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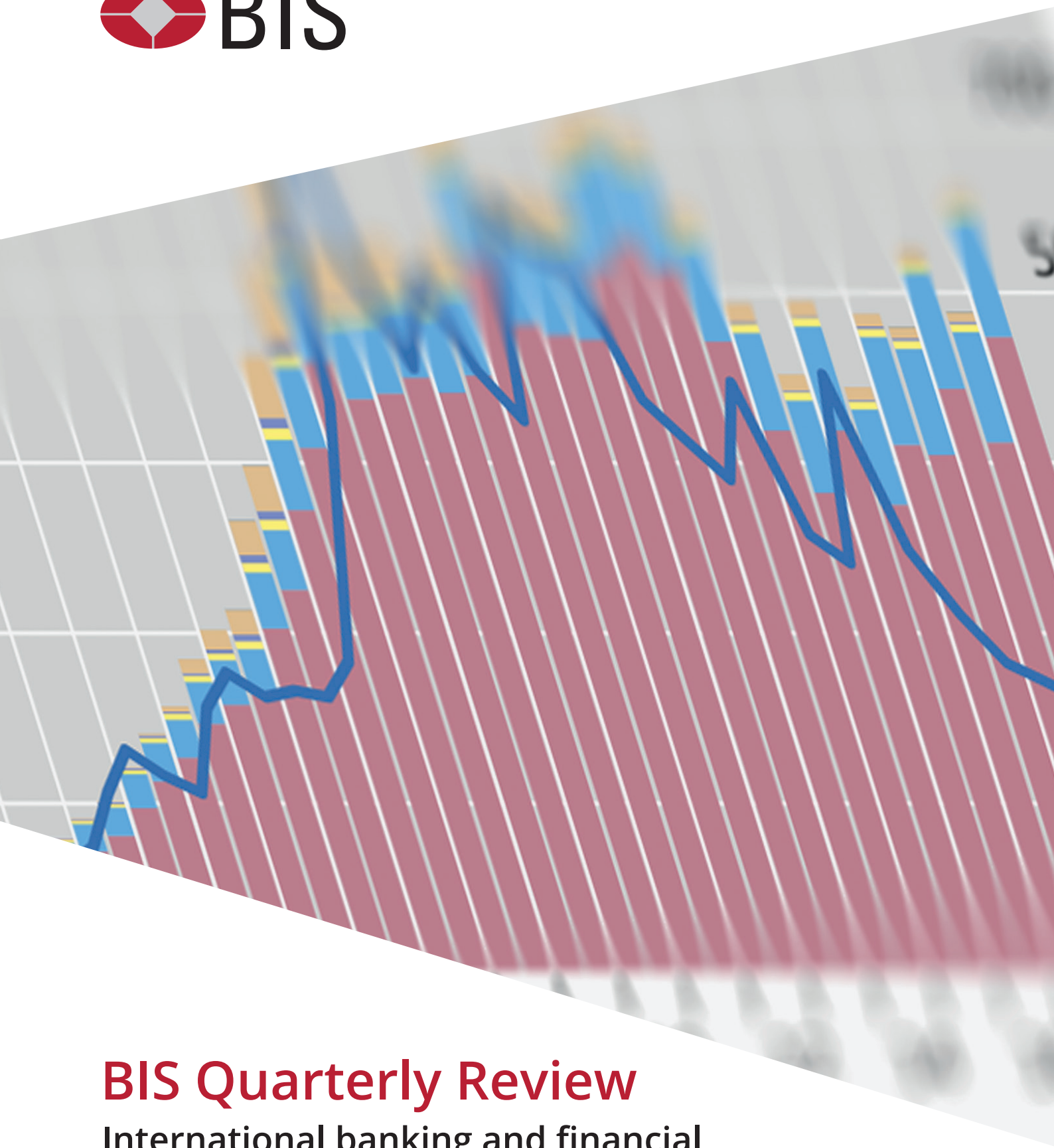

