads on EME corporate debt breached the floor of the range in which they had traded during most of 2019, reaching levels comparable to those observed during the first half of 2018, before the escalation of trade tensions (Graph 8, right-hand panel, yellow line). At the same time, the spreads on US dollar-denominated EME sovereign debt narrowed at a quicker pace, slipping below those on corporate debt (Graph 8, right-hand panel, green line). Although EME credit spreads (sovereign and corporate) widened noticeably in response to the Covid-19 outbreak, the increase was due almost entirely to a decline in comparable-maturity US benchmark yields. This pattern had characterised fluctuations in EME spreads throughout 2019 and suggests that recent

EME government yields trend down, while US benchmarks move spreads

Graph 8



The solid vertical lines indicate the trading day preceding 11 October 2019 (US announces that a phase-one trade deal with China has been agreed) and 13 December 2019 (US and China announce that the phase-one deal is to be signed the following month). The dashed vertical lines indicate 20 January 2020 (Chinese officials acknowledge that Covid-19 might be transmissible between humans).

[1] JPMorgan Chase EMBI Global index. [2] JPMorgan Chase GBI-EM index. [3] Stripped spread. [4] JPMorgan CEMBI index.

Sources: JPMorgan Chase; BIS calculations.

swings in investors' sentiment have had a larger impact on the US benchmarks – possibly through movements in the term premia – than on the corresponding EME yields.

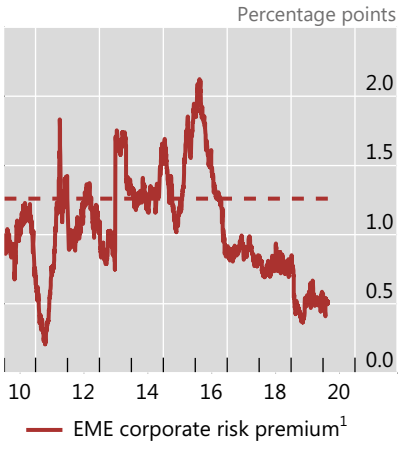
Despite some repricing, the compensation for bearing EME corporate credit risk has hovered at low levels by historical standards. As noted, the spread between EME dollar-denominated corporate and sovereign debt, as measured by the difference between the CEMBI (corporate) and the EMBI Global (sovereign), turned positive during the risk-on phase. This move re-established the expected relationship between spreads demanded by investors in these two asset classes. The spread inversion that had persisted for some time is wholly accounted for by the difference in the set of EMEs included in the two indices. In fact, such an anomaly disappears when corporate and sovereign spread indices are constructed using a matched sample of underlying EMEs (Graph 9, left-hand panel). According to this metric, EME corporate risk premia are quite compressed, sitting well within the lowest decile of their historical distribution. Moreover, they were largely unaffected by factors that shaped developments in financial markets over the past year.

Investors' sanguine outlook for the EME corporate bond market is consistent with the steady investment flows into EME bond funds, which surged in January and continued through mid-February. Historically, such inflows are strongly associated with low levels of risk compensation in this market (Graph 9, centre panel). Investors' robust appetite for EME fixed income assets is also evident in a significant decline in the correlations between yields on dollar-denominated sovereign bonds and the trade-weighted US dollar across a range of EMEs (right-hand panel). Against this backdrop, EME corporates issued a record amount of foreign currency-denominated bonds in the first few weeks of the year.

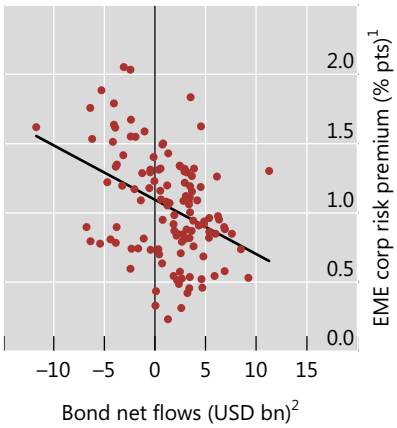
Appetite for EME assets remains strong

Graph 9

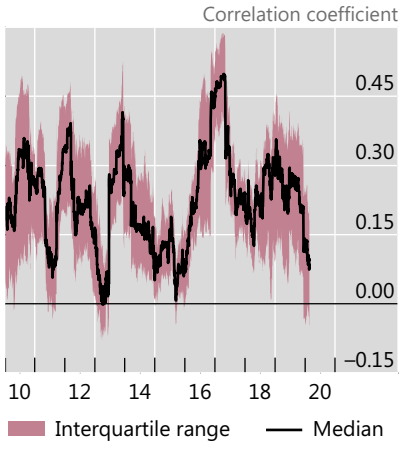
Corporate risk premia are compressed…



…as suggested by sustained strong bond portfolio inflows



Correlation between USD and EME government yields stays low[3]



The dashed horizontal line in the left-hand panel indicates 2007–current averages.

[1] Weighted average of country-matched version of JPMorgan EMBI Global index and CEMBI index stripped spreads. [2] Monthly sums of weekly data up to 31 January 2020; excluding AR. [3] 120-day rolling correlation between the change in the country-specific EMBI Global sovereign yield and the percentage change in the trade-weighted US dollar broad index.

Sources: Federal Reserve Bank of St Louis, FRED; Datastream; EPFR; JPMorgan Chase; BIS calculations.

Box A

Private credit: recent developments and long-term trends

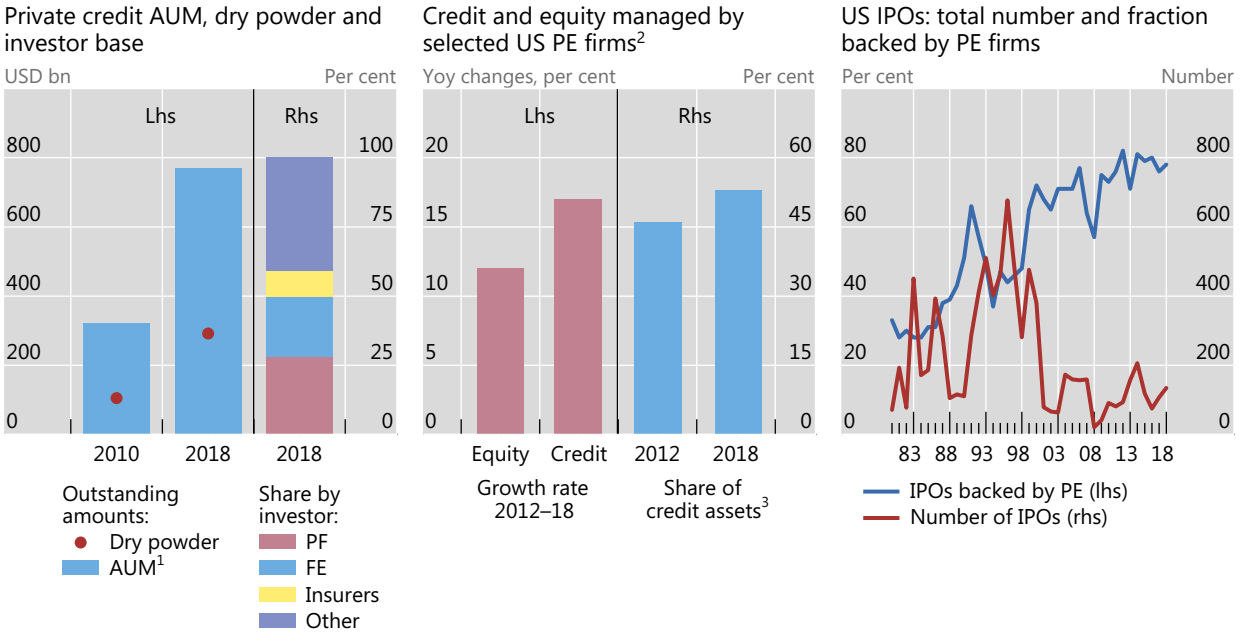
Sirio Aramonte[①]

Non-bank investors are increasingly extending loans directly to firms, with limited involvement on the part of banks. Such lending is frequently referred to as private credit, to distinguish it from bank-intermediated credit.[②] Private credit is typically offered to firms that are smaller, with earnings well below $100 million, than those borrowing through leveraged loans, which are originated mostly by banks. The outstanding amount of private credit grew from little more than $300 billion in 2010 to nearly $800 billion in 2018 (Graph A, left-hand panel, first two bars). The leveraged loan market is larger, yet the nearly $500 billion increase in private credit between 2010 and 2018 mirrored the approximately $600 billion rise in leveraged lending. The growth of private credit represented about 8% of the expansion in credit to non-financial corporates (NFCs) in advanced economies (AEs) over the 2010–18 period. Surveys indicate that roughly half of private credit asset managers invest predominantly in the United States, one fourth focus on the United Kingdom, and the remainder are spread around the world.[③]

There are structural similarities between the private credit and leveraged loan markets. First, the respective investor bases overlap substantially. As of end-2018, insurance companies and pension funds together backed about one third of private credit (Graph A, left-hand panel, third bar) and one fourth of leveraged loans (either directly or through collateralised loan obligations (CLOs)). The combined exposure of these intermediaries to high-yield corporate loans totalled nearly $600 billion. Second, asset managers that oversee funds investing in private credit also manage CLOs and other leveraged loan funds. Third, lack of transparency in post-origination loan trading, together with the opacity of the leverage some investors take on, complicates the mapping of credit risk exposures.

Growth of private credit

Graph A



AUM = assets under management; FE = foundations/endowments; PE = private equity; PF = pension funds.

[1] As of end-year (as of June for 2018). [2] Calculations from 10-K filings. Companies are Apollo Global Management, Blackstone Group, The Carlyle Group and KKR & Co. "Credit" refers to all credit assets. [3] Share is calculated as credit AUM divided by the sum of credit and equity AUM.

Sources: IPE, "Private debt activity slowed sharply in 2019, but 2020 starts crowded", 13 January 2020; McKinsey&Company, "Private markets come of age", *McKinsey Global Private Markets Review*, 2019; Preqin, *2019 Preqin Global Private Debt Report*; Preqin Insights, "Private debt dry powder: Europe and North America-based managers seeing fundraising success", 13 November 2015; Jay R Ritter, *Initial public offerings: updated statistics*, University of Florida, Table 4, 2018; company reports; author's calculations.

While the growth in private credit is a decades-long trend, it accelerated after the Great Financial Crisis (GFC) of 2007–09. Banks had started retrenching from credit provision to the US corporate sector as early as the mid-1980s, and the current size of private credit and leveraged lending combined amounts to no less than about 90% of US banks' commercial and industrial loans.④ Post-GFC, the expansion of private credit was fuelled by the combination of stagnating bank asset growth and attractive private debt yields relative to syndicated loans. The 2% higher yield has been key in attracting investors such as pension funds and insurance companies, which added private credit to their portfolios of leveraged loans and CLOs. These investors have stronger incentives to reach for yield because they often need to meet absolute return targets.

Even though banks are not involved in the origination of private credit, they are still exposed to developments in this market through the provision of leverage to private credit funds. Slightly less than 50% of portfolio managers reported borrowing against fund assets. Typically, the ratio of debt to equity is less than two. About 40% of portfolio managers borrowed using subscription credit lines, whose collateral is a fund's "dry powder", or undrawn capital commitments made by investors.⑤ Subscription credit lines are meant to reduce the frequency of capital calls, and are typically provided by banks. Private credit funds have nearly $300 billion of dry powder ready to be invested should suitable opportunities arise (Graph A, left-hand panel). As a result, subscription credit lines are a potentially significant channel of indirect bank exposure to private credit, echoing the indirect exposure of banks to CLOs that arises from prime brokerage financing to hedge funds.⑥

Private equity (PE) firms have taken on an increasingly central role in private credit. In addition to financing mergers and acquisitions, PE firms traditionally provided equity to small or distressed firms for early development or restructuring, in the form of venture capital or buyouts. Besides gaining expertise in financing high-risk businesses, PE firms also built relationships with a broad set of potential borrowers. Indeed, private credit lenders expected that one third of future lending opportunities would arise from collaboration with PE firms. Building on their expertise and relationships, several PE firms expanded the number of credit funds they set up and manage, including those specialising in private credit. Among the main US PE firms, the assets under management (AUM) of their credit funds rose by 17% per year between 2012 and 2018, compared with 12% for their equity funds. In 2018, credit AUM stood at $430 billion and represented 53% of equity and credit AUM combined, up from 46% in 2012 (Graph A, centre panel).

PE firms took on a more prominent role in private credit at the same time as they grew their influence on early-stage equity financing. While the overall number of initial public offerings (IPOs) in the United States declined substantially between 1995 and 2018, from 461 to 134, a larger fraction of IPOs, from 47% to 78%, were by companies backed by PE firms in the form of venture capital or buyouts (Graph A, right-hand panel).

The emerging ecosystem of credit provision to small and medium-sized firms raises issues concerning financial stability and investor protection. Four stand out: first, the interaction between unexpectedly large losses and lender vulnerabilities; second, potentially heightened procyclicality in loan supply; third, possible conflicts of interest linked to the more prominent and multifaceted role of PE firms; and fourth, the relative opacity of certain strategies that raise effective leverage above reported values.

Unexpectedly large losses could have significant adverse effects on certain lenders. Much as in the market for leveraged loans, higher yields on private credit loans have attracted investors, and strong demand has been accompanied by deteriorating covenant protection. Roughly 30% of portfolio managers indicated that loan covenants had become less stringent in 2018, compounding the loosening observed during the previous three years. While much of private credit takes the form of secured loans, which have relatively high recovery rates, any repricing would be sharper if weaker covenants had lowered recovery rates. Sizeable losses could be particularly detrimental to some lenders, especially at times of limited access to wholesale credit. For instance, insurance companies could have difficulties meeting unusually large cash flow shortfalls with asset sales, even if these shortfalls were relatively small compared with their portfolios, due to asset-liability matching.⑦

Private credit might prove strongly procyclical, as fund managers have incentives to time the (illiquid) market. Unlike mutual funds, private credit funds are typically closed-end and investors cannot withdraw capital in the event of persistently poor fund returns. However, AUM growth depends on past performance. To avoid losing future AUM to competitors, fund managers might scale back loan origination and dispose of existing loans at the first signs of a downturn, before already low market liquidity declines further. Funding costs for smaller firms would increase rapidly, unless appropriate hedges are in place, since most private credit loans have floating interest rates.

Conflicts of interest could arise if equity and credit funds managed by a PE firm invested in the equity and debt of the same company. In principle, private credit investors could, for instance, face the risk of unexpected losses in the event of debt restructurings unduly favourable to equity holders. To be sure, investors already benefit from the oversight of securities regulators on PE firms in both Europe and the United States. Even so, the intrinsic opaqueness of private credit borrowers, on top of market illiquidity, poor loan-price transparency and increasing deal leverage, could lead lenders to further minimise risks by consolidating assets at incumbent PE firms with an established reputation. As a result, smaller companies could have fewer funding options.

Private credit funds can employ certain strategies that increase effective leverage above reported leverage. For instance, business development companies (BDCs) are US funds that typically invest in loans to small companies. While subject to strict leverage limits, certain BDCs purchase loans through vehicles in which BDCs hold a subordinated interest, thus increasing the sensitivity of their returns to loan values, just as leverage would. Overall, these strategies can make it harder for investors in private credit funds to gauge risk accurately.

① The views expressed are those of the author and do not necessarily reflect the views of the Bank for International Settlements. ② This box focuses on corporate loans, but the term "private credit" is sometimes interpreted as also including other types of non-bank credit (for instance, infrastructure and real estate debt). The defining characteristic of the various types of private credit is the limited involvement of banks at origination. ③ Survey statistics on regional concentration are from Alternative Credit Council, "Financing the economy 2017", 2017. ④ Trends in bank lending are from Federal Deposit Insurance Corporation, "Leveraged lending and corporate borrowing: increased reliance on capital markets, with important bank links", *FDIC Quarterly*, December 2019. ⑤ Figures on fund leverage are from Alternative Credit Council, *Financing the economy 2018*, 2018. ⑥ 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. ⑦ See N Foley-Fisher and B Narajabad and S Verani, "Assessing the size of the risks posed by life insurers' non-traditional liabilities", *FEDS Notes*, 21 May 2019.

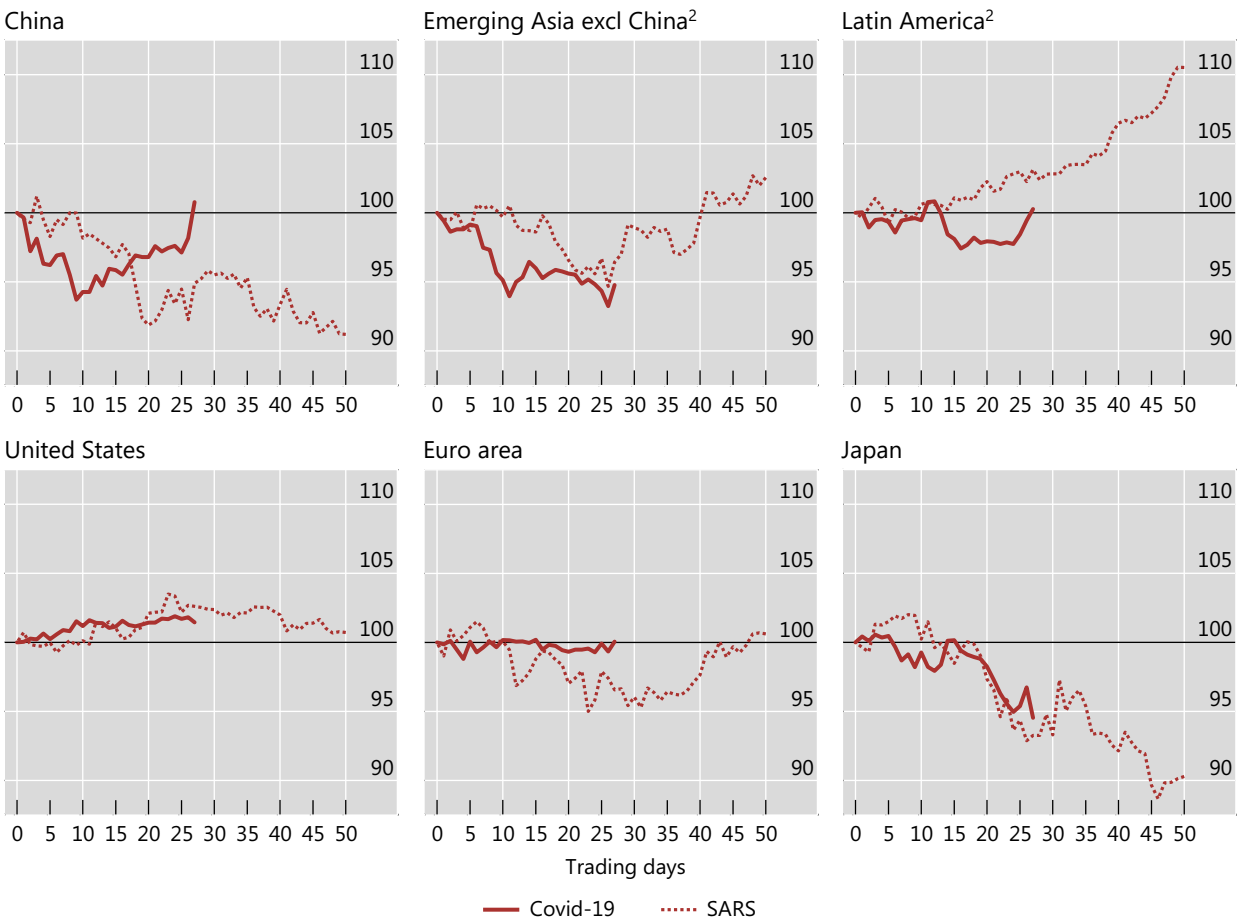
Covid-19 and SARS: what do stock markets tell us?

Fernando Avalos and Egon Zakrajšek[①]

The rapid spread of Covid-19 since mid-January invariably brings up a comparison with the early 2003 outbreak of severe acute respiratory syndrome (SARS). In this box, we provide a preliminary assessment of the relative impact of the Covid-19 and SARS epidemics on various economies through the lens of equity investors. An advantage of looking at the stock markets of different countries is that equity valuations should encompass both the local and global risk factors that the investors view as important. Fluctuations in the global risk factor – gauged, for instance, through the returns on the MSCI Global index – may be driven by investors' concerns about the global economic fallout of a virus outbreak. Such fluctuations are likely to have a differential effect on each country's stock market performance; moreover, the magnitude of these effects is likely to have changed in the nearly two decades between the two epidemics.② Nevertheless, we can calculate "idiosyncratic" stock returns, the portion of a country-specific stock return that is not explained by fluctuations in the global risk factor, as the residual from a regression of the country's returns on the returns on the MSCI Global index.③ The comparison of the idiosyncratic country-specific returns during periods in which the Covid-19 and SARS epidemics unfolded can thus provide a cleaner assessment of the relative fallouts from the two outbreaks across countries and time, at least as perceived by equity investors.

Compared with SARS, Covid-19 front-loads costs for China and emerging Asia[1]

Index of cumulative idiosyncratic returns — Graph B



[1] Reference point "Day 0" for SARS and Covid-19 is, respectively, 7 February 2003 (China notifies the SARS outbreak to the World Health Organization) and 19 January 2020 (the day before Chinese officials acknowledge that Covid-19 might be transmissible between humans). For Covid-19, updated to 25 February 2020. [2] Simple averages of regional economies.

Sources: Datastream; BIS calculations.

According to this metric, the Covid-19 outbreak appears to have had an appreciably more front-loaded adverse effect on the Chinese stock market than the 2003 SARS epidemic (Graph B, first panel). Abstracting from the Chinese stock market's co-movement with the global market, Chinese equity valuations were down more than 5% after the 10th trading day following the news of the outbreak. In contrast, it took about 20 trading days for the Chinese market to incur such a loss during the SARS epidemic, as the very early phase of the outbreak saw a performance quite in line with the global MSCI. Part of this difference may be explained by the more forceful reaction of the Chinese authorities to the Covid-19 outbreak, which may have cued investors about the seriousness of the problem, whereas in the past this realisation took longer to be priced in. After the 10th trading day Chinese stocks began to recoup their losses vis-à-vis the global market, while during the SARS epidemic losses continued to cumulate for a considerably longer period.

Emerging Asian stock markets outside China also suffered greater losses initially than during the SARS outbreak (second panel). This result is likely to reflect the increase in China's global economic imprint, and its greater integration in the world economy since the first epidemic, as well as the proximity of Asian economies to the epicentre of the Covid-19 outbreak. By the 20th trading day, however, the cumulative losses in those markets had roughly converged to those registered during the SARS epidemic. The average initial impact of the Covid-19 outbreak on the stock markets of emerging market economies in Latin America, again controlling for their co-movement with the global market, had been very muted and in line with that of the SARS epidemic (third panel). In early February, however, the performance of stock markets in Latin America deteriorated noticeably. This may be partly explained by investors' growing concerns that weak commodity prices are unlikely to recover soon, which would have a negative effect on those economies. Back in 2003, in contrast, commodity prices were in the early stages of a sustained rally that was interrupted only by the Great Financial Crisis of 2007–09.

Turning to advanced economies, the fallout on US and Japanese equities from the Covid-19 outbreak roughly paralleled that from SARS for the first 25 trading days following the news of the respective outbreaks (fourth and sixth panels). In contrast, the idiosyncratic performance of euro area stocks has thus far been slightly better than that registered during the comparable period of the SARS epidemic (fifth panel).

① The views expressed are those of the authors and do not necessarily reflect the views of the Bank for International Settlements. ② The global risk factor should also reflect other features of the environment that were influencing stock market developments in different countries at different times. For example, the global economy during the SARS outbreak, which began in November 2002 and spread most rapidly between February and April 2003, was in a state of lingering weakness following the 2001 dotcom bust and the ensuing recession. The Covid-19 outbreak, by contrast, occurred during one of the longest economic expansions on record, with robust labour markets and solid consumer spending worldwide. The SARS epidemic also coincided with escalating political tensions that culminated in the Iraq war in mid-March 2003, a sequence of events that had its own effect on financial markets and the global economy. The Covid-19 outbreak, in contrast, is unfolding amid swings in trade-related tensions that have had a significant effect on stock markets throughout the world. ③ The regression is based on the capital asset pricing model (CAPM).

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Shaping the future of payments

Technology is transforming payment systems. The pace of change and potential for disruption to incumbent service providers have propelled payment systems to the top of policymakers' agenda. The BIS and central banks have a leading role in shaping the response.

JEL classification: E42, E58.

Technology is transforming payments. Digital innovation is disrupting the instruments (eg cash) and institutions (eg banks) that have historically dominated payments. New players are developing innovative payment solutions that compete with traditional means of payment provided by banks. Incumbents are also redesigning payment systems to make them faster, cheaper and easier to use. And consumers have come to expect continuous improvements in the convenience and safety of payment services.

This special issue of the BIS Quarterly Review examines the fast-changing world of payments. The five articles explain the strengths and shortcomings of existing payment systems, describe how these systems are changing and assess emerging solutions.[1]

Innovations are shaking up payment systems

Payment systems are vital to the functioning of the economy. A payment system is a set of instruments, procedures and rules for the transfer of funds between participants. Safe and efficient transfers underpin the purchase and sale of goods, services and financial instruments. Indeed, a pre-condition for engaging in transactions is trust that payments will be executed.

Established payment systems have evolved to become safer, faster and cheaper. As Bech and Hancock (2020, in this issue) explain, wholesale payment systems – for large-value transfers, mainly between banks – have experienced successive waves of innovation over the past few decades. Retail payment systems – for low-value but high-volume transfers between consumers and businesses – initially lagged behind but are now changing rapidly. Changes to payment systems require coordination among many participants. Wholesale systems typically have a small number of

[1] The views expressed in the articles are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

Key takeaways

- The pace of change and potential for disruption have propelled payment systems to the top of policymakers' agenda.
- The BIS and central banks have a leading role in shaping policymakers' response to these changes.

participants and include the central bank in a leading role, which helps to align incentives to change. As a result, innovations are simpler to develop and implement in wholesale systems.

Retail payment systems are becoming increasingly convenient, instantaneous and available 24/7. Nevertheless, payment systems still suffer from shortcomings in two areas: access and cross-border payments. Large numbers of people have limited or no access to a bank or other type of account for making payments, especially in emerging market and developing economies. Obstacles to opening a payment account include high costs and a lack of documentation or trust. Furthermore, cross-border payments remain slow, expensive and cumbersome. As Bech, Faruqui and Shirakami (2020, in this issue) explain, the coordination problem among participants is especially acute for cross-border payments because changes involve multiple systems, currencies, and legal and regulatory regimes. Furthermore, risks associated with money laundering and terrorist financing can be more difficult to manage across borders.

A high share of cross-border payments flows through correspondent banks. Correspondent banking is an arrangement whereby one bank holds deposits owned by other banks and provides those banks with payment and other services. The number of correspondent banks fell by about 20% between 2011 and 2018. Rice, von Peter and Boar (2020, in this issue) find that all regions experienced a decline, not only those jurisdictions with a blemished record for corruption or inadequate cross-border information-sharing. The retreat of correspondent banks is a potential concern because it might result in higher costs for cross-border payments, less diversity in available products or services, or even a loss of access to the global banking system, all of which in turn could lead to greater use of informal, unregulated payment networks.

Technology is expanding the options for cross-border payments. Fintech and big tech companies are increasingly offering cross-border payment services. Other initiatives aim to improve the infrastructure that links payment service providers in different countries. Bech, Faruqui and Shirakami (2020, in this issue) review initiatives to build payment systems designed to operate across borders, link domestic payment systems or establish procedures for payment service providers to access systems remotely. While there are currently a small number of functioning examples, including in Mexico, South Africa and Switzerland, more such initiatives are being implemented or planned. If successful, these initiatives could help bank-based payment systems remain competitive with alternative arrangements.

The most transformative option for improving payments is a peer-to-peer arrangement that links payers and payees directly and minimises the number of intermediaries. Many peer-to-peer arrangements use distributed ledger technology (DLT). Whereas account-based systems record transactions in a central ledger, DLT systems record transactions in multiple places at the same time, resulting in a decentralised, synchronised ledger. Examples that have garnered attention in recent years include Bitcoin and so-called "stablecoin" initiatives like Libra.

Central banks are increasingly exploring the desirability and feasibility of establishing their own peer-to-peer systems through digital currencies. Auer and Böhme (2020, in this issue) identify features that a central bank digital currency (CBDC) needs to become a trusted and widely usable medium for retail payments. These include scalability, accessibility, convenience, resilience and privacy. Various technical designs differ in how well they support these features; the challenge is to design a CBDC that combines the virtues of a direct claim on the central bank with the convenience offered by intermediaries.

Auer, Cornelli and Frost (2020, in this issue) find that the results of past CBDC pilot projects are mixed, with some projects determining that the costs exceed the benefits but others advancing towards implementation. Central banks in emerging market economies in particular are moving from conceptual research to practical development (Boar, Holden and Wadsworth (2020)).

Peer-to-peer arrangements also have the potential to transform wholesale payments. Bech, Hancock, Rice and Wadsworth (2020, in this issue) analyse how tokenisation – or the digital rendition of assets – could improve the clearing and settlement of securities. They conclude that tokenisation might reduce costs and complexity but does not eliminate the risks associated with one party failing to settle transactions. The success of token-based settlement systems could depend on how well they interact with traditional account-based systems.

BIS and central banks have a leading role

The pace of change and potential for disruption have propelled payment systems to the top of policymakers' agenda. Indeed, as president of the G20 in 2020, Saudi Arabia has made improving cross-border payments one of the G20's priorities (G20 FMCBG (2020)). The BIS is taking a leading role in these efforts.

The G20's efforts are led by two bodies hosted by the BIS: the Financial Stability Board (FSB) and the Committee on Payments and Market Infrastructures (CPMI). The FSB, in coordination with the CPMI and other relevant international bodies, is developing a roadmap to enhance cross-border payments (FSB (2019)). The roadmap will include practical steps and indicative time frames and will be published before the G20 Leaders' Summit in November 2020. As part of this work, the CPMI is identifying the building blocks for an improved system of cross-border payments. In particular, it is investigating the current cost structure, frictions and risks of cross-border payments and identifying potential private and public sector actions to address them.

Central banks have a core role in payment systems, and the changes under way require them to step up and play a more significant part in improving the safety and efficiency of these systems. Money and payment systems are founded on trust in the currency – whether cash or digital – and this trust is something that only the central bank can ensure. It is a "central bank public good": the trust underpinned by the central bank establishes a solid foundation on which innovative payment solutions can be built (Carstens (2019a)).

The BIS has established its Innovation Hub to spearhead central banks' response to digital innovation. The Hub's mission is to foster international collaboration on innovative financial technology within the central banking community. Its mandate is threefold. First, it will identify and develop in-depth insights into critical trends in

financial technology of relevance to central banks. Second, it will explore the development of public goods to enhance the functioning of the global financial system. And third, it will serve as a focal point for a network of central bank experts on innovation.

Digital innovation knows no borders, and thus the BIS is setting up its Innovation Hub in multiple locations in partnership with central banks. The first Hub centres were launched in late 2019 in Hong Kong SAR, Singapore and Switzerland. Initially, the Hub will build on the efforts of central banks that have made significant advances in digital innovation (Carstens (2019b)). In doing so, the Hub will catalyse collaborative efforts among central banks, and cooperate, when appropriate, with academia, financial service providers and the broader private sector to develop public goods for the benefit of the global financial system. As the Hub gathers experience, a home-grown agenda will quickly be developed. A key question informing the BIS Innovation Hub's work is whether money itself needs to be reinvented for a changing environment, or whether the emphasis should be on improving the way it is provided and used.

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Innovations in payments[1]

Technological innovation is transforming payments. Domestic payments are increasingly convenient, instantaneous and available 24/7. However, shortcomings in access to payments and cross-border payments remain. Lack of access to payments is a problem in some emerging market and developing economies. Improving cross-border payments will require international coordination. Initiatives to improve cross-border payments would benefit from better data to quantify both the extent and the drivers of the problems.

JEL classification: E42.

Technological innovation is transforming financial services and products. Payments have been and continue to be the activity most affected by technological innovation (Petralia et al (2019)). Recent years have seen the introduction of new payment methods, platforms and interfaces, and there are more projects under way.

Despite this, there are two major shortcomings in payments: access and cross-border payments. There are 1.7 billion adults globally who are tied to cash as their only means of payment, as they do not have a transaction account[2] (World Bank (2018)). In addition, cross-border payments remain slow, expensive and opaque, especially retail payments such as remittances. The interaction of these two shortcomings is a particular challenge for emerging market and developing economies (EMDEs), where remittances account for a substantial proportion of GDP. Recent so-called "stablecoin" initiatives have highlighted these shortcomings and the importance of improving the access to transaction accounts and cross-border payments in particular.[3]

This feature provides a primer on the key concepts in payment systems. It goes on to describe how innovation is making domestic payments increasingly convenient,

[1] We thank Raphael Auer, Claudio Borio, Stijn Claessens, Marc Hollanders, Wenqian Huang, Hyun Song Shin, Takeshi Shirakami and Philip Wooldridge for helpful comments and suggestions. We are also grateful to Ismail Mustafi, Róbert Szemere and Luis López Vivas for excellent research assistance. The views expressed are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

[2] An account (including e-money/prepaid accounts) held with a bank or other authorised payment service provider that can be used to make and receive payments and to store value.

[3] A stablecoin is a cryptoasset that seeks to stablise the price of the "coin" by linking its value to that of an asset or pool of assets (G7 (2019)).

Key takeaways

- Technological advances are making domestic payments safer, faster and cheaper.
- Many people still lack access to payment systems, especially in emerging market and developing economies.
- Cross-border payments are improving more slowly, partly because coordinating changes across borders is more difficult.

instantaneous and available 24/7. Next it describes the scope of the problems besetting access to accounts. Finally, it provides context on the different models of cross-border payments, which are discussed in greater detail in other articles in this issue of the BIS Quarterly Review.

Payments: a primer[4]

A *payment system* is a set of instruments, procedures and rules for the transfer of funds between or among participants. The system encompasses both the participants and the entity operating the arrangement. Payment systems come in many shapes and sizes, and new designs continue to emerge.

The first distinguishing feature of a payment system is the type of payment it is designed to process: retail or wholesale.[5] *Retail payments* typically relate to the purchase of goods and services by consumers and businesses. Each of these payments tends to be for relatively low value, but volumes are large. Within retail payment, there are person-to-person payments (eg transfer of money to a friend or family member), person-to-business payments (eg bill payments), business-to-person payments (eg salary payments) and business-to-business payments. These payment systems are run by both private and public sector providers.

In contrast, *wholesale payments* are between financial institutions – for example, payments to settle securities and foreign exchange trades, payments to and from central counterparties, and other interbank funding transactions. These are typically large-value payments that often need to settle on a particular day and sometimes by a particular time. While there are significantly fewer wholesale payments compared with retail payments, their value – both individually and in aggregate – is much larger. Given their systemic importance, wholesale payment systems are generally owned and operated by central banks.

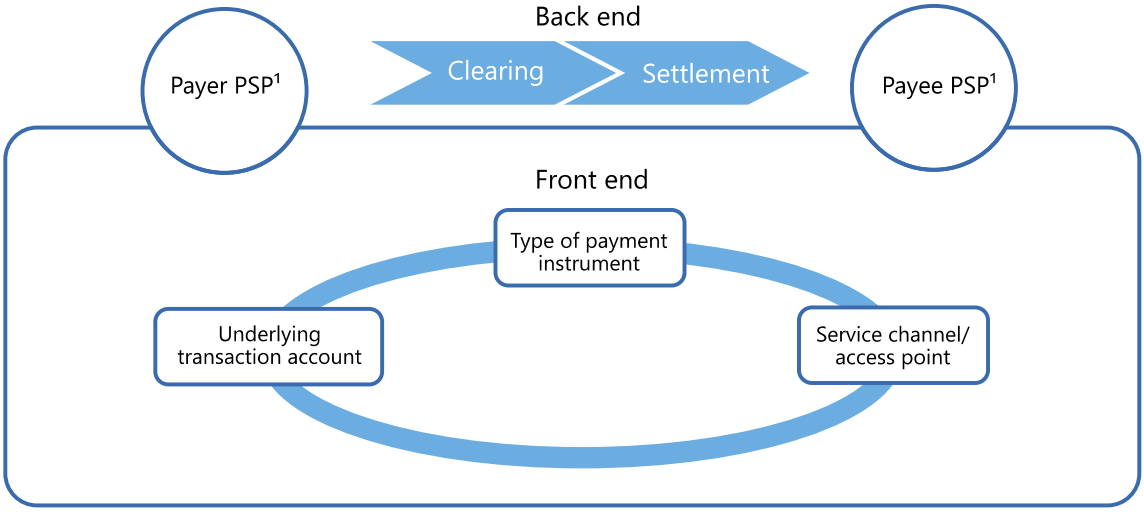
Payments usually flow through a *front end* via which the payer[6] initiates the payment and a number of *back-end* arrangements that clear and settle payments (Graph 1).

[4] This section draws heavily on the online glossary maintained by the Committee on Payments and Market Infrastructures (CPMI) at www.bis.org/cpmi/publ/d00b.htm, as well as CPSS (1997, 2005), CPSS-IOSCO (2012) and CPMI (2016, 2018).

[5] Most jurisdictions have separate systems to process retail and wholesale payments. Two notable exceptions are Mexico and Switzerland, where both retail and wholesale payments are processed by the same system.

[6] In some circumstances, the payee can initiate the payment, eg a direct debit.

Elements of a payment system Graph 1



[1] PSP = payment service provider.

Source: CPMI (2018).

The front end comprises the source of the funds (eg a bank account), the service channel used to initiate the payment (eg a mobile payment application) and the payment instrument (eg a credit transfer). The wide variety of situations in which consumers and businesses initiate payments leads to a wider variety of front ends in retail payments.

The back end comprises the arrangements for the clearing and settlement of payments. *Clearing* is the process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement.[7] Given the large volume of payments a retail payment system needs to handle, traditionally files containing batches of payment instructions are transmitted rather than the details of each payment being transmitted individually. *Payment service providers* (PSPs),[8] such as banks, can clear transactions bilaterally, but more often this is facilitated by *automated clearing houses* (ACHs), which are multilateral arrangements that facilitate the exchange of payment instructions between PSPs.

Settlement of payments is the process of transferring funds to discharge monetary obligations between two or more parties. Payments can be settled either on a gross basis individually or on a net basis as a batch. The former is known as *real-time gross settlement* (RTGS), since, provided the payer's PSP has sufficient funds, each payment is settled as soon as it enters the system. When the payer's PSP has insufficient funds to settle immediately, the payment is rejected or queued. The alternative is known as *deferred net settlement* (DNS), since the netting and settlement take place after a specified period. *Hybrid* systems offer a mix of RTGS and DNS settlement. For example, if a payment is queued because the payer's PSP does not have sufficient funds to settle on an RTGS basis, the system may offer *liquidity saving*

[7] If payments are settled on a net basis, clearing can also involve the calculation of net positions for settlement.

[8] In addition to banks, there are non-bank PSPs that provide payment services but do not take deposits and use these deposits to make loans. Non-bank PSPs include operators of payment systems (eg Visa, MasterCard, AliPay, WeChat Pay) and participants in payment systems (eg Adyen, First Data).

mechanisms that attempt to settle the payment by netting or offsetting it against other payments.

The different settlement methods involve a trade-off between different risks. Because each payment in an RTGS system is settled individually on a gross basis, RTGS systems require more liquidity (funding) to operate. In contrast, the netting in DNS systems means that incoming and outgoing payments offset each other to lower the liquidity requirement. However, the flip side of this is that because DNS systems settle payments only periodically, for the period during which settlement is deferred there is a risk that it will not take place as expected (ie *settlement risk*).[9] Settlement risk could stem from the risk of the payer or the payer's PSP defaulting prior to final settlement (ie *credit risk*) or being unable to settle the payment when it falls due, resulting in a delay in the receipt of funds (*liquidity risk*). *Final settlement* is a legally defined moment when funds (or other assets) have been irrevocably and unconditionally transferred. Because DNS systems settle batches of payments, the default of one PSP can affect all surviving PSPs involved in the batch. Payments involving the failed PSP would be unwound and new net obligations would be calculated. Conceivably, one of the other PSPs that had been expecting funds from the failed PSPs may not be able to meet its recalculated (higher) obligation, potentially setting off a cascade of failures.

The difference in the value and volume of payments that retail payment systems and wholesale payment systems need to handle tends to lead to differences in the design of their back-end arrangements. Box A illustrates these differences with reference to US payment systems. In almost all countries, wholesale payments are settled in RTGS systems (CPSS (2005)). In contrast, traditionally it has taken a day or more after initiation of a cashless retail payment for the funds to reach the payee. This is because retail payment systems have tended to process payments in batches, with settlement occurring on a DNS basis and PSPs releasing funds to payees only after final settlement among PSPs. However, in recent years a growing number of fast payment systems (FPSs) have been launched, in which "final" funds are available to the payee in real time or near real time on as near to a 24/7 basis as possible.[10]

Traditionally, most payments involve a payee and a payer that reside within the same jurisdiction and use the same currency (ie *domestic* payments). But owing to globalisation, the two increasingly reside in different jurisdictions, giving rise to *cross-border* payments. Examples of different types of cross-border payment are purchases of securities issued overseas, purchases by overseas tourists, international purchases executed over the internet and *remittances*.[11] Many cross-border payments involve two different currencies (ie they are *cross-currency* payments).[12]

[9] If the payment is in exchange for some other good or service that has already been delivered, the payee will be exposed to settlement risk from the time of delivery until they receive "final" funds. Depending on when the failure occurs and the relevant legal arrangements, settlement risk may be borne by the payee, one of the PSPs or the payment system operator (if that operator guarantees settlement).

[10] In some FPSs, funds are made available to the payee prior to final settlement between PSPs, which exposes the PSPs to credit risk. For further details on the settlement arrangements for FPSs, see Bech et al (2017).

[11] Remittances are person-to-person payments of relatively low value. They can be domestic, but for the purposes of this article the term is used to refer to cross-border ones.

[12] Payments between two countries within the euro area are an example of a cross-border payment that is not a cross-currency payment.

Box A

Payment systems in the United States

Domestic payment systems can be categorised along three key dimensions: *payment type* (wholesale or retail), *operator* (central bank or private sector) and *settlement mode* (real-time or deferred). The United States is the largest payment market in the world and has a multitude of different public and private systems. Graph A applies a simple taxonomy to US payment systems to illustrate the three key dimensions.

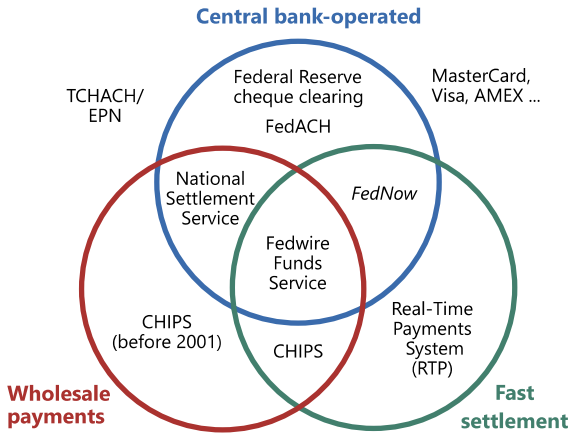
Wholesale systems

At the centre of the taxonomy is Fedwire Funds Service, which is the US Federal Reserve's RTGS system. It dates back to 1918, when the Federal Reserve inaugurated a network of wire communications among Reserve Banks. Fedwire has close to 6,000 direct participants and settles time-critical payments on behalf of participants and their corporate customers. CHIPS (originally, the Clearing House Interbank Payment System) is a privately operated system. It started operation in 1974 as a DNS system, but in 2001 it moved to a "hybrid" settlement model that continuously matches and nets payments. CHIPS currently has about 45 direct participants and settles large-value international and domestic payments, including those associated with commercial transactions, bank loans and securities transactions. National Settlement Service (NNS) is a multilateral settlement service owned and operated by the Federal Reserve. NSS settles interbank obligations arising in other retail payment and securities settlement systems on a net deferred basis. The files of multilateral net obligations are processed on receipt.

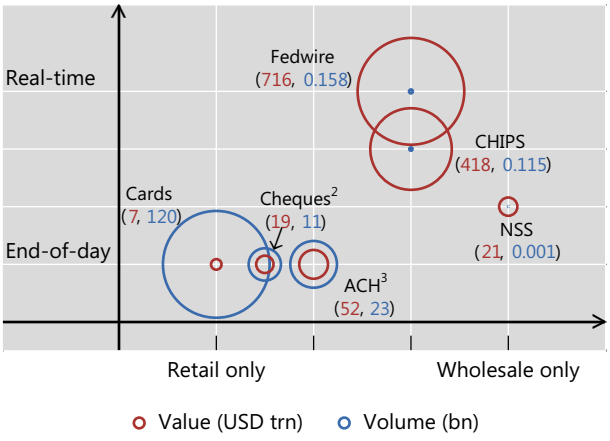
US payment systems

Graph A

Taxonomy



Transactions processed in 2018[1]



[1] Size in brackets (value, volume). [2] Includes Federal Reserve and private. [3] Includes FedACH and TCHACH/EPN.

Source: BIS Red Book statistics.

Retail systems

FedACH and TCHACH are ACHs that provide clearing services for electronic debit and credit transfers from retail customers, with final settlement occurring on the following banking day. FedACH is operated by the Federal Reserve while TCHACH is provided by The Clearing House, a consortium of banks. The Federal Reserve provides cheque processing services to depository institutions. Most collected cheques are settled within one business day. Card payments in the United States are processed by one of the card payment networks (eg Visa, MasterCard, American Express, Discover). They are generally settled on a net basis with a one- or two-day lag. Real Time Payments is The Clearing House's fast payment service for retail payments. It was launched in November 2017. FedNow is the Federal Reserve's new project to deliver 24/7/365 instant settlement service for retail payments. FedNow is expected to go live in 2023 or 2024.

Innovations in domestic payments

It is no small task to improve payments. Payments by their nature define a network, so any change typically requires coordination between the operator of the payment system, PSPs and third-party service providers. In addition, to be successful, new services need to be adopted by both payers and payees, who may face different incentives. This coordination problem has been more tractable in the domestic context, where individual central banks and payment operators have spearheaded innovation. This is particularly true for wholesale payment systems, which typically have fewer direct participants and where central banks have a leading role.

As a result of information and communications technology improvements and (more recently) consumer demand, domestic payments are increasingly convenient, instantaneous and available 24/7. The improvements started in wholesale payments, with the introduction of RTGS in almost every country in the 1990s (CPSS (2005)). Innovations in retail payments began to emerge in the 2000s (CPSS-IOSCO (2012)). Initially these innovations were limited to making the front end more convenient, but more recently innovations have started to address the back end and have increased the speed of retail payments.

Wholesale payments

Innovations in wholesale payments have occurred in waves over the past few decades. In 1990 there were fewer than 10 RTGS systems, whereas now there are over 176 (Bech et al (2017)).[13] The introduction of RTGS decreased the credit risk from wholesale payments, but it also made them more liquidity-intensive. Consequently, the second wave of innovation involved the introduction of liquidity-saving mechanisms in the 2000s (CPSS (2005)). Some systems also introduced multicurrency functionality, which supports cross-border payments (Bech, Faruqui and Shirakami (2020, in this issue)).

Since the mid-2000s, trends have included opening up access to non-banks, expanding operating hours and improving the interoperability of systems. Traditionally, only domestic banks have been allowed to directly participate in wholesale systems. There has been a pattern of central banks opening up access to non-banks. This has the potential to increase competition. However, the number of non-banks with direct access to wholesale payment systems remains small.

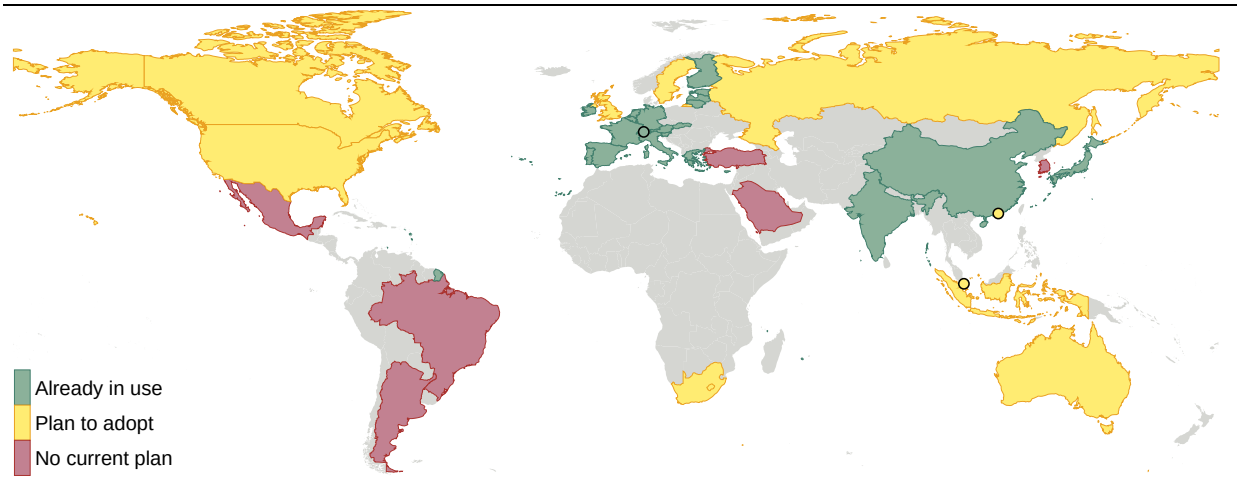
Over the same period, all RTGS systems have extended their operating hours, and several jurisdictions have plans for further extensions over the next few years. Roughly a quarter of RTGS systems are now open for at least some hours on Saturday and Sunday, while in Mexico and South Africa the systems are open all day every day of the year.