BIS Quarterly Review

International banking and financial market developments

December 2019

BIS Quarterly Review
Monetary and Economic Department

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Special features

Notations used in this Review

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

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

Abbreviations

Currencies

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

Countries

AE	United Arab Emirates	CY	Cyprus
AF	Afghanistan	CZ	Czech Republic
AL	Albania	DE	Germany
AM	Armenia	DJ	Djibouti
AO	Angola	DK	Denmark
AR	Argentina	DM	Dominica
AT	Austria	DO	Dominican Republic
AU	Australia	DZ	Algeria
AZ	Azerbaijan	EA	euro area
BA	Bosnia and Herzegovina	EC	Ecuador
BD	Bangladesh	EE	Estonia
BE	Belgium	EG	Egypt
BF	Burkina Faso	ER	Eritrea
BG	Bulgaria	ES	Spain
BH	Bahrain	ET	Ethiopia
BI	Burundi	FI	Finland
BJ	Benin	FJ	Fiji
BM	Bermuda	FO	Faeroe Islands
BN	Brunei	FR	France
BO	Bolivia	GA	Gabon
BR	Brazil	GB	United Kingdom
BS	The Bahamas	GD	Grenada
BT	Bhutan	GE	Georgia
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
UA	Ukraine	ZA	South Africa
US	United States	ZM	Zambia
UY	Uruguay	1C	International organisations
UZ	Uzbekistan	1Z	British West Indies

Easing trade tensions lift sentiment

An easing of US-China trade tensions in October triggered a risk-on phase in global financial markets.[1] In September, risky asset prices across the globe stayed range-bound, supported by additional monetary accommodation in a context of subdued prospects for global activity. As sentiment shifted, stocks posted large gains in most markets but China, and credit spreads tightened. Term spreads in advanced economies (AEs) initially widened in line with the change in market sentiment. But their upward momentum petered out after a few weeks.

Faced with persistently low inflation and a still tepid outlook for growth, central banks eased further in several major economies. Policy rates were lowered in the United States, the euro area and a number of emerging market economies (EMEs), including Brazil, China, Indonesia and Mexico. The ECB restarted its programme of government bond purchases.

As sentiment shifted with more constructive developments in the US-China relationship (and better prospects for an orderly Brexit), equities rose across the globe, with the notable exception of Chinese stocks, which lost ground in October and November. In the United States, stock prices reached historically high levels, with risk appetite spurred by a still resilient consumer sector, early signs of stabilisation in manufacturing and earnings reports that came in line with – or slightly ahead of – expectations. Sentiment was also helped by still patchy evidence in October's activity gauges that several economies, advanced and emerging, were bottoming out.

Corporate spreads fell globally and long-term sovereign yields rose in AEs. Spreads on euro area and US corporate bonds declined, especially for investment grade issuers. In the high-yield segment, and also EME corporates, spreads widened in late September but compressed again in mid-October as the news turned more positive. Government bond yields rose, steepening yield curves, but long bond yields traced back some of their gains in November.

As the demand for safe assets retreated, the US dollar weakened broadly, in particular against EME currencies. EME sovereign yields, little affected by sentiment swings, continued on the downward trend that prevailed for most of the year.

Loose financial conditions intensified the focus on the sustainability of asset valuations. Corporate bonds appeared relatively expensive, particularly in the light of the still comparatively subdued economic outlook. Equity valuations seemed high in the United States compared with historical averages, but were moderate in most other countries and relative to sovereign yields. However, investors' compensation for bearing equity risk seems to hinge on the term premium; to the extent that the premium is unusually low, it may flatter valuations.

[1] The period under review extends from 12 September to 27 November 2019.