Many RTGS systems have introduced technical changes that support interoperability. *Interoperability* refers to the technical or legal compatibility that enables a system or mechanism to be used in conjunction with other systems or mechanisms. This can deliver cost efficiency and risk reduction for users of multiple

[13] This includes Canada, which has a hybrid system that is considered the equivalent of RTGS in terms of settlement risk.

Adoption of standardised payment messages[1]

Wholesale payment systems in 2017[2] Graph 2



The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the BIS.

[1] Adoption of ISO 20022. [2] Status is shown only for jurisdictions that are members of the CPMI. The circles indicate Switzerland, Hong Kong SAR and Singapore. For the euro area, limited to securities settlement-related transactions; for Japan, limited to cross-border payments.

Source: CPMI survey.

systems by promoting straight through processing. The adoption of ISO 20022, which is an international standard for electronic data interchange between financial institutions, is helping to improve technical compatibility between wholesale payment systems. CPSS-IOSCO (2012) requires payment systems to accommodate internationally accepted communication procedures and standards. Accordingly, many of these jurisdictions currently use or have plans to adopt ISO 20022 (Graph 2). SWIFT (a global provider of financial messaging services) plans to migrate all cross-border payments sent over its network to ISO 20022 by 2025.

Retail payments

Technological developments and changes in consumer preferences have altered the retail payment landscape, and they continue to do so. Initially, much of the innovation focused on increasing consumer convenience by improving the front end. New ways of initiating payments (eg mobile and contactless payments) have been introduced, and *overlay* systems (eg ApplePay, PayPal, SamsungPay, GooglePay) that provide innovative customer interfaces have been launched. These systems use existing payment systems for settlement.

However, there are also a growing number of initiatives that are making back-end arrangements faster. In China, Alipay (launched in 2004) and WeChat Pay (launched in 2011) together account for 92% of mobile payments (Klein (2019)). They are both *closed-loop* systems, which means they provide services directly to both payers and payees. M-Pesa in Kenya is also a closed-loop system; it processes payments equivalent to just under half of Kenya's GDP (McGath (2018)). Closed-loop systems have back-end arrangements that are largely internal to their respective companies; these arrangements are simple and fast. Technological developments have also made fast retail payment systems increasingly viable (Box B).

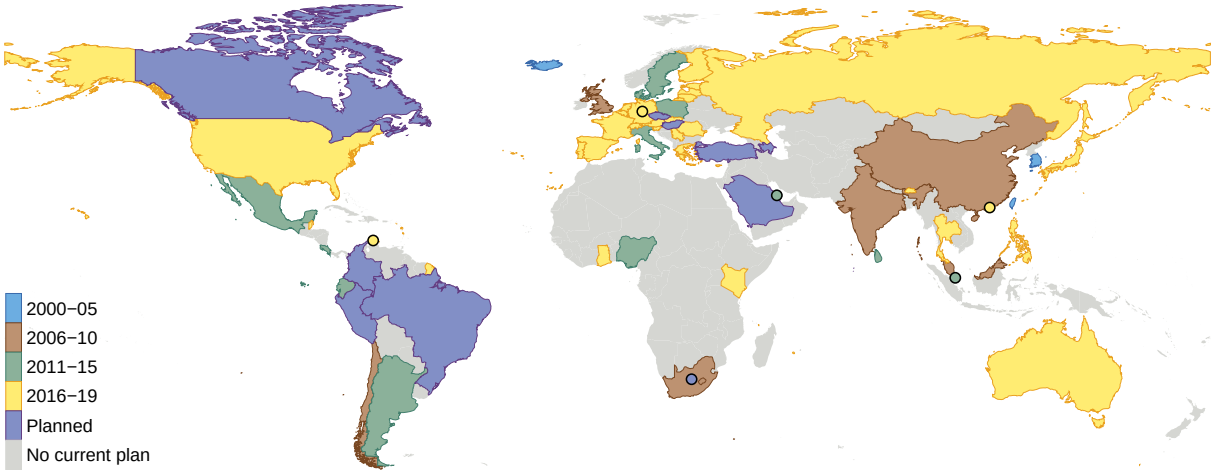
Fast retail payment systems

Morten Bech, Jenny Hancock and Wei Zhang[1]

Fast (retail) payment systems (FPSs) have been (or are being) developed in many jurisdictions. An FSP is a system in which the transmission of the payment message and the availability of the final funds to the payee occur in real time or near real time on as near to a 24/7 basis as possible.[2] While closed-loop systems can also be near real-time and available 24/7, FPSs are payment infrastructure that facilitates payments between account holders at multiple PSPs rather than just between the customers of the same PSP. Currently, 55 jurisdictions have FPSs, and this number is projected to rise to 65 in the near future (Graph B.1). While the adoption speed is fairly similar to that of wholesale RTGS systems, early adopters are predominantly emerging market rather than advanced economies.

Geographical diffusion of fast payment systems

Graph B.1



The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the BIS.

The yellow circle in Europe represents the Eurosystem FPS. The FPSs in Aruba, Bahrain, Hong Kong SAR and Singapore are also represented by circles.

Sources: CPMI survey; national data.

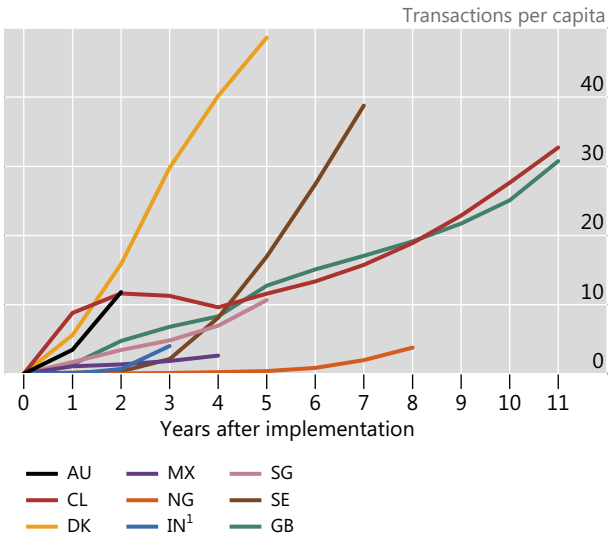
Take-up and usage vary significantly across jurisdictions (Graph B.2, left-hand panel). The FPSs in Chile and the United Kingdom, which have been operating for 10 years, processed just over 30 payments per capita in 2018. In contrast, those in Sweden and Denmark were launched more recently but processed more payments per capita – 40 and 48, respectively – in 2018. This is largely due to the popularity and strong growth in the use of mobile payment apps that are the front end of the FPS in these jurisdictions. In Australia, growth in transaction volumes has also been very rapid, reaching an annualised rate of around 12 fast payments per capita per year in just the second year of operation.

The average transaction value of faster payments varies significantly, suggesting that FPSs are used for a variety of retail payments (Graph B.2, right-hand panel). The average transaction value of fast payments in Denmark and Sweden are less than 0.3% of GDP per capita, indicating they are used mainly for person-to-person payments. At the other end of the scale, the average transaction value of fast payments in Hong Kong SAR is over 6%, suggesting that they are used mainly for payments involving businesses (eg payment of rent).

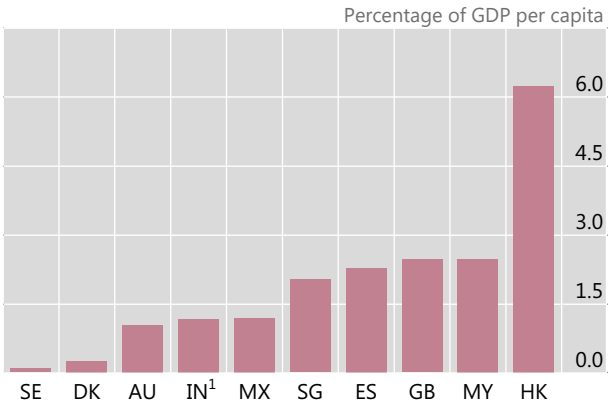
Fast retail payment systems

Graph B.2

Adoption rates



Average transaction value, 2018



[1] Indian figures comprise only fast payments via Unified Payments Interface (UPI).

Sources: BIS Red Book statistics; CPMI survey; national data.

① The views expressed are those of the authors and do not necessarily reflect those of the Bank for International Settlements. ② Committee on Payments and Market Infrastructures, *Fast payments – enhancing the speed and availability of retail payments*, November 2016.

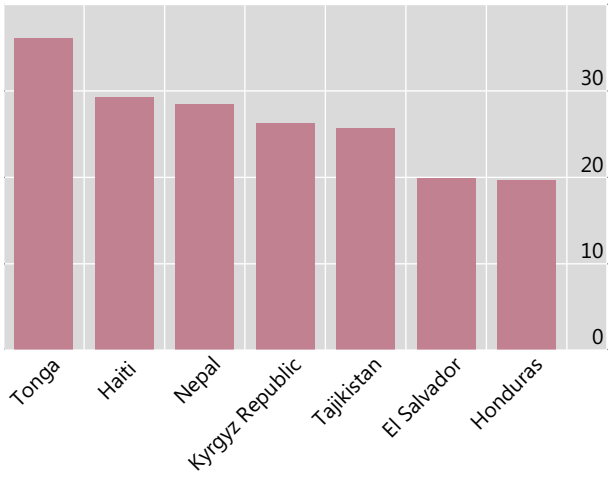
The shortcomings

Despite the innovations described above, there are two major shortcomings: access by consumers to transaction accounts and cross-border payments. Access is largely a problem for a subset of jurisdictions, and in EMDEs these two shortcomings interact where remittances account for a substantial proportion of GDP (Graph 3, left-hand panel). If the payee or the payer does not have a transaction account, their choice of remittance provider is restricted, and the networks of physical locations required to support cash payments are expensive (*The Economist* (2019)). Despite a G20 commitment to reduce the cost of remittances to 5% or less by 2014 (G20 (2011)), on average costs remain around 6.8% (Graph 3, right-hand panel). It is also significantly more expensive to remit money to certain regions. For example, the costs of remittances to Sub-Saharan Africa have remained around 9% for the last two years.

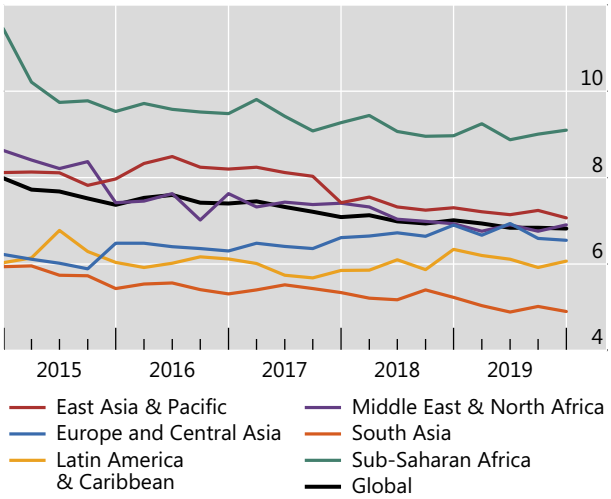
Remittances

In per cent — Graph 3

Are a substantial proportion of GDP in developing economies[1]



Average costs by region[2]



[1] Net remittances calculated as the difference between inflows and outflows. [2] Regions according to the World Bank.

Sources: World Bank (2019); authors' calculations.

Access to accounts

In large parts of the world, many people do not have access to transaction accounts. While almost all adults in North America, Europe and other advanced economies have a transaction account, in many EMDEs 25% or more of adults have no such account (Graph 4, left-hand panel). In Africa and the Arab world, the share not having an account exceeds 50%. Everywhere, the problem is much worse for women.

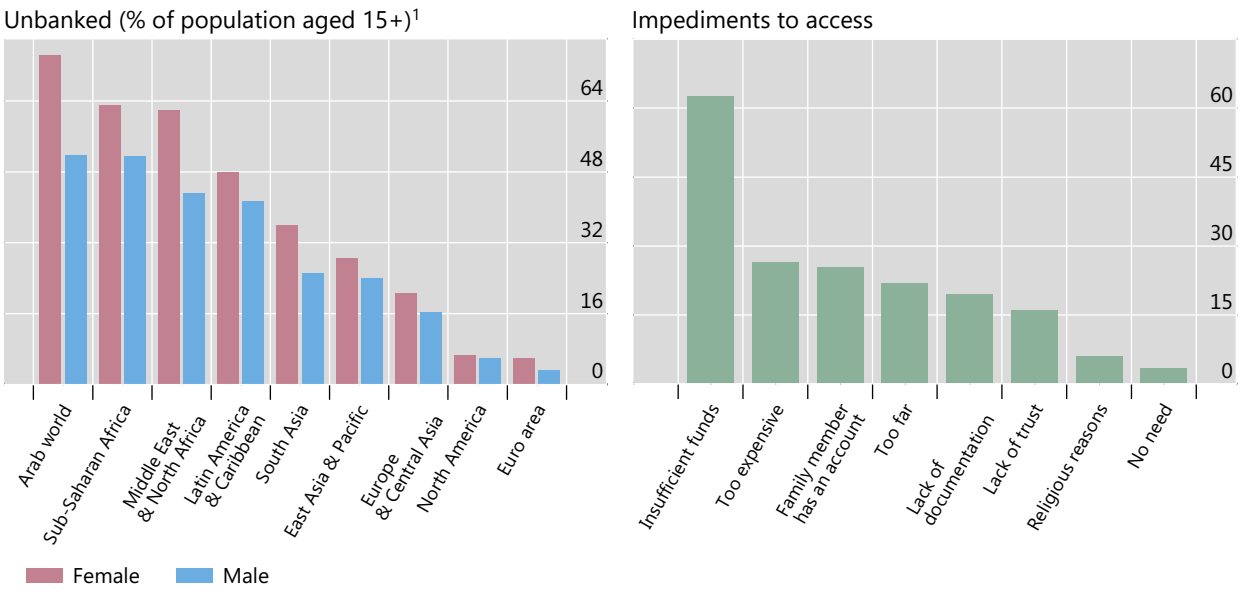
Financial exclusion is often part of a much wider social exclusion, with individuals also lacking access to education, insurance and healthcare. Payments are the gateway to other financial services, such as savings accounts, credit or insurance, which allow individuals to invest and protect their income against risks. Access to a basic bank account has been shown to reduce poverty, as it promotes saving and supports better financial management (Iqbal et al (2019), World Bank (2017)).

There are a range of reasons why the unbanked do not have access to transaction accounts. The major ones relate to the direct and indirect cost (eg cost of visiting a branch or other point of service) of access, lack of documentation and lack of trust (Graph 4, right-hand panel). While innovations in payments can provide an incentive to open a transaction account, there is also a need for broader initiatives around identity and financial literacy.[14] An example of such an initiative is the Aadhaar programme in India, which provides all residents with a biometric identity so that they can prove who they are (D'Silva et al (2019)).

[14] CPMI and World Bank (forthcoming) identifies the impact of fintech developments on universal access to and frequent usage of transaction accounts.

Access to payment services

In per cent — Graph 4



[1] Regions according to the World Bank.

Source: World Bank, Global Findex database.

Cross-border payments

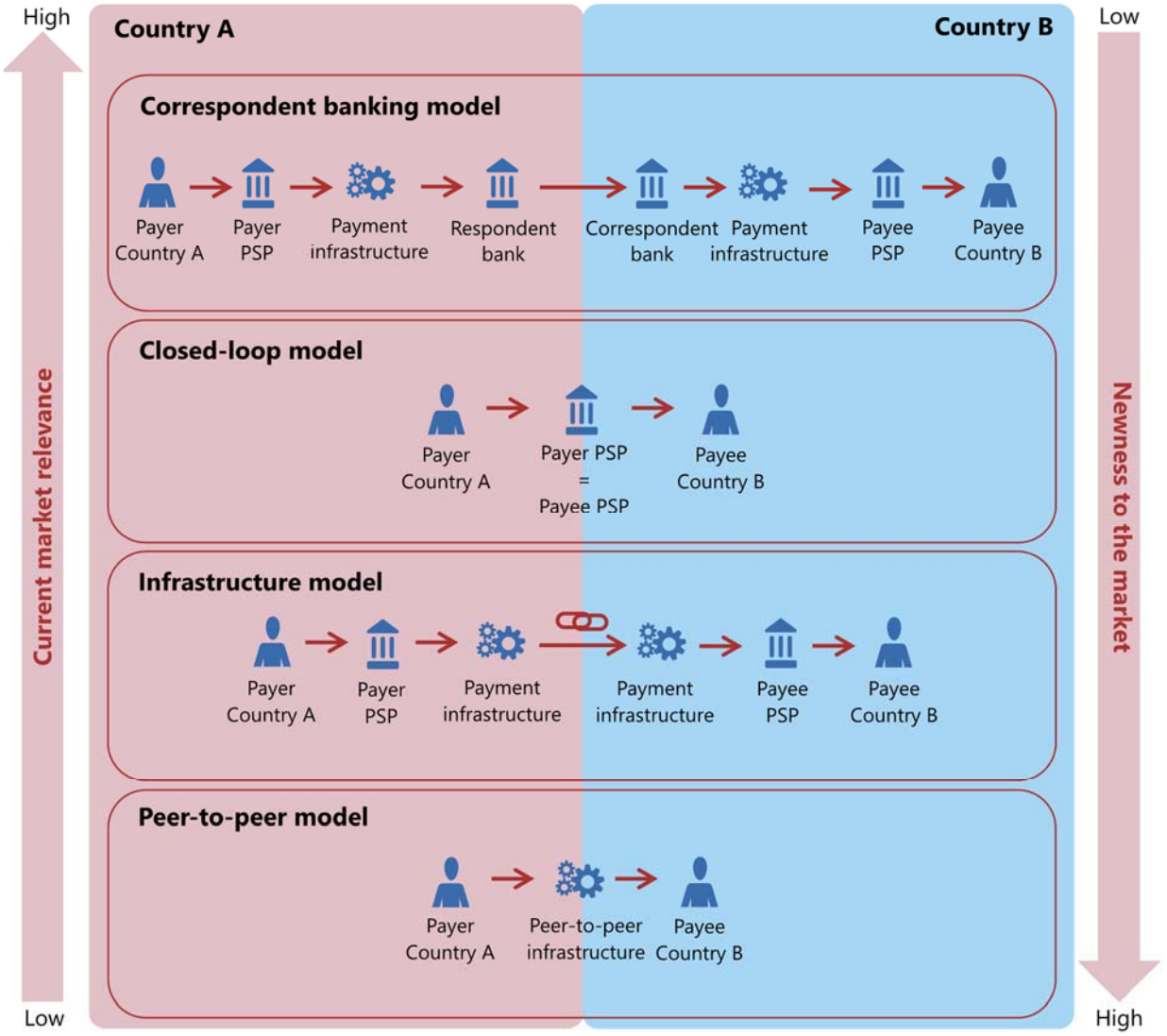
Cross-border payments are vital for global commerce and finance and for migrants who send remittances home. However, they are generally slower, more expensive and more opaque than domestic payments (CPMI (2018)).

Unlike for access, where the World Bank has carefully quantified the extent of the problem and its drivers, for cross-border payments there are limited data available to analyse the problems. The World Bank monitors remittances (Graph 5), but these are only a subset of cross-border payments. McKinsey (2016) found that the average cost for a US bank of executing a cross-border payment is more than 10 times that for a domestic payment. However, differences in remittance costs across regions (Graph 3) suggest that this average may mask significant variation in the costs of cross-border payments. A survey by the CPMI (2018) indicates that it can take up to seven days to complete a cross-border payment, yet SWIFT recently demonstrated that it is possible to complete a cross-border payment in 13 seconds (SWIFT (2019)).

While there is a lack of data to measure the problem, its underlying reasons – additional compliance costs and more complex back-end arrangements – are well understood. Complying with multiple regulatory regimes adds to costs, and the risk of money laundering and terrorist financing can be more difficult to manage for cross-border payments. Where possible, public and private sector efforts have sought to minimise the additional costs by standardising processes and clarifying expectations.[15] Back-end arrangements for cross-border payments are more challenging due to a lack of standardisation of messaging formats, different

[15] For further details, see FSB (2018).

Stylised overview of back-end cross-border payment arrangements Graph 5



The arrows represent the movement of funds and messages containing instructions about the payment flow in both directions.

Source: CPMI (2018).

operating hours in different jurisdictions, and the need to settle in different currencies (CPMI (2018)).

Arrangements for cross-border payments can be classified into four models: correspondent banking, closed loop, infrastructure and peer-to-peer (Graph 5).

Correspondent banking

Correspondent banking is an arrangement whereby one bank (the correspondent) holds deposits owned by other banks (the respondents) and provides payment and other services to them. For example, a customer of PSP A in country A (shaded pink in Graph 5) wants to pay someone who uses PSP B in country B (shaded blue in Graph 5), but PSP A does not have an account in country B and PSP B does not have an account in country A. As a result, it is not possible to execute a direct payment. Thus, to move the funds from country A to country B, PSP A pays respondent bank A in country A, which has an account at correspondent bank B in country B. Once

respondent bank A receives the funds, it transfers them to its account at correspondent bank B to fund the payment to PSP B in country B. This is facilitated by correspondent B, which is a participant in the payment infrastructure in that country.

Correspondent banking is the traditional back-end arrangement for cross-border payments. Today most cross-border payments flow this way. However, correspondent banking relationships are declining globally. Rice, von Peter and Boar (2020, in this issue) analyse the drivers for this decline.

Closed loop

The second model is a *closed loop*. This is sometimes known as an in-house or intragroup transfer system because there is a single central PSP that provides services to both the payee and the payer.[16] Western Union and MoneyGram have a long history of providing remittances via closed-loop systems; they have a physical presence in each of the jurisdictions they serve and do not require users to open an account. More recently, AliPay and WeChat Pay have been very successful using a closed-loop model for domestic payments in China. Nevertheless, this is unlikely to be a feasible global solution. It would require payees and payers around the world to all use the same PSP, which would be a coordination challenge and lead to concentration risk.

Closed loops are mainly improving particular niche cross-border payments. AliPay and WeChat Pay are increasingly partnering with overseas payment operators to allow Chinese travellers to use their mobile payments application whilst abroad. Other fintech firms, such as Revolut and Transferwise, provide services in currency pairs for which there is high turnover, using incoming payments to fund outgoing payments in the same currency to minimise costs.

Infrastructure

As the name suggests, the *infrastructure* model involves building a payment system or linking payment systems to operate cross-border. The link facilitates (remote) access to domestic systems for banks located abroad. For example, Directo a México links FedACH in the United States with the Mexican RTGS system to facilitate remittances from the US to Mexico. Bech, Faruqui and Shirakami (2020, in this issue) explain the different ways infrastructure can be used to facilitate cross-border payments.

Peer-to-peer

In contrast to the other models, peer-to-peer arrangements cut out the financial intermediary PSPs between the payer and the payee.

There are some private initiatives. So-called "stablecoins" such as Libra are examples of the genre. Libra is a consortium led by Facebook that proposed a private global stablecoin. Libra's initial proposal involved creating its own unit of account, avoiding the need to deal with different currencies when settling cross-border payments. Further detail and analysis of these initiatives is set out in G7 (2019).

[16] While a multinational bank may provide services to both the payer and the payee in a particular transaction, unlike in closed-loop systems users are not restricted to making payments to someone with an account at that bank.

In addition, central banks are undertaking extensive work on central bank digital currencies (CBDCs) that could support cross-border payments. The Bank of Thailand and the Hong Kong Monetary Authority (2020) recently completed a proof of concept to that effect for wholesale payments. In a recently published survey, central banks rated improving the efficiency of cross-border payments as a "somewhat important" reason for establishing CBDCs. However, in general, the safety and efficiency of domestic payments were the most highly rated motivation (Boar et al (2020)). Auer and Böhme (2020, in this issue) set out the design options for retail CBDC and investigate how they could become a widely usable and trusted means of payment.

Bech, Hancock, Rice and Wadsworth (2020, in this issue) also analyse peer-to-peer arrangements, focusing on how their use could change the clearing and settlement arrangements for securities.

Conclusion

Innovation in domestic payments continues to occur. Wholesale systems are opening up access to non-banks, extending operating hours and improving the interoperability of systems. Fast or instant retail payment systems have been or are being developed in many jurisdictions. However, shortcomings in access and cross-border payments remain.

Access issues can be addressed through targeted interventions in individual jurisdictions. Quantification of the extent and relative importance of the various drivers facilitates such interventions. Fintech is also likely to improve universal access to and frequent usage of transaction accounts.

The way to address the problems surrounding cross-border payments is less clear. First, more data are needed to help understand the extent and the drivers of the problems. Initiatives to improve cross-border payments would benefit from being able to quantify both the relative importance and the costs and benefits of the various types of back-end arrangements. Second, coordinating efforts to address the issues besetting cross-border payments is more challenging. There are more stakeholders involved and no organisation with a clear leadership role. In 2020, the G20 took on a leadership role when it decided to give priority to enhancing cross-border payments (Carstens (2020, in this issue)).

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On the global retreat of correspondent banks[1]

Correspondent banks have been paring back their cross-border banking relationships for the past decade. The retreat is broad-based, but affects some countries more than others. Jurisdictions with weaker governance and deficient controls to prevent illicit financing have lost more relationships, while trade and growth were supportive. Technological developments, as well as private and public sector initiatives, could help to reduce frictions in cross-border payments. Further monitoring and action are warranted to ensure that all countries enjoy access to safe, low-cost cross-border payment channels.

JEL classification: F23, F24, F35, G21, G28.

Cross-border payments are vital for economic development in a globalised economy. The bulk of payments flows through correspondent banks that operate a vast network of bank relationships. These critical linkages facilitate the cross-border payments that underpin global trade, finance and remittances.

Yet, over the past decade, cross-border correspondent bank relationships have declined by about one fifth. Policymakers across the globe have focused on understanding the causes and implications of the retreat.[2] Complementing existing case studies and surveys, this article analyses the drivers of the retreat and identifies three issues that warrant particular attention going forward.

First, some jurisdictions could face inadequate access to the global financial system. Connections with particular countries, such as those from which migrants send remittances, provide a critical source of income to households. Remittances drive financial inclusion by promoting the use of transaction accounts. We find that a complete loss of access is rare, and typically linked to weak governance or deficient controls on illicit financing. Most countries can still be reached through longer payment chains.

Second, costs for sending cross-border payments remain high in some countries, despite international efforts to reduce remittance costs. Greater concentration in correspondent banking could keep costs elevated. While there is little evidence of

[1] We thank Claudio Borio, Stijn Claessens, Henry Holden, Marc Hollanders, Ruth Judson, Benoît Mojon, Jan Paulik, Stephane Mahieu, Swapan-Kumar Pradhan, Catherine Schenk, Rupert Thorne and Philip Wooldridge for helpful comments and suggestions. We are grateful to Adam Čáp and Luis López Vivas for excellent research assistance. We also thank Nikolai Boeckx and Tim Stevens (National Bank of Belgium) and Astrid Thorsen (SWIFT) for their calculations and assistance on SWIFT data. The views expressed are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

[2] See CPMI (2016, 2018), FSB (2015, 2017, 2019), IMF (2017) and World Bank (2018a).

Key takeaways

- The number of correspondent banks fell by 20% between 2011 and 2018, even as the value of payments increased.
- Banks withdrew more from countries where governance and controls on illicit financing were poor, and less where economic growth and trade were robust.
- The retreat of correspondent banks might hurt financial inclusion, raise the cost of cross-border payments or drive them underground.

rising costs, we do find that costs are higher in countries with more limited access to correspondent banking services.

Third (and related), if banks are not providing critical payment services, users may resort to less regulated or unregulated channels. Shifting payments outside the banking system may undermine international financial integrity. Information-sharing initiatives between financial institutions, as well as between jurisdictions, offer opportunities for reducing cross-border frictions.

The following section reviews recent trends in correspondent banking. We then examine what is driving the retreat of correspondent banks and explore some potential consequences. The final section concludes.

Correspondent banking trends

Correspondent banking is an arrangement whereby one bank (correspondent) holds deposits owned by other banks (respondents) and provides those banks with payment and other services (CPMI (2016)). Correspondent banking networks are critical for firms and households that conduct business or send payments internationally. The arrangement requires that respondents open accounts in the correspondent's books and are able to exchange messages to settle obligations by crediting and debiting those accounts (Bech and Hancock (2020, in this issue)).

Historically, banks have maintained broad networks of banking relationships across the globe. As far back as the 14th century, the Venetian Senate recognised that banks were essential to support international trade (Dunbar (1892)). In the late 1800s, with globalisation and innovation in communications, an international network of correspondent banks began to emerge (Panza and Merrett (2018)). During the second wave of globalisation in the late 20th century, the scale and complexity of this network grew substantially.

Over the past decade, however, correspondent banks have been retreating. Correspondents have become less willing to provide such services to new respondent banks and have been selectively exiting the business or reducing their number of respondents (CPMI (2016), FSB (2017), IMF (2017)).

To investigate these trends, we examine changes in SWIFT payment messages from 2011 to 2018. As Box A explains, the messaging data map out a network of interbank relationships, for which SWIFT provides certain statistics on the value of payments and the number of banks involved. A payment message from one country to another identifies a ***corridor***. A cross-border payment message from one bank to another identifies a correspondent bank relationship; the count of

Box A

Correspondents and corridors through the lens of SWIFT and the BIS banking statistics

Most payment systems are domestic in scope and operate in a single currency.① The global network of correspondent bank relationships provides the main linkages between those payment systems. Most cross-border payments flow through a correspondent banking network (CPMI (2018)), and the overwhelming majority use the SWIFT financial messaging service (CPMI (2016)). These facts combined suggest that SWIFT data capture the bulk of cross-border payments, and deliver an accurate picture of the trends in correspondent banking payments. Those payments includes remittances and trade finance, but also wholesale payments related to financial market activity.

SWIFT messaging data cover payments between more than 200 countries and jurisdictions, mapping out a network of bilateral relationships. These relationships can be defined at the bank-to-bank or country-to-country level. A payment message from one country to another identifies a ***corridor***. A cross-border payment message from one bank to another identifies a correspondent bank relationship; the count of ***active correspondents (ACs)*** measures, corridor by corridor, the number of banks abroad that have received messages sent by banks in a given country.③

This article relies on data that SWIFT and its overseer, the National Bank of Belgium, have aggregated to the country or regional level.② Our analysis is limited to the data received, as made available on the CPMI website. At the country level, only percentage changes are available, and they exclude data on corridors (Table A1). Information on levels, ie the number of ACs and corridors, is available only as (sub)regional averages. We examine the ***percentage change in the number of ACs*** from 2012 to 2018 by country (yellow cell). No SWIFT data on corridors are available at the country level. Since international access hinges on corridors from and to other countries, we estimate the number of corridors from the BIS locational banking statistics (LBS) instead (green cell).

Inventory of public cross-border SWIFT data[1] Table A1

	Countries (>200)	Subregions (22)	Regions (6)	World total (1)
Value of payments	% changes			Levels, % changes
Volume of payments	% changes		Levels, % changes	Levels, % changes
Number of ACs	% changes	Levels, % changes	Levels, % changes	Levels, % changes
Number of corridors		Levels, % changes	Levels, % changes	Levels, % changes
LBS: number of corridors	*Levels, % changes*	*Levels, % changes*	*Levels, % changes*	*Levels, % changes*

[1] Each cell states whether series on levels or percentage changes are available; grey cells indicate that the series at this level of granularity is not available from SWIFT. Some series are available at different frequencies or points in time; some have additional breakdowns not listed here, such as currency or message type. The available series are hosted on the CPMI website as part of its annual quantitative review.

Sources: CPMI (2019); SWIFT BI Watch, National Bank of Belgium; BIS locational banking statistics.

Definitions of correspondent banking have in common that the correspondent holds deposits owned by respondent banks to provide payment and other services to those banks (CPMI (2016)). The bank in country A placing a deposit with a bank in B allows the bank in A to make a payment in country B. These accounts are part of the interbank positions captured in the BIS LBS, which include positions with unaffiliated banks as well as intragroup positions. The LBS cover positions of 47 BIS reporting countries (including major emerging market economies (EMEs) and offshore centres) with more than 200 countries and jurisdictions. Overlaying asset and liability data helps to enhance global coverage (Brei and von Peter (2018)). Even so, counts based on the LBS (Table A1, green cell) may understate the number of corridors for all but the 47 BIS reporting countries, since any positions between two non-reporting countries are unobserved.

① Cross-border payment infrastructures include TARGET2, the euro area's interbank funds transfer system, as well as CLS and others featured in Bech, Faruqui and Shirakami (2020, this issue). ② Data relating to SWIFT messaging flows are published with permission of S.W.I.F.T. SC. SWIFT © 2020. All rights reserved. Because financial institutions have multiple means to exchange information about their financial transactions, SWIFT statistics on financial flows do not represent complete market or industry statistics. SWIFT disclaims all liability for any decisions based, in full or in part, on SWIFT statistics, and for their consequences. ③ SWIFT data include retail and wholesale cross-border payments in all currencies; the message type distinguishes customer payments (MT103) from interbank payments (MT202) along the payment chain. (However, MT103 messages sent under the cover method may identify some pairs that do not have a correspondent bank relationship.)

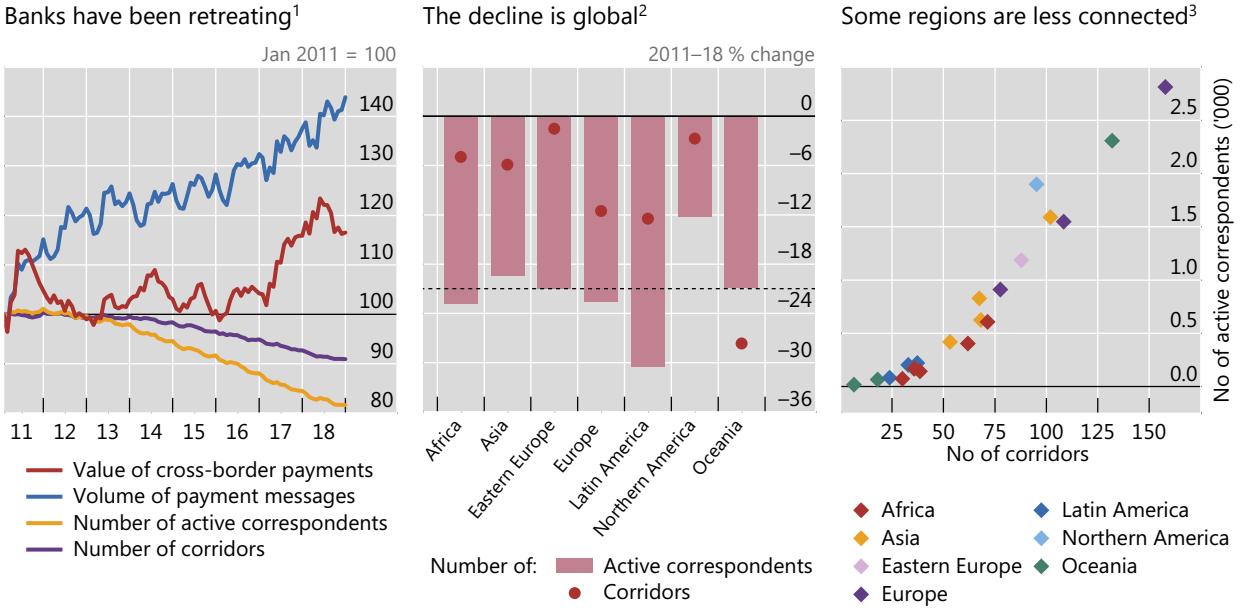
active correspondents (ACs) measures, corridor by corridor, the number of banks that have sent/received messages.[3]

The SWIFT data show that the number of ACs has declined by 20% since 2011 (Graph 1, left-hand panel). Virtually all countries and jurisdictions lost correspondents during that time. All regions have seen a drop, although to varying degrees: the rates of decline range from 12 to 30%, with Northern America at the low end and Latin America at the high end (centre panel).[4] Latin America and Oceania experienced the largest decreases between 2011 and 2018.

SWIFT data also show that the number of corridors between countries fell by 10% over the same period. Between 2011 and 2018, the global number of corridors declined from 10,800 to 9,800, less than a quarter of the maximum number of country pairs that could in principle be connected through SWIFT payments. Here too, the decline was uneven across regions (Graph 1, dots in centre panel) and left some regions with fewer remaining corridors (right-hand panel). Unfortunately, SWIFT data on corridors are not available at the country level; only percentage changes of ACs, value and volume are (Box A). To explore implications for international access, we estimate the number of corridors from the BIS locational banking statistics (see below).

Correspondent banking landscape

Graph 1



[1] Three-month moving averages. [2] The black dotted line shows the average percentage change of active correspondents across regions. [3] 2018 data. Correspondent banks that are active in several corridors are counted several times. Averages across countries in the following subregions: Africa: Eastern, Middle, Northern, Southern and Western; Asia: Central, Eastern, South-Eastern, Southern and Western; Eastern Europe; Europe: Northern, Southern and Western; Latin America: Caribbean, Central and South America; Northern America; Oceania: Australia and New Zealand, Melanesia, Micronesia and Polynesia.

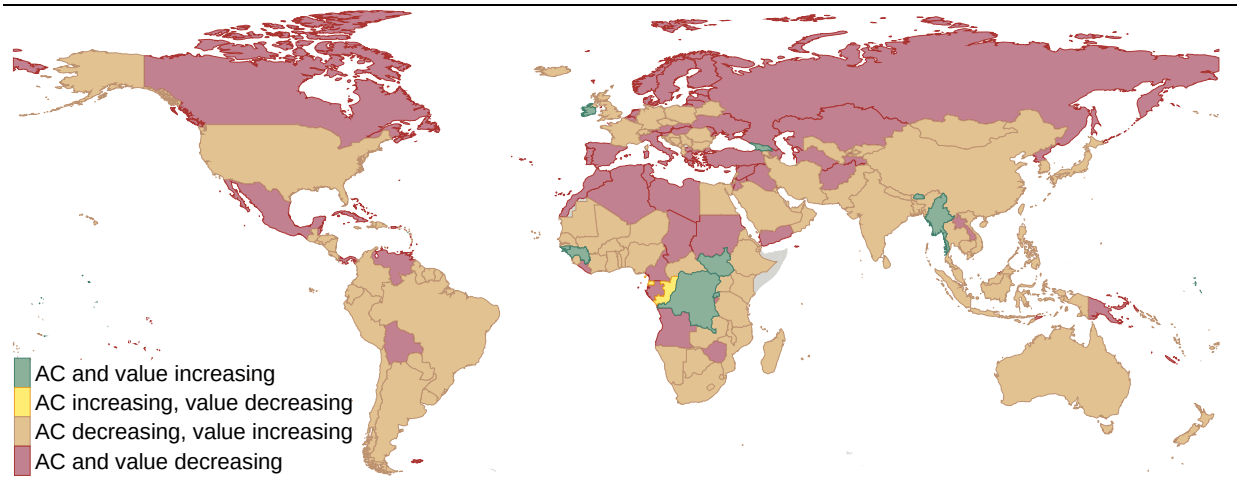
Source: SWIFT BI Watch, National Bank of Belgium.

[3] To illustrate, suppose banks in country A send payment messages to three different banks in the United States. For this corridor (A to US), country A has three active correspondents in the United States that will settle those payments. Country A's total number of ACs is the sum of these correspondent counts across all of A's corridors to other countries.

[4] The regions and subregions used in this article are those defined by the United Nations Statistical Division (https://unstats.un.org/unsd/methodology/m49/).

Active correspondents vs value of cross-border payments

Country classification based on 2012–18 percentage changes Graph 2



The boundaries shown and the designations used in this map do not imply official endorsement or acceptance by the BIS.

The graph crosses country-level data on active correspondents (ACs) with the value of payments sent or received over the same period, identified from SWIFT payment messages (see Box A). Individual countries appear in one of four colours, according to whether a positive/negative change in ACs was accompanied by a positive/negative change in the value of payments.

Source: SWIFT BI Watch, National Bank of Belgium.

Even as the number of corridors and active correspondents declined, the global value and volume of payments continued to grow (Graph 1, left-hand panel). This divergence in the aggregate is widely shared (Graph 2): the countries shown in orange lost ACs, yet saw the value of cross-border payments increase between 2012 and 2018. Whether this increase reflects continued financial globalisation or a lengthening of payment chains is unclear in the absence of bilateral data. The map also identifies countries (in red) that experienced a decline in ACs *and* in the value of cross-border payments. Those countries either sent/received fewer payments altogether, or used other cross-border payment arrangements that are not reflected in SWIFT data.

What are the drivers of this retreat?

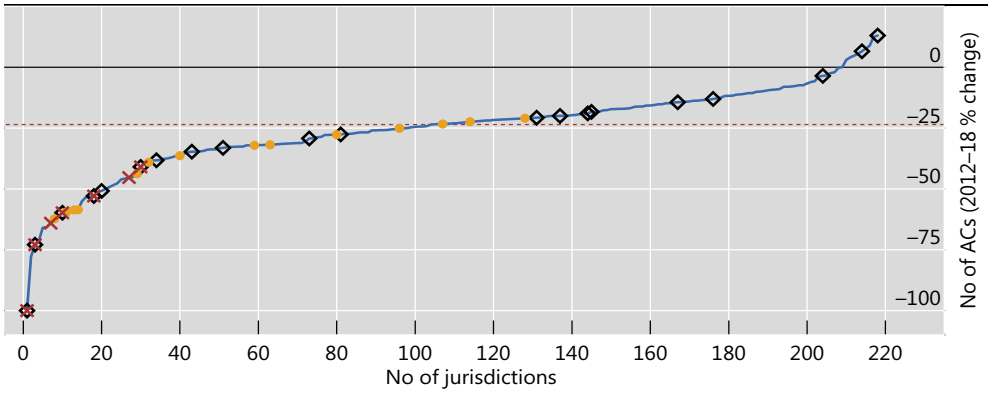
The broad-based changes in correspondent banking present a complex picture. An overarching theme is that in the aftermath of Great Financial Crisis, global banks have reassessed their business strategies against the backdrop of lower bank profitability, dampened risk appetite and tighter regulation and supervision.

One of the largest drivers appears to be banks' reconsideration of their business strategy. In a recent survey, about 40% of banks cited this as a reason for terminating relationships (FSB (2017)). About a third of banks reported that they exited relationships which were no longer profitable or cost-effective because of the required due diligence or other economic reasons (FSB (2017)). As a result, it is possible that smaller countries with less demand, trade or relative growth experienced a greater decline in relationships than larger and more dynamic markets.

Risk-related considerations ranked second among surveyed banks. As correspondent banks conduct business globally, they must comply with the relevant laws and regulations in all jurisdictions in which they operate. These include anti-money laundering and combating the financing of terrorism (AML/CFT) regulations, tax transparency codes and economic and trade sanctions. Jurisdictions have also

The global retreat of correspondent banks

Graph 3



● Offshore financial centres[1] ◇ Countries sanctioned by the US × FATF high-risk jurisdictions[2]

The graph shows the percentage decline in the number of active correspondents (ACs) at the jurisdiction level as a cumulative distribution. The x-axis represents the number of jurisdictions that lost the percentage shown on the y-axis, or more, between 2012 and 2018. The red dotted line shows the average change in ACs (–23.5%). The graph omits the 10 jurisdictions (out of 222) with an increase in ACs of more than 13% during this period.

[1] Jurisdictions designated as tax havens or offshore financial centres by the BIS, Financial Stability Forum, IMF and OECD. [2] FATF = Financial Action Task Force.

Sources: SWIFT BI Watch, National Bank of Belgium; authors' calculations.

cracked down on tax havens and offshore financial centres (Zucman (2015)). About 22% of correspondent banks terminated active relationships for reasons related to compliance and reputation (FSB (2017)).

In recent years, stringent enforcement of AML/CFT regulations, tax transparency requirements and economic and trade sanctions has resulted in high-profile actions and penalties across the banking industry (IMF (2017)). Authorities, particularly in the United States and European Union, have imposed fines for banks' misconduct and/or criminal behaviour (Carletti (2017)). As a result, banks and other financial institutions have had to step up their efforts to comply with the standards and regulations. Faced with higher regulatory expectations, banks may choose to scale up or stop providing correspondent services, concentrating the business in larger global transaction banks.

Jurisdictions which lack robust implementation and enforcement of international financial standards provide greater scope for actors to engage in illicit financing practices. Those designated in multiple areas (ie deficient AML/CFT compliance, sanctioned countries, tax havens/offshore centres) could be considered high-risk countries, and many have indeed lost large shares of active correspondents (Graph 3).

An additional set of drivers pertains to technological advances which could lead to more choices for making cross-border payments. Such developments have the potential to reduce the costs and increase the speed and transparency of payments. Some may complement correspondent banking, such as payment aggregators, which combine a large number of (generally small-value) payments and send them through the correspondent banking network, to be unbundled at the destination. Others may substitute for it in part, eg "netters", where only net imbalances need to be settled. While technological developments make it easier to send and receive payments digitally, they are unlikely to replace correspondent banking. Some netting models work only in corridors where flows balance over time.

Preliminary analysis

In our empirical section, we test the generality of these drivers. This simple, cross-sectional analysis provides insight into some of the drivers that could help explain which countries lost more relationships (Box B). Critically, ACs declined most in

jurisdictions that stood out in terms of corruption and AML/CFT compliance. As banks reassessed their risks in such jurisdictions, those with a longer history of AML/CFT deficiencies lost 25 percentage points more ACs than the average. On the positive side, stronger macroeconomic performance and growth in trade helped maintain ACs. The demand for mobile phone services did as well.

Finally, the measured decline in ACs cannot be explained by purely mechanical factors. First, there has not been significant consolidation among global banks since 2012.[5] And while emerging cross-border payment infrastructures could shorten the payment chain or curb the need for correspondent bank relationships, such systems are limited, and most handle small volumes and values (Bech, Faruqui and Shirakami (2020, in this issue)). Finally, banks could expand internal markets by opening branches and subsidiaries in more foreign countries, reducing their reliance on correspondent relationships. Bank-level data, however, do not suggest that banks are expanding their networks to the point that their internal markets are replacing ACs in a generalised way.

[5] Most mergers between major banks predate 2012. There has also been limited evidence that local consolidation across countries would have substantially reduced the number of relationships.

Explaining country variation in the loss of active correspondents

This box describes preliminary evidence on the extent to which measurable drivers help explain the loss of active correspondents (ACs) in a simple linear regression framework. We relate SWIFT data on percentage change in ACs from 2012 to 2018 (see Box A) to various explanatory variables in a large cross-section of countries. Table 1 tests three groups of drivers, starting with macroeconomic variables relevant for the demand side (users): countries experiencing low growth, crises or subdued trade face conditions that generally reduce banking services.

Moving on to the supply side (correspondent service providers), column 2 tests proxies for risks and activities that pose challenges to regulatory compliance for banks providing correspondent services. Countries subject to US sanctions, designated as high-risk for illicit financing or perceived to be corrupt may lose a greater share of ACs. Finally, column 3 examines how the use of digital technologies might affect the loss of ACs. In all columns, a *negative* estimate, if significant, indicates that the variable exacerbates the loss of ACs, itself a negative percentage.

Explaining the loss of active correspondents

Table 1

	Decline in ACs regressed on:	(1)	(2)	(3)
Group	Explanatory variables	Type	Risk	Technology
Macro	Real GDP growth[1]	0.16**	0.22***	0.18**
	Trade growth[1]	0.11**	0.04	0.07*
	Crises[2]	–1.05	–1.88	–3.21
	Population (log of mn)	0.14	0.48	0.88
	GDP per capita (log)	0.41	–1.24	3.11*
Type	Financial centre[3]	3.95		
	Offshore centre (group A)[4]	–5.93	–0.64	
	Offshore centre (group B)[4]	–11.3**	–3.27	
Risk	FATF risk[5]		–2.14	–4.72*
	FATF high-risk[5]		–22.0*	–16.7
	US sanctions 2012–18[6]		1.08	0.67
	Corruption index[7]		–0.18**	–0.19**
	Bank concentration[8]		–0.07	0.05
Tech	Pay bills by mobile (%)[9]			0.73**
	Internet usage (%)[9]			–0.30***
	Constant	–28.0***	–4.99	–31.8*
	Fit: R^2	15.2%	23.4%	34.9%
	Fit: adjusted R^2	11.1%	16.7%	28.5%
	Number of jurisdictions	177	151	135

The table reports the results from a cross-sectional OLS regression of the percentage change in ACs from 2012 to 2018 on the explanatory variables listed on the left. The table omits standard errors and reports significance levels as: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] Cumulative growth from 2012 to 2018, respectively, in real GDP, and in imports and exports of goods and services (IMF *World Economic Outlook*). [2] The number of crises (0 otherwise), counting banking, currency and sovereign debt crises (from the database on systemic banking crises by Laeven and Valencia), civil wars and autocratic tightenings (defined as an increase of the institutionalised autocracy score of more than two to a level above its global mean of four). [3] Financial centres are coded 1 (other countries 0) following Lane and Milesi-Ferretti (2018). [4] Separate add-on effects estimated for two groups of tax havens and offshore centres: group A is designated by one or two international financial institutions, and group B by three to four institutions (BIS, FSF, IMF and OECD). [5] Separate add-on effects for high-risk and other risk countries monitored for compliance with AML/CFT standards by the Financial Action Task Force. [6] Number of years on the US sanctions list between 2012 and 2018. [7] Corruption Perceptions Index (as of 2016) from Transparency International, rescaled so that higher scores reflect greater perceived corruption. [8] Increase from 2012 to 2017 in the top three banks' share of total commercial banking assets (World Bank Global Financial Developments database). [9] Percentage of population (over age 15) using a mobile phone to pay bills / using the internet (World Bank Findex survey).

Sources: L Laeven and F Valencia, "Systemic banking crises revisited", *IMF Working Paper*, no WP/18/206, 2018; FATF; IMF; OECD; World Bank; US Treasury; Center for Systemic Peace; SWIFT BI Watch, National Bank of Belgium; Transparency International; national data; BIS; authors' calculations.

Looking across the columns suggests that the drivers identified in surveys and policy reports indeed help explain which countries lost more relationships. The negative constants reflect the generalised nature of the retreat. Stronger growth consistently stems the decline; conversely, shrinking economies lost more ACs. In addition, trade also tends to be supportive; indeed, facilitating trade always was a key purpose of correspondent banking. Next, countries in crisis tend to lose more ACs, though low growth rates and subdued trade already account for the effect, leaving "crises" insignificant. Testing five types of crises separately (not shown) reveals that banking crises reduce ACs the most (as do some sovereign debt crises).

Size controls matter little in most specifications. Richer countries or larger markets start with more ACs, but initial conditions hardly affect the rates of decline.① Yet the retreat of correspondent banks is not indiscriminate. Jurisdictions widely designated as offshore centres lost 11 percentage points more ACs (even after controlling for population). It may be more difficult for correspondent banks to know their customers in offshore centres offering anonymity and secrecy. The Channel Islands and Bermuda, for example, lost more ACs than centres with fewer designations (eg Singapore or Ireland). Major international financial centres, including the United Kingdom, saw no such response.

More important than location, presumably, is the nature of the activities conducted in a jurisdiction. Column 2 tests variables posing challenges to regulatory compliance.② Jurisdictions with deficient AML/CFT regimes lost far more ACs. Repeated designations by the FATF as being high-risk accelerated the loss of ACs by some 20 percentage points; shorter stints on the list of monitored countries has a weak effect if any. The number of years on the US sanctions list between 2012 and 2018 did not have the expected negative effect; some long-sanctioned countries gained ACs (eg Congo and South Sudan) while others (eg Syria, Yemen, North Korea) also happened to be FATF high-risk countries and saw negative growth.

The most robust risk-related driver is a corruption index. To capture perceived levels of public sector corruption, the composite index draws on 13 data sources capturing assessments of experts and business surveys. A higher perceived corruption score accelerates the decline of ACs, judging by the negative coefficient. The index explains more variation at the higher end (eg Eritrea, Sudan and Venezuela). Taken at face value, a 1-sigma (20-point) increase in the indicator results in 4% more ACs being lost.

Column 3 examines financial inclusion through digital technologies. Countries where more people use mobile phones to pay bills lost fewer ACs. The estimated coefficient suggests that an increase from the sample average to Kenya's 19% would cut the percentage of ACs lost from the sample average (–24%) in half (–12%). User demand for mobile technologies appears to complement banking services in this instance. By contrast, internet usage apparently went with greater loss of ACs, perhaps because it closely tracks a country's stage of development.③

Finally, we find little evidence that mechanical factors explain the loss in active correspondents. The need for correspondent banks may be lower in Europe thanks to TARGET2; yet, a euro area dummy is insignificant (not shown). Another mechanical driver would be bank consolidation. Most mergers between major banks predate 2012; still, 70 countries in the sample experienced an increase in their top three bank concentration ratio since 2012. This variable explains 5% of variation in ACs in a bivariate context, but fails to register in the multivariate context when included in columns 2 and 3.

Overall, the findings suggest that the number of ACs declined most in jurisdictions that stood out in terms of corruption and AML/CFT compliance, while strong growth, trade and demand for mobile phone services help maintain banking relationships. The analysis is preliminary and limited by data availability, which precludes more systematic testing-down: large drops in sample size change the composition of countries. A separate caveat is that a linear approach may not capture threshold effects and regional dependencies when banks put countries in the same basket in their de-risking efforts.

① In addition to growth in GDP and trade, the value of trade and remittances (log of shares to GDP, not shown) appear to have no robust effect on the loss of ACs. ② Offshore centre status loses its negative effect on ACs, because the added variables absorb some explanatory power and the sample loses several prominent offshore financial centres. ③ The correlation of internet usage with log GDP per capita (also included in the regression) equals 89%, and the two variables largely offset each other in column 3.

Issues that warrant attention

The fact that many jurisdictions experienced a retreat remains a source of concern for the international community. Judging by the drivers reviewed so far, the global decline in the number of ACs results from a confluence of developments over the past decade. Part is natural, eg following banks' post-crisis reassessment of costs and benefits, or consolidation and tiering in global transaction banking. Part is also

intended, a consequence of efforts to enhance international financial integrity. With this in mind, we consider three issues that warrant particular attention and further monitoring.

1. Loss of access

Did the retreat of ACs result in a critical reduction in access? A complete loss of access to cross-border payment services can entail hardship; in the extreme, migrants cannot send home remittances or firms do not receive payments for exports.[6] Most countries experienced moderate retreats with less dramatic consequences. In eight EMEs surveyed by the World Bank, the macroeconomic impact was found to be limited; local banks and money transfer operators (MTOs) have been able to cope by maintaining fewer (if costlier) correspondent bank relationships (World Bank (2018a)). Evidence from Asia and the Pacific, however, illustrates the challenges facing small states, and the fragility of the remittance system (IMF (2017)).

We examine two questions related to international access. First, does the retreat of correspondents entail a loss of corridors? Second, does a loss of corridors threaten a country's access to the global financial system altogether? As country-level SWIFT data on corridors are unavailable, we identify corridors using the BIS locational banking statistics (LBS) knowing that correspondent arrangements rely on interbank deposits (Box A).[7] Tracking the counts of interbank positions with other countries allows us to gauge which countries may have lost corridors and what corridors remain.

As banks cut respondents, we find that corridors tend to disappear as well – albeit at a lower rate. Graph 4 compares the percentage change of ACs (SWIFT) with that of corridors (LBS) from 2012 to 2018. Most countries are in the top left quadrant, suggesting that many correspondents can be lost without a commensurate loss of corridors.[8] That said, many countries lost both ACs and corridors (bottom left). That would not happen if correspondent banks only consolidated their respondents within each jurisdiction. This includes some jurisdictions designated as tax havens or offshore centres or high-risk in terms of AML/CFT. The fitted line suggests that country corridors vanish at half the rate at which correspondent bank relations cease. Indeed, a 20% loss of ACs and a 10% loss in corridors matches the trend in the global aggregates (Graph 1).

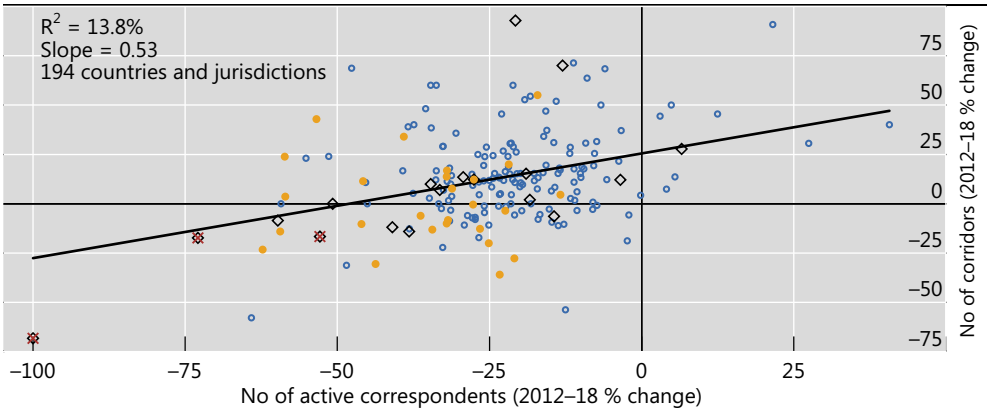
Does a loss of corridors threaten a country's access to the global financial system? A complete loss of access is rare, but the loss of corridors may lengthen payment chains as transfers are routed via third countries. The LBS interbank network shows that virtually all jurisdictions maintained corridors from and to banks in

[6] A case in point is Somalia, a country dependent on remittances to the tune of more than 25% of GDP (Scott et al (2015)).

[7] Interbank deposits capture the ability to make cross-border payments, rather than the actual value of payments. As they comprise interbank *and* intragroup positions, the corridors inferred from LBS data reflect correspondent bank arrangements as well as banks' internal markets.

[8] The new corridors partly reflect the expanding reporting BIS population (China and Russia started to report in 2015, the Philippines in 2016). However, these changes do not explain (but mitigate) the loss of corridors observed on the lower half of the scatter.

Did the retreat of correspondent banks close corridors? Graph 4



● OFCs[1] ◇ Countries sanctioned by the US × FATF high-risk jurisdictions[2] ○ Other

Each dot represents a jurisdiction, excluding 10 countries with more than a 100% increase in corridors (this comprises seven countries with few corridors in 2012, as well as China, Russia and the Philippines, which became BIS reporting countries since 2012). The corridor counts in 2012 and 2018 are derived from BIS data, and generally understate the number of corridors other than for the 47 BIS reporting countries (Box A).

[1] Jurisdictions designated as tax havens or offshore financial centres (OFCs) by the BIS, Financial Stability Forum, IMF and OECD. [2] FATF = Financial Action Task Force.

Sources: SWIFT BI Watch, National Bank of Belgium; BIS locational banking statistics; authors' calculations.

BIS reporting countries.[9] The 214 countries and jurisdictions in the LBS give rise to nearly 46,000 country pairs. In at least 14% of cases, the sender country holds interbank deposits in the receiver country (as of 2018). Another 74% can route payments through a third country, and 6% via two connected intermediaries. Eight destinations cannot receive this way, and four Pacific islands also cannot send. These network metrics may not capture the practical difficulties in routing payments, but they underscore that longer payment chains may be the more relevant concern, at least if such intermediation raises the cost of cross-border payments.

2. Rising costs of cross-border payments

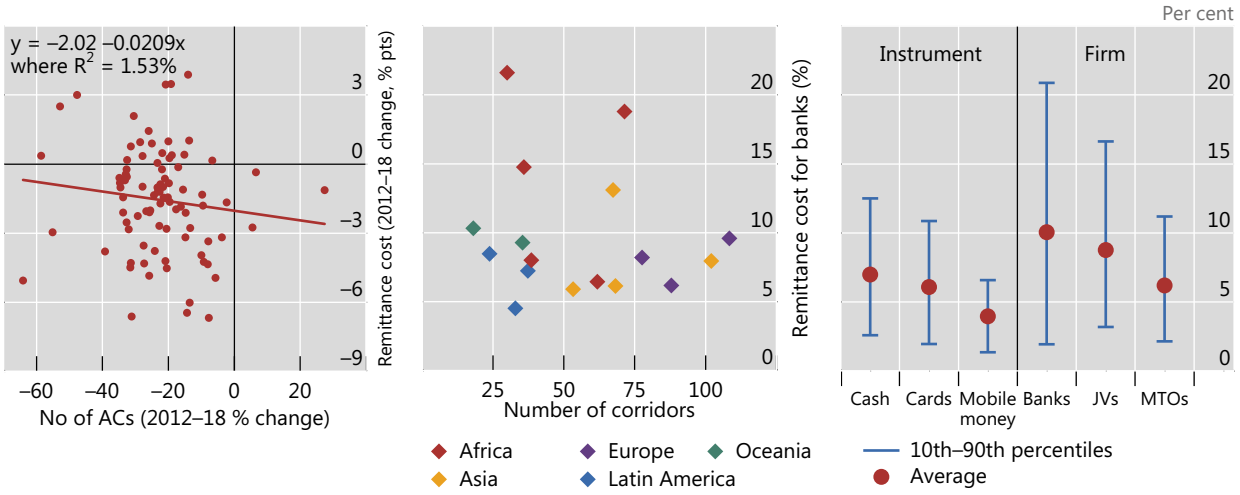
Costs for sending cross-border payments remain high, especially in some countries, despite international efforts to reduce such costs (World Bank (2015)). Accordingly, policymakers have set targets to significantly reduce remittance costs (World Bank (2019a,b)). Those costs have been declining slowly in recent years as financial inclusion has improved (Carstens (2019)).

Greater concentration, or fewer correspondent banks providing services, could keep such costs elevated. Most countries have seen falling remittance costs in spite of a loss of ACs (Graph 5, left-hand panel). Yet all instances of rising remittance costs are associated with lost ACs (top left quadrant). Remittance costs generally fall by less where more correspondents retreat. Additionally, regions associated with the fewest ACs, particularly in Africa, also face higher costs (Graph 5, centre panel).[10] Absent

[9] Table A6.1 of the BIS locational banking statistics report loans and deposits vis-à-vis banks in the 47 BIS reporting countries for more than 200 countries and jurisdictions.

[10] Higher remittance costs are also observed for countries with fewer corridors, countries whose own banks have few (or no) international branches and subsidiaries and country pairs that are not directly linked through the LBS interbank network.

Cost of sending remittances[1] Graph 5



[1] The cost of sending $200 to selected countries. [2] 2018 data. [3] Receiving subregions in each continent: Africa: Eastern, Middle, Northern, Southern and Western; Latin America: Caribbean, Central and South America; Asia: Eastern, South-Eastern, Southern and Western; Europe: Eastern, Northern and Southern; Oceania: Melanesia and Polynesia. [4] Cards = credit and debit cards; JVs = joint ventures (partnerships between non-bank firms and financial institutions); MTOs = money transfer operators.

Sources: SWIFT BI Watch, National Bank of Belgium; World Bank, Global Findex database and Remittance Prices Worldwide; authors' calculations.

robust competition and proper incentives, the costs may not continue to decline in line with international expectations.[11]

Technology could make cross-border payments more attractive. One emerging payment type, mobile money transfers (payments through a mobile phone), can be used for cross-border payments at a lower cost than cash or cards (Graph 5, right-hand panel). Non-bank players such as money transfer operators (MTOs) and joint ventures or partnerships between non-banks and other financial institutions provide remittance transfers at lower costs than banks (right-hand panel). Such competitive pressure helps lower costs more generally.[12]

3. International financial integrity

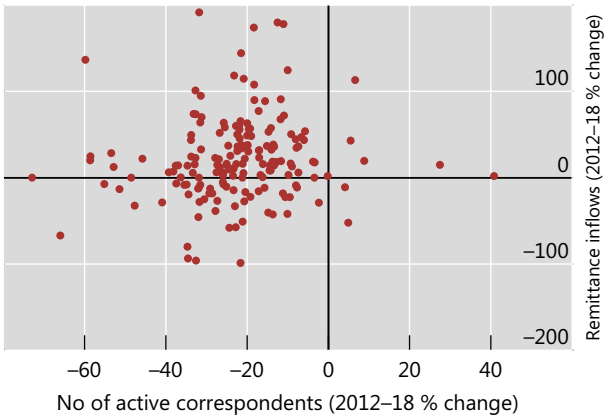
The continuing decline in the number of ACs around the world could adversely affect the integrity of the global financial system. If banks are not providing these critical cross-border financial services, users may resort to unregulated and potentially unsafe "shadow payments". For instance, in spite of losing ACs, most countries received greater remittance inflows in 2018 than in 2012 (Graph 6, left-hand panel, top left quadrant). Such countries could be making payments through less regulated non-bank channels. This includes informal networks for cash or unregulated cryptocurrency platforms for digital assets (Cœuré (2019a)). Such platforms lack

[11] The United Nations 2030 Agenda includes as a sustainable development goal that of reducing remittance costs to less than 3% on average and 5% maximum through any given corridor. The World Bank monitors progress on this goal through its Remittance Prices Worldwide. See https://datatopics.worldbank.org/sdgs/sdg-goals-targets.html.

[12] We examine average remittance prices at banks, MTOs and other providers across corridors. We find that bank remittance costs decline slightly when banks are presented with more diverse (non-bank) competition.

Cross-border payments through informal channels? Graph 6

Inflows may be finding other channels



Using $100 bill shipments to identify informal activity

Sources: Judson (2017); SWIFT BI Watch, National Bank of Belgium; Transparency International; World Bank; authors' calculations.

proper cyber security, basic risk management, legal certainty or consumer protection (Cœuré (2019b)).

One way of identifying countries with large informal economies is through foreign holdings of cash, namely the US dollar, the dominant international currency. Nearly 80% of $100 bills (the most commonly held bill as a store of value) are held overseas, more than twice the amount in circulation abroad in 1980 (Haasl et al (2018), Judson (2017)). In fact, Judson (2012) finds that economic and political instability contribute to this demand. Indeed, shipments of $100 bills are greater to jurisdictions where the perceived corruption index is higher (Graph 6, right hand-hand panel).

Digital assets or cryptocurrencies provide other channels for cross-border payments. One recent study estimates that around $76 billion of illegal activities per year involve Bitcoin (Foley et al (2019)). Additionally, an industry group that follows crypto-exchange compliance with AML/CFT standards finds that roughly 97% of direct Bitcoin payments from identifiable criminal sources have been received by unregulated cryptocurrency exchanges (CipherTrace (2018)).

While much has been done to improve regulatory compliance at banks, other institutions – such as non-bank financial institutions and crypto-exchanges – should be held to equally high standards and regulations. There are initiatives under way to make such improvements. One set of efforts seeks to improve anti-money laundering standards for cryptoassets. To that end, the Financial Action Task Force (FATF) has developed standards and guidance to enhance AML/CFT standards for crypto-exchanges and cryptoasset service providers to align them more closely with bank regulations (FATF (2019)).

Another set of initiatives seeks to improve information-sharing. For example, a number of jurisdictions have developed, or are working to develop, robust know-your-customer (KYC) utilities.[13] For example, India has developed a digital identify platform and electronic KYC utility that has greatly improved KYC processes (D'Silva et al (2019)). It enables paper-free KYC processes, reducing the costs of adding new customers while complying with regulations. Building on jurisdiction-level

[13] KYC is used to identify and verify potential customers, as well as monitor their behaviour. A KYC utility is a multilateral effort to centralise collection, verification, storage and sharing of clients' data and documents to comply with KYC procedures. See eg IFC (2018).

experiences, organisations are working to reduce cross-border frictions by establishing regional KYC utilities. One such example is the pan-African platform Mansa, launched in July 2018 (Afreximbank (2018)). The private sector plays a key role in improving compliance and reducing related costs. One recent initiative is the IIN, a peer-to-peer KYC information-sharing network of more than 400 banks built on distributed ledger technology (JPMorgan (2019)).

Looking ahead

For centuries, banks have been building networks of banking relationships across the globe. But over the past decade, correspondent banks have retreated, in part due to the need to improve profitability and maintain high standards of financial integrity. As banks pare back respondent relationships, country-to-country corridors tend to disappear as well. Countries with limited access to correspondent banking services see the costs of cross-border payments rise.

Where banks are retreating, users may resort to less regulated or unregulated channels. Shifting payments outside the banking system may undermine international financial integrity. While much has been done to strengthen international standards for banks, other institutions should be held to equally high standards.

Further monitoring and action are necessary to ensure that household and businesses in all countries enjoy access to safe, low-cost cross-border payment channels. Monitoring corridors more closely would help assess which jurisdictions risk losing access, impeding financial inclusion and growth. Corridors that have become prohibitively expensive may not be accurately reflected in survey data on costs, and warrant enhanced monitoring. That said, indirect payments routed through countries with global transaction banks may also bring efficiency gains.

Looking ahead, a key element is to overcome frictions inherent in cross-border payments. To this end, a number of promising private and public sector information-sharing initiatives are under way. Continued progress should provide welcome improvement to cross-border payments.

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Payments without borders[1]

Cross-border and multicurrency payment systems have the potential to make cross-border payments faster, cheaper and more transparent. A simple taxonomy reviews the different designs and functionality of existing systems. Such systems remain rare, and most handle small volumes and values. However, a number of new projects will go live in the next few years.

JEL classification: E42.

Cross-border payments are generally slower, more expensive and more opaque than domestic ones. They tend to flow through the so-called correspondent banking network, where chains of banks work to get funds from the payer to the payee.

There are several ways to potentially improve cross-border payments. One is to streamline processing along the chains of correspondent banks.[2] Another is to replace the payment chains (or parts thereof) with dedicated cross-border and/or multicurrency (CBMC) payment systems.

This special feature focuses on the latter approach by looking at existing systems with a view to drawing lessons. While CBMC arrangements are not new, they are relatively rare. One reason is the complications in setting them up. On top of operational challenges, some complexities of domestic systems are amplified in a cross-border context. These include cross-border governance, conflict of laws issues, and adherence to multiple anti-money laundering (AML) and combating the financing of terrorism (CFT) regimes. Moreover, some issues are unique to cross-border or cross-currency systems such as foreign exchange (FX) conversion and liquidity management in foreign currencies. These are not always straightforward to solve. In addition, the volumes and values processed by existing systems are often very low (both in absolute terms and relative to domestic systems), suggesting that "build it and they will come" does not uniformly apply to CBMC systems.

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[2] SWIFT's global payments innovation (gpi) initiative is designed to speed up cross-border correspondent banking transactions by allowing end-to-end tracking of payments in real time (SWIFT (2019)).

Key takeaways

- Payments across borders and currencies can be made faster, cheaper and more transparent by linking domestic systems, allowing banks from abroad remote access or building dedicated systems.
- Cross-border and multicurrency payment systems are more complex to set up and operate than domestic systems.
- There are only a handful of successful examples at present, but new systems are being implemented or planned.

After a recent lull in new CBMC systems, things may be at a turning point. A number of new systems are in the pipeline and likely to go live in the next few years. Moreover, the type of CBMC systems is changing. Whereas past systems have primarily focused on wholesale payments, some of the newer projects aim at retail flows.

The feature starts by presenting a taxonomy of CBMC systems. It then discusses the challenges involved in setting them up and concludes with a summary of emerging trends and policy issues.

Cross-border and multicurrency payments

Cross-border payments are those where the payer and payee reside in different jurisdictions. Many of these are also cross-currency payments – that is, payments where the payer and payee are debited and credited, respectively, in different currencies.

However, not all cross-border payments are cross-currency. Exceptions include payments within monetary unions or payments in parts of the global economy where there is a common invoice currency. For example, in the European Union the Single Euro Payments Area (SEPA) initiative has simplified euro bank transfers to make them as cheap and as fast as domestic ones (ECB (2014)). Globally, the US dollar remains the most common invoice currency, and for many markets, such as oil and other commodities, prices are quoted in USD. Regionally, other currencies may be a "vehicle" for funds transfers, such as the Australian dollar in the South Pacific and the South African rand in southern Africa.

There are also a number of other payment types that have cross-border elements embedded in them. These include foreign currency payments within a jurisdiction and situations where a payment in one currency is linked to a payment in another – a process known as payment versus payment (PvP). For the former type, the cross-border element relates to the fact that even if parties within a jurisdiction agree to pay each other in, say, USD, there is still need for a settlement agent[3] with access to the US payment system to square net positions at some point.

CBMC systems have been built to facilitate the various types of cross-border payments. The number of these systems is, however, low – especially if we disregard cross-border systems in currency areas, such as the euro area.

[3] An entity that manages the settlement process for transfer systems or other arrangements that require settlement. The settlement agent sometimes differs from the owner or settlement institution of the system (CPMI glossary).

Taxonomy of cross-border and multicurrency payment systems[1] Table 1

		Geographical reach	
		Within borders	Cross-border
Settlement currencies	Domestic/single	*Domestic payment systems*	*Single currency cross-border* (3 implemented, 1 under way)
	Foreign/multiple	*Offshore* (9 implemented, 0 under way)	*Multicurrency cross-border* (7 implemented, 3 under way)

[1] The numbers refer to authors' estimates of, respectively, systems in operation and projects under way targeting implementation in 2020–21.

A rudimentary survey of central bank and industry websites suggests that, around the world, there are currently about 20 systems that offer cross-border, cross-currency, multicurrency or PvP services (Table 1 and Annex Table A). In addition, there are at least four projects that aim to go live in the next few years. This compares with the more than 90 major domestic payment systems in the 27 jurisdictions that are members of the Committee on Payments and Market Infrastructures (CPMI).

The 23 systems and projects identified fall into three broad categories, as shown in Table 1, depending on the type or number of currencies that the system handles (domestic/single or foreign/multiple) and its geographical reach (within or across borders). The three categories are: (i) *offshore*, (ii) *single currency cross-border* and (iii) *multicurrency cross-border*.

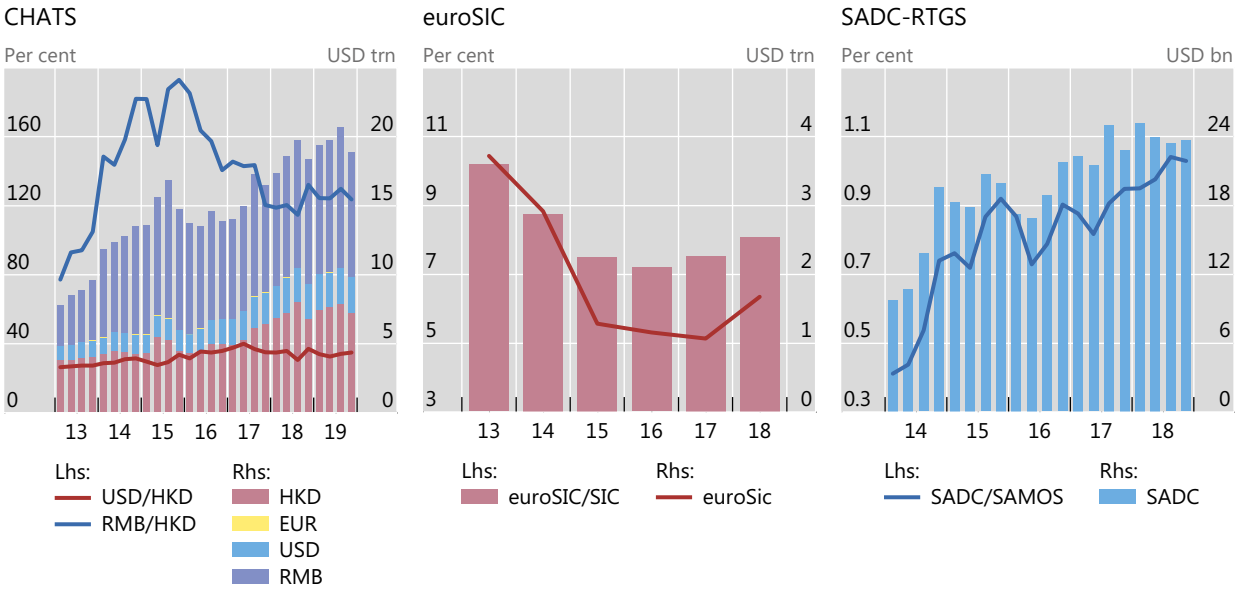
Offshore systems

Some jurisdictions have substantial volumes of payments between domestic financial institutions in one or more foreign currencies. In such cases, it might make sense to "onshore" these payments by building an offshore system. An offshore system processes payments denominated in a currency different from that of the jurisdiction (CPMI glossary). Typically, these systems are built by adding currencies to new or existing systems or reusing the same technical infrastructure for a new separate system that then operates with a foreign currency.

Offshore systems have potential advantages. These include the ability to make foreign currency payments during local business hours and the opportunity to save on liquidity in the foreign currency if payments are netted before they are settled using the designated settlement agent abroad. The Clearing House Automated Transfer System (CHATS) in Hong Kong SAR is the poster child of multicurrency offshore systems. It is a group of real-time gross settlement (RTGS) systems, each of which settles in HKD, USD, EUR and RMB. CHATS is operated by Hong Kong Interbank Clearing, a private entity jointly owned by the Hong Kong Monetary Authority (HKMA) and the Hong Kong Association of Banks. Real-time gross settlement of HKD payments began in 1994. In 2000, USD-CHATS was launched to allow settlement of USD transactions during Asian business hours. USD-CHATS uses HSBC as its settlement bank and also provides intraday liquidity to participants. CHATS added the euro in 2003 and Chinese renminbi in 2006 (Graph 1, left-hand panel). The settlement banks are Standard Chartered Bank (Hong Kong) and Bank of China (Hong Kong), respectively.

Payment volumes in single currency and offshore systems generally remain low

Transactions settled in selected systems — Graph 1



CHATS = Clearing House Automated Transfer System (Hong Kong SAR); euroSIC = Euro Swiss Interbank Clearing; SADC = South African Development Community; SAMOS = South African Multiple Option Settlement; SIC = Swiss Interbank Clearing.

Sources: South African Reserve Bank; Swiss National Bank; Hong Kong Interbank Clearing; SIX Group Interbank Clearing.

Other examples of offshore payment systems are the Lebanese RTGS system (BDL-RTGS), the USD options in the RTGS systems of the central banks of Azerbaijan, Jamaica, Tanzania and the United Arab Emirates, and the renminbi settlement service in Malaysia.

Single currency cross-border systems

Economic agents located across borders may wish or need to pay each other repeatedly in one of their currencies or even in a third currency. This occurs, for example, if one currency dominates trade or finance flows between the agents. If volumes are sufficient, then building a dedicated system to handle such flows may make sense.

In general, there are two models for providing single currency cross-border systems: one involves allowing some level of "remote access" to a common system, and the other entails interlinking systems across borders. Switzerland uses both models. The "domestic" RTGS system, Swiss Interbank Clearing (SIC), allows qualified foreign-domiciled banks to participate via remote access[4] – that is, a foreign bank does not need to have a physical presence in Switzerland via a branch or a subsidiary. This setup permits cross-border payments in Swiss francs; for instance, a participant located in London can transfer CHF to participants in Frankfurt or Basel directly via SIC and vice versa (Graph 2, first panel). This form of remote access to an RTGS system is, however, unique. Most central banks grant accounts only to financial institutions

[4] All participants with remote access to SIC must be subject to the equivalent level of standards regarding supervision, anti-money laundering and telecommunications infrastructure as Swiss participants are subject to.

that are supervised or overseen by domestic authorities. Roughly one in five SIC participants is a foreign-domiciled entity.

Swiss euroSIC links to the euro area RTGS system TARGET2[5] (Graph 2, third panel). The system dates back to the introduction of the euro in 1999. It runs on the same technical platform as SIC, and both systems are operated by SIX Interbank Clearing.[6] All cross-border euro payments to and from Switzerland are channelled through the Swiss Euro Clearing Bank (SECB) in Frankfurt, which acts as the link between the two systems. For banks in Switzerland, euro payments have over the last couple of years accounted for around 5–7% of the value of Swiss franc payments (Graph 1, centre panel).

In 1999, the common currency prompted also Denmark, Sweden and the United Kingdom to introduce new euro RTGS systems despite the fact that they did not join the euro. The systems became part of the TARGET system which interlinked the national RTGS systems in the euro area. Joining TARGET allowed banks in the three countries to make and receive cross-border euro payments (Graph 2, fourth panel). A combination of low volumes and the changing prospects of joining the euro ultimately led to the closure of the systems.

The countries of the Southern African Development Community (SADC)[7] provide another variation on how a single currency cross-border system can be set up via remote access. Eligible banks from SADC countries hold ZAR accounts in the SADC-RTGS and can access the system from their own country and make payments.

The SADC-RTGS was set up in 2013, partly with a view to enhancing regional monetary cooperation and financial integration. The system is owned and governed by the SADC Payment System Oversight Committee (Graph 2, second panel). The system is hosted by the South African Reserve Bank (SARB) and runs on the same infrastructure as the SARB's domestic RTGS system (SAMOS). The values settled by the SADC-RTGS have grown over time, but still represent only about 1% of the values in SAMOS (Graph 1, right-hand panel). This, in part, reflects the importance of the US dollar for cross-border payments in the SADC region, and the relatively high liquidity management costs for participating banks.[8]

[5] TARGET stands for Trans-European Automated Real-time Gross settlement Express Transfer system.

[6] SIX Interbank Clearing is a subsidiary of SIX Group, a private financial services company. It operates SIC on behalf of the Swiss National Bank.

[7] Angola, Botswana, Comoros, the Democratic Republic of the Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia and Zimbabwe.

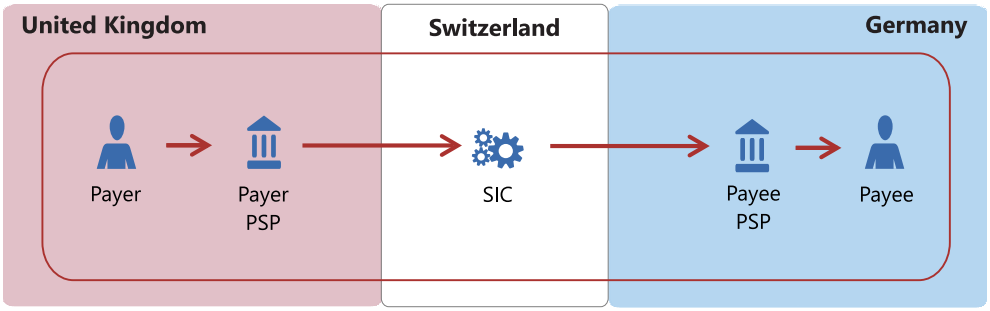
[8] Non-South African banks need to have a separate, off-system arrangement for prefunding their ZAR accounts in the SADC-RTGS through their correspondent banks in South Africa.

Payment flows in selected single currency cross-border systems

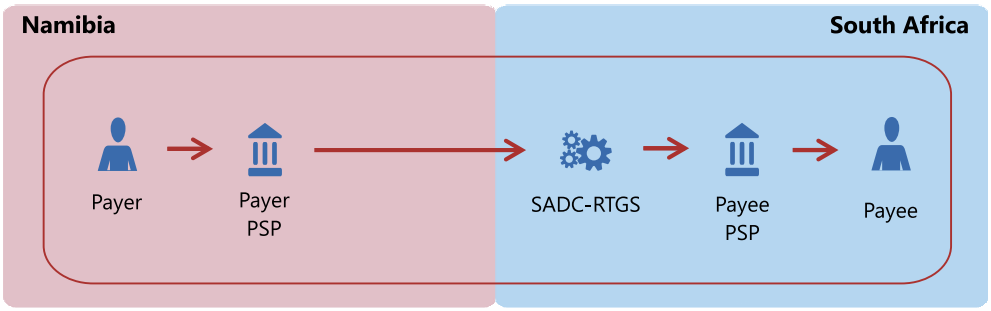
Stylised illustrations — Graph 2

Remote access

SIC

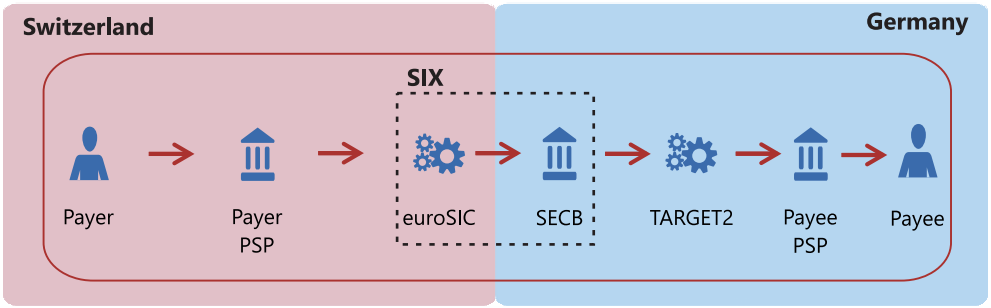


SADC-RTGS

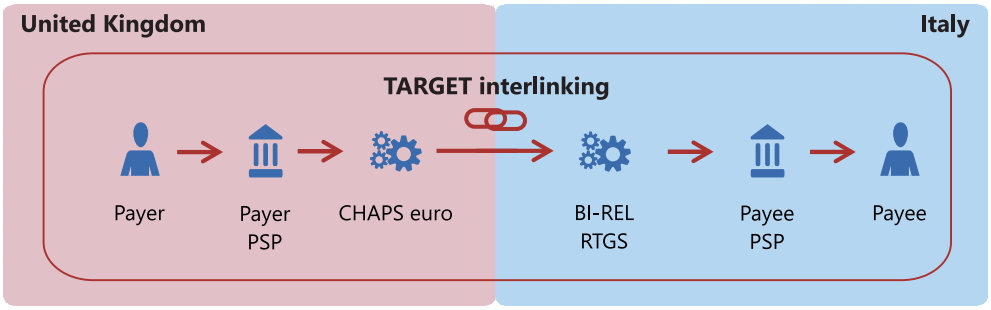


Interlinked systems

euroSIC



CHAPS euro



BI-REL = Banca d'Italia Regolamento Lordo; PSP = payment service provider; SADC = South African Development Community; SECB = Swiss Euro Clearing Bank in Germany; SIC = Swiss Interbank Clearing; SIX = SIX Group (a private financial services company in Switzerland); TARGET = Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET was the precursor of the current Eurosystem RTGS system, TARGET2).

Source: Authors' elaboration.

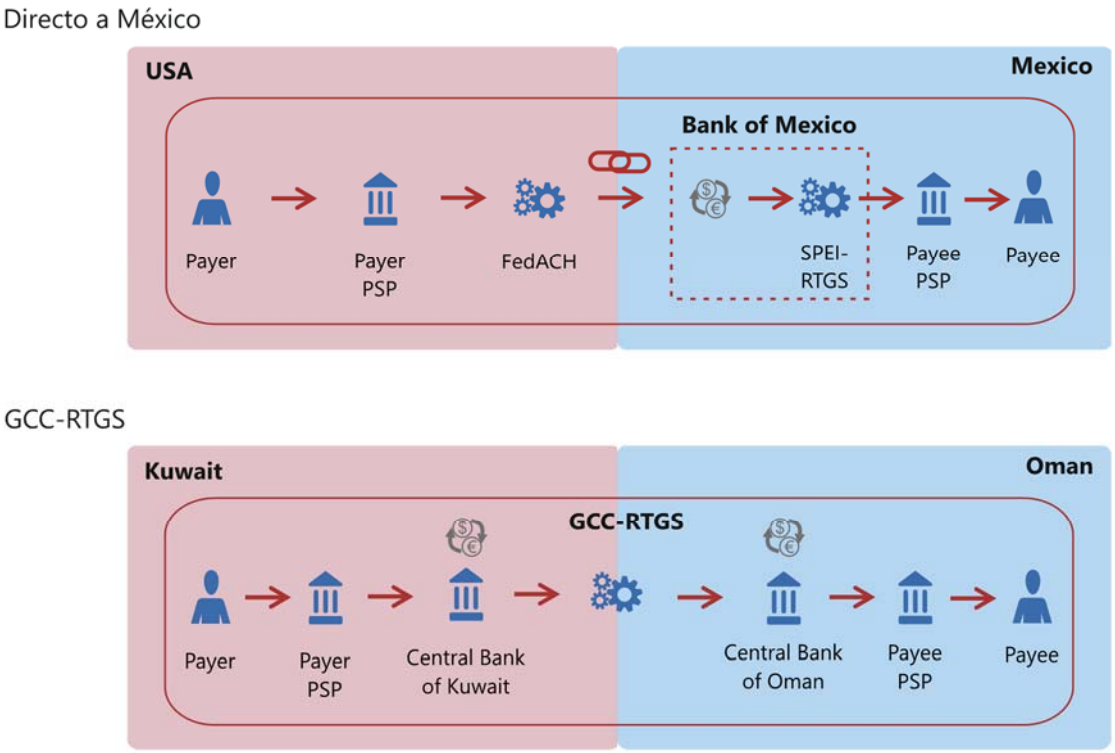
Multicurrency cross-border systems

There are about half a dozen multicurrency cross-border systems in operation and two projects under way. They fall into three groups, based on the services offered: *cross-currency*, *choice of currency* and *PvP* arrangements. Cross-currency service allows the payer to be debited in one currency and the payee to be credited in another. Examples are Directo a México and the forthcoming Gulf Cooperative Council RTGS system (GGC-RTGS). In contrast, choice of currency service allows users to select the currency of a payment from among those the system settles in; examples are the Regional Payment and Settlement System (REPSS) of the Common Market for Eastern and Southern Africa (COMESA), the East African Payment System (EAPS) of the East African Community (EAC) and the forthcoming Arab Regional Payment System (ARPS). PvP allows conditional processing of payments, a prime example being CLS.

Directo a México was set up in 2005 to facilitate remittances from the United States to Mexico. It links the Federal Reserve's automated clearing house (FedACH) with the Mexican RTGS system (SPEI),[9] and allows USD/MXN payments (Graph 3, top panel). The Bank of Mexico provides the FX conversion at near wholesale rates. In December 2019, the system processed some 43,000 payments worth USD 27.4 million, implying an average payment of USD 640 (Graph 4, left-hand panel).

Payment flows in selected cross-currency systems

Stylised illustrations — Graph 3



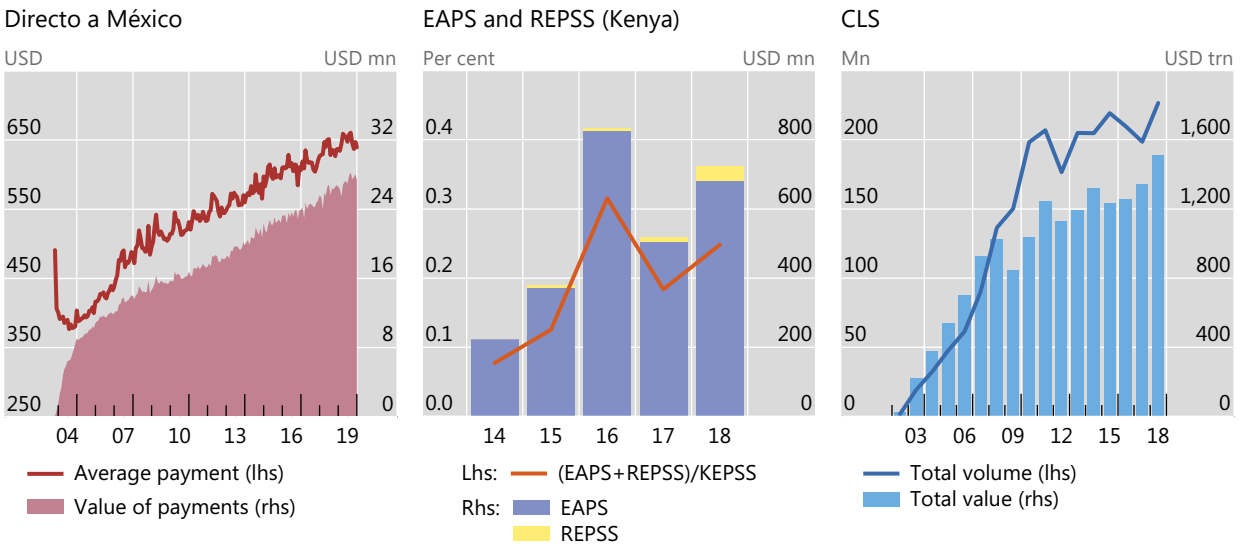
GCC-RTGS = Gulf Cooperative Council regional system; PSP = payment service provider.

Source: Authors' elaboration.

[9] SPEI is both the RTGS and the retail payment system in Mexico.

Other than CLS, multicurrency systems have not attracted large volumes

Transactions settled in selected systems — Graph 4



EAPS = East African Payment System (EAC); KEPSS = Kenya Electronic Payments and Settlement System (ie the domestic RTGS for the Kenyan shilling); REPSS = Regional Payment and Settlement System (COMESA).

Sources: Central Bank of Kenya; CLS; Quandl; BIS Red Book statistics.

Another example of a cross-currency system is the forthcoming GCC-RTGS (Graph 3, bottom panel). It is expected to go live later in the year, and will settle payments in the currencies of six Gulf region countries.[10] The central banks will convert the currencies based on FX rates set at the start of the business day. The fact that the GCC countries peg their currency to the US dollar[11] alleviates FX risk. Based in Saudi Arabia, the Gulf Payments Company will operate the system.[12]

REPSS offers choice of payment in either USD or EUR across COMESA countries. It has a common clearing house in Zimbabwe, and the Bank of Mauritius acts as its settlement bank, debiting and crediting the accounts of the participating central banks on its books. Any payments made between participating countries are cleared daily, on a net basis. CENFRI (2018) reports that REPSS is used infrequently and primarily for wholesale or trade transactions.

EAPS offers multicurrency payments across the EAC countries.[13] Unlike REPSS, EAPS settles in the local currencies of the participating countries. To settle, the system relies on the existing RTGS systems as well as bilateral account relationships between the central banks. Moreover, it requires commercial banks to prefund payments with their deposits at the central banks (CENFRI (2018)).

Volumes settled through the African cross-border payment systems are low. Kenya, for example, participates in both EAPS and REPSS. In 2018, its central bank

[10] Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

[11] Kuwait is the exception, as it pegs its currency to a basket of currencies (of which the US dollar is the most dominant).

[12] The Gulf Payments Company is owned and operated by the six GCC central banks.

[13] Burundi, Kenya, Rwanda, Tanzania and Uganda.

processed 18,307 EAPS and 620 REPESS payments, worth about USD 680 million and USD 43 million equivalent, respectively (Graph 4, centre panel).

ARPS, also known as Buna, is scheduled for launch in 2020. The system will be operated by a supranational entity – a subsidiary of the Arab Monetary Fund – and will be located in the United Arab Emirates. Regional central banks and qualifying commercial banks will be able to hold multicurrency accounts at ARPS, including in USD, EUR and eligible Arab currencies. Accounts need to be prefunded, and any FX conversions will take place outside ARPS.

CLS is a noteworthy example of a cross-border multicurrency system that provides PvP services. Founded in 2002 with the support of major central banks, it provides settlement services in 18 currencies to mitigate FX settlement risk (see box). CLS settles millions of trades worth trillions of dollars (Graph 4, right-hand panel).

Challenges of setting up

The rarity of cross-border and multicurrency systems is likely to be due to a combination of factors. In the first place, setting up any payment system – domestic or cross-border – is a complex undertaking (Bech and Hancock (2020, in this issue)). Some of the challenges in implementing a domestic payment system are amplified in a cross-border context. These challenges are both technical and political.

On the technical side, there are four key challenges. First, cross-currency payments require an *FX conversion* at some point. In the correspondent banking model, this conversion is done by one or more correspondent banks along the payments chain. Often it is done by either the first (ie the payer's) bank or the last (ie the payee's) bank in the chain. FX conversion is difficult to provide for most cross-border or multicurrency payment systems, as it requires a "balance sheet" and the willingness and ability to manage risks (eg market risk and FX settlement risk). Hence, in cases where FX conversion is part of a system's service offerings, it is typically done by a closely affiliated bank.

Second, *liquidity management* in foreign currencies can be costly. Liquidity is the grease that allows payment systems to operate smoothly. For domestic systems, the settlement agent (eg a central bank or a commercial bank) often provides intraday liquidity. For cross-border and multicurrency systems, the settlement agent might not be willing or able to provide intraday liquidity to foreign participants or in foreign currency. Thus, in the cross-border context, liquidity management is typically done via prefunding, ie keeping balances in relevant accounts. This comes with trade-offs. While the prefunding is essential in reducing the risk of payment delays and failures, it can add costs for participants (eg in the form of idle buffer balances) or create additional credit exposures elsewhere in the financial system (eg if credit is provided by commercial banks in the country of a foreign currency to support the prefunding).

Third, ensuring a high degree of technical *interoperability* across payment systems is difficult. Interoperability involves multiple facets, including operating hours, access criteria, clearing and settlement procedures, and messaging standards. Ensuring interoperability can be resource-intensive and time-consuming, especially when there are required changes to legacy IT systems in the domestic payment infrastructure and at member banks. In addition, any move towards interoperability across jurisdictions needs to be synchronised, further exacerbating the "collective action problem".

Payment versus payment

The settlement of FX trades can create significant risk exposures among counterparties. This FX settlement risk relates to the risk that arises when one counterparty fails to make a payment in a currency after the other has made its payment in a countercurrency (Bech and Holden (2019)). Over the past two decades, market participants have made significant progress in reducing FX settlement risk by using payment versus payment (PvP) and other risk-reducing methods such as netting.

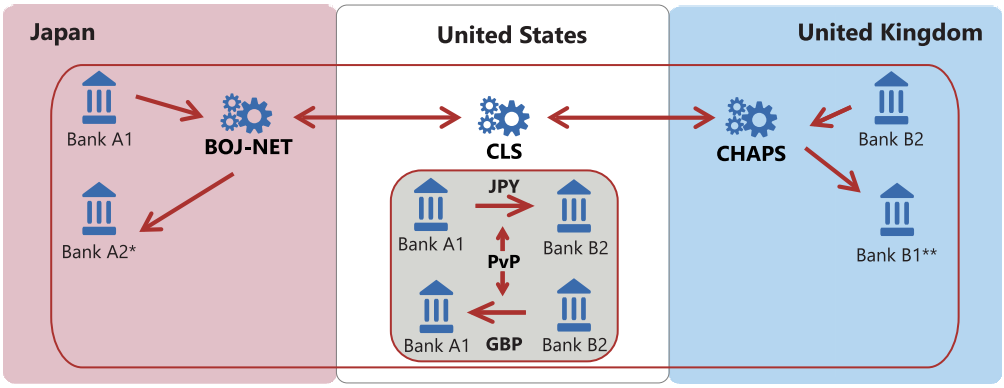
PvP ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place (CPMI glossary). Technically, PvP settlement can be achieved in different ways. It can be done through a direct link between two payment systems or through a common agent in the middle.