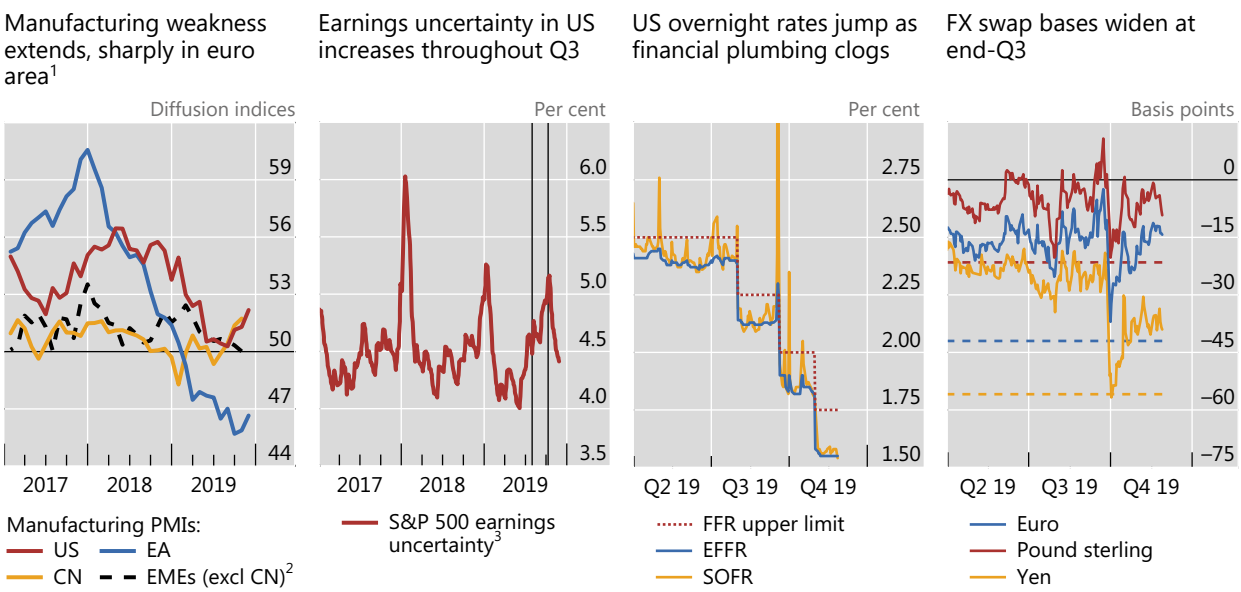
Lingering worries initially keep markets range-bound

Financial markets mainly reflected the ebb and flow of trade tensions during the period under review. Early on, sentiment stayed subdued and risky assets traded sideways, as investors continued to struggle with the uncertain outlook stemming from enduring US-China tensions and lingering signs of weakness in manufacturing. Faced with a deteriorating macroeconomic outlook, central banks in several jurisdictions chose to provide further monetary accommodation.

Sentiment remained downcast in September, despite the United States and China taking several steps to soothe the escalation of tensions that had occurred in August.[2] Early in the month, they announced that a new round of talks would start in October, and mutually exempted some imports from tariffs. But asset prices stayed range-bound, suggesting investors were unpersuaded. The muted reaction reflected, in part, continued concerns about the outlook for global activity, amid signs of sluggish manufacturing, which was dismal in Europe (Graph 1, first panel), and generally downbeat in EMEs.

Resilient labour markets, however, sustained the momentum of consumption in AEs, including those in Europe. In the United States, uncertainty over corporate

Dearth of good news keeps sentiment downbeat in September — Graph 1



The vertical lines in the second panel indicate 31 July (Shanghai trade talks break down) and 10–11 October 2019 (Johnson-Varadkar Brexit meeting and "phase one" trade deal between US and China).

The dashed horizontal lines in the fourth panel indicate the minimum reached in September 2018.

EFFR = effective federal funds rate; FFR = federal funds rate; SOFR = secured overnight financing rate.

[1] A value of 50 indicates that the number of firms reporting business expansion and contraction is equal; a value above 50 indicates expansion of economic activity. [2] GDP and PPP exchange rates weighted average of BR, IN, MX, RU and TR. [3] Five-day moving average of the standard deviation of earnings per share estimates divided by the average estimate for the S&P 500 index.

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

[2] Among other measures, the United States imposed 10% tariffs on $300 billion of Chinese imports and declared China a currency manipulator, while Chinese companies further cut their purchases of US agricultural products, and the government imposed tariffs on $75 billion of US imports and lodged a World Trade Organization tariff case against the United States.

earnings prospects, growing pari passu with trade tensions (Graph 1, second panel), also contributed to keeping equities flat throughout the third quarter.

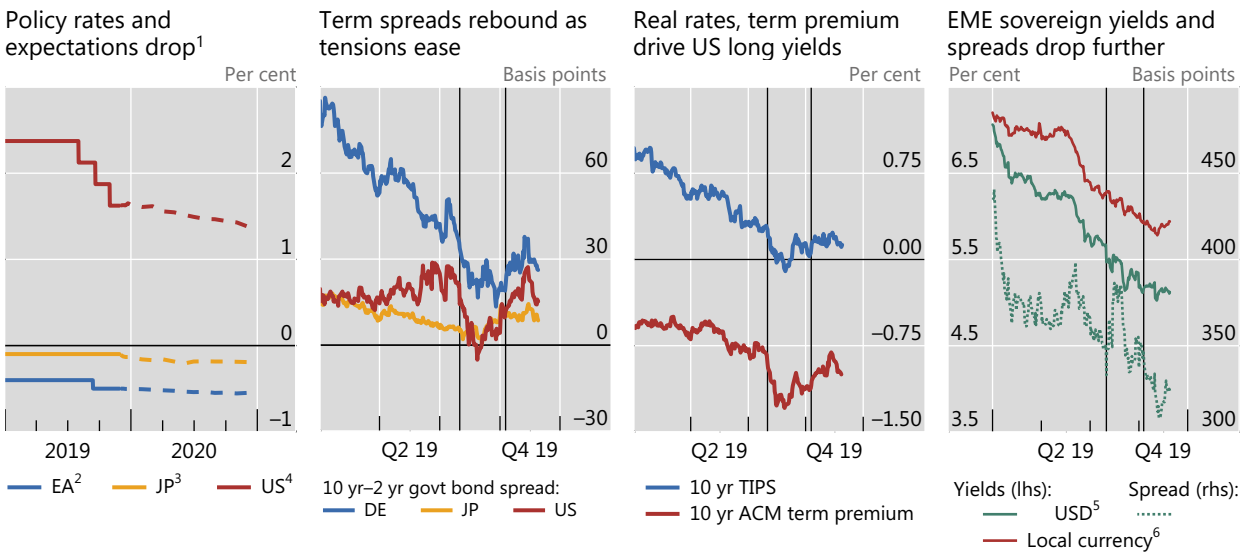
Other developments in September were not reassuring. Throughout the month, a fluid political situation in the United Kingdom appeared, at first, to strengthen the likelihood of a "no-deal" Brexit. In mid-September, oil prices jumped by almost 15% after an attack on oil facilities in Saudi Arabia. This was the largest daily spike in oil prices in almost 20 years, but prices fell back again within days.

Also in September, sudden stress in the US repo market raised concerns about the fragility of US dollar funding markets (see box). The benchmark repo rate (secured overnight financing rate, SOFR) more than doubled for a day, and the effective federal funds rate overshot the upper limit of the Federal Reserve's policy range (Graph 1, third panel). Actions by the Federal Reserve returned calm to this market, and the dislocation did not spread. However, the bases of major currency FX swaps, another key funding market, plummeted at the quarter-end, in a repeat of the stress observed the previous September (fourth panel). Observers worried about the prospects of renewed dislocations in these markets as the year-end approached.

Confronted with the combination of tepid activity and persistent low inflation, central banks in major economies eased monetary policy further. On 12 September, the ECB announced the resumption of the government bond purchase programme, a 10 basis point reduction in the deposit rate, lower rates for the longer-term refinancing operations and a new system of tiered remuneration of bank reserves to contain the effect of more negative interest rates on bank profitability. The Federal Reserve cut its policy rate twice, in September and October, in line with market expectations, but signalled that more reductions this year were unlikely. Nevertheless, forward rates indicated expectations of further declines in policy rates in 2020 (Graph 2, first panel).

Major central banks ease further before sentiment turns

Graph 2



The vertical lines indicate 31 July (Shanghai trade talks break down) and 10–11 October 2019 (Johnson-Varadkar Brexit meeting and "phase one" trade deal between US and China).

ACM = Adrian, Crump and Moench.