CHATS is an example of the former. In 2000, USD-CHATS was launched, allowing the clearing and settlement of US dollar transactions in Hong Kong SAR during Asian business hours. Since 2000, CHATS has added the capability of settling euro (2003) and renminbi (2006) transactions. These components of CHATS enable payments in multiple currencies. In addition, payments in any supported currencies can be linked and settled on a PvP basis. USD-CHATS is directly linked with the RTGS systems in Malaysia (since 2006), Indonesia (2010) and Thailand (2014), which enables PvP between the US dollar and those countries' currencies.

CLS is an example of the latter. It is a dedicated PvP settlement system and achieves PvP with a common agent in the middle, ie CLS Bank (CLSB). Each direct participant in CLS has a single multicurrency account at CLSB, which is located in the United States. CLSB, in turn, is a (remote) participant in the RTGS systems of the 18 currencies that it settles. Trades submitted by CLS participants settle on a gross basis (ie one by one) on their accounts at CLSB. By contrast, the funding by participants of their CLS accounts occurs through the local RTGS systems and on the basis of the multilateral net short position (Graph A).

Payment flows in CLS

Graph A



* = a subsidiary, branch or correspondent bank of Bank B2; ** = a subsidiary, branch or correspondent bank of Bank A1.

Source: Authors' elaboration.

Finally, compliance risks and costs related to *AML/CFT* are typically higher in the cross-border context. Yet AML/CFT requirements vary across jurisdictions, which generally weakens the business case for centralising the AML/CFT screening function within a cross-border payment system. Where that screening function is centralised, establishing clear rules as to who would be liable in case of irregularities is vital but difficult to operationalise.

On the political side, cross-border systems often need to be have a *high degree of shared political will* among participating jurisdictions. A common motivation for CBMC systems is to promote financial or economic integration in a region. Any new

system needs to attract transaction volume above a certain threshold to grow sustainably. This can be challenging where competing incumbent networks (eg correspondent bank chains or closed-loop services) exhibit "inertia" because of their network externality. Strong public policy support is often required to overcome such inertia.

Furthermore, connecting payment systems in different jurisdictions also gives rise to *legal issues*. For instance, differences in settlement finality rules may lead to a scenario where a payment is regarded as final in one jurisdiction but not final in another. The United Kingdom's withdrawal from the European Union has led several European countries to adapt their solvency laws to ensure settlement finality (Clancy (2018)). Moreover, it is more likely that cross-border systems will face issues arising from a conflict of laws (eg ambiguity as to which jurisdiction's laws apply). Closing such legal gaps sometimes requires new legislation or treaties.

Conclusions

A number of new cross-border systems are expected to be launched in the early 2020s. Beyond numbers, cross-border systems are also extending in scope. Until now, most of the implementations or augmentations have focused on wholesale payments and thus involve RTGS systems. Future projects are increasingly focused on retail payments. For instance, the SADC-TCIB system,[14] expected to go live in 2020, is geared towards remittance payments across a number of African countries. P27, a proposed payment infrastructure for Nordic area countries, will first link automated clearing houses and then retail fast payment systems. Sweden is planning to leverage the pan-European retail fast payment system (TIPS) to settle its domestic retail payments. Finally, new peer-to-peer technologies also hold promise with a view to easing cross-border frictions (HKMA-BOT (2020), Auer and Böhme (2020, in this issue)).

Safe and efficient CBMC systems can serve as public goods (Carstens (2019)). These systems can increase competition in the cross-border payments market. This can help contain the potential monopolistic powers of (existing or future) closed-loop or peer-to-peer arrangements (G7 (2019)). CBMC systems can also provide an alternative to the current correspondent banking setup for cross-border payments. This can be especially relevant if the decline in correspondent banking relationships continues (Rice, von Peter and Boar (2020, in this issue)).

However, as noted above, there are a number of challenges in setting up CBMC systems, which calls for planning and coordination. The public and private sectors both need to step up their game if payments are to flow across borders safely, efficiently and quickly – giving us payments without borders.

[14] TCIB stands for Transactions Cleared on an Immediate Basis.

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Annex

Cross-border and multicurrency payment systems

Table A

Selected implementations and major enhancements since 1998

Year	Country	System	Currencies	Retail[1]	Cross-border[2]	Off-shore[3]	Cross-currency[4]	PvP[5]	Settlement bank
1998	CH	SIC (remote access)	CHF		✓				SNB
1999	GB, SE, DK	~~CHAPS euro, E-RIX, DEBES~~	EUR		✓	✓			ECB
	CH	euroSIC	EUR		✓	✓			*SECB*[6]
2000	HK	CHATS[7]	USD			✓		✓	*HSBC*[8]
2002	Global	*CLS*[9]	AUD, CAD, CHF, EUR, GBP, JPY, USD		✓			✓	*CLSB*[10]
2003	HK	CHATS	EUR			✓		✓	*SCB*[11]
	Global	*CLS* (new currency)	DKK, NOK, SEK, SGD		✓			✓	*CLSB*
2004	Global	*CLS* (new currency)	HKD, KRW, NZD, ZAR		✓			✓	*CLSB*
2005	MX/US	Directo a México	MXN, USD	✓	✓		✓		BoM[12]
2006	HK	CHATS	RMB			✓		✓	*BoCHK*[13]
	MY/HK	CHATS/RENTAS[14]	MYR vs USD		✓			✓	CBM[15]
2008	Global	*CLS* (new currency)	ISL, MXN		✓			✓	*CLSB*
2010	HK	CHATS/BI-RTGS	IDR vs USD		✓			✓	BI[16]
	JM	JamClear	USD			✓			
2011	TZ	TISS, TACH[17]	USD	✓TACH		✓			
2012	LB	BDL-RTGS	EUR, GBP, USD			✓			BDL[18]
	COMESA[19]	REPSS[20]	EUR, USD		✓	✓			CCH/CBoM[21]
	MY	RSS	RMB			✓			CBM
	AE	UAEFTS	USD, EUR			✓			
2013	EAC[22]	EAPS[23]	BIF, KES, RWF, TZS, UGX		✓	✓			EAC CBs[24]
	SADC[25]	SADC RTGS	ZAR		✓				SARB[26]
2014	TH/HK	CHATS/BATHNET	THB vs USD		✓			✓	BoT[27]
	MU	MACSS[28]	CHF, EUR, GBP, USD, ZAR			✓			BoMU[29]
2015	Global	*CLS* (new currency)	HUF		✓			✓	*CLSB*
Projects									
2020	GCC[30]	GCC RTGS	AED, BHD, KWD, OMR, QAR, SAR		✓		✓		CBs
	SADC	SADC-TCIB[31]	ZAR	✓	✓		✓		SARB
2021	AMF[32]	ARPS[33]	EUR, USD		✓	✓			
	SE	*P27*	DKK, EUR, SEK	✓	✓				

~~Strikethrough~~ = no longer in operation; *italics* = private sector.

[1] Process retail payments. [2] Payer and payee in different jurisdictions. [3] Settling a foreign currency. [4] System does FX conversion. [5] Payment versus payment. [6] Swiss Euro Clearing Bank. [7] Clearing House Automated Transfer System. [8] Hong Kong and Shanghai Banking Corporation. [9] Continuous Linked Settlement. [10] CLS Bank. [11] Standard Chartered Bank. [12] Bank of Mexico. [13] Bank of China HK. [14] Real Time Electronic Transfer of Funds and Securities. [15] Central Bank of Malaysia. [16] Bank Indonesia. [17] Tanzania Interbank Settlement System; Tanzania Automated Clearing House. [18] Banque du Liban (Central Bank of Lebanon). [19] Common Market for Eastern and Southern Africa. [20] Regional Payment and Settlement System. [21] COMESA clearing house/Central Bank of Mauritius. [22] East African Community. [23] East African Payment System. [24] Central banks. [25] South African Development Community. [26] South African Reserve Bank. [27] Bank of Thailand. [28] Mauritius Automated Clearing and Settlement System. [29] Bank of Mauritius. [30] Gulf Cooperation Council. [31] Transactions cleared on an Immediate Basis. [32] Arab Monetary Fund. [33] Arab Regional Payment System.

Source: Central bank and company websites.

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On the future of securities settlement[1]

Innovative technologies, such as distributed ledgers, allow securities to be issued or represented in a new form known as digital tokens. Such "tokenisation" of securities will alter post-trade clearing and settlement, and could improve efficiency in some dimensions. But the fundamental trade-offs involving credit risk and liquidity remain in a tokenised world. To succeed, tokens will need to interoperate with account-based systems, at least in the interim.

JEL classification: G1, G15, G23.

"Tokenisation" is a new buzz word in finance. Incumbent financial institutions as well as new entrants are investing heavily in projects seeking to transform securities into digital tokens – digital representations of value that are not recorded in accounts. A key motivation is to lower the estimated USD 17–24 billion spent annually on trade processing (Broadridge (2015)). Tokenisation could also transform how the underlying risks are managed.

The clearing and settlement landscape could change rapidly in response to tokenisation. Today, securities such as equities and bonds are maintained in electronic book-entry accounts at centralised securities depositories. In the future, they could "live" on distributed ledgers held across a network of traders where each has a synchronised copy.

This article describes the extent to which tokens and distributed ledgers might alter clearing and settlement processes. It first reviews the main features of traditional account-based clearing and settlement arrangements. It then introduces the concept of tokenised securities and explains the potential implications. Finally, it introduces a taxonomy to illustrate how securities settlement might change with tokenisation.

Securities settlement

Securities are tradable financial assets issued to raise funds from investors. Historically, securities were issued as paper certificates and the bearer was presumed

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Key takeaways

- Tokenisation of securities – the conversion of financial assets into digital tokens – could transform the clearing and settlement of securities trades.
- Tokenisation might reduce costs and complexity, but does not eliminate risks associated with one party failing to settle transactions.
- The success of token-based systems will depend on how well they interact with traditional account-based systems.

to be the owner (*bearer securities*). However, moving paper certificates around is costly and risky. Therefore, central securities depositories (CSDs) were set up to *immobilise* paper certificates and eliminate the need to settle trades by physical transfers. Later, technological advancements enabled securities to be *dematerialised* – that is, to exist only in electronic book-entry form in an account at the CSD (Box A).

Today, most securities are book entries, with the details of who owns them typically maintained, at least in part, at a CSD. Some countries have a *direct holding* system, which means that each beneficial owner has an individual account with the CSD. More common, however, is an *indirect holding* system, where intermediaries (eg custodians, brokers) hold securities on behalf of their clients with the CSDs (Benos et al (2019)). The latter setup minimises the amount of information the CSD has to manage and update but makes ownership of information more fragmented and difficult to reconcile. In both setups, securities change hands via "book entry" across accounts of either a CSD or an intermediary.

Settlement cycle

In financial markets, *trading* – the buying and selling of financial assets – takes place either on centralised exchanges or in decentralised over-the-counter (OTC) markets. For exchange-traded markets, transactions are routed via a central intermediary that is responsible for matching buyers and sellers. In contrast, OTC markets have multiple intermediaries (eg dealers) that compete to match buyers and sellers.

The *settlement cycle* is the period between execution of a trade and final settlement. Currently, most securities are settled under a rolling cycle where trades are executed on day T and settled at a later date (typically one to three days later). There are two processes that occur during this cycle: clearing and settlement. Each of these is explained below.

Once a trade has been executed, the details are transmitted to relevant third parties to reconcile and confirm what is to be settled. Moreover, trade obligations may also be offset or netted. This process is known as *clearing*. Depending on the market structure, clearing can involve a central counterparty (CCP) to protect counterparties from *replacement cost risk* (ie the risk of a trade failing to settle and having to be replaced at an unfavourable price).[2]

[2] A CCP interposes itself between counterparties to a trade, becoming the buyer to every seller and the seller to every buyer. CCPs are common in exchange-traded markets, where trading is anonymous, which means that participants are unable to assess the risk of a counterparty defaulting prior to the trade being executed.

Central securities depositories and securities settlement systems

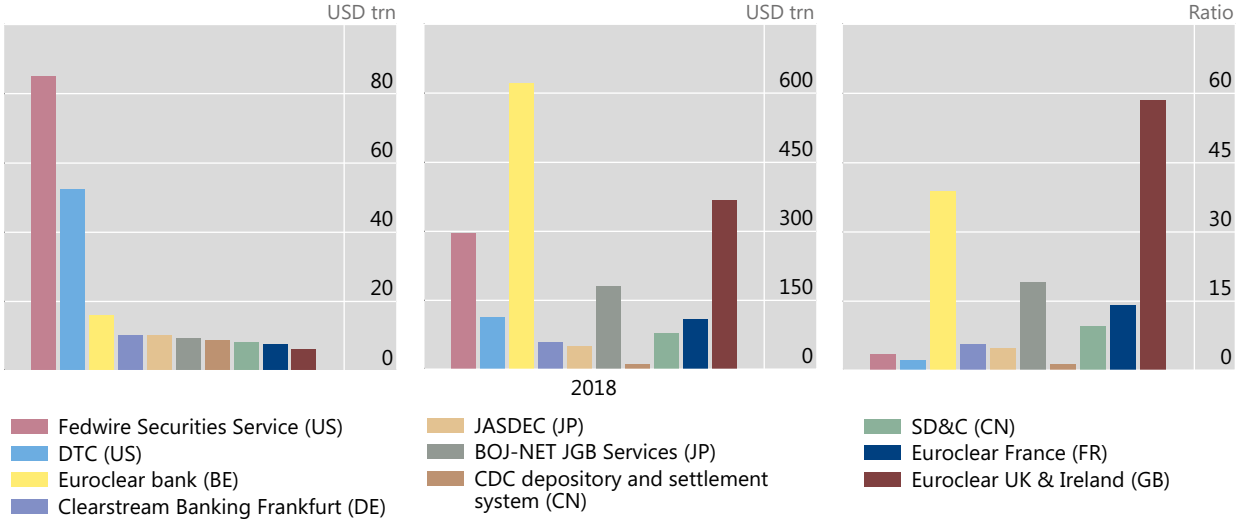
Morten Bech, Jenny Hancock and Amber Wadsworth[①]

A *central securities depository* (CSD) and a *securities settlement system* (SSS) are two types of financial market infrastructure that are critical to the settlement of securities. A CSD provides securities accounts, central safekeeping services and asset services, which may include the administration of corporate actions and redemptions, and plays an important role in helping to ensure the integrity of securities issues (that is, to ensure that securities are not accidentally or fraudulently created or destroyed or their details changed). An SSS is an entity that enables ownership of securities to be transferred and settled by book entry according to a set of predetermined multilateral rules. In many instances, a CSD also serves as an SSS.②

The BIS's Red Book statistics provide annual data on CSDs and SSSs in jurisdictions that are members of the Committee on Payments and Market Infrastructures. By value of securities held, the largest CSD/SSS is the Fedwire Securities Service for US government and agency securities (Graph A1, left-hand panel). By value of deliveries, the most active CSD/SSS is Euroclear Bank, based in Belgium (centre panel). Euroclear Bank is an international CSD that facilitates the holding of securities across borders. In terms of deliveries relative to securities held, turnover is highest at Euroclear UK & Ireland, which mainly provides services for equities and debt securities issued in the United Kingdom and Ireland (right-hand panel). The differences in value of securities held and delivery instruction are due to the fact that different CSD/SSSs settle different types of securities (ie equities or debt securities) that are used for different purposes (eg for trading or as buy and hold investments).

Securities held and delivered by selected CSDs/SSSs

Graph A1



[1] Flow of transactions in the CSD/SSS.

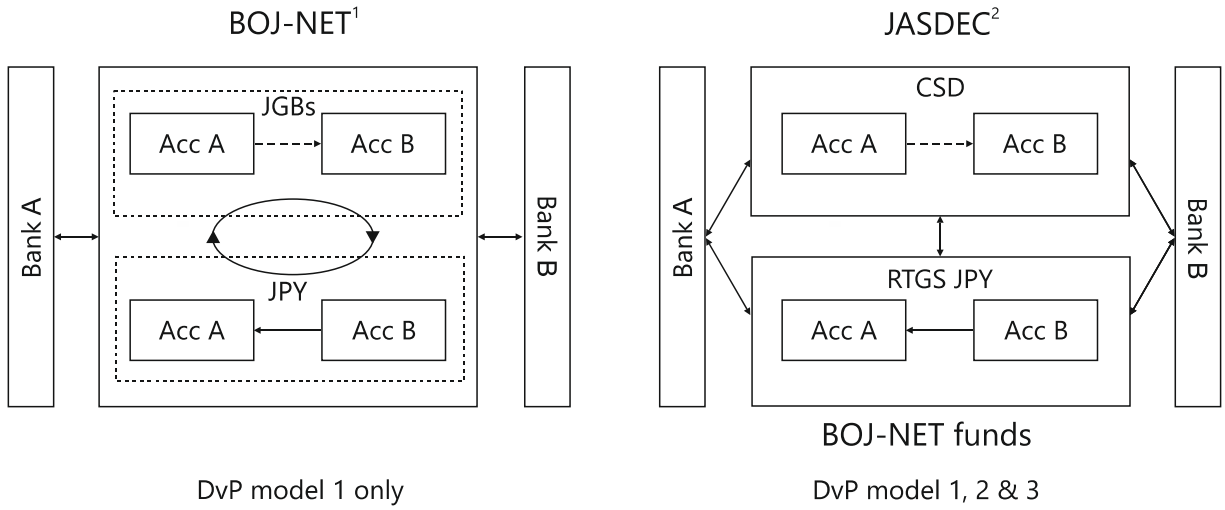
Source: BIS Red Book statistics.

Settlement in Japan

Japan is an example of how account-based settlement works. Japan has two CSDs, which also serve as SSSs. The Bank of Japan Financial Network System (BOJ-NET) settles trades in Japanese government bonds (JGBs) held in its book-entry system. BOJ-NET is also the real-time gross settlement system for Japanese yen. The second CSD/SSS is Japan Securities Depository Center (JASDEC). It is a CSD for debt and equity securities issued by the private sector. Whereas BOJ-NET transfers JGBs and cash within a single platform, settlement of securities held at JASDEC requires coordination with BOJ-NET for the transfer of cash (Graph A2). This coordination is automated by locking securities to be delivered in accounts at JASDEC until final settlement of cash has occurred at BOJ-NET, after which the deliveries are completed. If the cash transfer fails to settle by a specified time, then the lock on the securities is removed so that the seller regains control of those securities. This ensures that securities delivery occurs if and only if the corresponding cash transfer occurs.

Central securities depositories in Japan

Graph A2



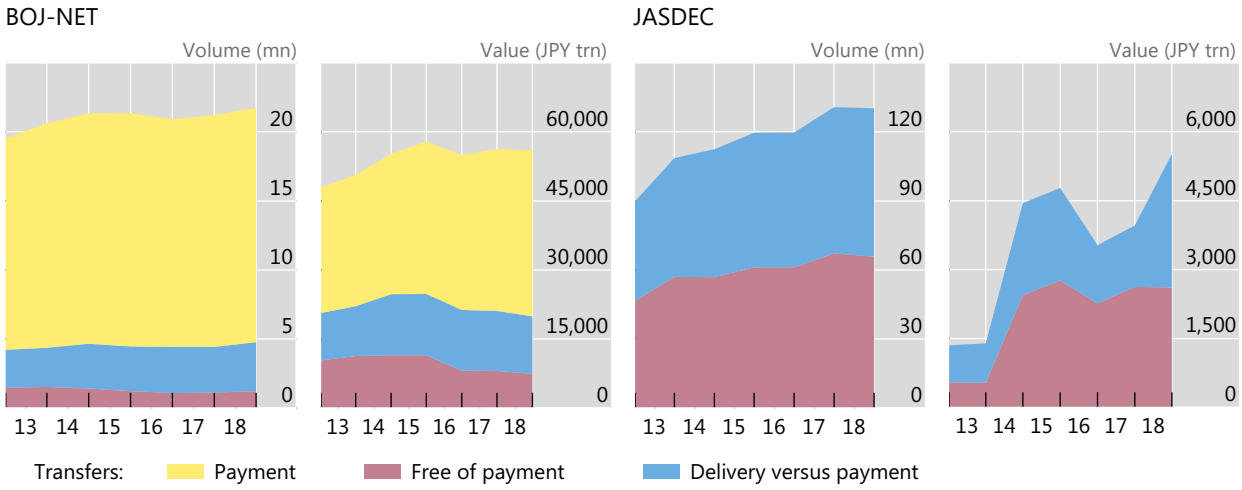
[1] Bank of Japan Financial Network System. [2] Japan Securities Depository Center.

Source: ECB and Bank of Japan (2018).

In 2018, BOJ-NET handled about 17 million transfers, with over 4 million being related to transfers of securities. In total, the transfers were worth some JPY 55,000 trillion (Graph A3). In comparison, JASDEC processed over 120 million transfers in 2018, worth JPY 5,500 trillion. In JASDEC, about half of both the volume and value related to transactions involving the delivery of securities in return for payment.

Settlement transfers in Japan

Graph A3



Payment = a transfer of cash; free of payment = a transfer of securities without a corresponding transfer of funds; delivery versus payment = a transfer of securities in exchange for cash.

Source: BIS Red Book statistics.

① The views expressed are those of the authors and do not necessarily reflect those of the Bank for International Settlements. ② For details, see CPMI and IOSCO, *Principles for financial market infrastructures*, April 2012.

Securities settlement is the transfer of ownership in accordance with the terms of an underlying agreement. Typically, the agreement is either to sell securities, to use securities as collateral for other obligations or to lend securities.[3] The sale of securities involves two transfers (*legs*). One leg transfers ownership of the securities from the seller to the buyer – this is commonly known as the *delivery leg*. The other leg transfers the corresponding cash from the buyer to the seller – this is known as the *payment leg*. Depending on the legal arrangements, the use of securities as collateral can require ownership to be transferred.[4] If so, there is a delivery leg, but not a corresponding payment leg. Such deliveries are commonly known as *free-of-payment* (FoP) transfers. Securities loans are often settled FoP, with collateral taken separately, sometimes through another system and even in another country or time zone.

When settling securities trades, *principal risk* is a key concern. This is the risk that one counterparty will lose the full value of a transaction – for example, the risk that a seller of securities will irrevocably deliver them, but not receive payment. One way to mitigate principal risk is to link the delivery and the payment legs so that the securities move if and only if the corresponding cash transfer occurs – this is known as *delivery versus payment* (DvP).

CPSS (1992) sets out three models for linking the delivery and payment legs. In *DvP model 1*, trades are settled individually on a gross basis. In *DvP model 2*, the delivery legs are settled individually on a gross basis throughout the processing cycle (typically a business day), with the net payment obligation settled at the end of the cycle. While delivery is final prior to payment, the link is achieved through the operator guaranteeing payment.[5] In the third model (*DvP model 3*), both legs are settled on a net basis.[6] In terms of where the delivery and the payment occur, both can take place on the same technical platform, or DvP can be achieved by coordinating across platforms. This is illustrated in Box A with reference to examples of account-to-account settlement in Japan.

Tokenising securities

Tokenising securities is the process of issuing new securities or representing existing securities as digital tokens.[7] Both book-entry and tokenised securities are digital representations of value (such as a claim on an issuer or a specific asset). However,

[3] Sometimes securities are only needed temporarily, whether for just one day or for a few weeks. If so, it is often cheaper, quicker and/or less risky to borrow securities than to buy them outright. Securities lending involves the owner of the securities transferring them temporarily to a borrower. In return, the borrower transfers other securities or cash to the lender as collateral and pays a borrowing fee.

[4] There are two main arrangements for using securities as collateral: pledge and title transfer. A pledge is an arrangement whereby the securities remain with the collateral provider but the collateral taker has a right to the securities in certain circumstances. A title transfer arrangement involves the collateral provider transferring ownership of the securities to the collateral taker, with an agreement to return them under a given set of circumstances.

[5] This guarantee is typically supported by a lien on the securities held by the buyer. For further details, see CPSS (1992).

[6] While the payment obligations for trades in different securities can be netted against each other, only transfers of fungible securities can be netted for delivery.

[7] The tokenisation of book-entry securities is the inverse of the immobilisation of bearer securities, where the tokens are digital rather than paper certificates. Tokenisation involves immobilising the book-entry securities and trading representations of them (in the form of digital tokens).

there are a number of distinctions, in particular regarding the verification process and degree of centralisation.

The properties of a digital token depend in part on design choices and features of the underlying technology. Current payment- or securities-token projects commonly use distributed ledger technology (DLT). A *distributed ledger* (DL) is a record of transactions held across a network of computers (nodes) where each node has a synchronised copy. A DL usually relies on cryptography to allow nodes to securely propose, validate and record state changes (or updates) to the synchronised ledger without necessarily the need for a central authority (CPMI (2017)). Possible updates include adjustments in the "token" holdings associated with a particular cryptographic key.

Verification process

The first distinction between book-entry and tokenised securities is how transfers are authorised. For book-entry securities, transfer authorisation ultimately depends on the CSD verifying the identity of the account holder. In contrast, for digital tokens authorisation depends on "validation" of the token. The analogy with bearer securities is instructive. For physical securities, holding a valid paper certificate bestowed certain rights. Bearer bonds had coupons attached that were submitted for interest payments, and the bond certificate itself was handed in at maturity for the principal amount. In a digital world, the holder has private knowledge in the form of a cryptographic key rather than a paper certificate. The private key permits the holder to "unlock" certain rights vis-à-vis the token (Box B).

Degree of centralisation

The second key distinction is the degree of centralisation. It manifests itself primarily in terms of who can update records, initiate transactions and see transaction histories; it is not a matter of the number of copies of the data that exist. A CSD is highly centralised. There can be only one entity that updates the central ledger and sees all transaction histories. In contrast, DLT platforms for tokenised securities exhibit different degrees of decentralisation (Table 1).

Almost all examples of tokenised securities have used permissioned, private and hierarchical DLs. While such systems are not completely open, they can be less centralised than CSDs. The restrictions on who can do what mean that there are identified parties that can be held accountable for compliance with regulatory

Elements of a distributed ledger — Table 1

Updating the ledger	Permissionless	Anyone can validate transactions on the ledger.
	Permissioned	Only trusted parties can validate transactions on the ledger.
Access to use the ledger	Public	Anyone can read and initiate transactions on the ledger.
	Private	Only trusted parties can read and initiate transactions on the ledger.
Access to view the ledger	Non-hierarchical	Everyone can hold a full copy of the ledger and can read all the information on the ledger.
	Hierarchical	Only some parties can hold a full copy of the ledger or read all information on the ledger.

Source: Wadsworth (2018).

Box B

An introduction to public-private key cryptography in digital tokens

Raphael Auer, Rainer Böhme, and Amber Wadsworth

Public-private key cryptography is a mathematical method for encrypting and decrypting instructions. It uses a widely broadcasted public key as an identifier (akin to a bank account number) and a secretly held private key. Both keys are a string of numbers that are mathematically related to each other via "one-way" mathematical functions. The latter are harder to reverse than to compute, much like it is more difficult to factorise 221 than multiply 17 and 13.

The properties of this one-way function mean that the private key can be used to digitally sign an instruction without being revealed. The private key, the one-way function and the instruction are used to produce a string of output, which acts as a digital signature. Just like a handwritten signature, digital signatures are attached to an instruction and prove that the specific instruction came from a particular sender. Anyone can use the corresponding public key and the instruction to verify the digital signature.

Using public and private keys to transfer tokens: an example

Transfers of digital tokens in distributed ledgers are often authorised using such digital signatures. Consider an example where sender A would like to pay one token to receiver B. The transfer takes place in three steps.

1. Signed instruction: Sender A uses her private key and the related one-way function to digitally sign an instruction to pay one token to B.
2. Verification: Receiver B – or any other third party – verifies the signed instruction by pairing sender A's public key with the signature attached to the instruction.
3. Updating the ledger: If the signed instruction is verified, the payment instruction can be added to the ledger and the digital token would then be connected to receiver B's public-private keys instead of sender A's keys. This completes the transfer, and only B can initiate the next transfer of that token. If the digital signature cannot be verified, then the instruction is not added to the ledger and the token is not transferred to receiver B. Such a situation can occur if sender A's private key did not create the initial signature or if the instruction was tampered with.

A digital signature thus enables transfers of digital tokens based on knowledge of the corresponding private key alone and without requiring personal identification. A person can have more than one private key, and public and private key pairs are not necessarily linked to natural persons. However, the ledger can record the history of public keys that have held each token.

requirements relating to know-your-customer, anti-money laundering and combating the financing of terrorism, and consumer protection.

Permissioned DLs allow only trusted third parties to be involved in the updating process. Because validators are trusted, it is possible to use less computationally intensive mechanisms to validate transactions (Pisa and Juden (2017)). In some permissioned DLs, only one entity can update the ledger; this replicates the role of the CSD.

Private DLs restrict who can initiate transactions. This is similar to an account-based system where users must apply to open an account before they can use the system (or at least open an account at an intermediary that has access). Consequently, private DLs can replicate the restrictions in current account-based systems. However, they can also be designed to open up access.

Access to view a DL can be restricted through so-called hierarchies. The current account-based CSDs restrict access, so each entity can view only transactions across

its own accounts. This may be necessary in order to comply with privacy[8] and bank secrecy laws, and it prevents others from trading on information about others' trading strategies. These kinds of restrictions can be replicated by making the DL *hierarchical*,[9] so that only one more or trusted third parties have a full view of information on the ledger (Wadsworth (2018)). Nevertheless, hierarchical DLs can be used to improve transparency where it is consistent with legal obligations. For example, they could be designed to allow issuers to see through intermediaries to identify the beneficial owners of their securities.

Potential implications of tokenisation

Tokenising securities on a DLT has the potential to reduce some of the costs and complexities in clearing and settlement, but it is not without risks. Tokenisation does not change the underlying risks in the settlement cycle, but it may transform some of them and change how they are managed. It may also have implications for the role of intermediaries in securities clearing and settlement.

Reduced costs and complexity

DLT supports the wider distribution of ownership records and transaction histories. In principle, having a single ledger that is held by all parties reduces the need for reconciliation and confirmation of trade details between back offices post-trade.

Like a direct holding system, a synchronised DL minimises the need to reconcile the records held by the CSD and the various intermediaries. This could involve a combination of more direct access to initiate transactions and/or greater transparency of records. A single source of truth as to who owns what is also useful for streamlining compliance,[10] shareholder voting, distributions and other corporate actions. This could lead to a reduction in the number of intermediaries and overhead costs in clearing and settlement. However, it is not desirable to do away with intermediaries. They play many important roles to smooth the flow of trades (eg by providing liquidity), in particular at times of stress (OECD (2020)).

DLT permits the automation of many actions via so-called *smart contracts*, ie protocols or code that self-execute when certain conditions are met. For example, recent tokenisation projects have automated the payment of interest or dividends to the holders of tokens. While automation also occurs today, what is different with DLT is the ability for individuals to write smart contracts.[11] This puts control of the decision to automate in the hands of users. The use of smart contracts on a DL could also reduce the ability to strategically renege on contractual obligations such as

[8] However, the immutable nature of the DL makes data erasure rights (ie the "right to be forgotten") challenging.

[9] Each node still has a full copy of the ledger, but some details are hidden through the use of cryptography.

[10] If the public keys can be linked to personal identities, then the complete transaction chains (that might otherwise be used to hide illicit activity) can be traced.

[11] However, access to a private DL can be restricted in such a way that only the central authority can initiate smart contracts.

settlement fails (Benos et al (2019)).[12] However, self-executing contracts could trigger contagion and adverse feedback loops if they react automatically to an event (CPMI (2017)).

Risks

Risks rarely disappear, but new technologies may transform them and the way they are managed. In a tokenised world, post-trade processes still need to manage credit risk and liquidity. There are two types of credit risk that arise in the clearing and settlement of securities: *replacement cost risk* (from the point at which a trade is executed until it settles); and *principal risk*, during the settlement process itself.

Tokenisation could enable shorter settlement cycles that mitigate replacement cost risk. The length of the settlement cycle today reflects back office processes, legal arrangements and liquidity management rather than technology limitations (Benos et al (2019)). Nonetheless, DLs may shorten settlement cycles by streamlining reconciliation processes and reducing the number of intermediaries. A shorter cycle lowers the exposure to replacement cost risk without the need for a CCP.[13] That said, market participants might not want to move to shorter settlement cycles, as this could increase liquidity requirements and give market-makers less time to source the cash or securities needed for settlement.

Tokenisation is likely to result in more trades settling via DvP model 1, as netting is in general more complex in a decentralised environment (Chapman et al (2017)). Settling trades individually generally requires more liquidity. Moreover, if each tokenised securities ledger had its own cash token, then the need to hold cash tokens on several ledgers could increase aggregate liquidity requirements. There are also questions as to whether DvP can be achieved between two tokenised systems in all circumstances (Box C).

Tokenisation could, in addition, increase legal and operational risks, at least in the short term. Currently, these risks are mitigated in well established account-based settlement systems, but could be reintroduced in the transition to tokenised assets and with the introduction of new platforms and processes. The legal basis of security tokens and settlement finality is likely to be uncertain in the short term. This may be an issue for cross-border transactions in particular, as tokens and settlement finality might be treated differently in the relevant jurisdictions.

The net effect of tokenisation on operational risk is uncertain. One of the key drivers of DLT implementation has been its potential to strengthen resilience and reliability (CPMI (2017)). This is due to the distributed nature of its design, as the ledger is held at multiple nodes. However, private, permissioned and hierarchical DLs still have some degree of centralisation, which could result in a single point of failure. The capacity and resiliency of applying DLT and smart contracts to clearing and settlement is also yet to be proven. In addition, there will be operational risks associated with the transition.

[12] Large and protracted settlement fails undermine the liquidity and smooth functioning of securities markets. As a result, market groups and policymakers try to limit them.

[13] Settlement could be instantaneous if cash and security tokens are locked pre-trade.

Box C

Putting the "vs" in token versus token

Atomic settlement and hash timelock contracts

Token-versus-token transfers can take place on one ledger or across two ledgers. The method to achieve DvP will differ.

If security tokens and the cash tokens exist on the same ledger, then an *atomic settlement* smart contract can be used to coordinate clearing and settlement. There are different methods of atomic settlement, but the outcome is an instant and simultaneous transfer of two tokens. In short, atomic settlement could achieve DvP as follows:

1. The seller of the security tokens and the buyer each submit their tokens (using digital signatures) as inputs to a single smart contract along with the transaction instructions.
2. The smart contract is submitted for validation on the distributed ledger:

   2 (a) The transaction is validated. The cash and security tokens are instantly and simultaneously delivered to their respective recipients and DvP is achieved. In certain smart contracts, this involves invalidating the old tokens (inputs) and generating new tokens (outputs) which are delivered to their new owners.

   2 (b) The transaction is not validated and the tokens remain with their original owners.

If the security tokens and the cash token exist on separate ledgers, then either a centralised party could be introduced to coordinate the transfer or a *hash timelock contract (HTLC)* could be used. An HTLC combines a "hashlock" function and a "timelock" function to facilitate transfers across unconnected ledgers. In short, an HTLC could achieve DvP as follows:

1. The *seller* generates a secret (X) and its corresponding hash (Y = f(X)). The seller uses this hash to lock the security tokens on its ledger with a specified time limit (eg four hours). The seller creates an instruction to either send the securities to the buyer using the hash (Y) or, if the time limit expires, return them to the seller.
2. The *buyer* locks the cash token on its ledger with a shorter time limit (eg two hours). The buyer creates a conditional instruction to either send the cash token to the seller using the hash (Y) or return it to the buyer after two hours.
3. The seller reveals the secret (X) to unlock and retrieve the cash token.
4. The buyer can then use the secret (X) to unlock and retrieve the security tokens.

The timelocks ensure that if the assets are not unlocked by a certain time, they will both be returned to their owners, giving both parties certainty over the timing of settlement or its failure. The shorter time limit for the buyer prevents the seller from waiting for time to expire to retrieve the security tokens and then using the secret to also receive the cash token. Furthermore, the timelock enables traders to choose how long after the trade the settlement should occur. Current industry norms are between one and three days.

Settlement could fail at several points in an HTLC transaction. Notably, if the buyer waits too long to collect the securities after the cash has been collected by the seller, then the securities timelock could expire and leave the buyer exposed to principal risk. In this case, the seller could end up with both the securities and the cash tokens. This would be a consideration for trades that occur across different time zones where there are different hours of operation.

Sources: ECB and Bank of Japan (2018); Deloitte et al (2018).

Securities settlement with tokens

Settlement can be "tokenised" for the delivery leg, the payment leg or both. Table 2 presents a framework for thinking about the impact of securities and cash tokens on settlement. The top left-hand quadrant represents existing account-based arrangements for payments, FoP transfers and DvP transfers. Payments and FoP transfers are single-leg transactions, involving only the transfer of cash and securities, respectively. Consequently, these will occur on a single platform, which may be account- or token-based. Account-to-account (AvA) transfers can occur on a single platform or cross-platform. A single platform can also support multiple types of transfer. For example, BOJ-NET processes account-based payments, both legs of AvA transfers of JGBs, and the payment leg of trades in securities held at JASDEC (Box A).

Introducing tokens results in three new arrangements for DvP, two of which would require the linking of deliveries and payments across different types of platform. The Annex describes selected projects or proofs of concept and where they fit within this taxonomy.

Linking tokens and accounts

Securities could be settled by transferring account-based securities in exchange for cash tokens (AvT transfer) or transferring security tokens in exchange for cash in accounts (TvA transfer). Such arrangements would require coordination, including addressing technical and legal compatibility, across token- and account-based systems.

The following examples show that such AvT and TvA interoperability can already be used to settle securities.

Taxonomy of settlement arrangements

Account and token-based system — Table 2

			Payment (cash) leg	
		×	Account	Token
	×		Payment ↺	Payment ↺
Delivery (securities) leg	Account	Free-of-payment transfer ↺	AvA ↺/↔	AvT ↔
	Token	Free-of-payment transfer ↺	TvA ↔	TvT ↺/↔

DvP

Red text = new settlement arrangements; blue shaded area = delivery versus payment (DvP); red shaded area = free of payment; yellow shaded area = payment.

↺ = single platform; ↔ = cross-platform; × = no counter leg.

AvA = account versus account; AvT = account versus token; TvA = token versus account; TvT = token versus token.

Source: Authors' elaboration.

- The World Bank and the Commonwealth Bank of Australia have issued security tokens called *Bond-i*. These security tokens are issued and maintained using DLT, but paid for using cash in accounts.
- The Bank of England intends to support TvA arrangements by ensuring that the new real-time gross settlement system it is implementing can interoperate with token-based systems.
- ID2S is a DLT-based CSD for European commercial paper that interoperates with TARGET2-Securities[14] for settlement of the payment leg achieving TvA arrangements.
- Fnality envisions that its cash token (USC) could be used to settle trades of securities that are held in CSD accounts, supporting AvT arrangements.

Tokenising both legs

Tokenising both the delivery and the payment leg represents an entirely new arrangement for achieving DvP. Such TvT arrangements can be executed within a single ledger or across two ledgers, depending on where the cash and security tokens reside.

If both the securities and the cash reside on one ledger, then a single-ledger transfer can take place. DvP across a single ledger is achieved through a process called "atomic settlement" (Box C). Project Jasper III by the Bank of Canada (BoC) and Project Stella by the ECB and the Bank of Japan have tested TvT transfers on a single ledger.[15] In the case of Project Jasper III, the security and cash tokens were issued by Canada's Securities Depository and the BoC, respectively, and transferred over a ledger. The project concludes that TvT did achieve DvP on a gross basis (DvP model 1) as well as technical efficiencies relative to current systems.

Other projects have tested whether TvT can be practically carried out if the security tokens and the cash tokens exist on two separate ledgers using hash timelock contracts (Box C). For example, Project Stella and Project Ubin III by the Monetary Authority of Singapore have tested TvT across two ledgers. In both projects, the two tokens were locked on their respective ledgers and sequentially released to their new owners (on the same ledger) using smart contracts. Project Stella concludes that cross-ledger arrangements may reintroduce principal risk.

Future market structure

Tokenisation could result in a proliferation of securities settlement systems (SSSs) – at least in the short term. Currently, securities settlement tends to be monopolistic in each jurisdiction, with little or no competition among providers (Benos et al (2019)). This is because CSDs/SSSs benefit from economies of scale, but potential conflicts of law encourage separate CSD/SSS in each jurisdiction.[16] As Table 2 shows, tokenisation opens up new possibilities. Even if the industry eventually converges on

[14] TARGET2-Securities is a platform operated by the Eurosystem that facilitates DvP, where the payment leg is settled across accounts at the Eurosystem central banks.

[15] The Deutsche Börse Group and HQLAx have also successfully completed a commercial exchange of two security tokens (delivery versus delivery) (Deutsche Börse Group (2019)).

[16] There are two international CSDs – Euroclear and Clearstream – whose business model involves operating at the global level.

one type of arrangement, there will most probably be a reduction in the network benefits during the transition as new arrangements are introduced but existing ones are maintained.

Interoperability between account- and token-based systems will be necessary for any transition from account-based to token-based systems. Tokenisation of different assets is likely to occur at varying times due to the independent management of each system, and each system will reach the end of its technology life cycle at differing times. Even within a given system, all assets may not be tokenised at the same time. Moreover, interoperability is likely to remain important in the long run, to the extent that some systems remain account-based.

Conclusion

Tokens may be the future of securities settlement, but they will not change the fundamental nature of securities transactions. In particular, there will continue to be trades where the delivery of the securities and the payment need to be linked to eliminate principal risk. While this is possible using tokens, in certain arrangements there is some risk of reintroducing principal risk. Tokenisation could also change the way that replacement cost risk is managed – for example, shortening settlement cycles as an alternative to central clearing.

Using tokens and the underlying DLT may offer a number of benefits. It could reduce the complexity in securities settlement by facilitating simpler, more direct holding systems. It can also facilitate increased automation through the use of smart contracts.

The ability of tokenised systems to interoperate with account-based systems will be key to their success. Currently, transfers are largely conducted across account-based systems. Tokenisation introduces three new types of arrangement, depending on whether the security or the cash or both are tokenised. As tokenisation is likely to occur at different times for different assets, arrangements that link deliveries and payments across different types of platform will be a necessary part of any transition.

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Annex

Tokenising settlement: selected examples

Central banks and private institutions are experimenting with tokens to settle payments and DvP transfers. A short description of the projects or proofs of concept (PoCs) proposed is listed below.

Tokenised payments

JPM Coin is a proposal by JPMorgan Chase that aims to enable instantaneous transfer of US dollar payments between institutional clients. As such, JPM Coin is a liability of JPMorgan, and the value of each coin is USD 1. Signet and Wells Fargo Digital Cash are similar proposals by other large commercial banks.

Utility Settlement Coin (USC) is a proposal by Fnality International (a consortium of 15 large financial institutions) that aims to provide digital tokens called USC in local currencies. Fnality intends initially to set up five local USC tokens – one each in Canada, the euro area, Japan, the United Kingdom and the United States – and then has plans to extend to other jurisdictions. Each local USC would represent a par value claim on a pool of reserves held at an account at the central bank in its jurisdiction and be governed and managed by a local Fnality consortium. To make a payment, participants first submit fiat currency to the local Fnality in exchange for USC tokens at par value. Domestic USC payments would be conducted over the local Fnality-operated ledger, and cross-border payments would be conducted between other Fnality jurisdictions using cross-ledger processes.

Projects Ubin and Jasper (phases I and II) are two central bank-led PoCs completed in 2017 by the Monetary Authority of Singapore (MAS) and the Bank of Canada (BoC), respectively. They simulated real-time gross settlement (RTGS) systems on DLT platforms. The PoCs create cash tokens that represent a claim on the central bank and have par value with fiat currency. The central banks conclude that some uncertainties remain regarding whether DLT could improve efficiencies for wholesale payments but efficiencies might be found if multiple assets were settled on the same ledger.

Tokenised DvP

Tokenised DvP is supported by issuing securities and/or cash tokens on a DL (or other platform), and by designing interoperability between account-based and token-based technologies. The following section describes selected examples of central bank PoCs, real world security tokens, and platforms and projects supporting security tokenisation that are currently under way.

Central bank proofs of concept

Project Jasper (phase III) is a collaboration between Payments Canada and the BoC. It successfully tested token-versus-token (TvT) securities settlement transfers where both tokens exist on the same ledger. The equity tokens represented a claim on equity held at Canada's Depository System, and the cash tokens represented a claim on the BoC at par value. A process called atomic settlement (Box B) is used to instantly and simultaneously transfer the tokens to their new owners. This process was found to

remove principal risk. Further, once transferred, cash and security tokens were exchanged for their underlying assets. In this sense, the project concludes that it achieved gross DvP settlement with central bank money (DvP1). Given the higher liquidity requirements for DvP1, the PoC also tested whether credit could be extended on the DLT to CDS members. It concludes that the single-ledger approach resulted in greater technical efficiencies than provided by Canada's current securities settlement system.

Project Stella (phase II) is a collaboration between the ECB and the Bank of Japan. The project also tested DvP using security and cash tokens over a single ledger by means of atomic settlement. It then tested DvP settlement when the tokens reside on separate and unconnected ledgers. It focused on identifying scenarios where settlement might fail in each case. It finds that settlement on a single ledger would fail if the trading details were not agreed between parties (clearing failure) or if the transaction failed to be validated on the ledger (operational failure). In each case, the tokens would remain with their owners and not be transferred. In this sense, the traders could be exposed to replacement cost risk but not principal risk. Regarding cross-ledger DvP, the project identified an additional situation where settlement could fail: it found that one leg of the transfer could be delivered but the second leg might not be delivered and participants could also be exposed to principal risk. Therefore, the project concludes that an arbitrator on the ledger would be required to resolve such disputes.

Project Ubin (phase III) is a collaboration between MAS and Singapore Exchange (SGX) and was completed in 2018. It built on the conclusions of Project Stella, and further explored the operational and governance arrangements required to settled securities trades across two interconnected ledgers. The project identified several technological and operational considerations to ensure operational resiliency of TvT transfers and suggests a framework for governing the settlement processes, including arbitration processes if settlement fails.

Real world security tokens

The World Bank and the Commonwealth Bank of Australia have issued a security token called Bond-i. This token is issued and maintained using DLT but paid for using cash in accounts.

Société Générale issued EUR 100 million in covered bonds as security tokens on the Ethereum blockchain (public, permissionless) in 2019, demonstrating that securities could be issued on a blockchain and meet legal and compliance requirements.

Börse-HQLAx is a collaboration between Deutsche Börse Group and HQLAx. It tests DvD settlement using tokenised securities. In 2019, the PoC successfully completed a tokenised securities swap between Commerzbank, Credit Suisse and UBS using a single ledger. The securities or bonds were tokenised using digital collateral records (DCRs) to represent baskets of securities held at a custodial CSD.

Platforms and projects supporting security tokenisation

SIX Digital Exchange (SDX) is a project currently under way that creates cash tokens based on a deposits within SIX's account at the Swiss National Bank and equity tokens based on corresponding underlying equities held at SIX. The project intends to hold and transfer cash and equity tokens on a single ledger.

The Bank of England's RTGS Renewal Programme seeks to replace its ageing RTGS with one that is fit for the future with enhanced resilience and greater

capabilities. The renewal consultation has been investigating how the RTGS upgrade can deliver new features and capabilities, eg wider interoperability by synchronising account-based settlement with other assets, including those recorded on external ledgers. In particular, the new RTGS could support DvP settlement with account-based cash and security tokens.

ID2S is a DLT-based CSD owned by Orange and Citi. It was launched in 2019 for European commercial paper and interoperates with TARGET2-Securities for settlement of the payment leg.

Nasdaq Linq is a DLT created by Nasdaq that provides a platform for tokenised equities to be issued and traded. It was launched in 2015 and enables an issuer to digitally represent a record of ownership on the DLT, thus circumventing the need for other intermediaries.

Fnality has also proposed that its cash tokens (USC) could be used for DvP transfers. In particular, the cash tokens could be used to settled securities transactions where the securities are held either as a token or in accounts (facilitating TvA or TvT transfers). Such transfers would require either cross-ledger processes or interoperability between Fnality's ledgers and account-based platforms. USC could also be used for PvP transfers where both legs are cash tokens or where one leg is account-based.

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The technology of retail central bank digital currency[1]

Central bank digital currencies (CBDCs) promise to provide cash-like safety and convenience for peer-to-peer payments. To do so, they must be resilient and accessible. They should also safeguard the user's privacy, while allowing for effective law enforcement. Different technical designs satisfy these attributes to varying degrees, depending on whether they feature intermediaries, a conventional or distributed infrastructure, account- or token-based access, and retail interlinkages across borders. We set out the underlying trade-offs and the related hierarchy of design choices.

JEL classification: E42, E44, E51, E58, G21, G28.

The question of whether central banks should issue digital currency to the general public has attracted increasing attention. This special feature sketches out some key technological design considerations for a retail CBDC, in the event that a central bank decided to issue one. We do not investigate the case for or against issuance, the systemic implications, or how these might be managed.[2]

We structure our approach around consumer needs and the associated technical design choices. Current electronic retail money represents a claim on an intermediary, rather than functioning as the digital equivalent of cash. CBDCs could potentially provide a cash-like certainty for peer-to-peer payments. At the same time, they should offer convenience, resilience, accessibility, privacy and ease of use in cross-border payments. Different technical designs meet these criteria to varying degrees, with attendant technical trade-offs. We explore these issues. The aim is not to promote or highlight any particular approach, but to lay some groundwork for more systematic discussions.

[1] We thank Morten Bech, Codruta Boar, Claudio Borio, Stijn Claessens, Benoît Cœuré, Jon Frost, Leonardo Gambacorta, Marc Hollanders, Henry Holden, Ross Leckow, Cyril Monet, Hyun Song Shin, Rastko Vrbaski, Amber Wadsworth and Philip Wooldridge for comments, and Haiwei Cao, Giulio Cornelli and Alan Villegas for exceptional 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.

[2] For the systemic implications, see the survey in CPMI-MC (2018). Andolfatto (2018), Kumhof and Noone (2018), and Bindseil (2020) examine how the impact on the central bank's balance sheet can be managed, while Brunnermeier and Niepelt (2019) investigate how financial instability risks can be mitigated.

Key takeaways

- A trusted and widely usable retail CBDC must be secure and accessible, offer cash-like convenience and safeguard privacy.
- Various technical designs satisfy these criteria to different degrees, and the associated trade-offs need to be identified.
- The design of a retail CBDC needs to balance the credibility of direct claims on the central bank with the benefits of using payment intermediaries.

Our approach is graphically represented in the "CBDC pyramid", which maps consumer needs onto the associated design choices for the central bank. This scheme forms a hierarchy in which the lower layers represent design decisions that feed into subsequent, higher-level decisions.

We start by introducing the four main design choices, as represented in the four layers of the CBDC pyramid. We assess the legal structure of claims and the operational roles of the central bank and private institutions in different CBDC architectures. We discuss the choice between distributed ledger technology (DLT) and a centrally controlled infrastructure. We compare token-based systems and account-based systems. Before concluding, we assess how the development of CBDCs might reinforce current efforts to overhaul cross-border payments.

From consumer needs to design choices: the CBDC pyramid

The focus of our approach is the "retail" aspect of CBDC; we ask what consumer needs a CBDC could address.[3] We thus sketch the development of a CBDC through an approach that proceeds from consumer needs to design choices.[4] The left-hand side of the CBDC pyramid (Graph 1) sets out such consumer needs and six associated features that would make a CBDC useful. Starting with cash-like peer-to-peer usability, these features also comprise convenient real-time payments, payments security, privacy, wide accessibility and ease of use in cross-border payments. The pyramid's right-hand side lays out the associated design choices.

The consumer's prime need is that the CBDC embodies a cash-like claim on the central bank, ideally transferable in peer-to-peer settings. Today, even consumers who normally prefer to pay electronically are confident that, if an episode of financial turmoil were to threaten, they could shift their electronic money holdings into cash. This flight to cash has been seen in many crisis episodes, including recent ones. The main concern is that if, in the future, cash were no longer generally

[3] All private sector non-financial users are referred to as "consumers" in what follows. For a discussion of "wholesale" CBDC for use in the financial industry, see CPMI-MC (2018).

[4] The survey in Boar et al (2020) highlights that central banks have advanced other motivations for issuance, including monetary policy implementation and financial stability considerations. These aspects are considered in the CBDC design frameworks of Fung and Halaburda (2016), Bjerg (2017), CPMI-MC (2018), Mancini-Griffoli et al (2018), Wadsworth (2018), Kahn et al (2019) and Adrian (2019). Although it takes a more positive stance towards CBDC, our focus on technical design elements is related to Pichler et al's (2020) analysis of the limits of CBDC when compared with cash.

accepted, a severe financial crisis might create further havoc by disrupting day-to-day business and retail transactions.[5]

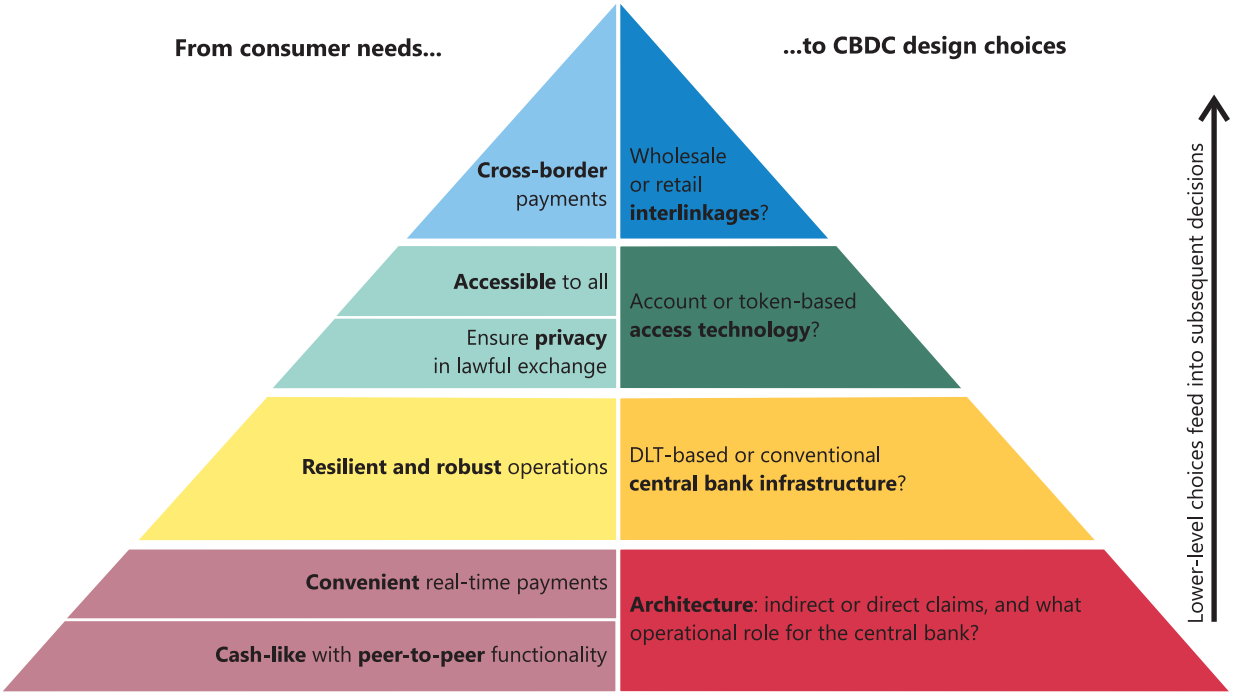
At the same time, consumers are unlikely to adopt a CBDC if it is less convenient to use than today's electronic payments. Banks and payment service providers run sophisticated infrastructures that can handle peak demand, such as on Singles Day in China or Black Friday in the United States. And intermediaries help to smooth the flow of payments by taking on risk, for example during connectivity breaks or offline payments.

These two needs – cash-like safety and convenience of use – lead to the foundational design consideration for a CBDC (see lowest layer of pyramid in Graph 1): the choice of the operational architecture, and how it will balance the consumer's demand for a cash-like claim on the central bank with the convenience that intermediaries confer on the payment system. The choice is shaped by two questions. Is the CBDC a direct claim on the central bank or is the claim indirect, via payment intermediaries? What is the operational role of the central bank and of private sector intermediaries in day-to-day payments?

Further, the consumer's need for cash-like payment safety means that a CBDC must be secure not only from the insolvency or technical glitches of intermediaries, but also from outages at the central bank. The choice is whether to base this infrastructure on a conventional centrally controlled database or instead on DLT – technologies that differ in their efficiency and degree of protection from single

The CBDC pyramid

Graph 1



The CBDC pyramid maps consumer needs (left-hand side) onto the associated design choices for the central bank (right-hand side). The four layers of the right-hand side form a hierarchy in which the lower layers represent design choices that feed into subsequent, higher-level decisions.

Source: Authors' elaboration.

[5] In Sweden, where cash use has already declined substantially, considerations along these lines have led the central bank to propose a review of the concept of legal tender (Sveriges Riksbank (2019)).

points of failure. Importantly, this decision can only be made once the architecture has been decided upon, as DLT is only feasible for some operational setups. This is why the choice of infrastructure lies in the pyramid's second layer.

Two further consumer needs are easy, universal access and privacy by default.[6] From a technical perspective, there is an underlying trade-off between privacy and ease of access on the one hand and ease of law enforcement on the other. The associated design choice – the pyramid's third layer – is whether access to the CBDC is tied to an identity system (ie an account-based technology) or instead via cryptographic schemes that do not require identification (ie an access technology based on so-called digital tokens).

The final consumer need we consider is that CBDCs should also enable cross-border payments. At a design level, this could be arranged via technical connections at the wholesale level that are built on today's systems. Alternatively, novel interlinkages could be envisaged at the retail level, ie allowing consumers to hold foreign digital currencies directly. Importantly, the means of implementing the latter option would depend on whether the CBDC was account- or token-based. This is why this design choice belongs in the top layer of the pyramid.

Architecture: indirect or direct claims, and the operational role for the central bank

The CBDC pyramid's bottom layer is the legal structure of claims and the respective operational roles of the central bank and private institutions in payments. Our analysis starts with an overview of possible technical architectures for CBDCs. In all three architectures shown in Graph 2, the central bank is, by definition, the only party issuing and redeeming CBDC. We note that all three architectures could be either account- or token-based, and might run on various infrastructures. These choices are discussed below.

The key differences here are in the structure of legal claims and the record kept by the central bank. In the "indirect CBDC" model (Graph 2, top panel), the consumer has a claim on an intermediary, with the central bank keeping track only of wholesale accounts. In the "direct CBDC" model (centre panel), the CBDC represents a direct claim on the central bank, which keeps a record of all balances and updates it with every transaction. The "hybrid CBDC" model (bottom panel), is an intermediate solution providing for direct claims on the central bank while allowing intermediaries to handle payments.

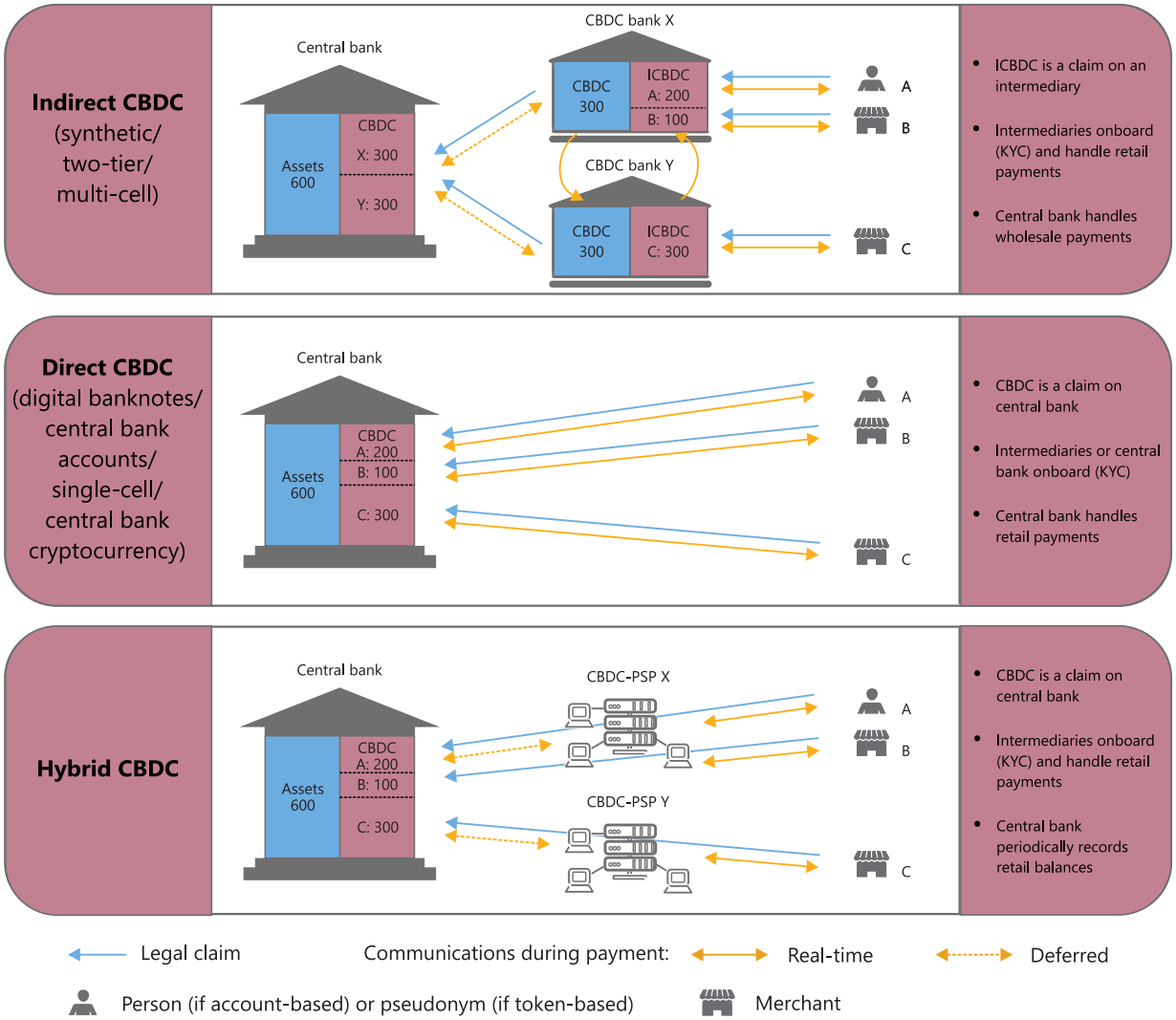
Consider first the indirect CBDC model (top panel). This term is used by Kumhof and Noone (2018), and is equivalent to the "synthetic CBDC" in Adrian and Mancini-Griffoli (2019). This model is also known as the "two-tier CBDC" for its resemblance to the existing two-tier financial system; a token-based variant is proposed as a "multi-cell CBDC" in Ali (2018). For consumers, this type of CBDC is not a direct claim on the central bank. Instead, the intermediary (labelled "CBDC bank" in Graph 2 for its close resemblance to a narrow payment bank) is mandated to fully back each outstanding indirect CBDC-like liability to the consumer (labelled "ICBDC"

[6] Privacy here means that the consumer's data are used only in steps strictly necessary for the specific purpose of determining whether a transaction is lawful and, if this the case, executing it. "By default" implies that privacy is ensured without requiring any intervention by the user.

in Graph 2) to retail consumers via its holding of actual CBDCs (or other central bank money) deposited at the central bank.[7] Just as in today's system, intermediaries handle all communication with retail clients, net payments and send payment messages to other intermediaries and wholesale payment instructions to the central bank. The latter settles wholesale CBDC accounts with finality.

Besides offering the convenience of today's systems based on intermediaries, the indirect CBDC also relieves the central bank of the responsibility for dispute

An overview of potential retail CBDC architectures — Graph 2



In all three architectures, the CBDC is issued only by the central bank. In the indirect CBDC architecture (top panel), this is done indirectly, and an ICBDC in the hands of consumers represents a claim on an intermediary. In the other two architectures, consumers have a direct claim on the central bank. In the direct CBDC model (centre panel), the central bank handles all payments in real time and thus keeps a record of all retail holdings. The hybrid CBDC model (bottom panel) is an intermediate solution providing for direct claims on the central bank while real-time payments are handled by intermediaries. In this architecture, the central bank retains a copy of all retail CBDC holdings, allowing it to transfer holdings from one payment service provider to another in the event of a technical failure. All three architectures allow for either account- or token-based access.

Source: Authors' elaboration.

[7] Some have argued that this architecture does not warrant the CBDC label. However, the label does apply if one follows CPMI-MC (2018) in defining a retail CBDC as any claim on the central bank that is different from today's wholesale accounts (see also Bech and Garratt (2017)).

resolution, know-your-customer (KYC) and related services. But the downside is that the central bank keeps no record of individual claims (only the intermediaries do, whereas the central bank records only wholesale holdings) nor is there any cash-like direct proof of the claim. Thus, the central bank cannot honour claims from consumers without information from the intermediary.[8] If the intermediary is under stress, determining the legitimate owner might involve a potentially lengthy and costly legal process with an uncertain outcome. This model's regulatory and supervisory issues, as well as those pertaining to deposit insurance, are hence similar to those of today's system.

Consider next a CBDC directly operated by the central bank, the direct CBDC architecture (centre panel). One version would comprise accounts managed by the central bank. Several private sector companies are developing token-based variants, or "digital banknotes".[9] In this architecture, KYC and customer due diligence could be handled by the private sector or the central bank or another public sector institution. The central bank, however, would be the only institution handling payment services.

The direct CBDC is attractive for its simplicity, as it eliminates dependence on intermediaries by doing away with them. However, this entails compromises in terms of the payment system's reliability, speed and efficiency. One aspect is that building and operating technical capacity on this scale is often viewed as being better undertaken by the private sector, as seen in today's credit card networks. Second, even if a central bank were to build the necessary technological capability, the resulting CBDC might be less attractive to consumers than today's retail payment systems. Electronic payments must deal with connectivity outages or offline payments, which involves risk-taking by intermediaries. Importantly, it is the customer relationship – based on KYC – that allows the intermediary to accept such risks. Unless a central bank were to take on responsibility for KYC and customer due diligence – which would require a massive expansion of operations, well beyond existing mandates – it would find it difficult to provide this service.[10]

In addition to these two pure options, one can also envisage novel future solutions that merge elements of both the indirect and the direct CBDC.[11] We label this third type of architecture the hybrid CBDC (bottom panel). In this model, a direct claim on the central bank is combined with a private sector messaging layer. Again, variations on this theme might include both token- and account-based ones.

One key element of the hybrid CBDC architecture is the legal framework that underpins claims, keeps them segregated from the balance sheets of the payments service providers (PSPs), and allows for portability. If a PSP fails, holdings of the

[8] A further difficulty is that it is unclear what the holder of an ICBDC would actually be entitled to, as, by definition, retail investors are prohibited from holding the actual CBDCs issued by the central bank.

[9] These token-based versions are termed "single-cell" CBDC structures in Ali (2018) and "central bank cryptocurrencies" in Berentsen and Schär (2018).

[10] The respective advantages and disadvantages of direct and indirect CBDC architectures mirror those of the direct and indirect security holding systems that are discussed in the context of the future of settlement in Bech, Hancock, Rice and Wadsworth (2020, in this issue).

[11] Although these authors do not spell out the underlying structure of legal claims, several ways to distribute payment functions and communications over multiple parties have been studied in the field of computer science. One example is the proposal of Danezis and Meiklejohn (2016), which shifts real-time communications from the central bank to dynamically appointed intermediaries.

CBDC are not considered part of the PSP's estate available to creditors. The legal framework should also allow for portability in bulk, ie give the central bank the power to switch retail customer relationships from a failing PSP to a fully functional one.[12] The second key element is the technical capability to enable the portability of holdings. Since the requirement is to sustain payments when one intermediary is under technical stress, the central bank must have the technical capability to restore retail balances. It thus retains a copy of all retail CBDC holdings, allowing it to transfer retail CBDC holdings from one PSP to another in the event of a technical failure.[13]

The hybrid CBDC would have both advantages and disadvantages vis-à-vis the indirect or direct CBDC architectures. As an intermediate solution, it might offer better resilience than the indirect CBDC, but at the cost of a more complex to operate infrastructure for the central bank. On the other hand, the hybrid CBDC is still simpler to operate than a direct CBDC. As the central bank does not directly interact with retail users, it can concentrate on a limited number of core processes, while intermediaries handle other services including instant payment confirmation.

Conventional or DLT-based central bank infrastructure?

What infrastructure might the different CBDC architectures require for the central bank, and how could they be implemented in the most resilient way? This choice, represented as the second tier of the CBDC pyramid, follows immediately after the decision on architecture because the infrastructure requirements for the central bank differ substantially across the three architectures shown in Graph 2.

For the central bank, the indirect CBDC implies loads similar to those of today's system. By contrast, the direct CBDC would require massive technological capabilities, as the central bank processes all transactions by itself, handling a volume of payments traffic comparable with that of today's credit or debit card operators. The hybrid CBDC architecture is more complex to operate than the indirect model, as the central bank does maintain retail balances. Nevertheless, it could be implemented at scale using today's technology and with a relatively modest infrastructure even in the world's largest currency areas.[14]

The infrastructure could be based on a conventional centrally controlled database, or on a novel distributed ledger. Graph 3 shows how elements of DLT could play a role in CBDC. The first DLT-related design choice hinges on whether

[12] While functionally similar, such segregation differs from deposit insurance in terms of legal procedures and associated delays. Today's deposits are often insured but, in the case of a bank failure, the funds can only be retrieved through a reimbursement process. Further, deposit insurance may be limited in amount and ultimately depends on the strength of the deposit insurer (see Baudino et al (2019) for an overview).

[13] Note that a variant of this CBDC architecture could allow users to retain cryptographic proofs of their CBDC balances, rather than oblige the central bank to hold them. These proofs could be used to retrieve balances in case of a technical failure. The advantage would be to circumvent potential privacy and legal issues connected with the central bank storing retail account balances. The disadvantage would be that entrusting users with cryptographic proofs may open the door to loss and theft of funds.

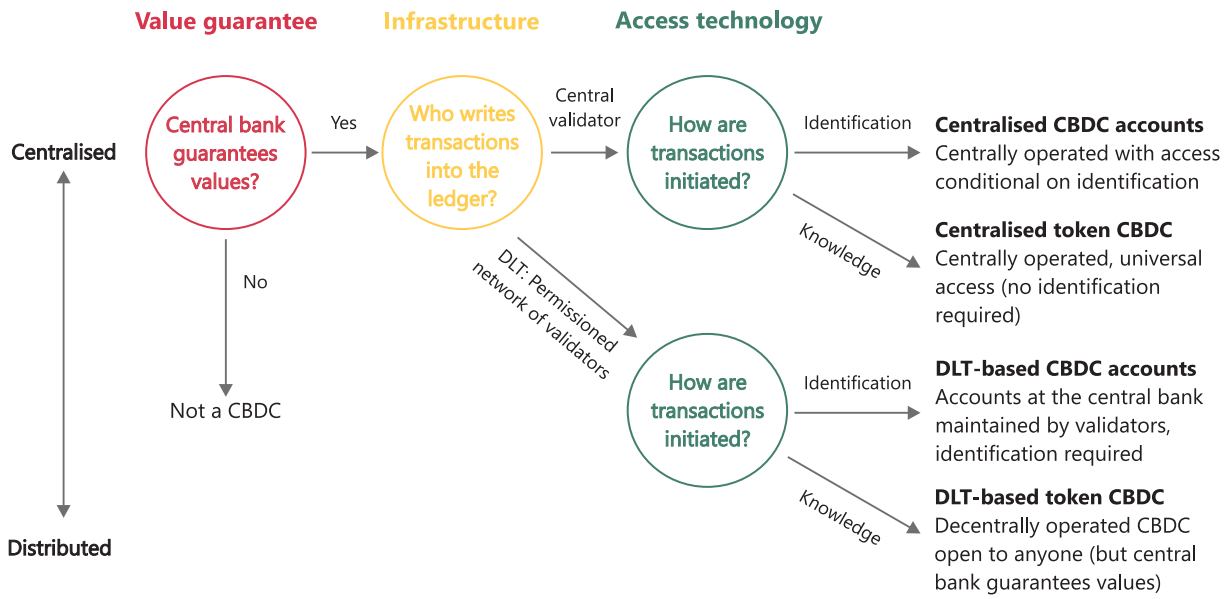
[14] For example, even for a payment area with a billion users, it would be feasible to verify each digital signature (computationally, the most costly operation of a transaction) for all accounts on an hourly basis with a two-digit number of standard servers.

the authority to update the database is centralised or delegated to a network of identified and vetted validators.[15]

Conventional and DLT-based infrastructures often store data multiple times and in physically separate locations. The main difference between them lies in how data are updated. In conventional databases, resilience is typically achieved by storing data over multiple physical nodes, which are controlled by one authoritative entity – the top node of a hierarchy. By contrast, in many DLT-based systems, the ledger is jointly managed by different entities in a decentralised manner and without such a top node. Consequently, each update of the ledger has to be harmonised between the nodes of all entities (often using algorithms known as "consensus mechanisms"). This typically involves broadcasting and awaiting replies on multiple messages before a transaction can be added to the ledger with finality.

The overhead needed to operate a consensus mechanism is the main reason why DLTs have lower transaction throughput than conventional architectures. Specifically, these limits imply that current DLT could not be used for the direct CBDC except in very small jurisdictions, given the probable volume of data throughput. However, DLT could be used for the indirect CBDC architecture, as the number of transactions in many wholesale payment systems is comparable with that handled by existing blockchain platforms, as also demonstrated in several wholesale

Elements of decentralisation: DLT and token-based access — Graph 3



This graph maps out the four possible combinations of whether a CBDC infrastructure is distributed or centralised and whether access is based on identification (accounts) or cryptographic knowledge (digital tokens). All four combinations are possible for any CBDC architecture (indirect, direct or hybrid), but in the different architectures, the central bank and the private sector operate different parts of the respective infrastructure.

Source: Authors' elaboration.

[15] Most likely, central banks would consider only "permissioned" DLT, in which a network of pre-selected entities performs the updating. While it is technically possible to use "permissionless" technology, in which unknown validators perform the updating, the economic cost of this process is very high (see Böhme et al (2015) for an introduction for the case of Bitcoin, Auer (2019a) for a discussion of the underlying economics and Ali and Narula (2020) for a specific analysis in the context of CBDCs).

CBDC experiments conducted by central banks (Bech, Hancock, Rice and Wadsworth (2020, in this issue)). Enterprise versions of DLT might also be feasible for the hybrid CBDC architecture.

When it comes to achieving resilience, neither a DLT-based system nor a conventional one has a clear-cut advantage. The vulnerabilities are simply different. The key vulnerability of a conventional architecture is the failure of the top node, for example via a targeted hacking attack. The key vulnerability of DLT is the consensus mechanism, which may be put under pressure, for example, by a denial-of-service type of attack.

Overall, one needs to weigh carefully the costs and benefits of using DLT. This technology essentially outsources to external validators the authority to adjust claims on the central bank balance sheet,[16] which is advantageous only if one trusts this network to operate more reliably than the central bank. Ongoing assessments of DLT-based proofs-of-concept tend to be negative (see box for a brief overview). Among the DLT-based projects that are still ongoing, it remains to be seen whether scalable implementations will actually rely on the technology.[17]

That said, even if one decides against using DLT as the backbone infrastructure of a CBDC, one closely related technology might still be useful. Whether or not the infrastructure is based on DLT, access can still be based on cryptography rather than identification – Graph 3 outlines the possible combinations, and the box shows which combinations are being investigated by central banks.

Token- or account-based access, and how to safeguard privacy?

Once the CBDC's architecture and infrastructure have been chosen, the question arises of how and to whom one should give access. This is the third layer of the CBDC pyramid.

A first option is to follow the conventional account model and tie ownership to an identity (Graph 4, left-hand side). Claims are represented in a database that records the value along with a reference to the identity, just as in a bank account. This has drawbacks in the case of CBDCs. In particular, it depends on "strong" identities for all account holders – schemes that map each individual to one and only one identifier across the entire payment system. Such schemes can present a challenge in some jurisdictions, thus impairing universal access.[18]

The second option is for the central bank to honour claims solely when the CBDC user demonstrates knowledge of an encrypted value – an option sometimes

[16] In the indirect CBDC architecture, validators of the central bank ledger update the wholesale accounts, while in the hybrid and direct architectures they update the retail accounts.

[17] Experiments are based on enterprise versions of distributed ledgers, which allow for decentralisation but, in practice, are often run under centralised control. Ali and Narula (2020, p 6) note that the platforms typically used "are useful for experimentation and prototyping because of their flexibility and features […]. However, what is helpful for prototyping might not be good for practice; these complex platforms make trade-offs when it comes to security, stability, and scale."

[18] There are broader benefits to universal digital identity frameworks, such as the scope for supporting open banking and enabling the distribution of other financial services. D'Silva et al (2019) discuss the Indian experience.

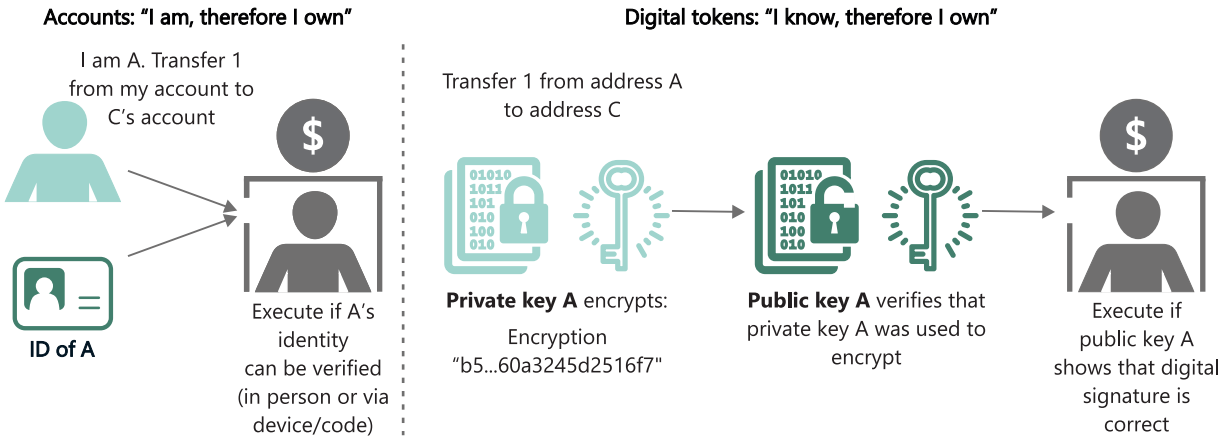
referred to as digital tokens (Graph 4, right-hand side). One example is when the secret part of a public-private key pair is used to sign a message, a technology outlined by Auer, Böhme and Wadsworth (2020, in this issue).

A token-based system would ensure universal access – as anybody can obtain a digital signature – and it would offer good privacy by default. It would also allow the CBDC to interface with communication protocols, ie be the basis for micropayments in the internet of things. But the downsides are severe. One is the high risk of losing funds if end users fail to keep their private key secret. Moreover, challenges would arise in designing an effective AML/CFT framework for such a system. Law enforcement authorities would run into difficulties when seeking to identify claim owners or follow money flows, just as with cash or bearer securities. Retail CBDCs would thus need additional safeguards if they followed this route.[19]

We emphasise that the privacy dimension goes far beyond the question of whether the system is based on accounts or digital tokens. Transaction-level financial data reveal sensitive personal data. Hence, two aspects of privacy by default are crucial for the design of a CBDC. First is the amount of personal information transaction partners learn about each other when the system is operating normally.[20] Second is the risk of large-scale breaches of data held by the system operator or intermediaries.

Crucially, a CBDC that lets merchants collect and link payment data to customer profiles transforms the very nature of payments, from a simple exchange of value to the exchange of value for a bundle of data. Hence, a CBDC should preserve its users' privacy vis-à-vis their transaction partners, ie by default, transaction partners

Account-based access compared with token-based access — Graph 4



In an account-based CBDC (left-hand side), ownership is tied to an identity, and transactions are authorised via identification. In a CBDC based on digital tokens (right-hand side), claims are honoured based solely on demonstrated knowledge, such as a digital signature.

Source: Authors' elaboration.

[19] The legal framework would need to allow claims to be put "on hold" until the legitimacy of a transaction history has been demonstrated (Böhme et al (2015)). This could be part of a broader regulatory framework allowing for "embedded supervision", ie an approach in which supervisory and other public authorities automatically monitor market ledgers to check for compliance with regulatory goals (Auer (2019b)).

[20] See ECB (2019) for a practical proposal and Frost et al (2019) for a broader discussion of the use of data in finance.

would interact via "unlikable pseudonyms", as envisaged in Chaum's (1985) pioneering work on electronic money. In such a system, a merchant is presented with a proof that the payment for a specific invoice has been made, but no information about the payee is revealed.

Depending on the involvement of intermediaries and the information they receive, technical safeguards for data protection need to be complemented by a legal framework restricting data collection by front-end applications, for example the smartphone payment app. Data loss is a further threat, given that payment systems are a prime target for cyber attacks. In this context, it must be noted that not all privacy-enhancing technologies are mature. For example, some so-called zero-knowledge proofs have already been shown to be vulnerable (Ruffing et al (2018)). The only sure-fire way to avoid losing much data is not to store it or to irrevocably delete old transactions as soon as possible. This principle of data minimisation is embodied in many data protection laws. Where this is not an option, aggregation and anonymisation must be relied on. A last resort is storage in physically separated (and offline) places guarded by legal access procedures.

Cross-border payments: wholesale or retail linkages?

Once a CBDC's configuration is clear, as well as how resident consumers can access it, the question arises whether it can be used only domestically or also elsewhere. This is the topmost layer of the CBDC pyramid.

The demand for seamless and inexpensive cross-border payments has grown in parallel with growth in international e-commerce, remittances and tourism. A CBDC might come with the same wholesale interlinkage options explored in the current system (Bech, Faruqui and Shirakami (2020, in this issue)).

Here, one noteworthy aspect is that a coordinated CBDC design effort could take a clean-slate perspective and incorporate these interlinkage options right from the start. This would represent a unique opportunity to facilitate easier cross-border payments (eg Carney (2019) and Cœuré (2019)), reducing inefficiencies and rents by shortening the payment value chain.

CBDCs would also permit novel retail interlinkages if they were to allow consumers to hold multiple currencies. In today's account-based system, a cross-border transaction is inseparably linked to a foreign exchange transaction. The intermediary processing the transaction can apply extra fees and unfavourable exchange rates. In contrast, if consumers were given the option of buying foreign currency in advance, before spending it abroad, just as they can with cash, this would separate the payment from the foreign exchange transaction. In turn, this would open up the possibility of interfacing retail wallets directly with competitive foreign exchange markets.

Importantly, the scope for such retail interlinkages and their design would depend on the national access framework. If a national system is based on digital tokens, it will by default be accessible to foreign residents. If it is account-based, interoperability would be a design choice, one that could also be coordinated internationally.

Conclusion

As central banks play a key role in payment systems, both the declining use of cash and related developments in the private sector may require them to "step up" and take a more active role (Carstens (2019 and 2020, in this issue)). Should they wish to do so, many ways are open to them.

This feature has gone down a hypothetical road by investigating the choices that might be encountered during the design stage of a CBDC, and how the related decision-making process could be structured. On the way, we have highlighted how consumer needs might translate into technical trade-offs. Some design-related considerations emerge from our analysis, for example, regarding the feasibility of DLT-based vis-à-vis that of more conventional technical infrastructures, but other choices remain less clear-cut.

With a framework for decision-making in mind, more hands-on experience with specific design choices could be helpful. The box surveys ongoing technical design efforts by central banks along the technical dimensions identified in this feature. As most projects are still in their early stages, the most important takeaway is that central banks around the world are investigating a rich set of prototypes, spanning almost the full range of potential designs encompassed in the CBDC pyramid. If the results of these experiments are shared internationally, a clearer picture will emerge of which technological choices are generally suited for CBDCs, and how the optimal design might depend on the specific circumstances of each jurisdiction. This, in turn, could help to inform the debate on whether and how CBDCs should actually be issued.

Taking stock: ongoing retail CBDC projects

Raphael Auer, Giulio Cornelli and Jon Frost

Among the many central banks that are exploring the possibility of a retail CBDC (Boar et al (2020)), several have published research or statements on the related motivations, architectures, risks and benefits. The table below shows 17 selected projects or reports published before 19 February 2020. It does not cover wholesale CBDCs or cross-border payment projects that do not involve a CBDC. When it comes to the four main design choices (Graph 1 in the main text), many central banks are still considering multiple options, and it is not always possible to classify them. Regarding their architecture (Graph 2 in the main text), five projects focus on a direct CBDC, two on an indirect CBDC, and 10 investigate several designs or do not specify the architecture.

As for infrastructure (Graph 3 in the main text), only one project focuses on a conventional technology, whereas five focus on DLT. However, experience with the latter technology has not always been encouraging. Sveriges Riksbank (2018) notes that DLT still suffers from inadequate performance and scalability. The National Bank of Ukraine (2019) concludes that DLT may offer no fundamental advantages in a centralised issuance system. More generally, ECCB (2020) notes that DLT could not ensure cash-like resilience in the case of prolonged electricity outages.

On the access technology (Graph 4 in the main text), three projects provide for access based on digital tokens, whereas three focus on account-based access.

Regarding the focus on cross-border interlinkages, no CBDC project has an explicit focus on payments beyond the central bank's jurisdiction. It is noteworthy that several central banks are working on cross-border payment trials with a consumer focus in parallel to their CBDC efforts. Moreover, wholesale initiatives such as Project Jasper (Bank of Canada), Project Ubin (Monetary Authority of Singapore), Project Stella (ECB and Bank of Japan) and Project Lion Rock-Inthanon (Hong Kong Monetary Authority and Bank of Thailand) might potentially help support more efficient retail transactions through the banking system.

Only very few projects have already been completed, with considerable variation in the results. A few jurisdictions, including Denmark and Switzerland, have determined that, currently, the costs of a retail CBDC would outweigh the benefits. A larger number continues to actively develop retail CBDCs; Boar et al (2020) find that over a third of all surveyed central banks say that issuing a retail CBDC is a medium-term possibility. Looking ahead, the overall conclusion from a technological perspective is that a rich set of technical designs are currently under consideration. This underscores the need for international coordination to share experience.

Selected retail CBDC projects

Table A

Design choices				Project/country	Notes on status, motivation and conclusion
Architecture[1]	Infrastructure[2]	Access[3]	International[4]		
D	U	A	N	Rafkróna Iceland	Research; aims to address "steadily diminishing use of banknotes and coin"; "many issues have yet to be clarified, and they must be dealt with appropriately before a position can be taken".
D	U	A	N	Sand Dollar The Bahamas	Pilot; improve "financial inclusion …, [reduce] the size of legitimate but unrecorded economic activities, [strengthen] national defences against money laundering and other illicit ends [and]… deliver government services through digital channels, thereby improving tax administration and increasing the efficiency of spending".

D	U	U	N	E-krona* Denmark	Research; "the potential benefits of introducing CBDC [are not assessed to] match the considerable challenges that the introduction would present".
D	U	U	N	E-krona* Norway	Working group; focus on "independent back-up solution, credit risk-free alternative to bank deposits, competition, legal tender"; "more information is required before a conclusion can be reached".
D	U	U	N	E-krona Sweden	Ongoing work; "within a few years, if the current trend continues, we will find ourselves in a situation where cash is no longer generally accepted as a means of payment"; "an account-based e-krona could rationalise payments from agencies and make them less dependent on commercial agents".
I	D	T	N	Digital fiat currency Brazil	Research; "Improve the efficiency of the monetary function, … payment processes and systems, …. financial inclusion and … user experience".
I	D	U	I	E-euro* ECB	Research; "CBDC with the status of legal tender could guarantee that all users have, in principle, access to a cheap and easy means of payment"; "proof of concept also highlights a number of areas where there is room for improvement".
U	C	A	N	Dinero Electrónico Ecuador	Pilot; "means of payment available to absolutely all Ecuadorians". Operated 2014–16; discontinued.
U	D	T	I	DXCD Eastern Caribbean	Pilot; aims to address the "high cost of current payment instruments and banking services", needs of customers and inefficient cheque settlement.
U	D	U	N	Bakong Cambodia	Pilot; aims to "increase access to quality formal financial services"; "decrease demand for… cash".
U	D	U	N	E-hryvnia Ukraine	Pilot; test DLT "as a technological framework for e-hryvnia issuance and circulation"; no fundamental advantage in using DLT in a centralised model.
U	U	T	N	Electronic legal tender South Africa	Expression of interest; "The scope of this project is specific to the use of a CBDC as electronic legal tender (ELT), similar to the characteristics of, and complementary to, cash."
U	U	U	N	Billete Digital Uruguay	Pilot; "Digital bills that aim to have same functions and uses as physical bills"; ongoing evaluation.
U	U	U	N	DC/EP (Digital Currency/Electronic Payments) China	Ongoing work; aims to create digital alternative to cash and coins for retail use.
U	U	U	N	E-shekel Israel	Research; "help in the struggle against … unreported transactions"; "contribute to the high-tech sector (fintech)"; Conclusion that "the team does not recommend that the Bank of Israel issue digital currency (e-shekel) in the near future".
U	U	U	U	E-euro* France	Research; "account-based model would offer better results for a retail CBDC. However, it might also lead to a greater loss of resources for banks".
U	U	U	U	E-franc Switzerland	Research; "Examine the opportunities and risks of introducing a cryptofranc (e-franc)"; "additional benefits currently low and outweighed by risks".

[1] D = direct; I = indirect; U = unspecified or multiple options under consideration. [2] C = conventional; D = DLT; U = unspecified or multiple options under consideration. [3] A = account-based; T = token-based; U = unspecified or multiple options under consideration. [4] I = international; N = national; U = unspecified or multiple options under consideration. * Not an official designation.

Sources: Central bank websites; www.unescap.org; www.efd.admin.ch; www.cf40.org.cn.

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Annexes

BIS Statistics: Charts

The statistics published by the BIS are a unique source of information about the structure of and activity in the global financial system. BIS statistics are presented in graphical form in this annex and in tabular form in the *BIS Statistical Bulletin*, which is published concurrently with the *BIS Quarterly Review*. For introductions to the BIS statistics and a glossary of terms used in this annex, see the *BIS Statistical Bulletin*.

The data shown in the charts in this annex can be downloaded from the *BIS Quarterly Review* page on the BIS website (www.bis.org/publ/quarterly.htm). Data may have been revised or updated subsequent to the publication of this annex. For the latest data and to download additional data, see the statistics pages on the BIS website (www.bis.org/statistics/index.htm). A release calendar provides advance notice of publication dates (www.bis.org/statistics/relcal.htm).

A Locational banking statistics

B Consolidated banking statistics

C Debt securities statistics

D Derivatives statistics

E Global liquidity indicators

F Statistics on total credit to the non-financial sector

G Debt service ratios for the private non-financial sector

H Property price statistics

I Effective and US dollar exchange rate statistics

J Credit-to-GDP gaps

K Consumer price indices

L Central bank policy rates

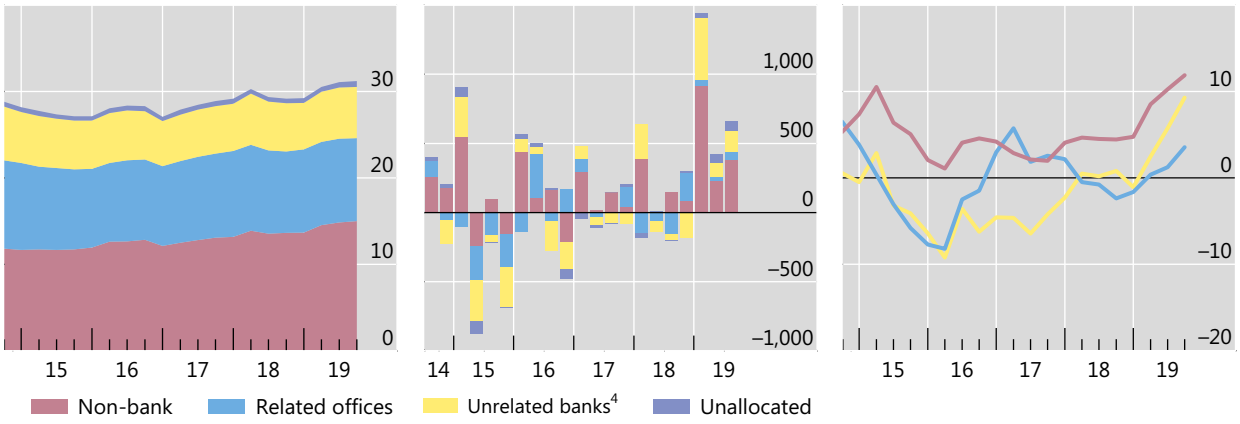
A Locational banking statistics

Cross-border claims, by sector, currency and instrument

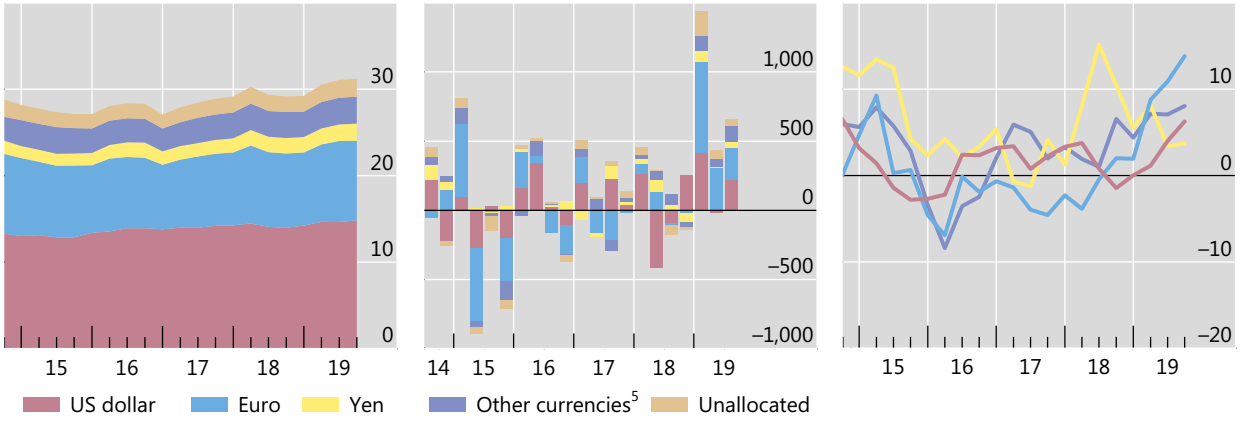
Graph A.1

Amounts outstanding, in USD trn[1] | Adjusted changes, in USD bn[2] | Annual change, in per cent[3]

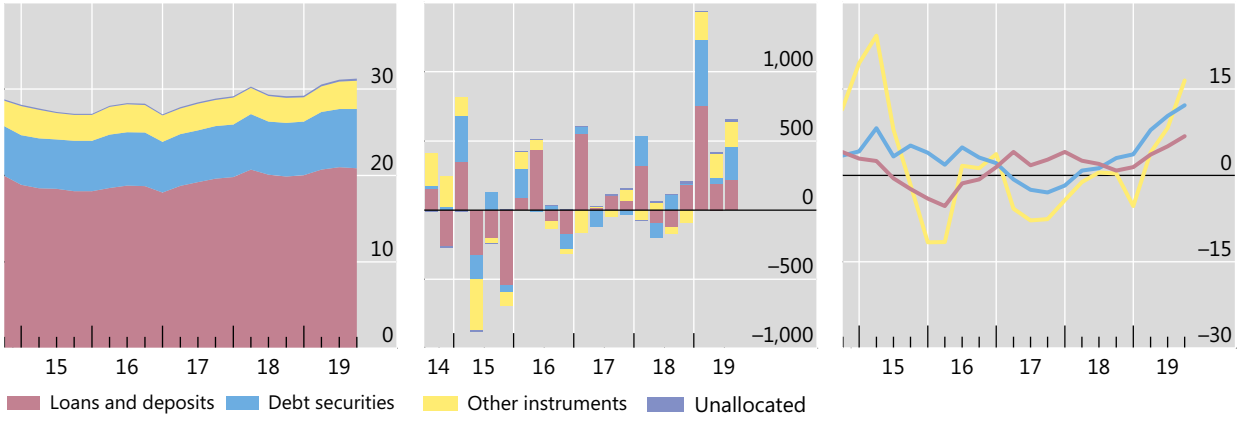
By sector of counterparty



By currency



By instrument



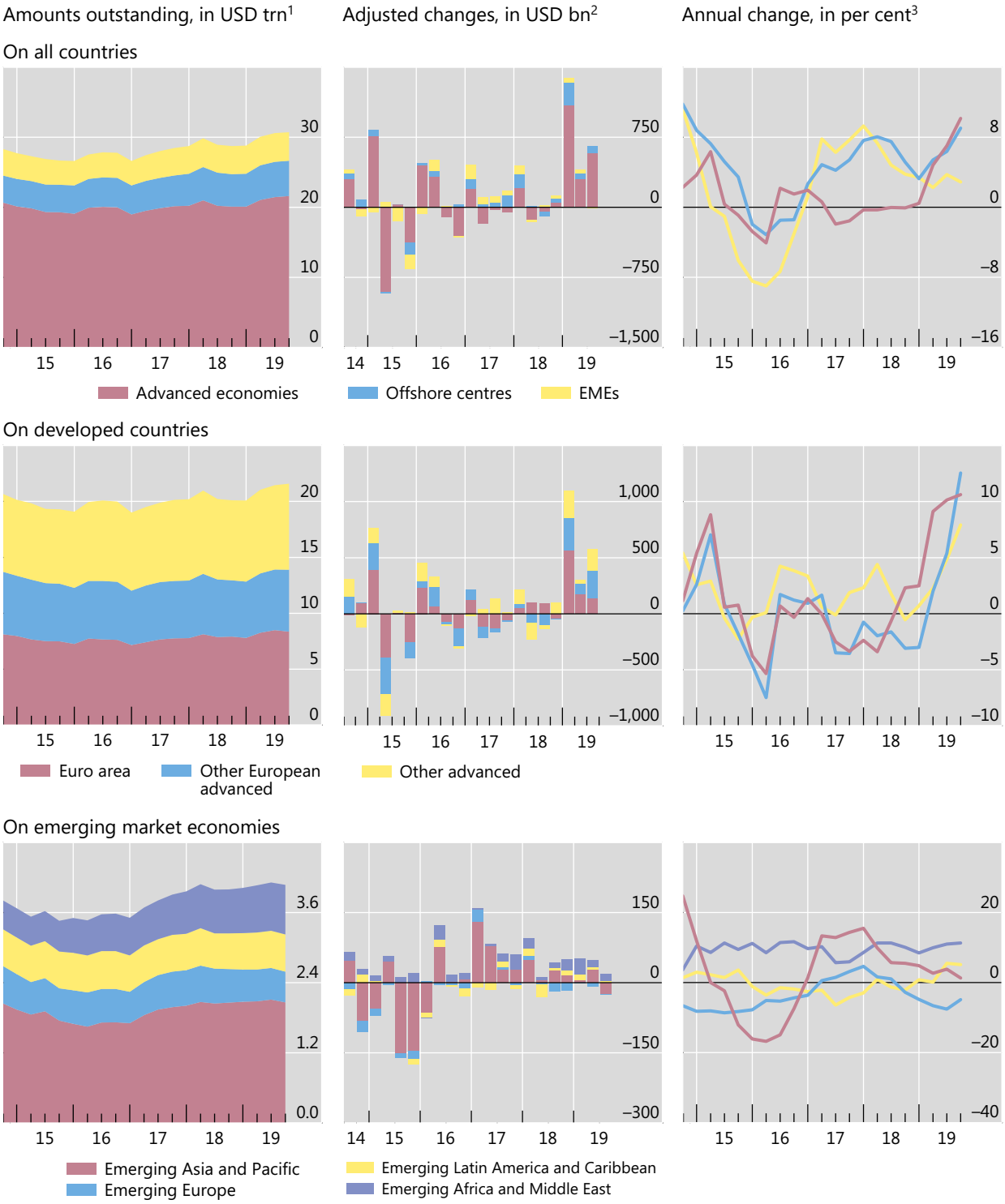
Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly changes in amounts outstanding, adjusted for the impact of exchange rate movements between quarter-ends and methodological breaks in the data. [3] Geometric mean of quarterly percentage adjusted changes. [4] Includes central banks and banks unallocated by subsector between intragroup and unrelated banks. [5] Other reported currencies, calculated as all currencies minus US dollar, euro, yen and unallocated currencies. The currency is known but reporting is incomplete.