[1] The dashed lines indicate expected rates based on overnight index swap (OIS) forward rates; as of 28 November 2019. [2] Deposit facility rate. [3] Interest rate applied to policy rate balances in current accounts that financial institutions hold at the Bank of Japan. [4] Federal funds rate. [5] JPMorgan Chase EMBI Global index. [6] JPMorgan Chase GBI-EM index.

Sources: T Adrian, R Crump and E Moench, "Pricing the term structure with linear regressions", *Journal of Financial Economics*, vol 110, no 1, 2013; Federal Reserve Bank of New York; Bloomberg; Datastream; JPMorgan Chase; national data; BIS calculations.

Several other central banks in AEs and EMEs echoed moves by the Fed and the ECB. In late September and throughout October, Australia, Brazil, India, Korea, Mexico, Russia and Turkey lowered their policy rates. After keeping interbank rates broadly stable for most of the year, the People's Bank of China (PBC) cut its one-year rate in early November, and then its seven-day interbank rate mid-month. Observers disagreed on the future path of monetary policy, as the PBC faced several challenges, including a perceived commitment to the deleveraging of the economy, weak economic activity, some degree of stress in local banks and rising inflation as food pushed consumer prices up. The Bank of Japan stayed on the sidelines, on the back of its assessment about the Japanese economy's prospects.

Easing tensions drive up sentiment and asset prices

An easing of geopolitical tensions during the first half of October set the stage for a turn in market sentiment. Moreover, tentative signs of stabilisation in global activity started to emerge. With prospects improving for both a Brexit deal and a sustained truce in trade tensions between the United States and China, a wave of risk appetite took hold of markets.

The mood started to improve in mid-October. After a meeting of the UK and Irish prime ministers on 10 October defused concerns of a "no-deal" Brexit, sterling regained some ground. The following day, the announcement of a limited "phase one" deal between China and the United States marked an inflexion point for asset prices. The rally was further spurred by tentative clues that economic activity in several countries had bottomed out: manufacturing PMIs appeared to bounce back modestly in the United States, and new manufacturing orders in Germany improved, though PMIs in Europe and other AEs remained less upbeat. In EMEs the picture was mixed, pointing to regional cleavages: conditions appeared to improve in an Asian bellwether like Chinese Taipei, but survey data from Korea and Malaysia still lagged. In Latin America, Brazil continued posting moderate yet solid activity numbers, but Mexico remained less dynamic. Emerging Europe was still fairly weak. In the United States, the concerns about earnings were dispelled by reports that generally came out in line with – or slightly above – expectations.

Government bond markets in AEs reacted, initially, in risk-on fashion. After flattening most of the year, yield curves steepened, mainly as a result of increases at the long end (Graph 2, second panel). In the United States, the upswing was driven in part by higher real long-term rates, as indicated by higher yields of Treasury Inflation-protected Securities (TIPS), a market gauge of real rates (third panel, blue line). Yields on 10-year TIPS had been steady since early October, possibly signalling investor confidence in a rebound in activity. The term premium embedded in the yield of the 10-year Treasury nominal benchmark also increased from historical lows – though it stayed negative – suggesting that an upward shift in risk appetite was part of the explanation (third panel, red line). Yet long yields did not sustain the upward momentum, and traced back some of their gains as November moved on.

Sovereign yields in EMEs, for debt denominated both in US dollars and local currency, continued on the downward path that dominated this year (Graph 2, fourth panel, green and red solid lines, respectively). EME yields have been gradually decreasing since the Federal Reserve's policy pivot began last November. The trend steepened especially after the Fed Chairman indicated in June that the central bank would act as appropriate to sustain the expansion in the face of economic challenges,