Source: BIS locational banking statistics.

Cross-border claims, by borrowing region

Graph A.2



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[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly changes in amounts outstanding, adjusted for the impact of exchange rate movements between quarter-ends and methodological breaks in the data. [3] Geometric mean of quarterly percentage adjusted changes.

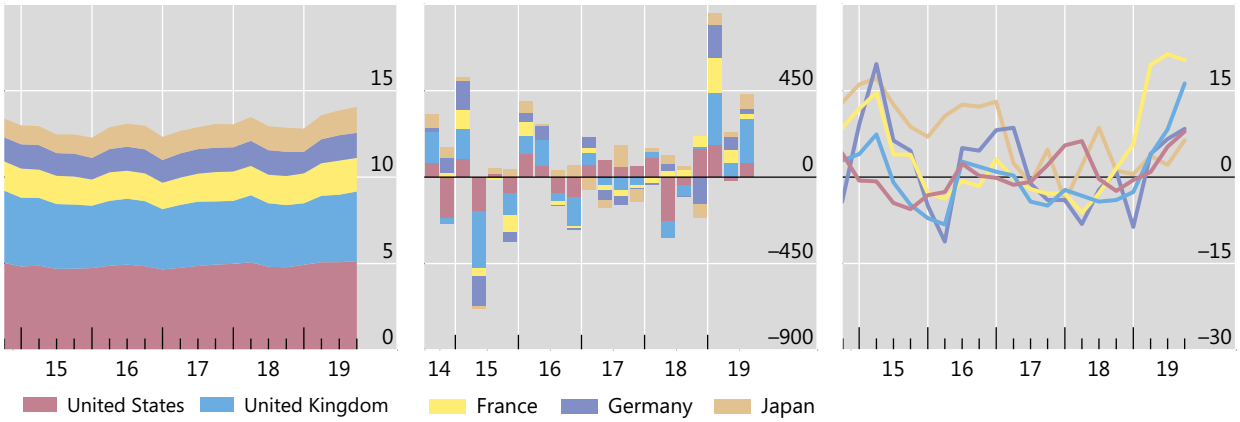
Source: BIS locational banking statistics.

Cross-border claims, by borrowing country

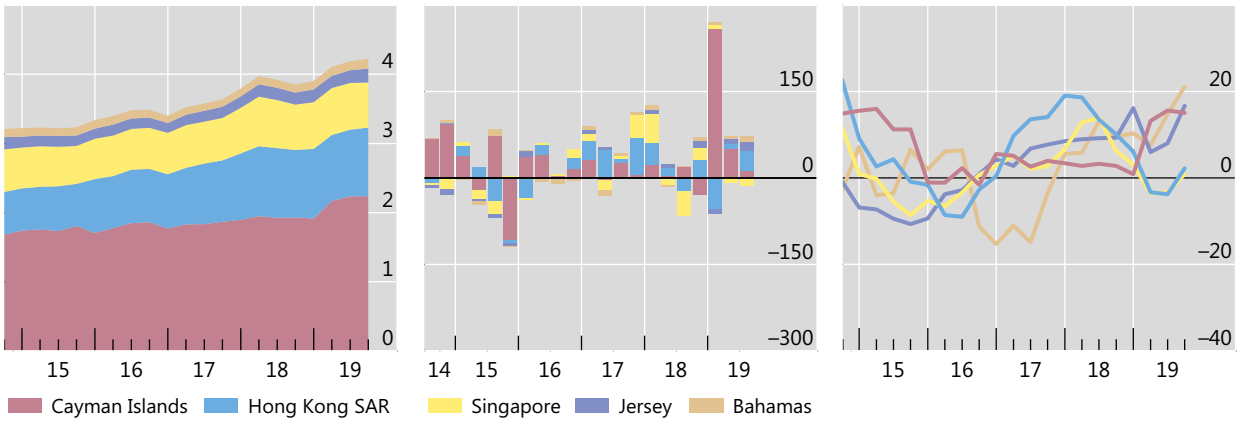
Graph A.3

Amounts outstanding, in USD trn[1] | Adjusted changes, in USD bn[2] | Annual change, in per cent[3]

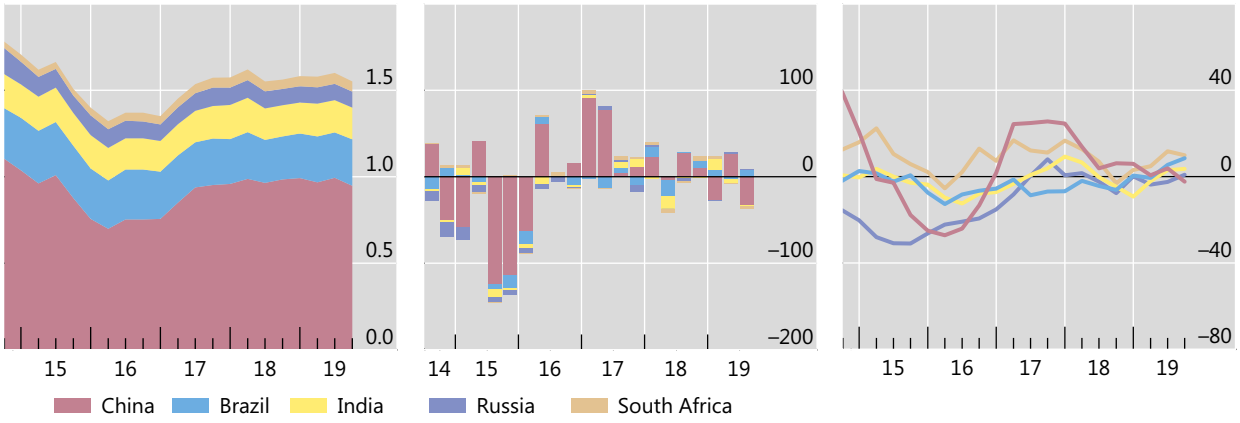
On selected advanced economies



On selected offshore centres



On selected emerging market economies



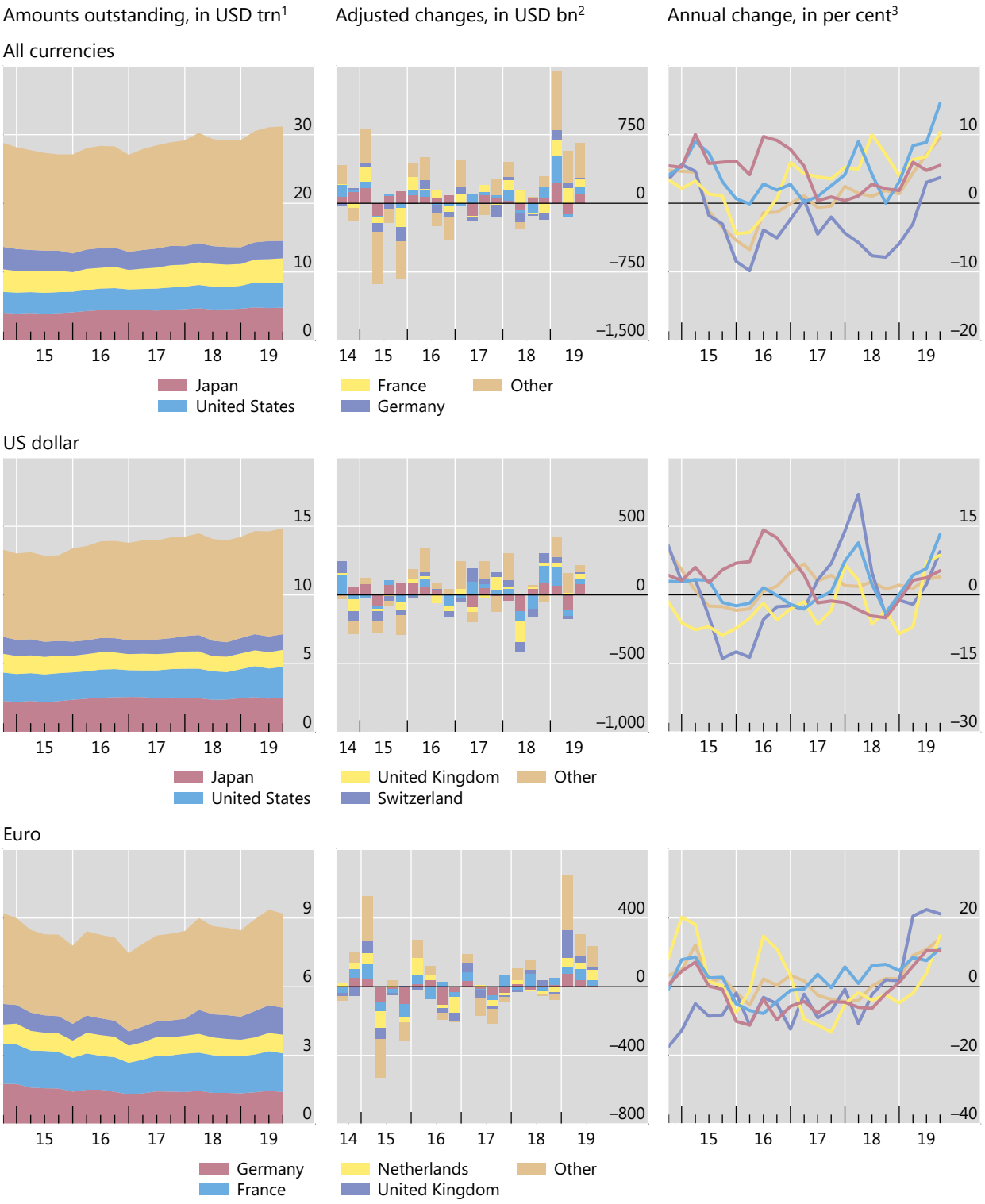
Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly changes in amounts outstanding, adjusted for the impact of exchange rate movements between quarter-ends and methodological breaks in the data. [3] Geometric mean of quarterly percentage adjusted changes.

Source: BIS locational banking statistics.

Cross-border claims, by nationality of reporting bank and currency of denomination

Graph A.4



Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly changes in amounts outstanding, adjusted for the impact of exchange rate movements between quarter-ends and methodological breaks in the data. [3] Geometric mean of quarterly percentage adjusted changes.

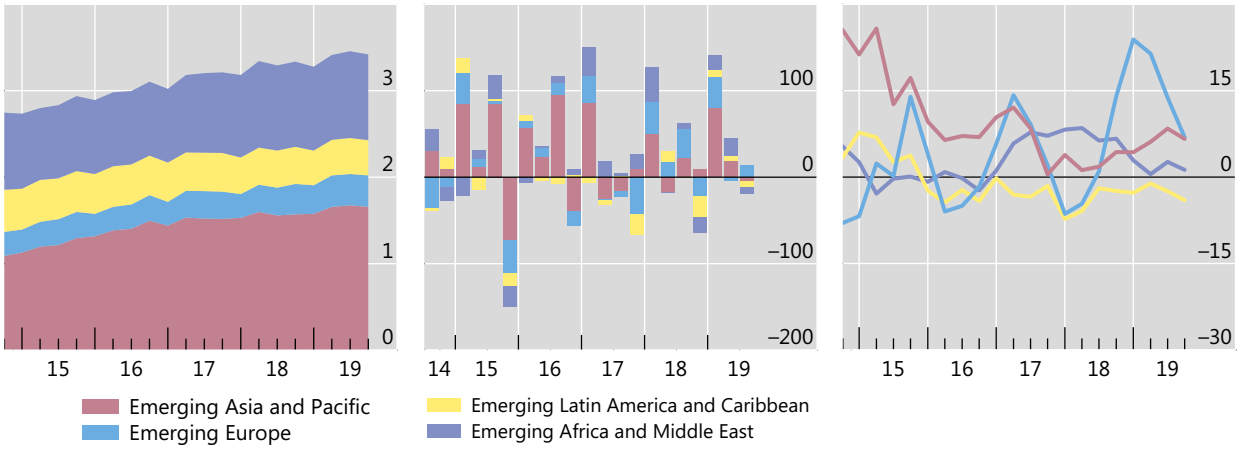
Source: BIS locational banking statistics.

Cross-border liabilities of reporting banks

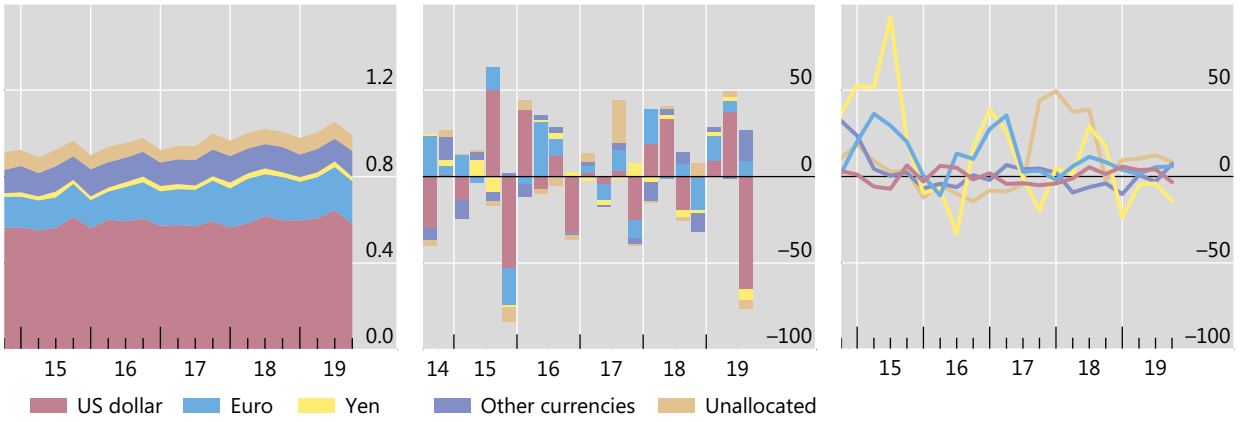
Graph A.5

Amounts outstanding, in USD trn[1] | Adjusted changes, in USD bn[2] | Annual change, in per cent[3]

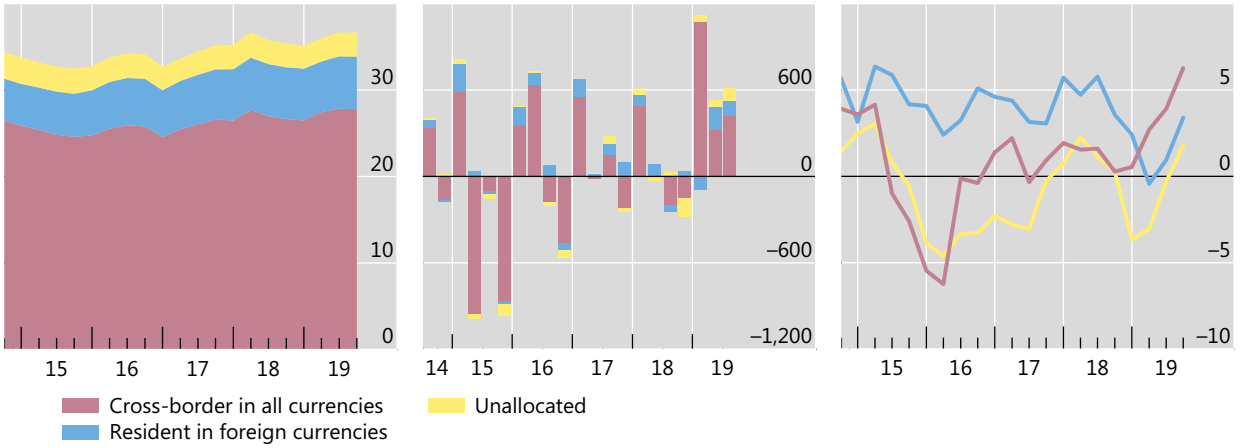
To emerging market economies



To central banks



By currency type and location



Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly changes in amounts outstanding, adjusted for the impact of exchange rate movements between quarter-ends and methodological breaks in the data. [3] Geometric mean of quarterly percentage adjusted changes.

Source: BIS locational banking statistics.

B Consolidated banking statistics

Consolidated claims of reporting banks on advanced economies

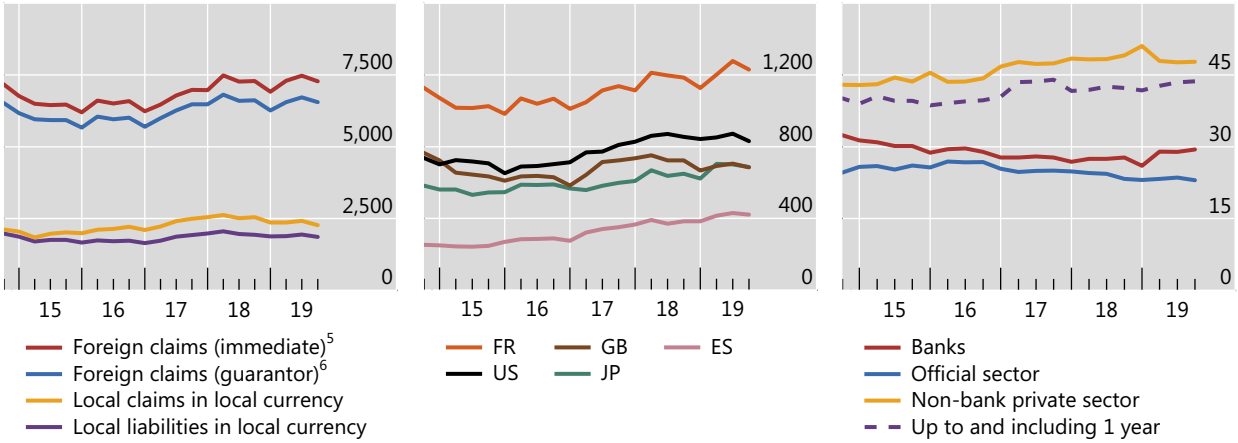
Graph B.1

Foreign claims and local positions, in USD bn[1, 2]

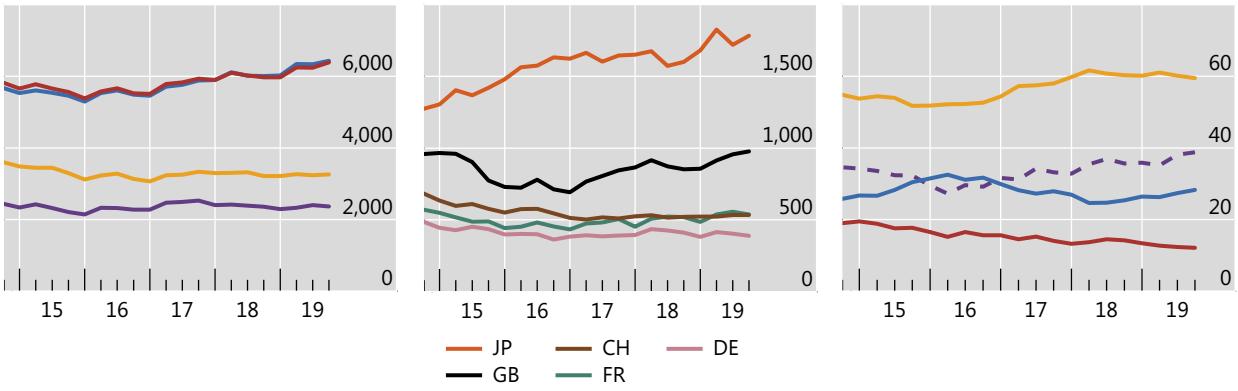
Foreign claims of selected creditors, in USD bn[1, 3]

International claims, by sector and maturity, in per cent[4]

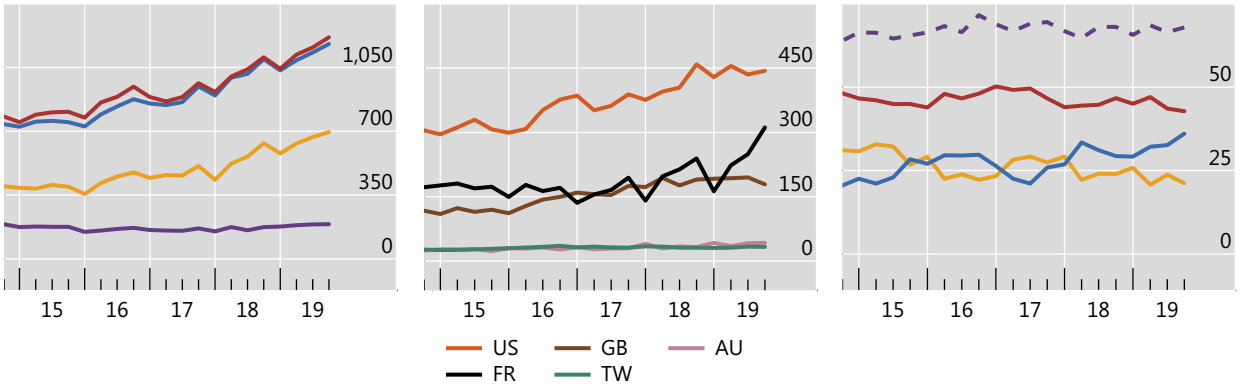
On the euro area



On the United States



On Japan



Further information on the BIS consolidated banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] Amounts outstanding at quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Excludes domestic claims, ie claims on residents of a bank's home country. [3] Foreign claims on a guarantor basis, by nationality of reporting bank. The banking systems shown are not necessarily the largest foreign bank creditors on each reference date. [4] As a percentage of international claims outstanding. [5] On an immediate counterparty basis. Includes the unconsolidated claims of banks headquartered outside but located inside CBS-reporting countries. [6] On a guarantor basis.

Source: BIS consolidated banking statistics (CBS).

Consolidated claims of reporting banks on emerging market economies

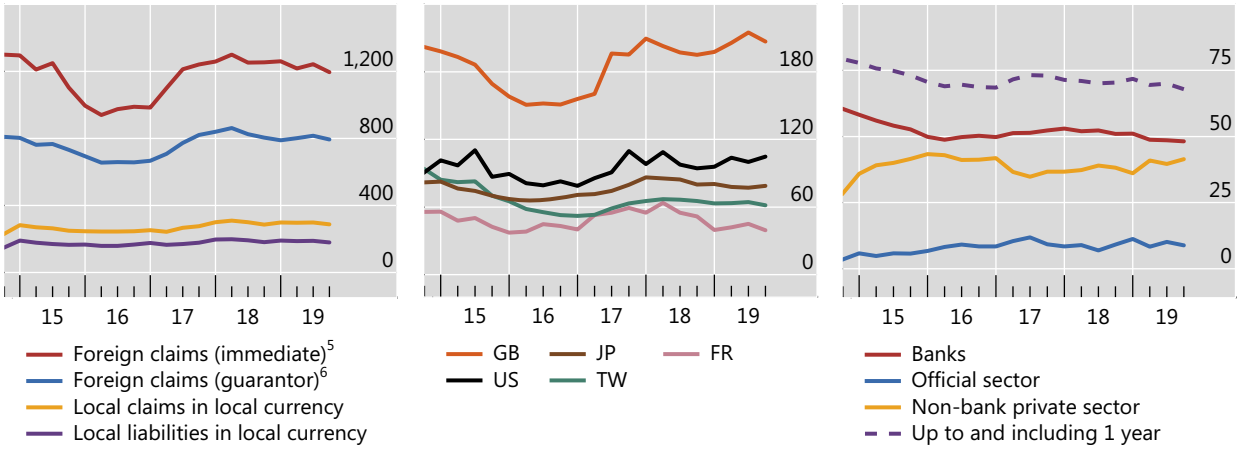
Graph B.2

Foreign claims and local positions, in USD bn[1, 2]

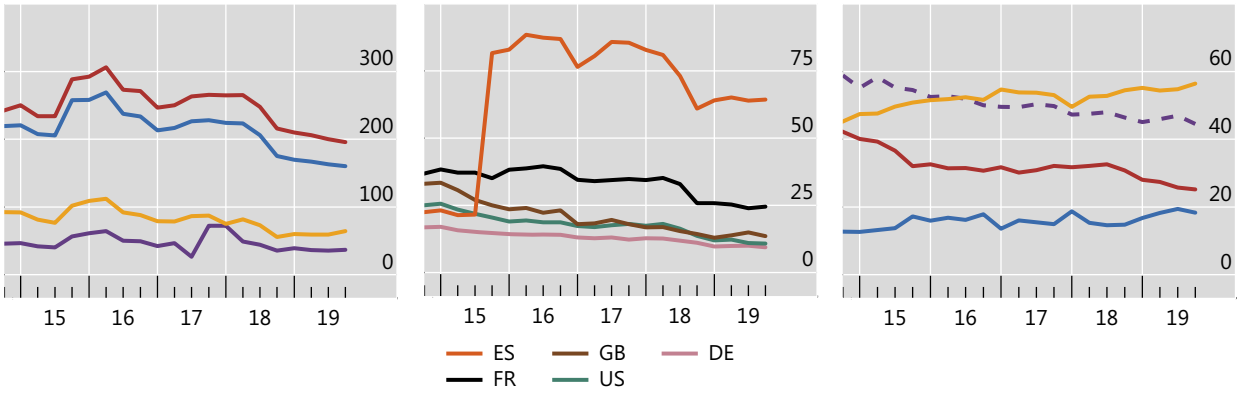
Foreign claims of selected creditors, in USD bn[1, 3]

International claims, by sector and maturity, in per cent[4]

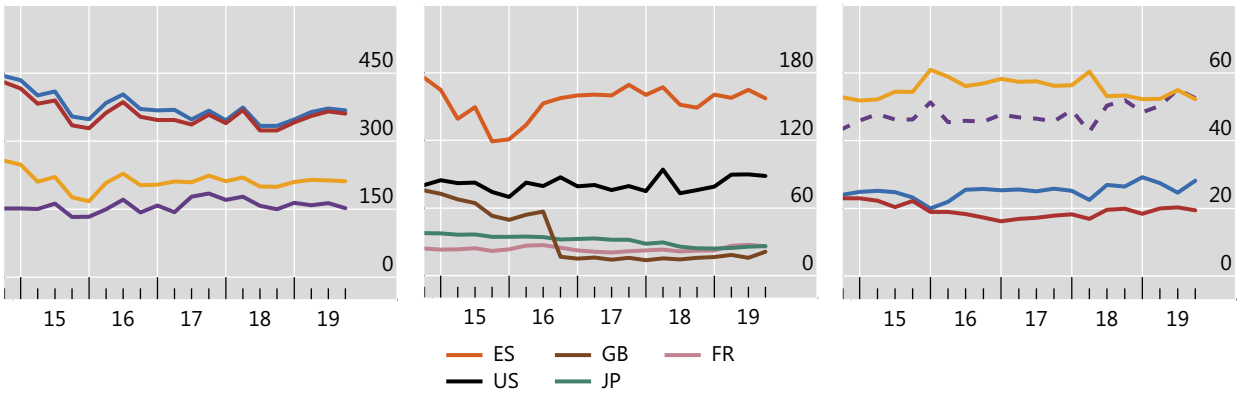
On China



On Turkey



On Brazil



Further information on the BIS consolidated banking statistics is available at www.bis.org/statistics/bankstats.htm.

[1] Amounts outstanding at quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Excludes domestic claims, ie claims on residents of a bank's home country. [3] Foreign claims on a guarantor basis, by nationality of reporting bank. The banking systems shown are not necessarily the largest foreign bank creditors on each reference date. [4] As a percentage of international claims. [5] On an immediate counterparty basis. Includes the unconsolidated claims of banks headquartered outside but located inside CBS-reporting countries. [6] On a guarantor basis .

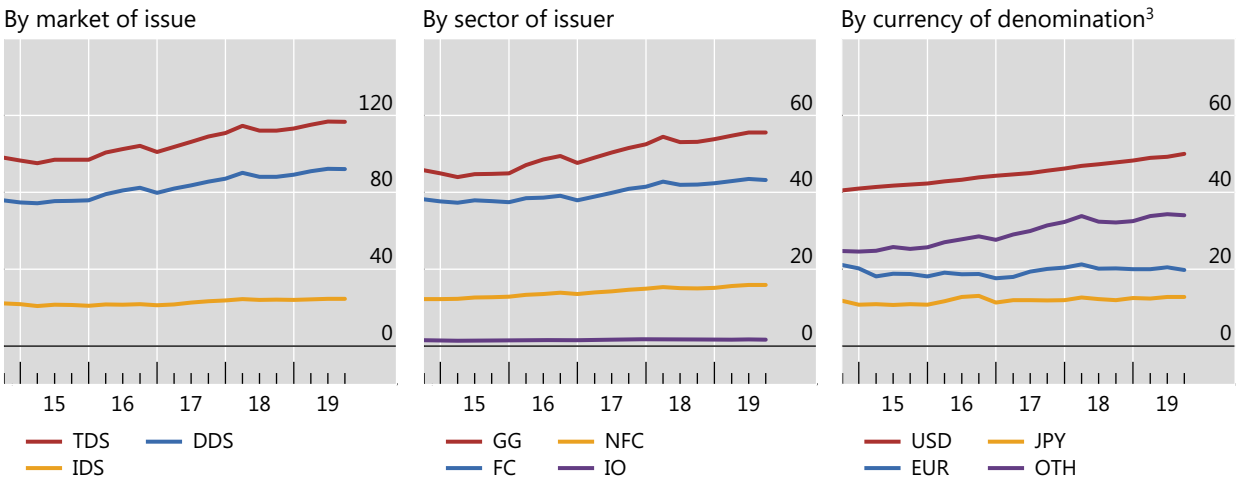
Source: BIS consolidated banking statistics (CBS).

C Debt securities statistics

Global debt securities markets[1]

Amounts outstanding, in trillions of US dollars[2]

Graph C.1



DDS = domestic debt securities; IDS = international debt securities; TDS = total debt securities.

FC = financial corporations; GG = general government; HH = households and non-profit institutions serving households; IO = international organisations; NFC = non-financial corporations.

Further information on the BIS debt securities statistics is available at www.bis.org/statistics/secstats.htm.

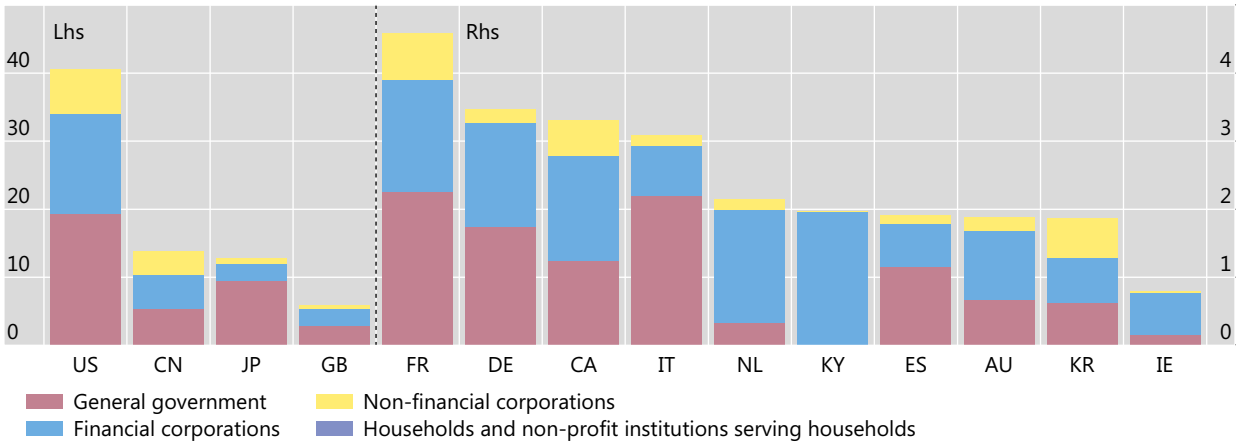
[1] Sample of countries varies across breakdowns shown. For countries that do not report TDS, data are estimated by the BIS as DDS plus IDS. For countries that do not report either TDS or DDS, data are estimated by the BIS as IDS. [2] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [3] Where a currency breakdown is not available, DDS are assumed to be denominated in the local currency.

Sources: Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS debt securities statistics; BIS calculations.

Total debt securities, by residence and sector of issuer[1]

Amounts outstanding for the latest available data, in trillions of US dollars[2]

Graph C.2



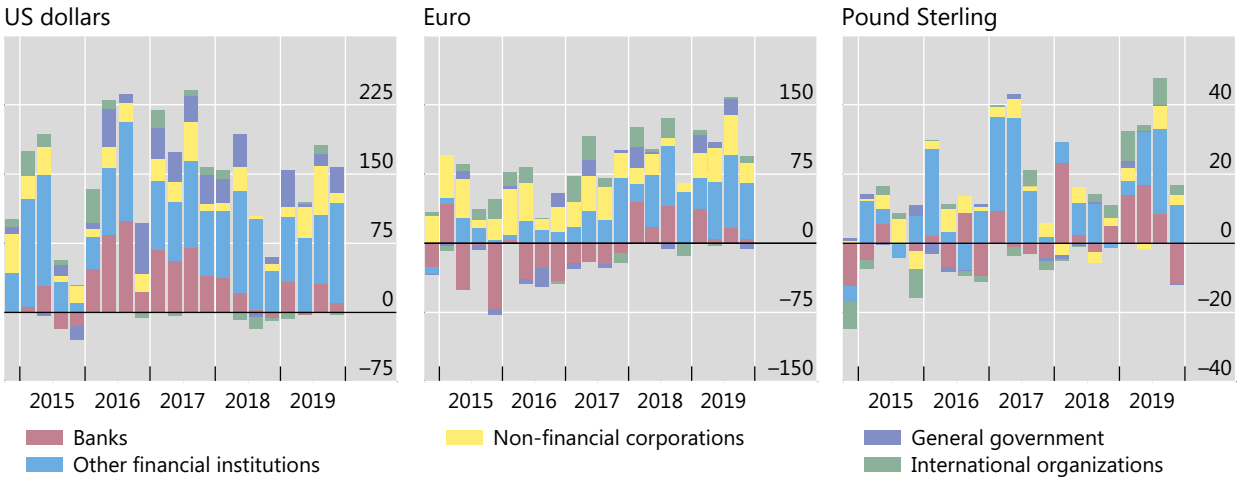
Further information on the BIS debt securities statistics is available at www.bis.org/statistics/secstats.htm.

[1] For countries that do not report TDS, data are estimated by the BIS as DDS plus IDS. [2] Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Sources: National data; BIS debt securities statistics.

Net issuance of international debt securities

By issuer sector and currency of denomination, in billions of US dollars — Graph C.3

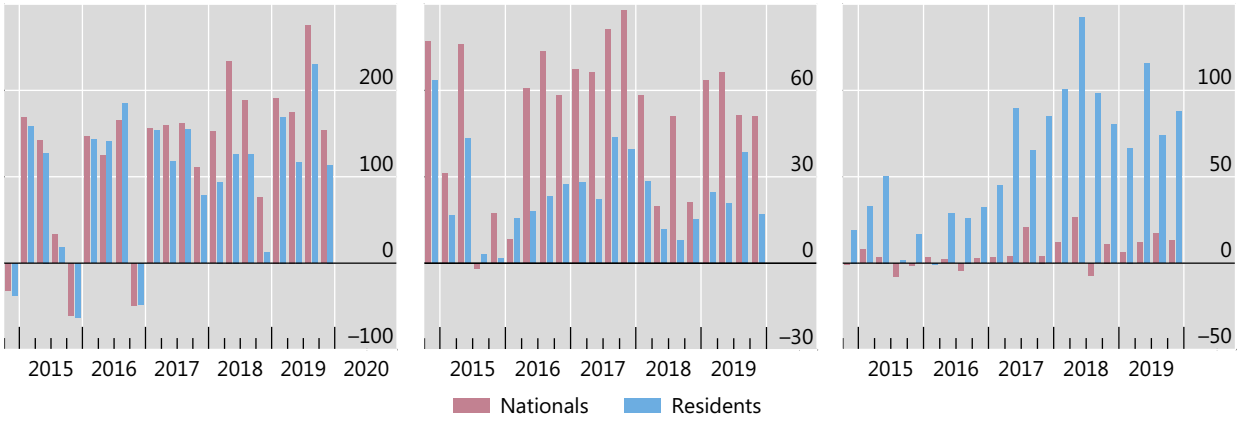


Further information is available at www.bis.org/statistics/secstats.htm.

Sources: Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; BIS debt securities statistics.

International debt securities issued by financial and non-financial corporations[1]

Net issuance by region, in billions of US dollars[2] — Graph C.4



Further information is available at www.bis.org/statistics/secstats.htm.

[1] Excluding general government. [2] For a list of countries in each region, see Table C1 (http://stats.bis.org/statx/srs/table/c1).

Sources: Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; BIS debt securities statistics.

D Derivatives statistics

Exchange-traded derivatives

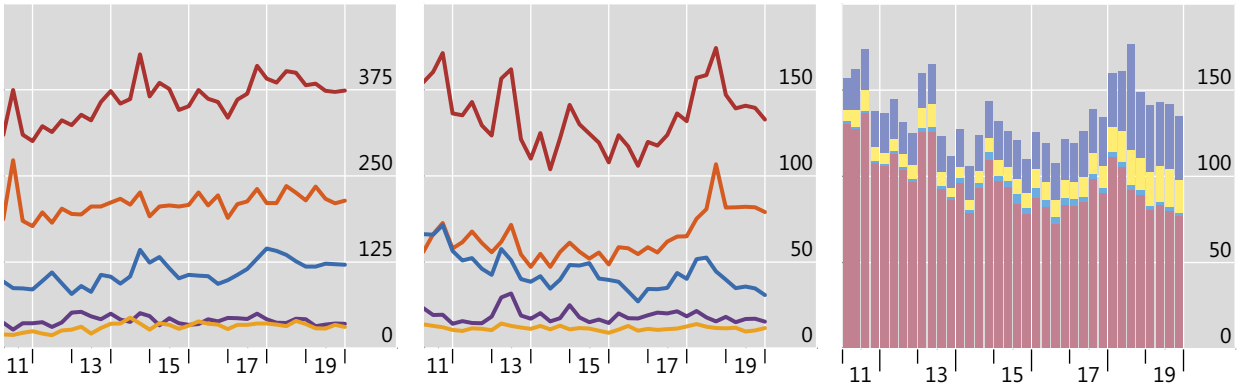
Graph D.1

Open interest, by currency[1]

Daily average turnover, by currency[2]

Daily average turnover, by location of exchange[2]

Foreign exchange derivatives, USD bn[3]



Interest rate derivatives, USD trn[3]

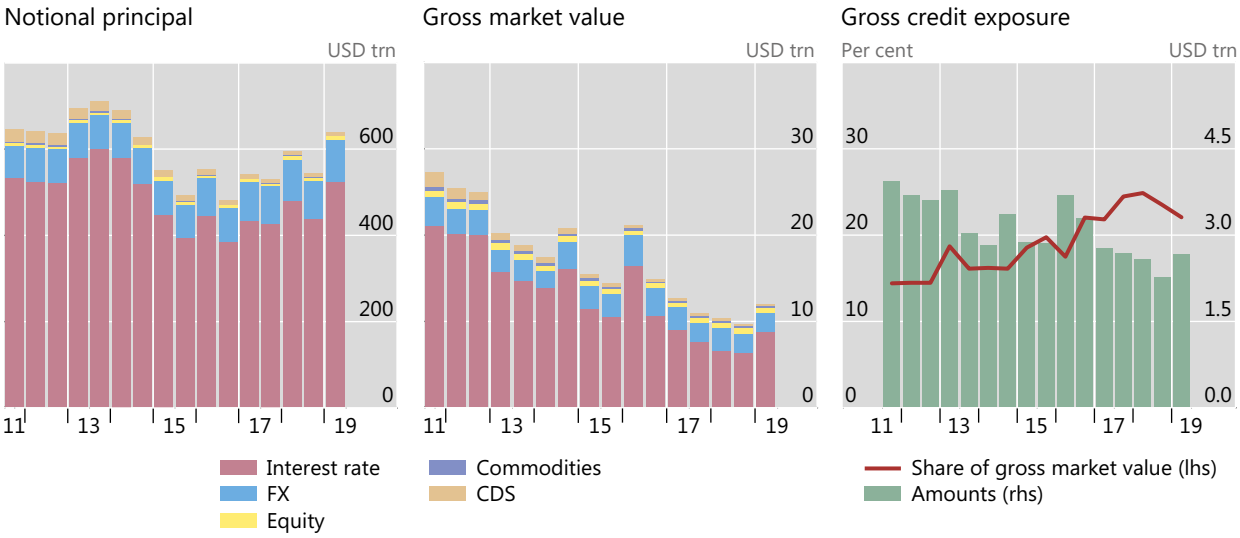
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/extderiv.htm. For definitions, see the online glossary.

[1] At quarter-end. Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date. [2] Quarterly averages of daily turnover. [3] Futures and options.

Sources: Euromoney TRADEDATA; Futures Industry Association; The Options Clearing Corporation; BIS derivatives statistics.

Global OTC derivatives markets[1]

Graph D.2



Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

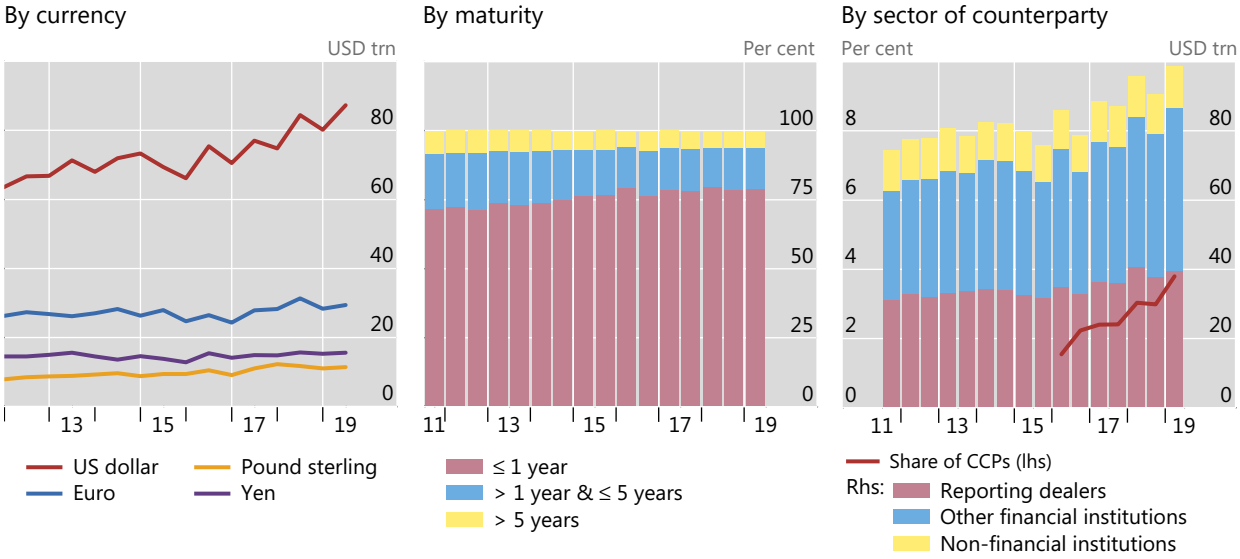
[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

OTC foreign exchange derivatives

Notional principal[1]

Graph D.3



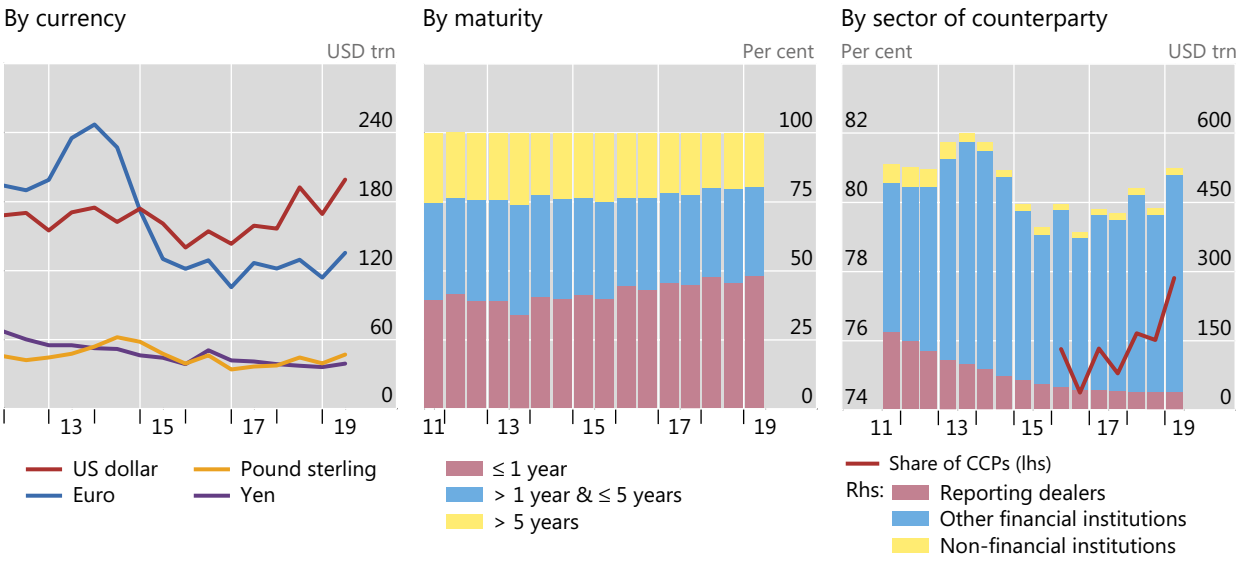
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

OTC interest rate derivatives

Notional principal[1] Graph D.4



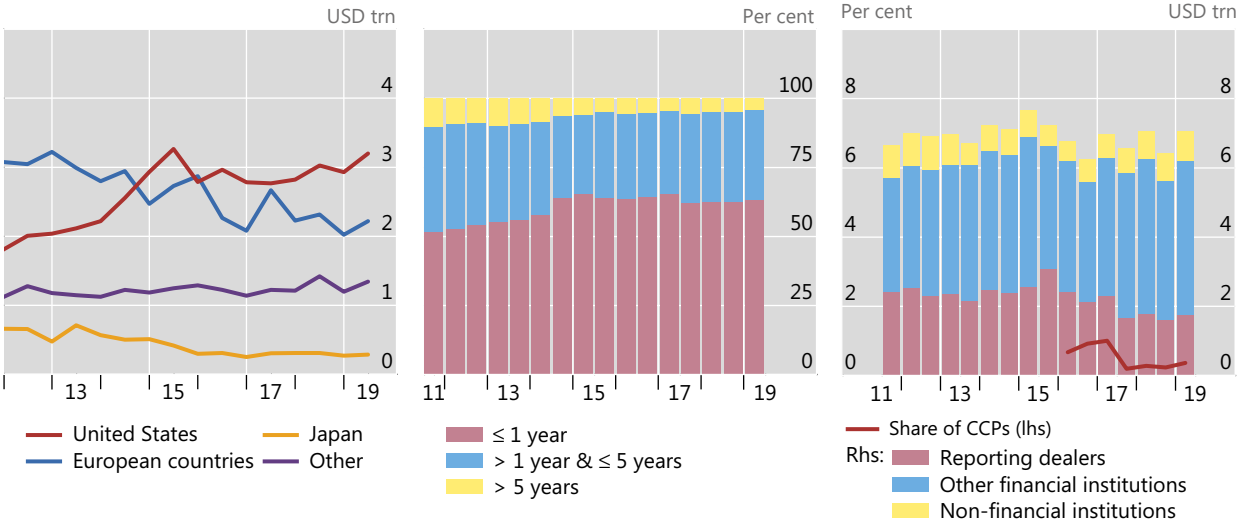
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

OTC equity-linked derivatives

Notional principal[1] Graph D.5



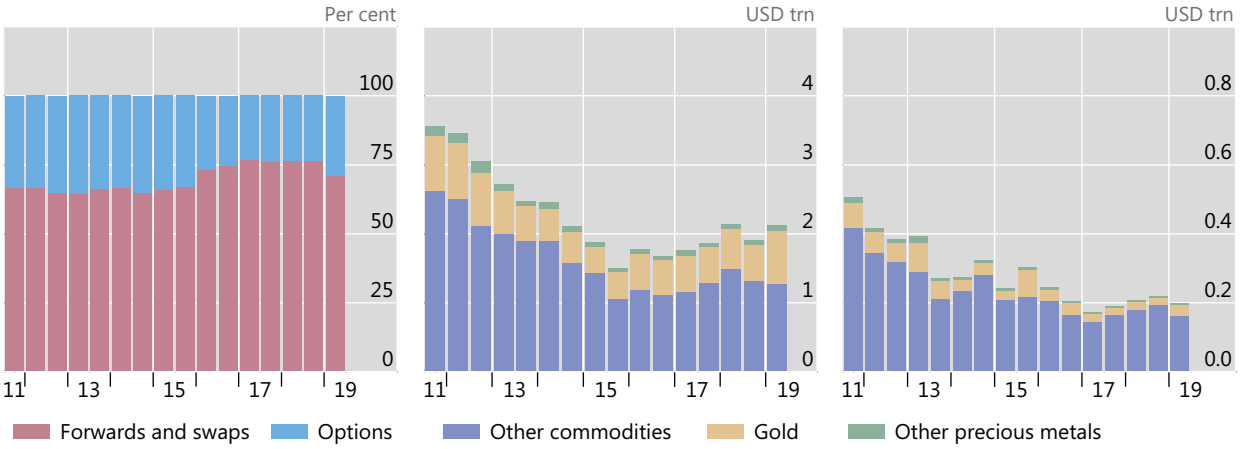
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

OTC commodity derivatives[1]

Graph D.6



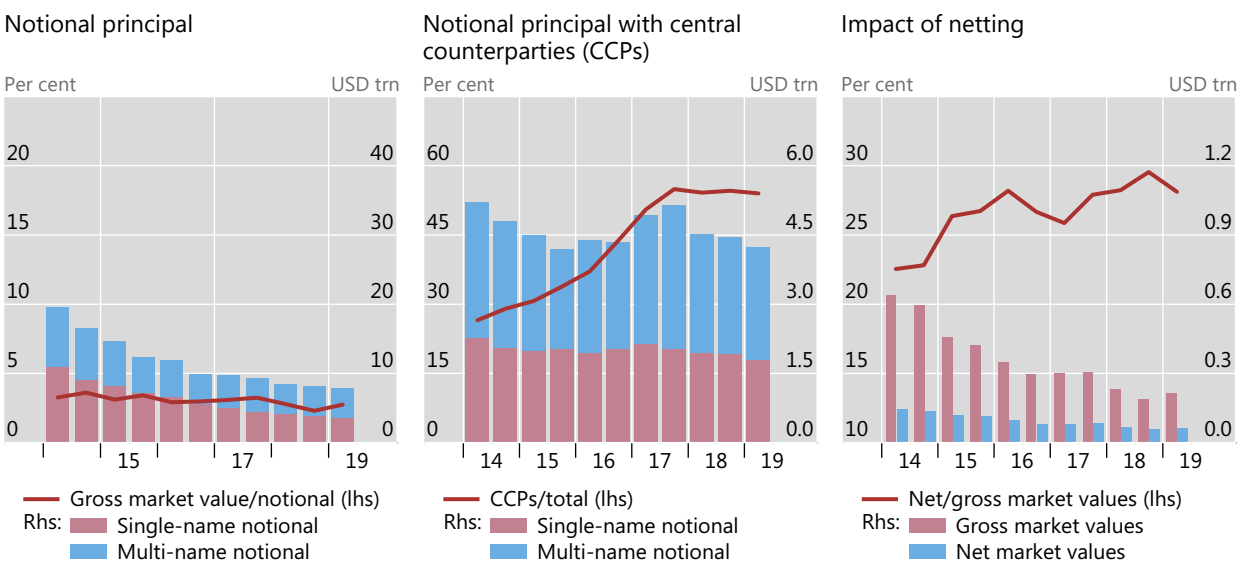
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

Credit default swaps[1]

Graph D.7



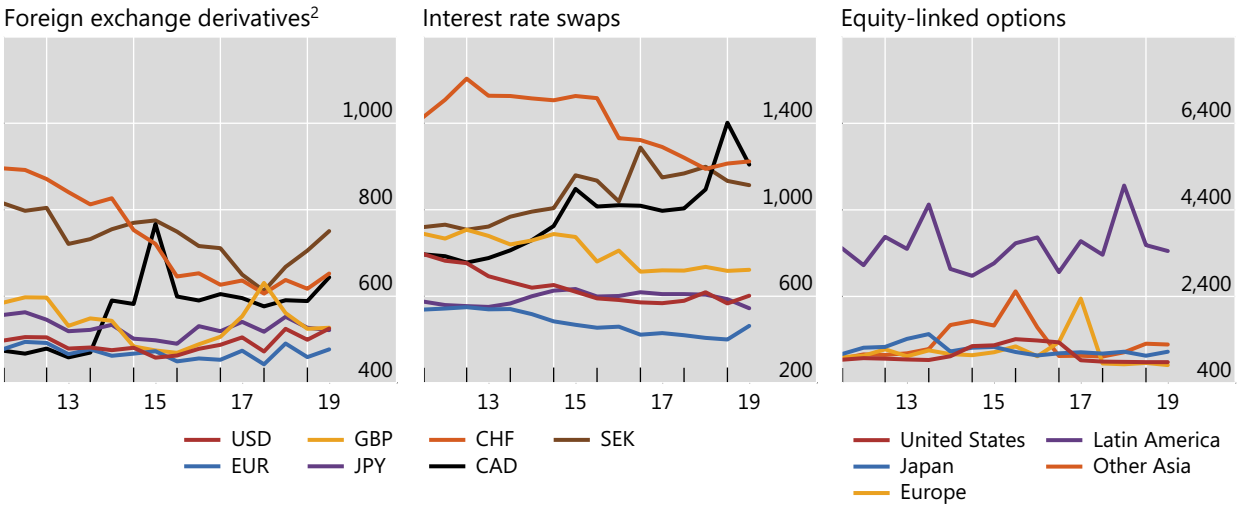
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

Concentration in global OTC derivatives markets

Herfindahl index[1] Graph D.8



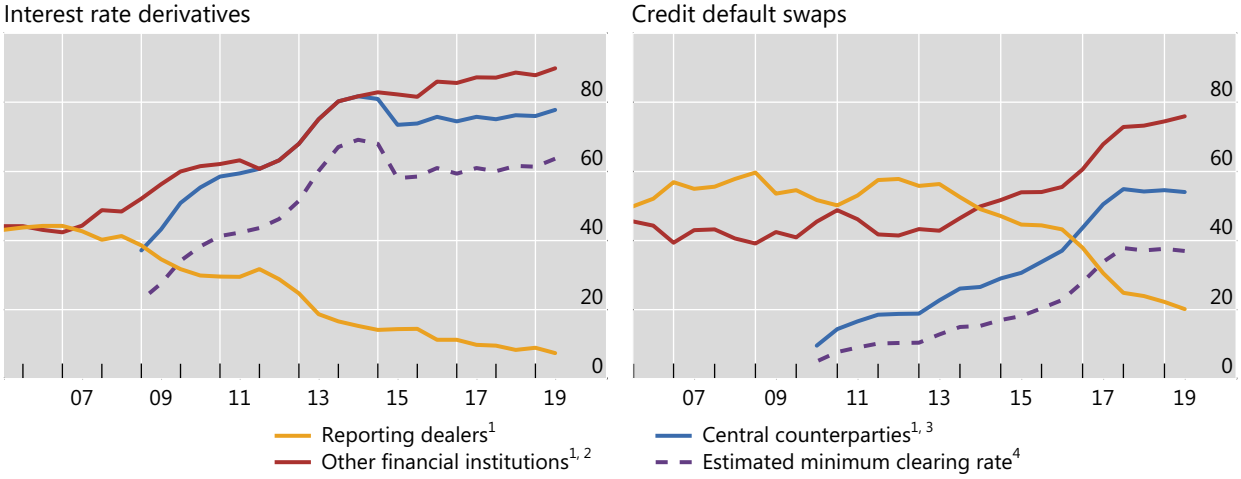
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] The index ranges from 0 to 10,000, where a lower number indicates that there are many dealers with similar market shares (as measured by notional principal) and a higher number indicates that the market is dominated by a few reporting dealers. [2] Foreign exchange forwards, foreign exchange swaps and currency swaps.

Source: BIS derivatives statistics.

Growth of central clearing

Notional amounts outstanding by counterparty, in per cent Graph D.9



Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[1] As a percentage of notional amounts outstanding against all counterparties. [2] Including central counterparties but excluding reporting dealers. [3] For interest rate derivatives, data for CCPs prior to end-June 2016 are estimated by indexing the amounts reported at end-June 2016 to the growth since 2008 of notional amounts outstanding cleared through LCH's SwapClear service. [4] Proportion of trades that are cleared, estimated as (CCP / 2) / (1 – (CCP / 2)), where CCP represents the share of notional amounts outstanding that dealers report against CCPs. CCPs' share is halved to adjust for the potential double-counting of inter-dealer trades novated to CCPs.

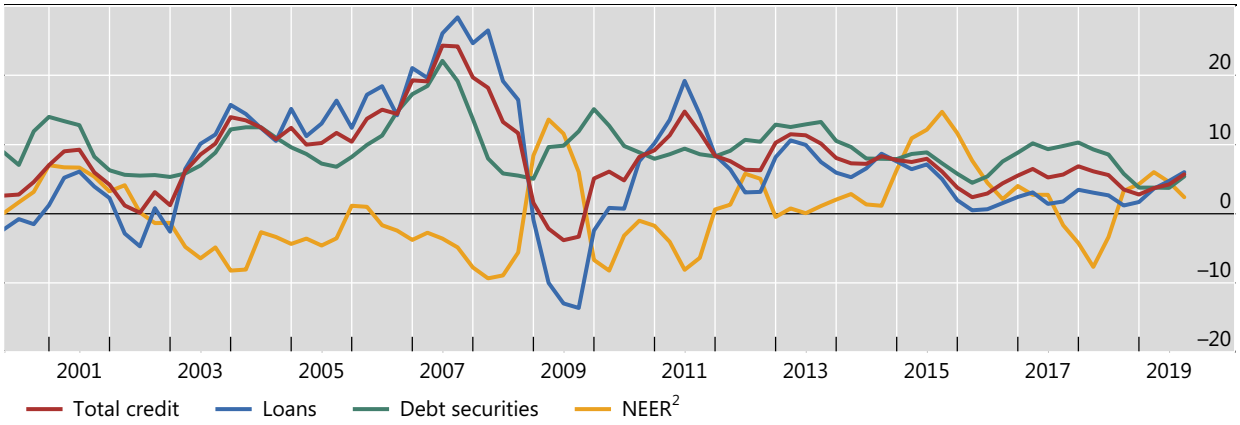
Sources: LCH.Clearnet Group Ltd; BIS OTC derivatives statistics (Table D7 and Table D10.1); BIS calculations.

E Global liquidity indicators

US dollar credit outside the United States[1]

Annual change, in per cent

Graph E.1



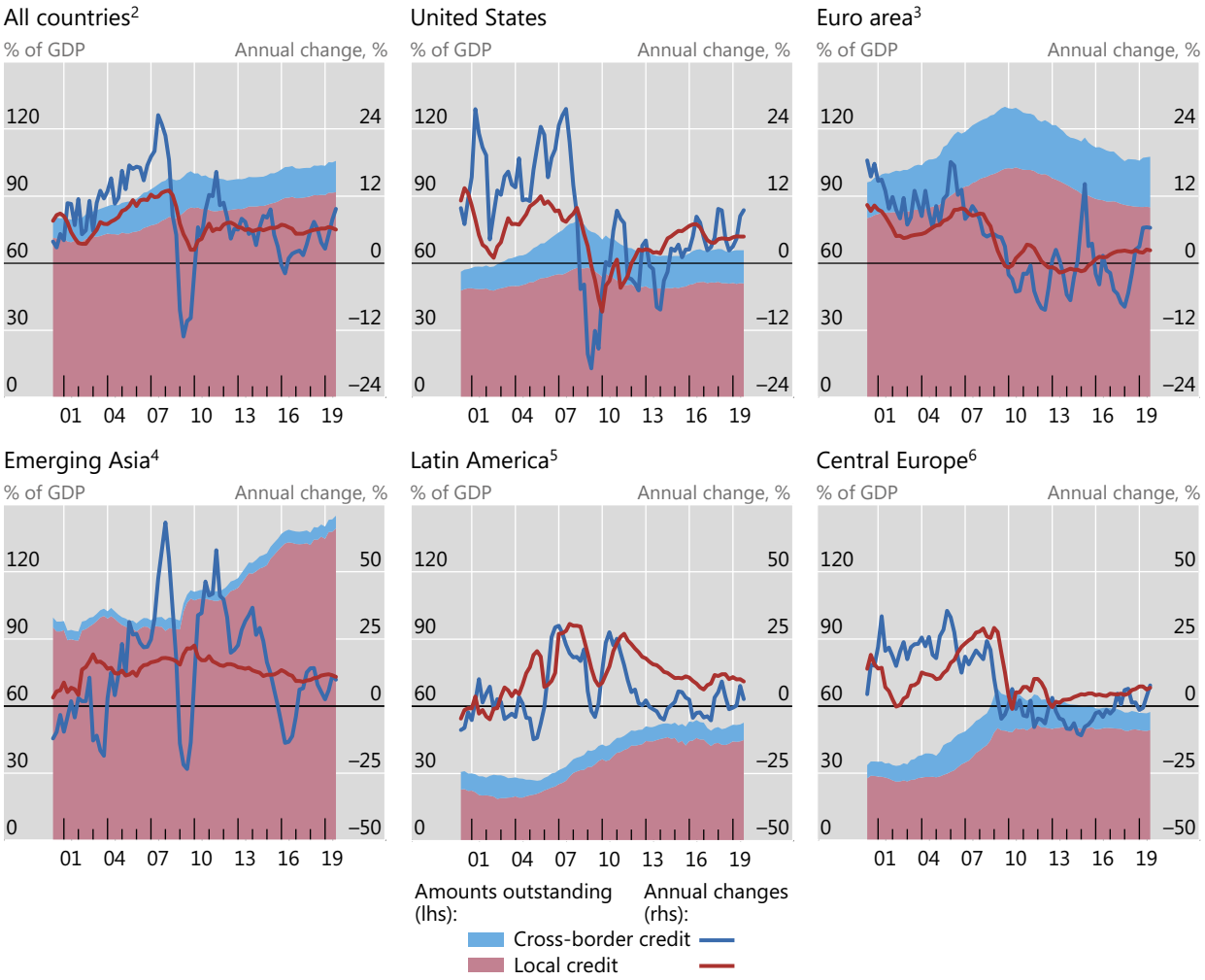
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[1] Annual growth of US dollar-denominated credit to non-banks outside the United States. [2] Annual growth of the US dollar nominal effective exchange rate.

Sources: Datastream; Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS locational banking statistics; BIS effective exchange rate statistics; BIS calculations.

Global bank credit to the private non-financial sector, by residence of borrower

Banks' cross-border credit plus local credit in all currencies[1] Graph E.2



Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[1] Cross-border claims of LBS reporting banks to the non-bank sector plus local claims of all banks to the private non-financial sector. Weighted averages of the economies listed, based on four-quarter moving sums of GDP. [2] Australia, Canada, Denmark, Japan, New Zealand, Norway, Russia, Saudi Arabia, South Africa, Sweden, Switzerland, Turkey and the United Kingdom, plus the countries in the other panels. [3] Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. [4] China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, Singapore and Thailand. [5] Argentina, Brazil, Chile and Mexico. [6] The Czech Republic, Hungary and Poland.

Sources: BIS credit to the non-financial sector; BIS locational banking statistics; BIS calculations.

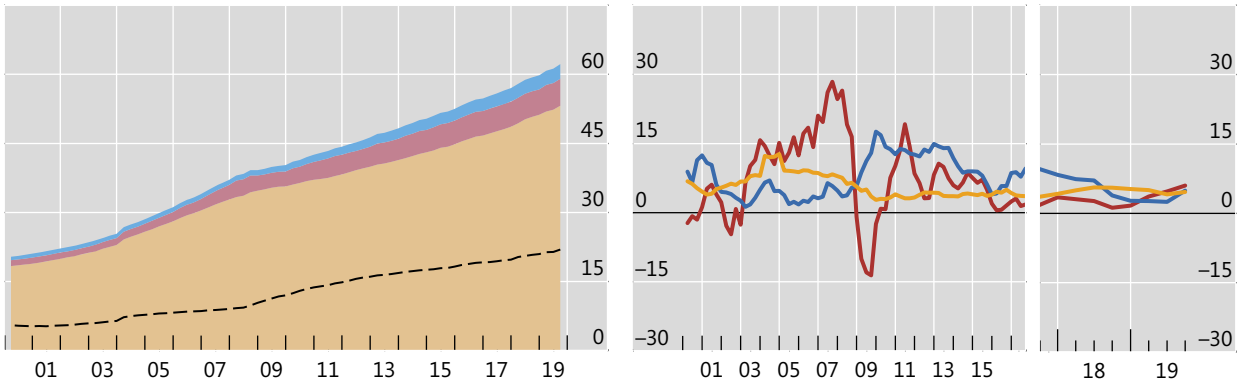
Global credit to the non-financial sector, by currency

Graph E.3

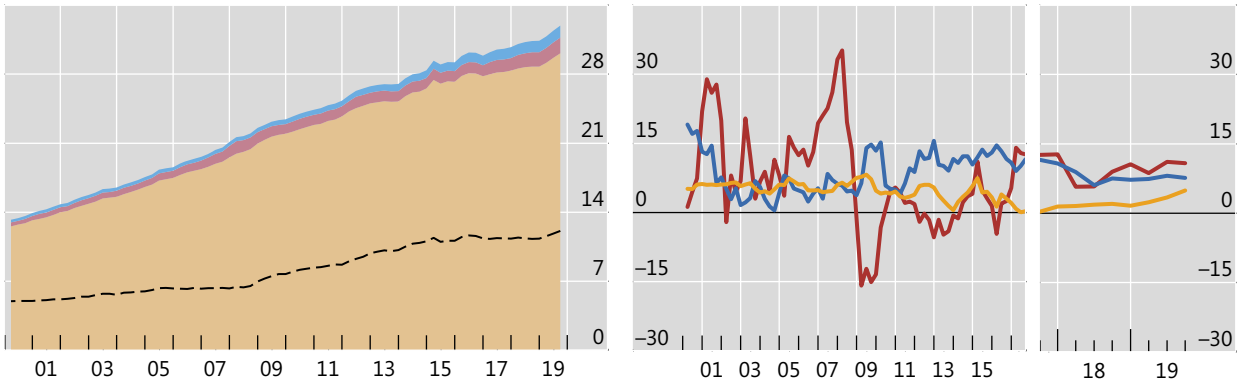
Amounts outstanding, in trillions of currency units[1]

Annual change, in per cent[2]

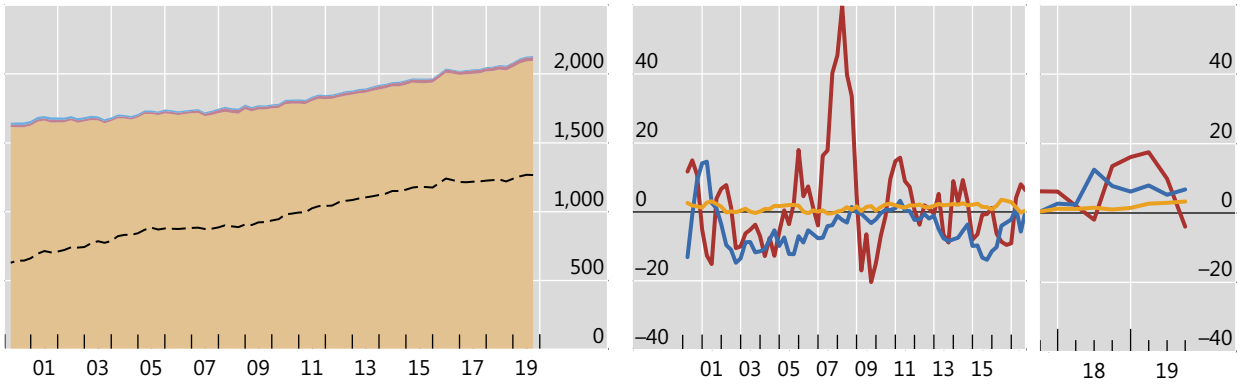
Credit denominated in US dollars (USD)



Credit denominated in euros (EUR)



Credit denominated in yen (JPY)



Credit to residents[3]
Of which:
Credit to government
Credit to non-residents:
Debt securities[4]
Bank loans[5]

Credit to residents[3]
Credit to non-residents:
Debt securities[4]
Bank loans[5]

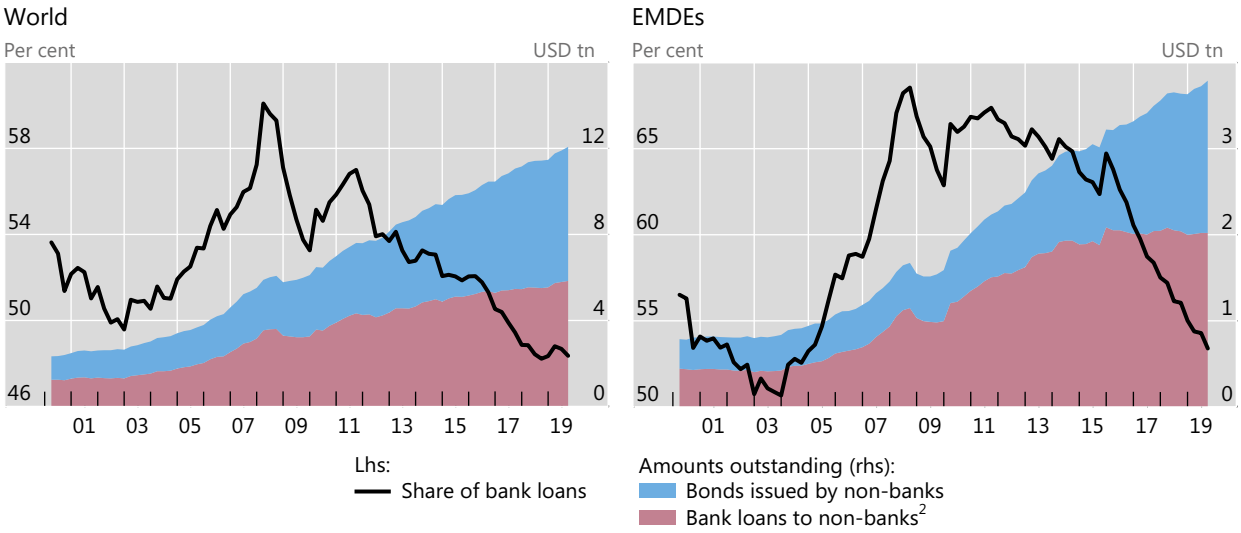
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[1] Amounts outstanding at quarter-end. [2] Based on quarterly break- and exchange rate-adjusted changes. [3] Credit to non-financial borrowers residing in the United States/euro area/Japan. National financial accounts are adjusted using BIS banking and securities statistics to exclude credit denominated in non-local currencies. [4] Excluding debt securities issued by special purpose vehicles and other financial entities controlled by non-financial parents. EUR-denominated debt securities exclude those issued by institutions of the European Union. [5] Loans by LBS-reporting banks to non-bank borrowers, including non-bank financial entities, comprise cross-border plus local loans.

Sources: Datastream; Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS locational banking statistics (LBS); BIS calculations.

US dollar-denominated credit to non-banks outside the United States[1]

Graph E.4



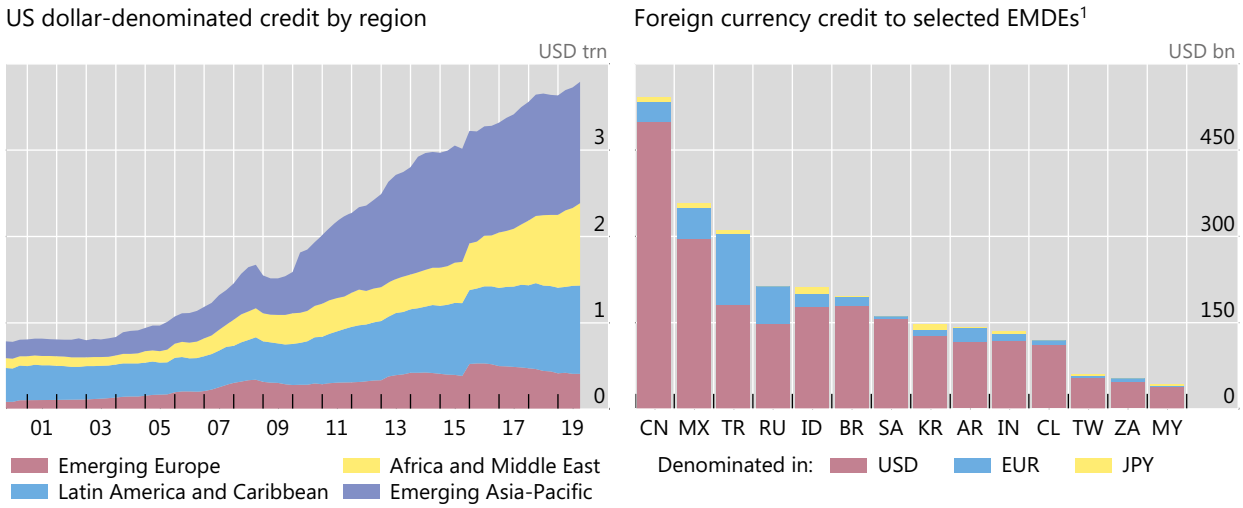
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[1] Non-banks comprise non-bank financial entities, non-financial corporations, governments, households and international organisations. [2] Loans by LBS-reporting banks to non-bank borrowers, including non-bank financial entities, comprise cross-border plus local loans.

Sources: Datastream; Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS locational banking statistics (LBS); BIS calculations.

Foreign currency credit to non-banks in EMDEs

Graph E.5



Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[1] Amounts outstanding for the latest available data.

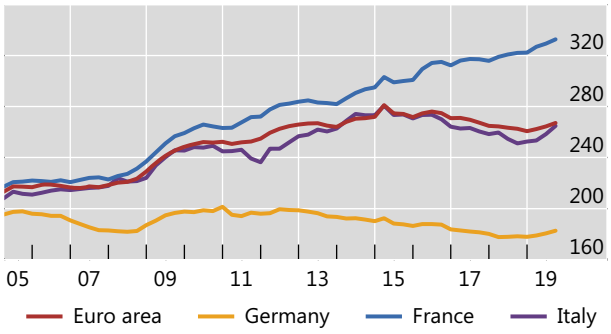
Sources: Datastream; Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS locational banking statistics (LBS); BIS calculations.

F Statistics on total credit to the non-financial sector

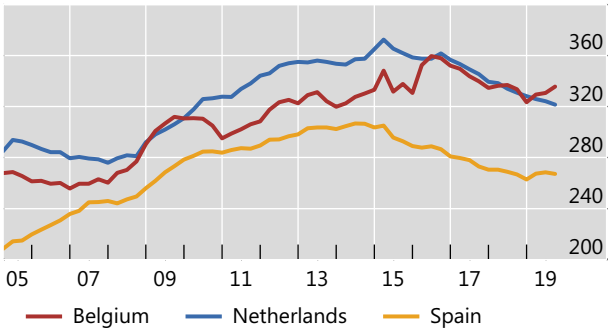
Total credit to the non-financial sector (core debt)

As a percentage of GDP — Graph F.1

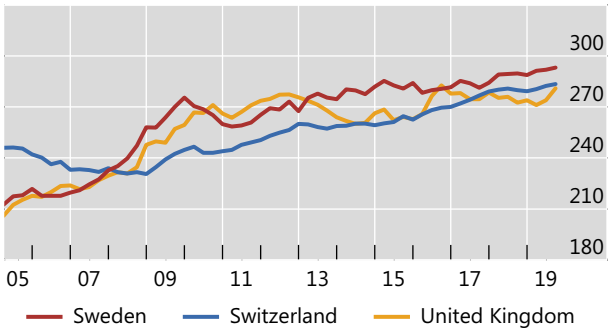
Euro area: aggregate and major countries



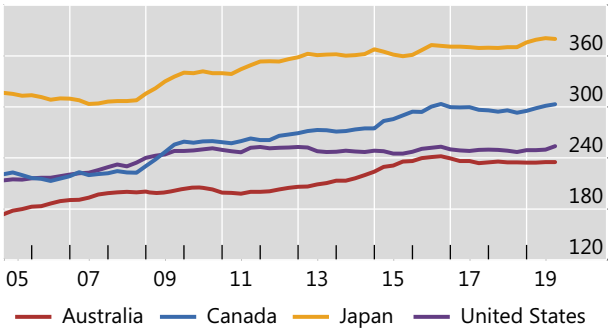
Euro area: other countries



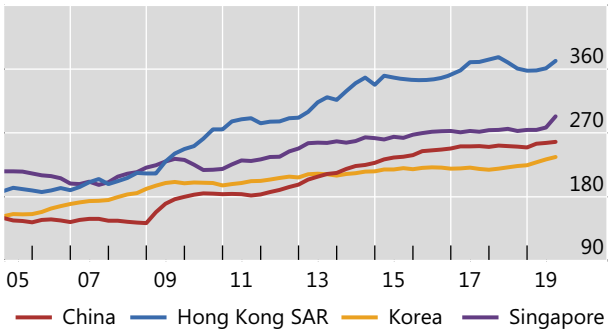
Other European countries



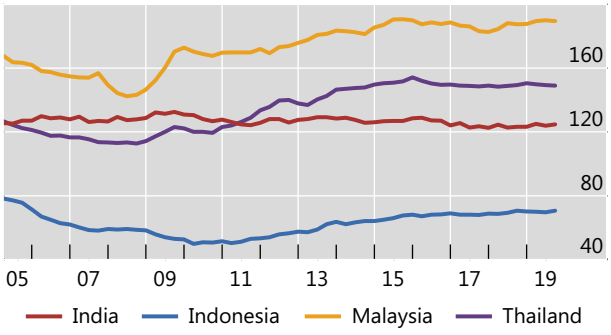
Major advanced economies



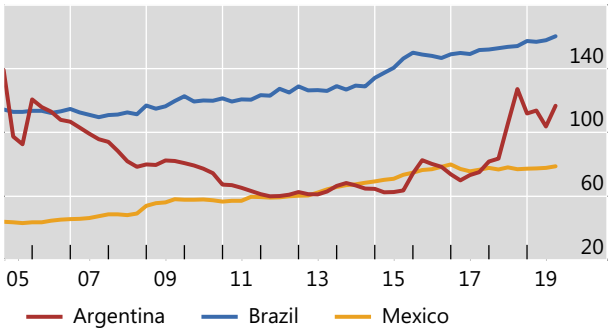
Emerging Asia



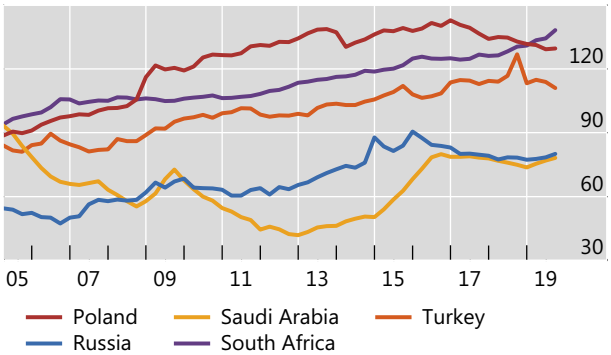
Other emerging Asia



Latin America



Other emerging market economies

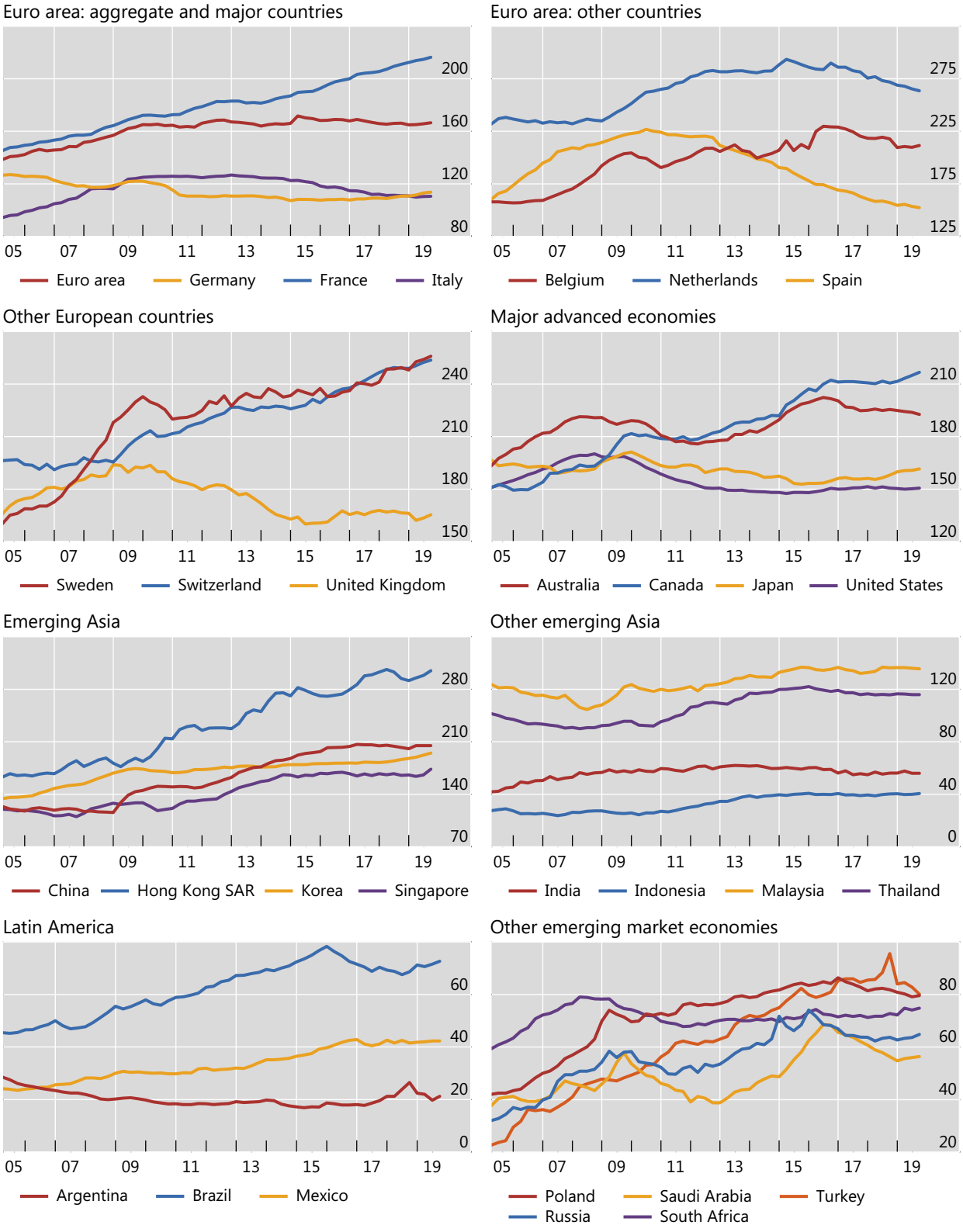


Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

Total credit to the private non-financial sector (core debt)

As a percentage of GDP — Graph F.2



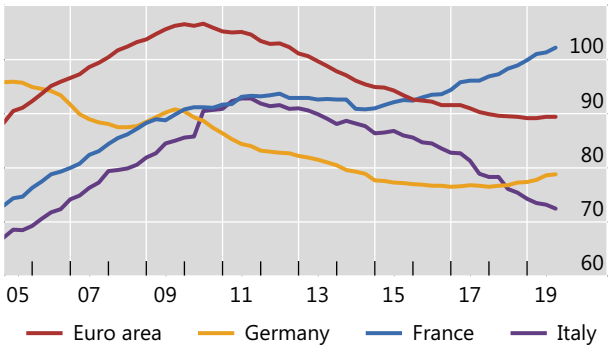
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

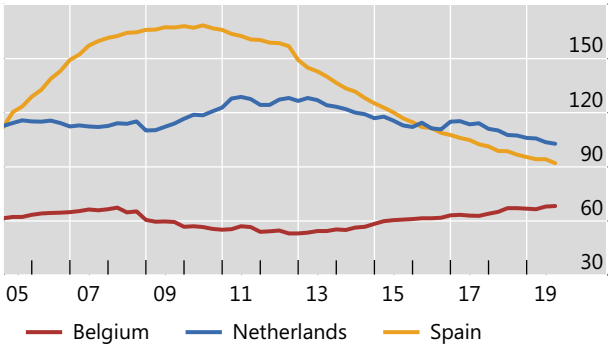
Bank credit to the private non-financial sector (core debt)

As a percentage of GDP — Graph F.3

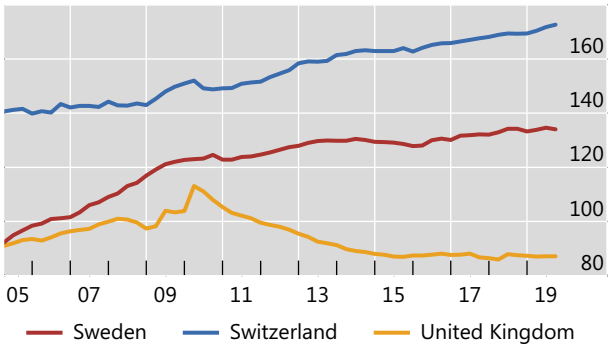
Euro area: aggregate and major countries



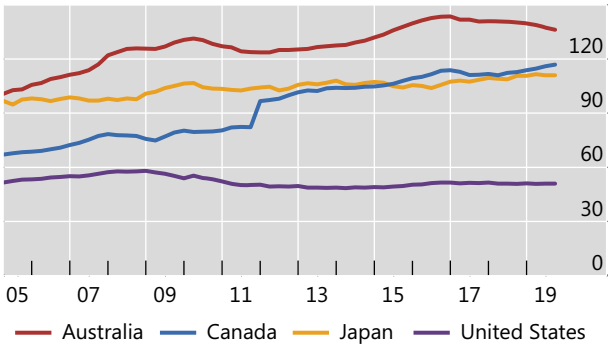
Euro area: other countries



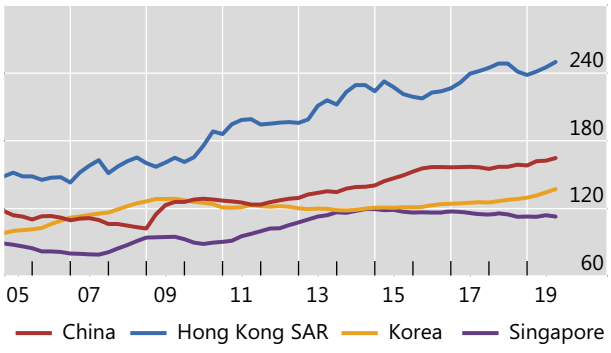
Other European countries



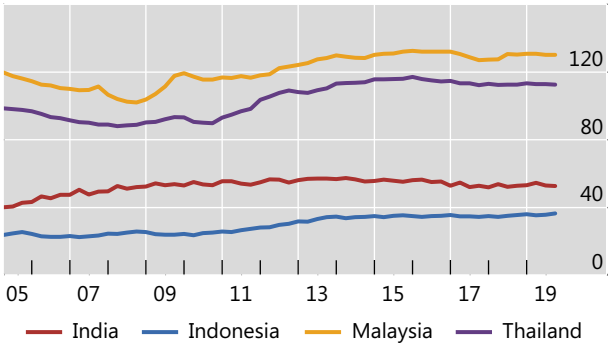
Major advanced economies



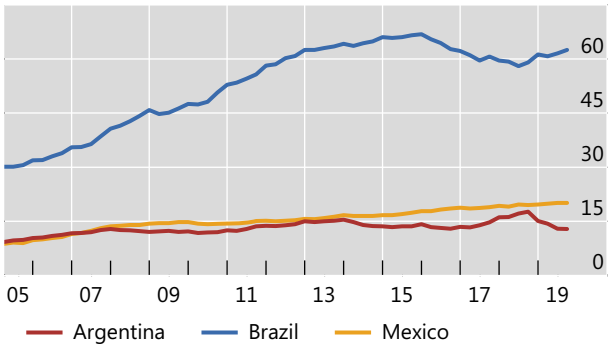
Emerging Asia



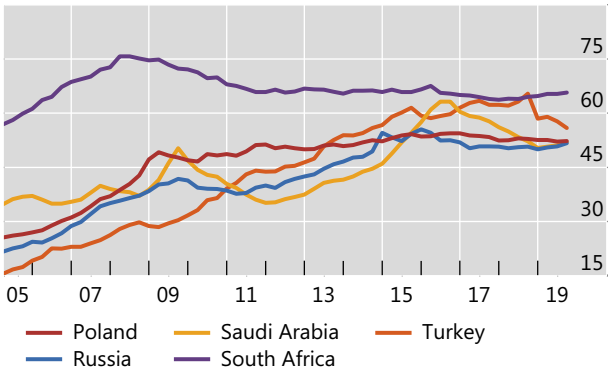
Other emerging Asia



Latin America



Other emerging market economies



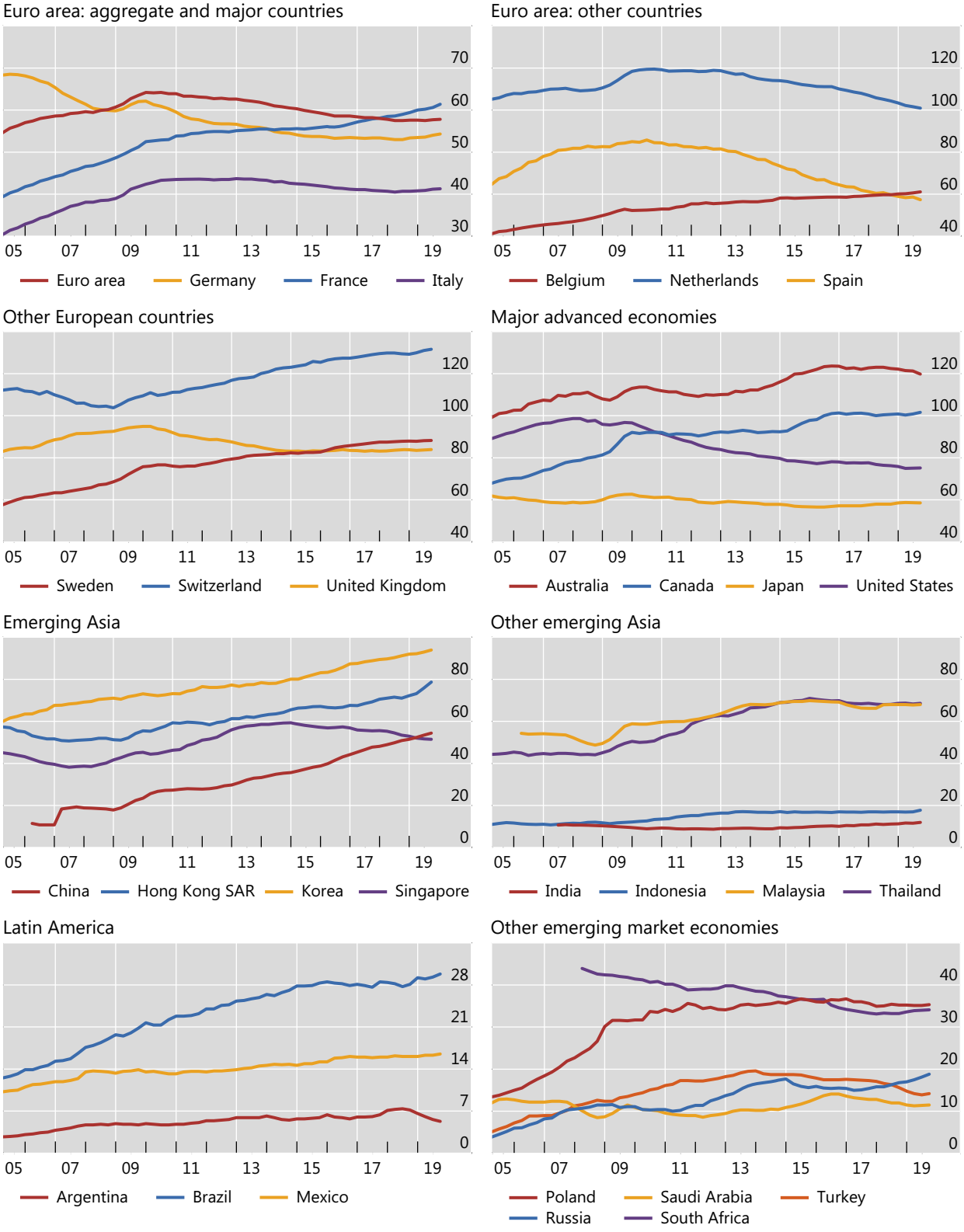
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

Total credit to households (core debt)

As a percentage of GDP

Graph F.4



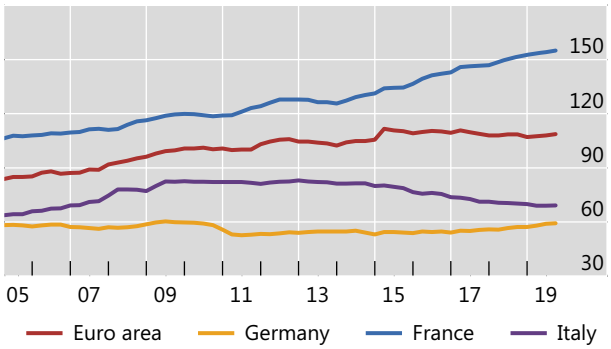
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

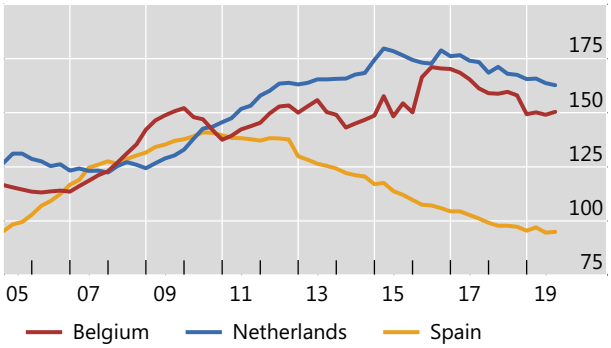
Total credit to non-financial corporations (core debt)

As a percentage of GDP — Graph F.5

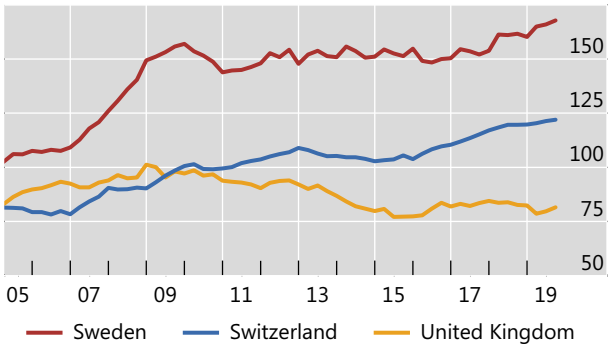
Euro area: aggregate and major countries



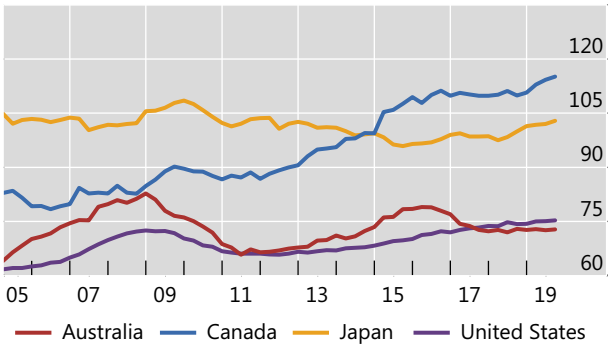
Euro area: other countries



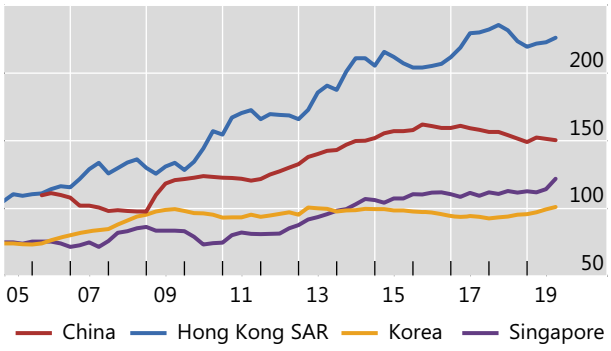
Other European countries



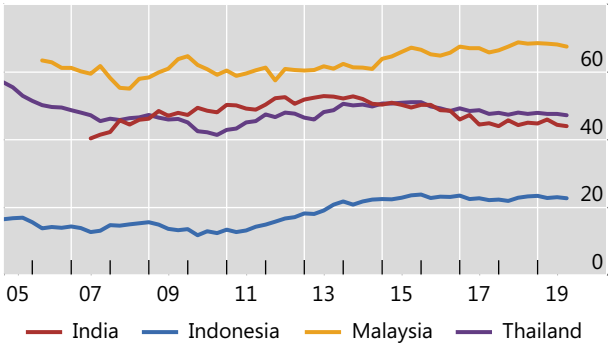
Major advanced economies



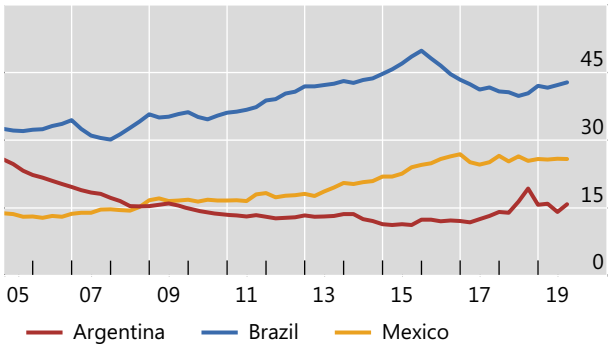
Emerging Asia



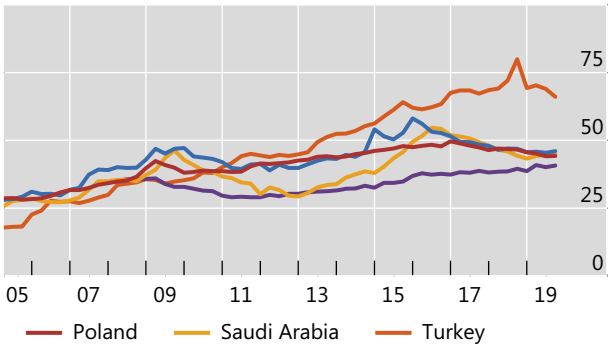
Other emerging Asia



Latin America



Other emerging market economies



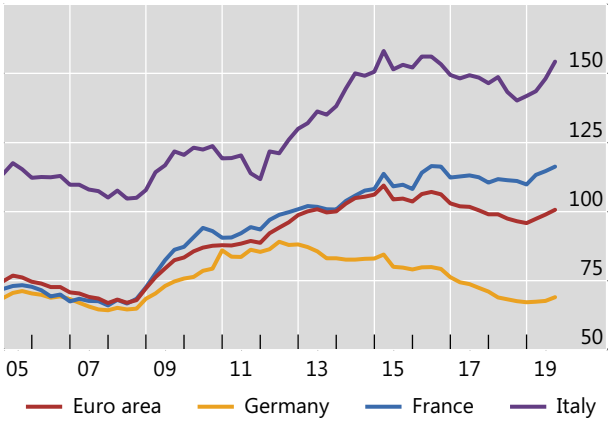
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

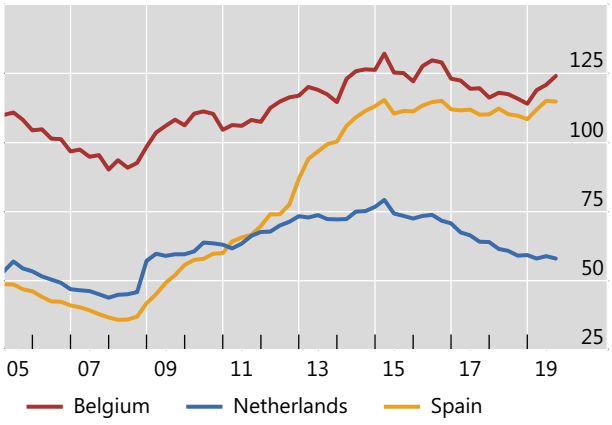
Total credit to the government sector at market value (core debt)[1]

As a percentage of GDP — Graph F.6

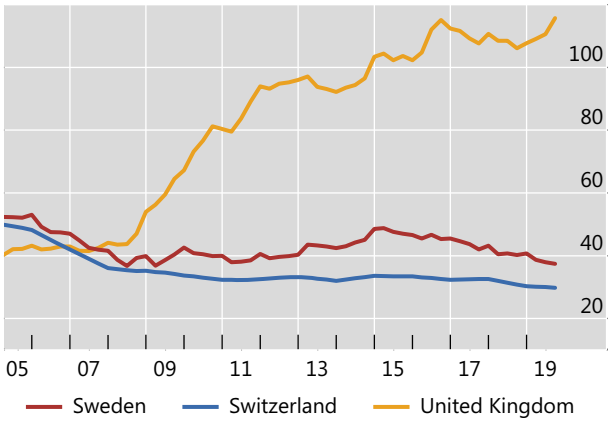
Euro area: aggregate and major countries



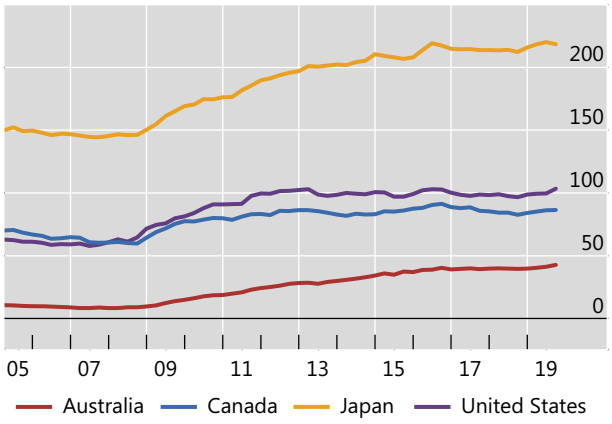
Euro area: other countries



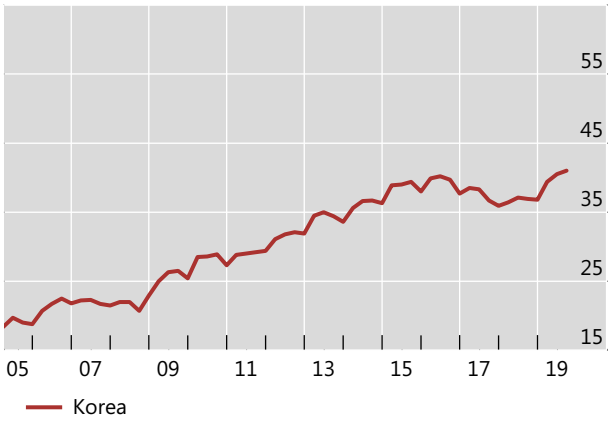
Other European countries



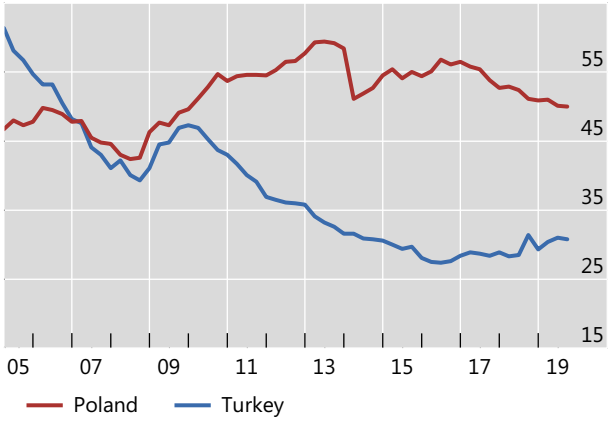
Major advanced economies



Emerging Asia



Other emerging market economies



Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

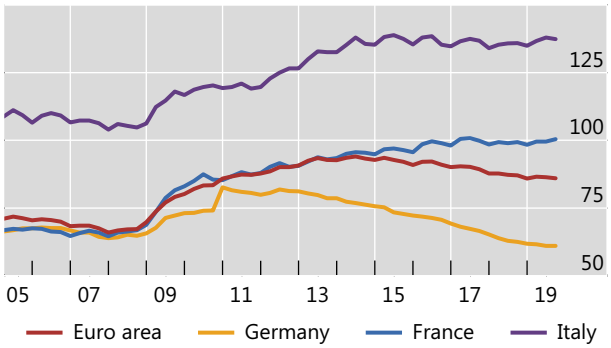
[1] Consolidated data for the general government sector.

Source: BIS total credit statistics.

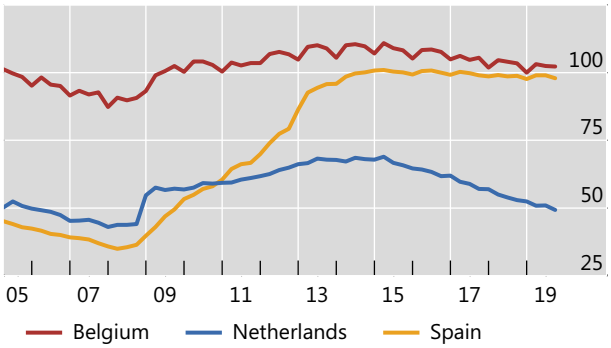
Total credit to the government sector at nominal value (core debt)[1]

As a percentage of GDP — Graph F.7

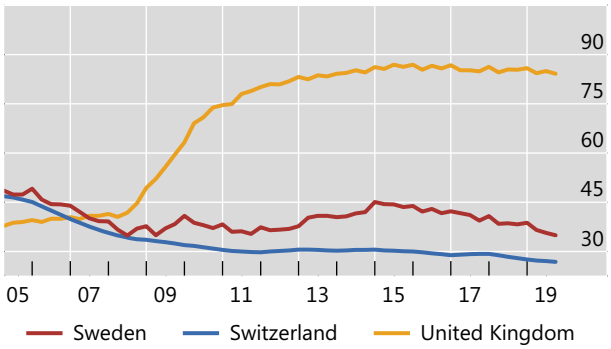
Euro area: aggregate and major countries



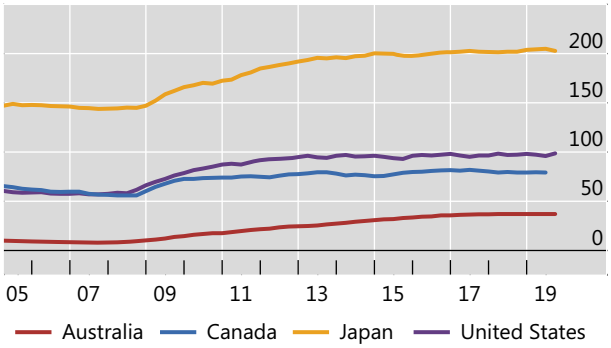
Euro area: other countries



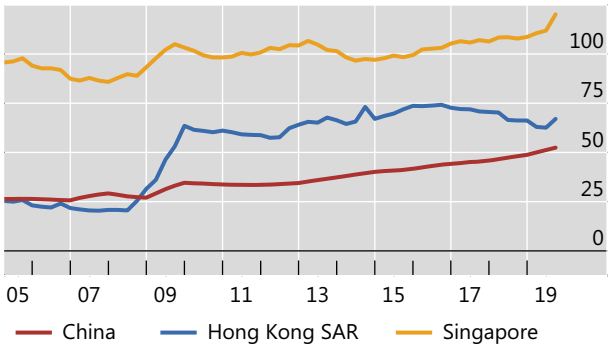
Other European countries



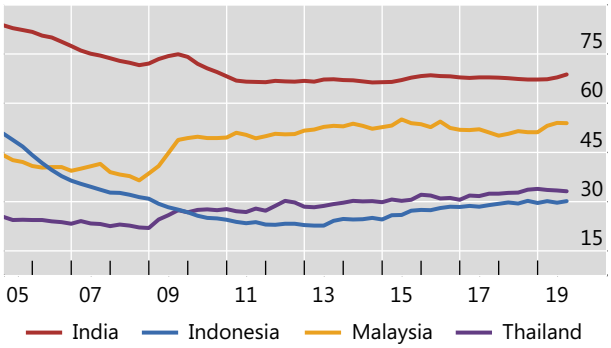
Major advanced economies



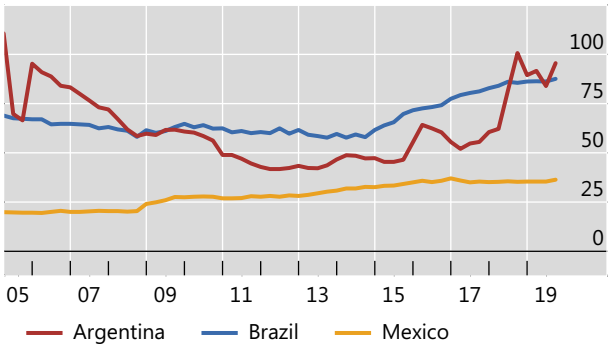
Emerging Asia



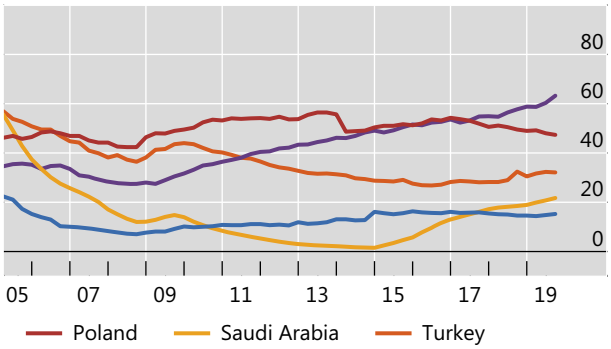
Other emerging Asia



Latin America



Other emerging market economies



Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

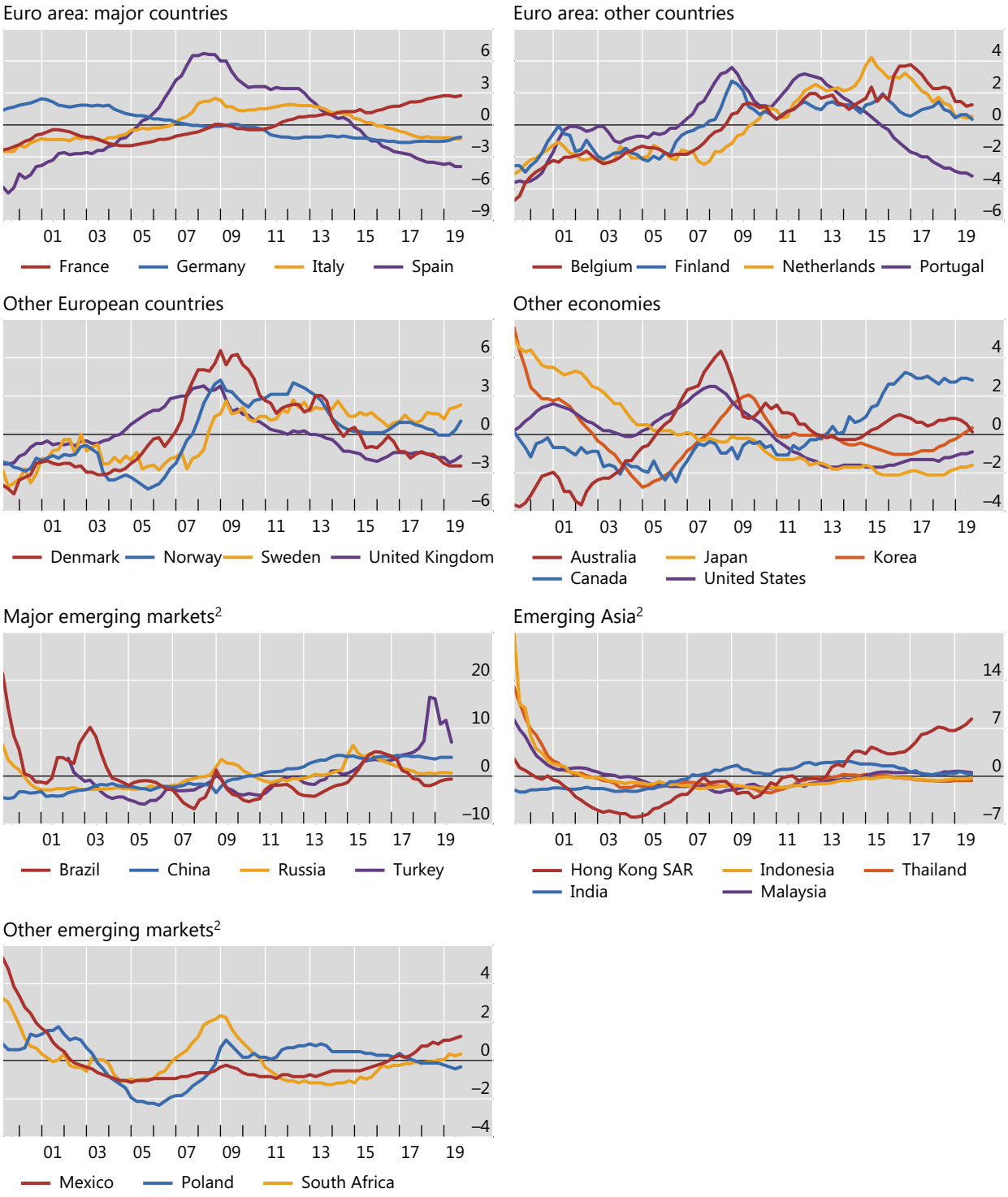
[1] Consolidated data for the general government sector; central government for Argentina, Indonesia, Malaysia, Mexico, Saudi Arabia and Thailand.

Source: BIS total credit statistics.

G Debt service ratios for the private non-financial sector

Debt service ratios of the private non-financial sector

Deviation from country-specific mean, in percentage points[1] Graph G.1



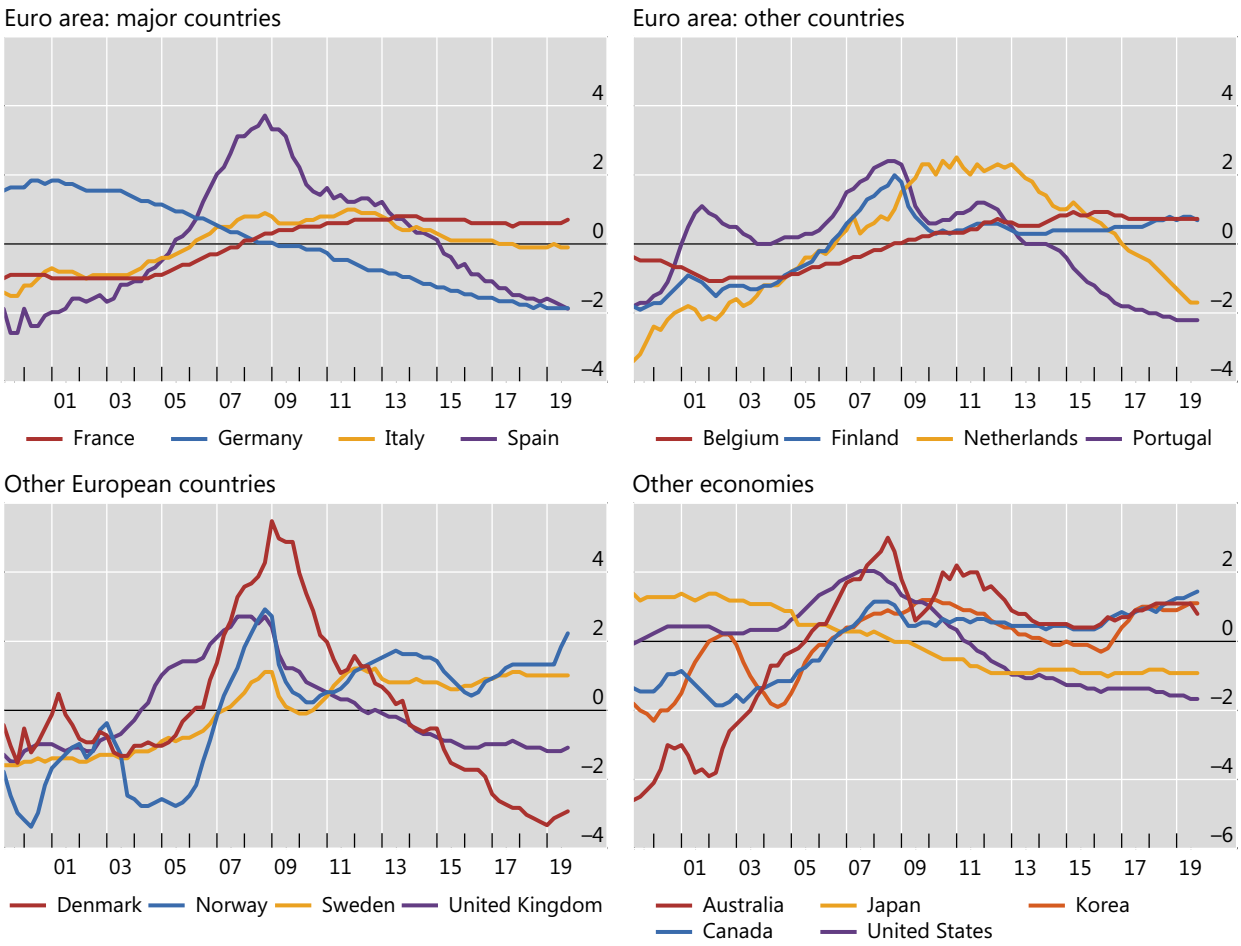
Further information on the BIS debt service ratio statistics is available at www.bis.org/statistics/dsr.htm.

[1] Country-specific means are based on all available data from 1999 onwards. [2] Countries which are using alternative measures of income and interest rates. Further information is available under "Metholodogy and data for DSR calculation" at www.bis.org/statistics/dsr.htm.

Source: BIS debt service ratios statistics.

Debt service ratios of households

Deviation from country-specific mean, in percentage points[1] Graph G.2



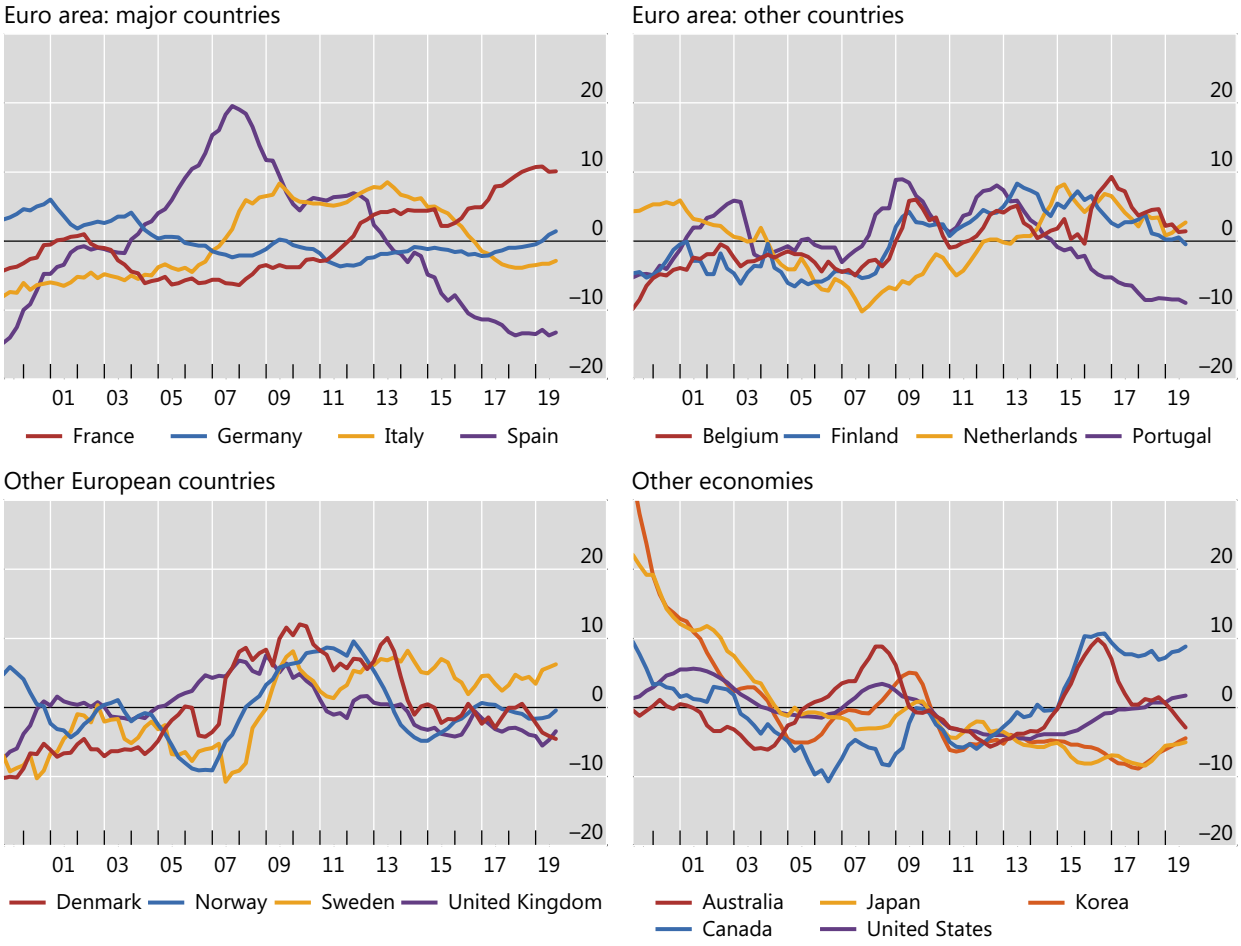
Further information on the BIS debt service ratio statistics is available at www.bis.org/statistics/dsr.htm.

[1] Country-specific means are based on all available data from 1999 onwards.

Source: BIS debt service ratios statistics.

Debt service ratios of non-financial corporations

Deviation from country-specific mean, in percentage points[1] Graph G.3



Further information on the BIS debt service ratio statistics is available at www.bis.org/statistics/dsr.htm.

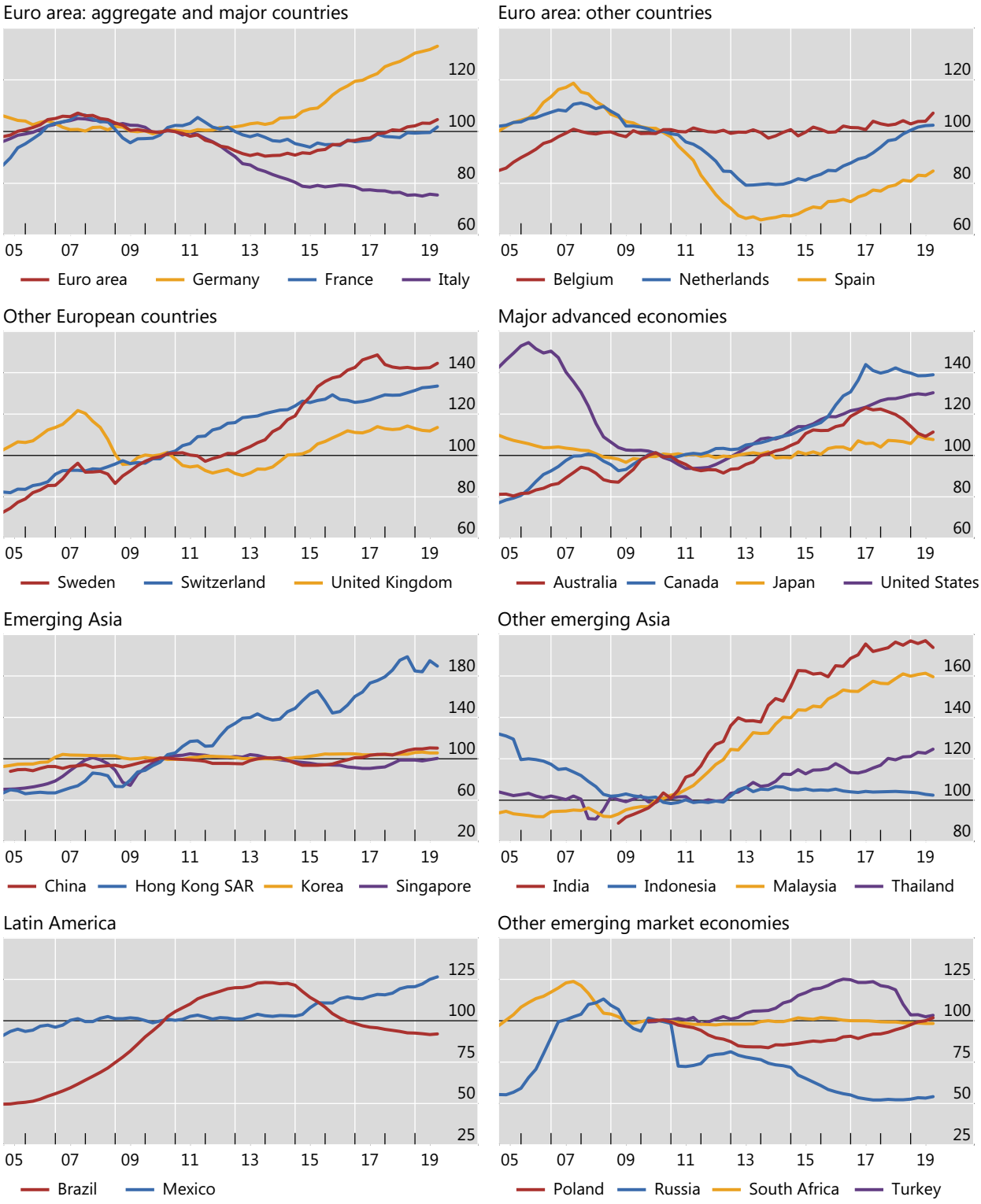
[1] Country-specific means are based on all available data from 1999 onwards.

Source: BIS debt service ratios statistics.

H Property price statistics

Real residential property prices

CPI-deflated, 2010 = 100 Graph H.1



Further information on the BIS property price statistics is available at www.bis.org/statistics/pp.htm.

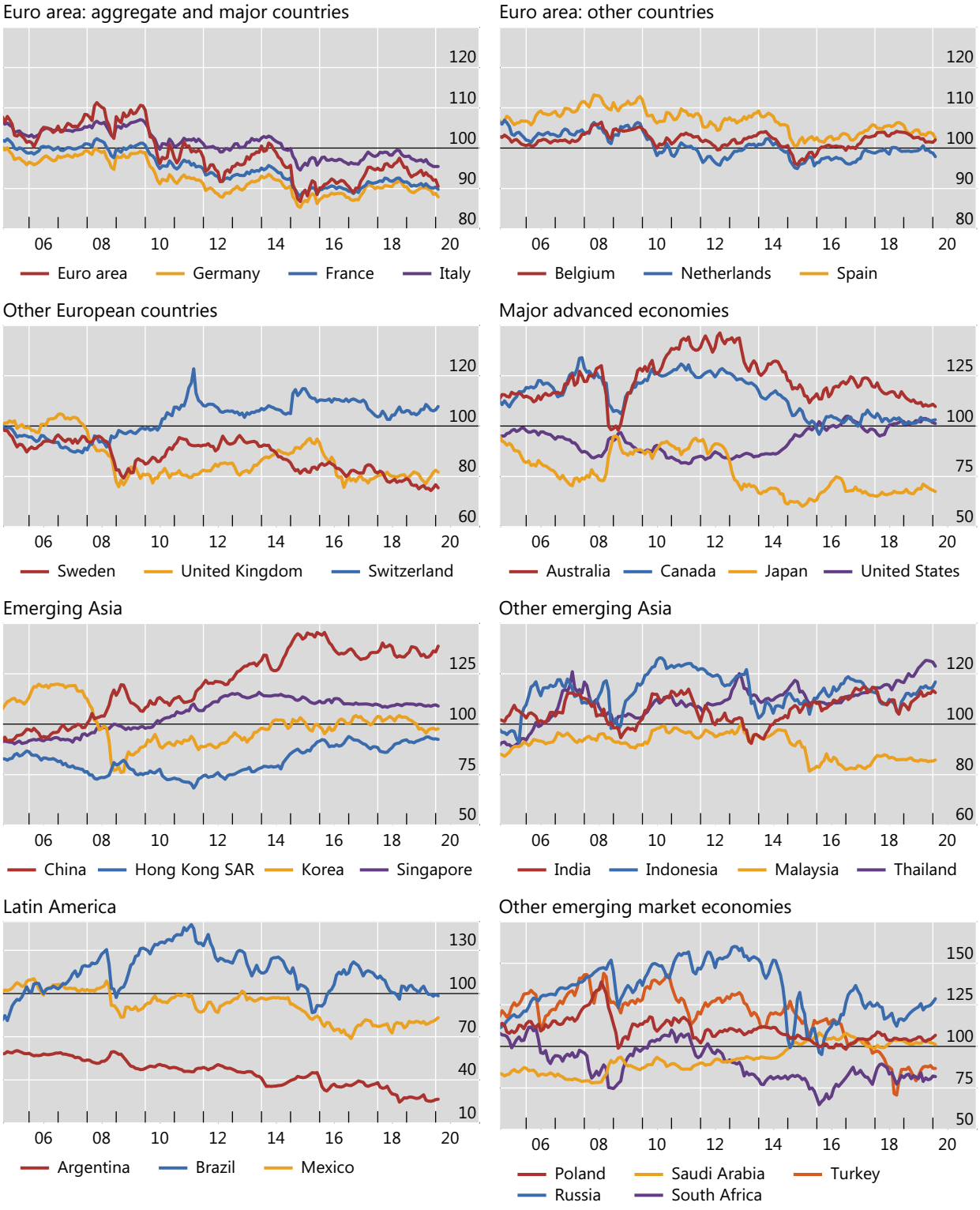
Source: BIS property prices statistics.

I Effective and US dollar exchange rate statistics

Real effective exchange rates

CPI-based, 1995–2005 = 100[1]

Graph I.1



Further information on the BIS effective exchange rate statistics is available at www.bis.org/statistics/eer.htm.

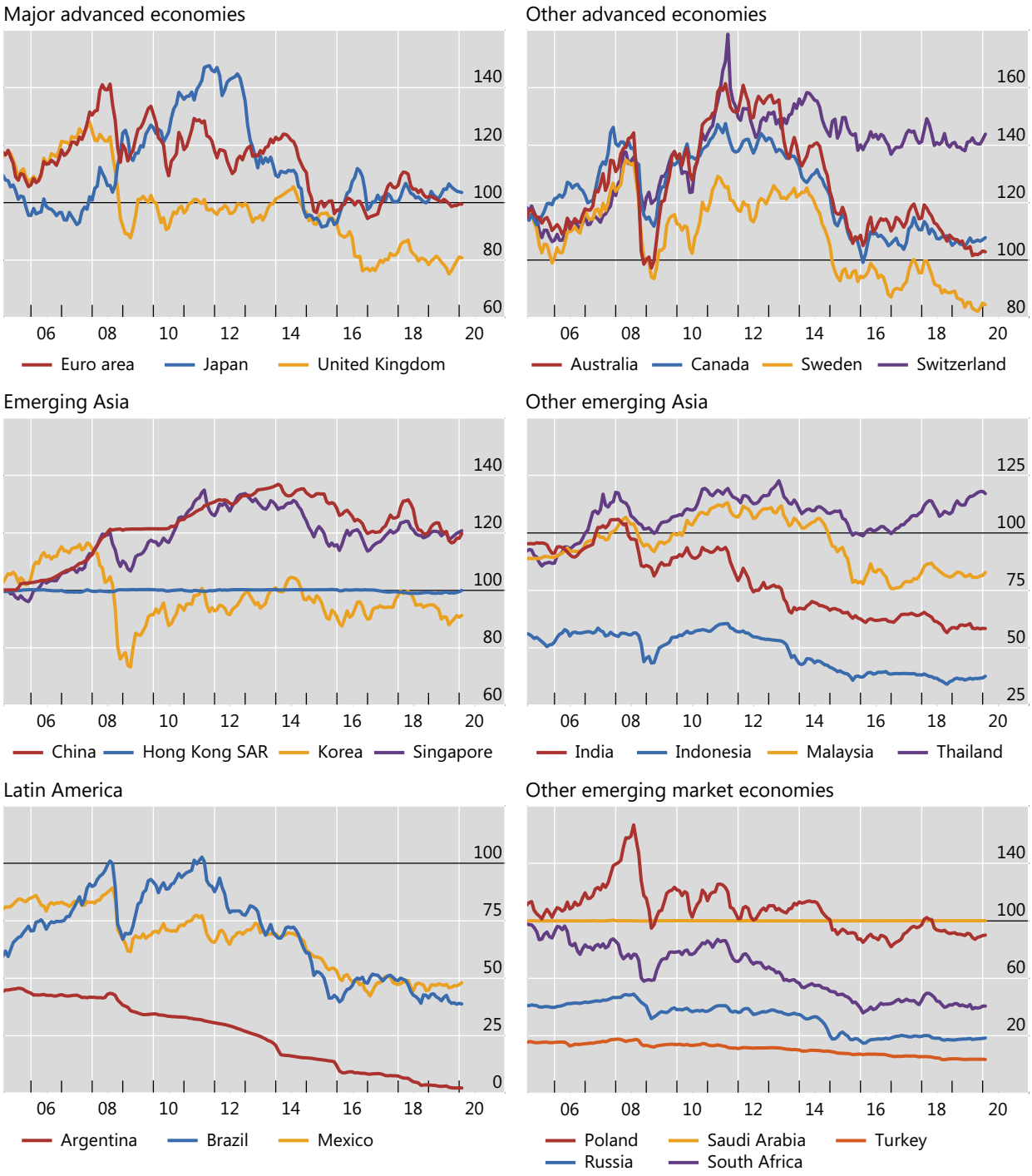
[1] An increase indicates a real-term appreciation of the local currency against a broad basket of currencies.

Source: BIS effective exchange rates statistics.

US dollar exchange rates

Indices, 1995–2005 = 100[1]

Graph I.2



Further information on the exchange rate statistics is available at www.bis.org/statistics/xrusd.htm.

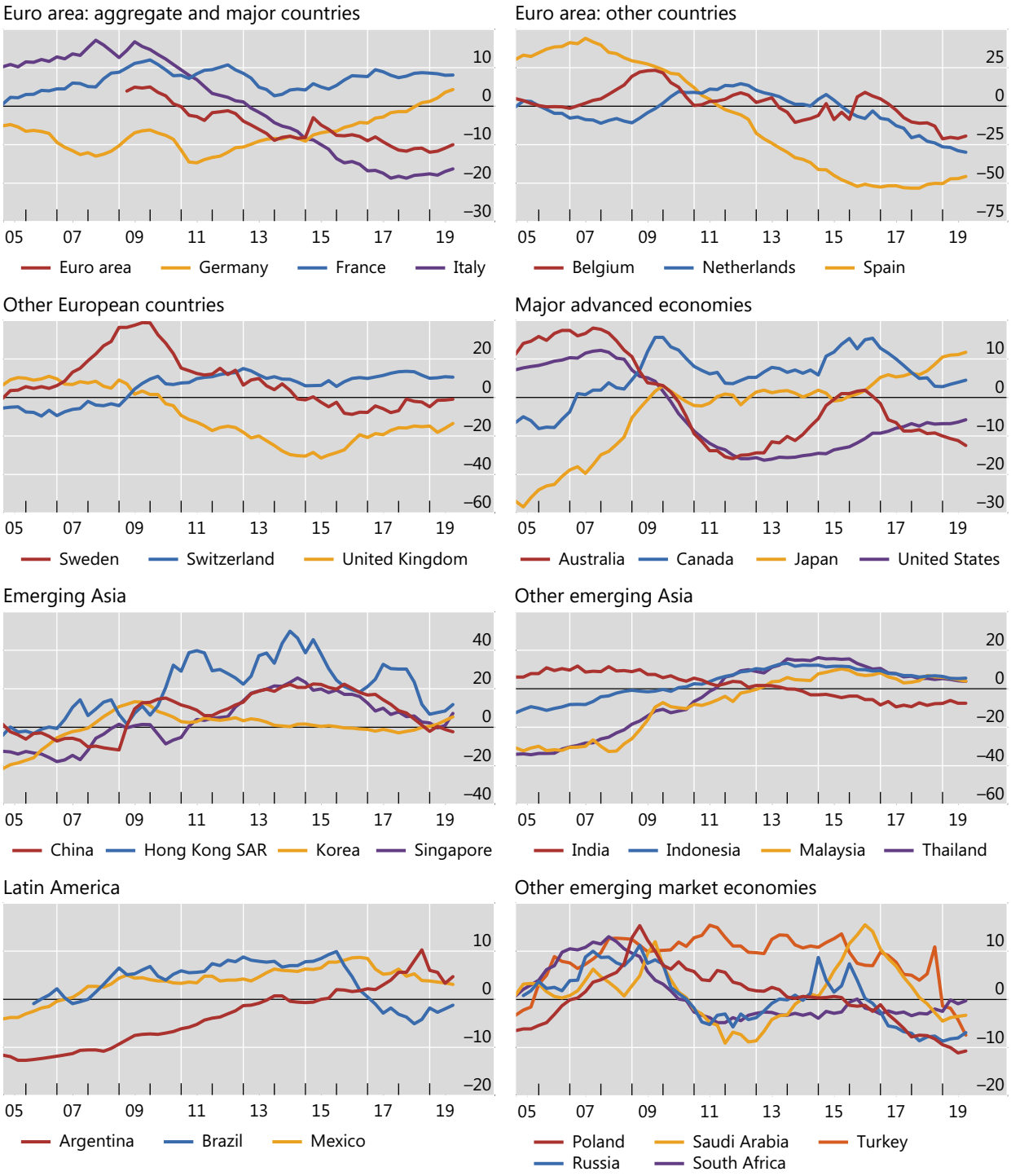
[1] An increase indicates an appreciation of the local currency against the US dollar.

Source: BIS US dollar exchange rates statistics.

J Credit-to-GDP gaps

Credit-to-GDP gaps

In percentage points of GDP — Graph J.1



[1] Estimates based on series on total credit to the private non-financial sector. The credit-to-GDP gap is defined as the difference between the credit-to-GDP ratio and its long-term trend; the long-term trend is calculated using a one-sided Hodrick-Prescott filter with a smoothing parameter of 400,000. Further information on the BIS credit-to-GDP gaps is available at www.bis.org/statistics/c_gaps.htm.

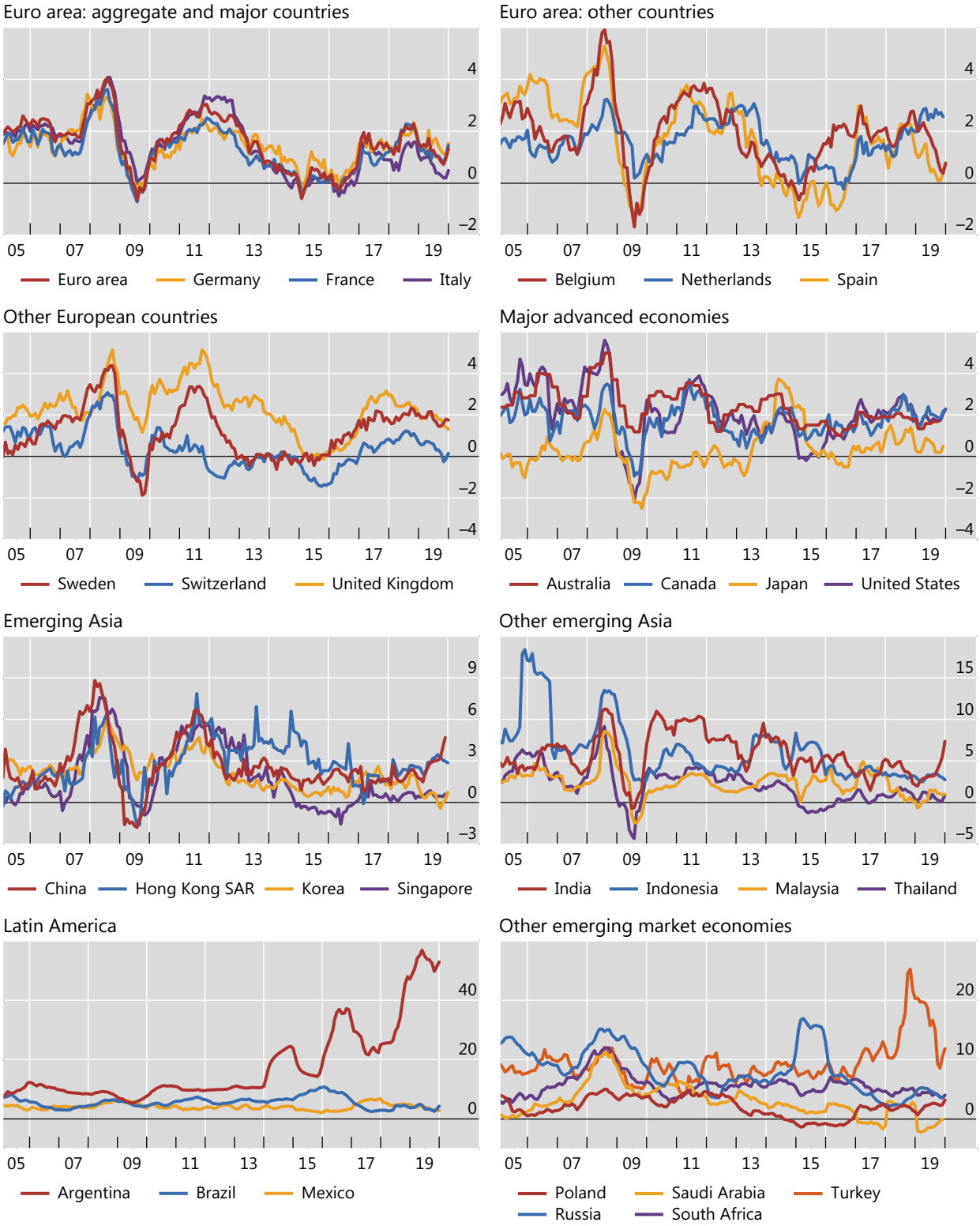
Source: BIS credit-to-GDP gaps statistics.

K Consumer prices

Consumer prices

Year-on-year percentage changes

Graph K.1



Further information on the BIS consumer prices is available at www.bis.org/statistics/cp.htm.

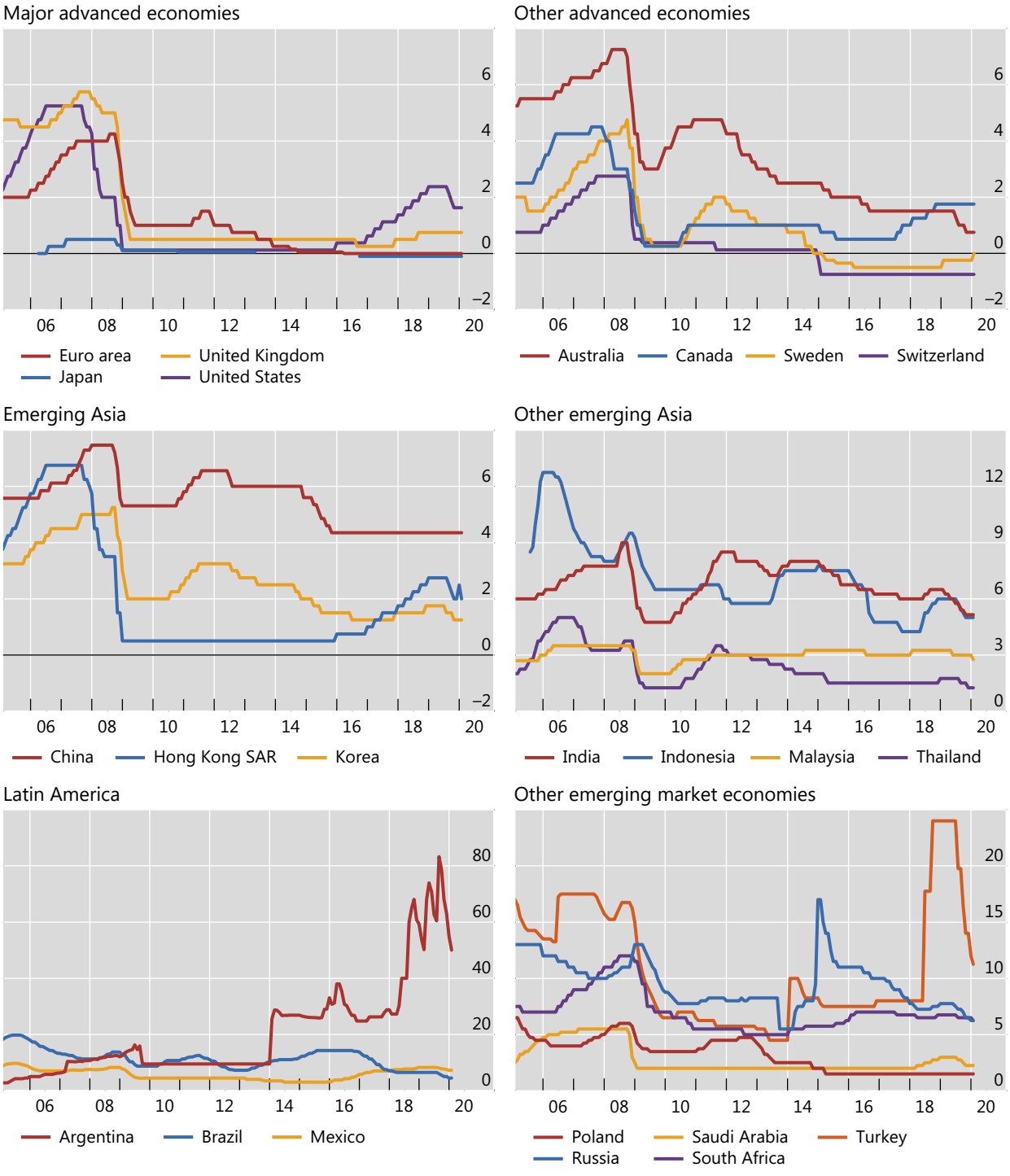
Source: BIS consumer price statistics.

L Central bank policy rates

Central bank policy or representative rates

Month-end; in per cent

Graph L.1



Further information on the policy rates is available at www.bis.org/statistics/cbpol.htm.

Source: BIS policy rates statistics.