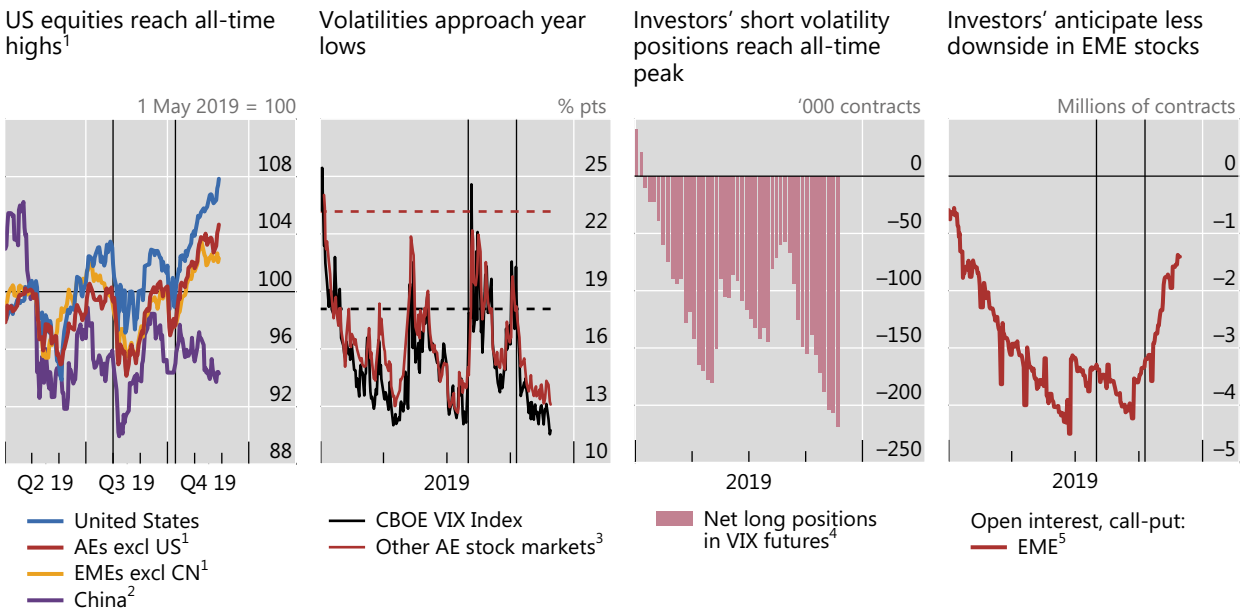
including those emerging from trade disputes.[3] Irrespective of still patchy evidence of economic rebound, EME yields were at their lowest levels since 2014.

EME sovereign spreads against US Treasury benchmarks for US dollar-denominated debt also narrowed further, again approaching post-Great Financial Crisis (GFC) lows (Graph 2, fourth panel, dotted green line). Spreads had recently been more volatile than yields, but most of that volatility stemmed from wide fluctuations in US Treasury benchmarks, not in EME yields. These patterns suggested that, in an unusual reversal, swings in market sentiment had a more pronounced effect in the pricing of AE fixed income. Rising EME government debt, which has surpassed 50% of GDP on the global average and was on its way to surpassing 70% of GDP in some regions by year-end,[4] did not deter investors: not only emerging market but also frontier, or pre-emerging market, economies were able to place large amounts of debt this year (see next section).

In October, stock markets broke out of the range in which they had been trading since mid-year. Benchmarks in advanced and emerging market economies other than China touched year highs in November (Graph 3, first panel). In the United States, the major stock indices reached new all-time peaks. With investors seemingly convinced that the economic and trade outlook had improved, forward-looking gauges of stock market volatility approached their minima for the year (second panel) and net short

Risk appetite returns to most equity markets as tensions subside

Graph 3



The vertical lines indicate 31 July (Shanghai trade talks break down) and 10–11 October 2019 (Johnson-Varadkar Brexit meeting and "phase one" trade deal between US and China).

The dashed horizontal lines in the second panel indicate averages over the period 2002–06.

[1] GDP weighted averages across regional economies. [2] Shanghai composite equity index. [3] Implied volatility of the EURO STOXX 50 and Nikkei 225 indices; weighted average based on market capitalisation. [4] Non-commercial. [5] iShares MSCI Emerging Markets ETF.

Sources: IMF, *World Economic Outlook*; Bloomberg; BIS calculations.

[3] See BIS, "Markets swing on trade and monetary policy", *BIS Quarterly Review*, September 2019, pp 1–14.

[4] See the Methodological and Statistical Appendix in International Monetary Fund, *Fiscal monitor: How to mitigate climate change*, October 2019.

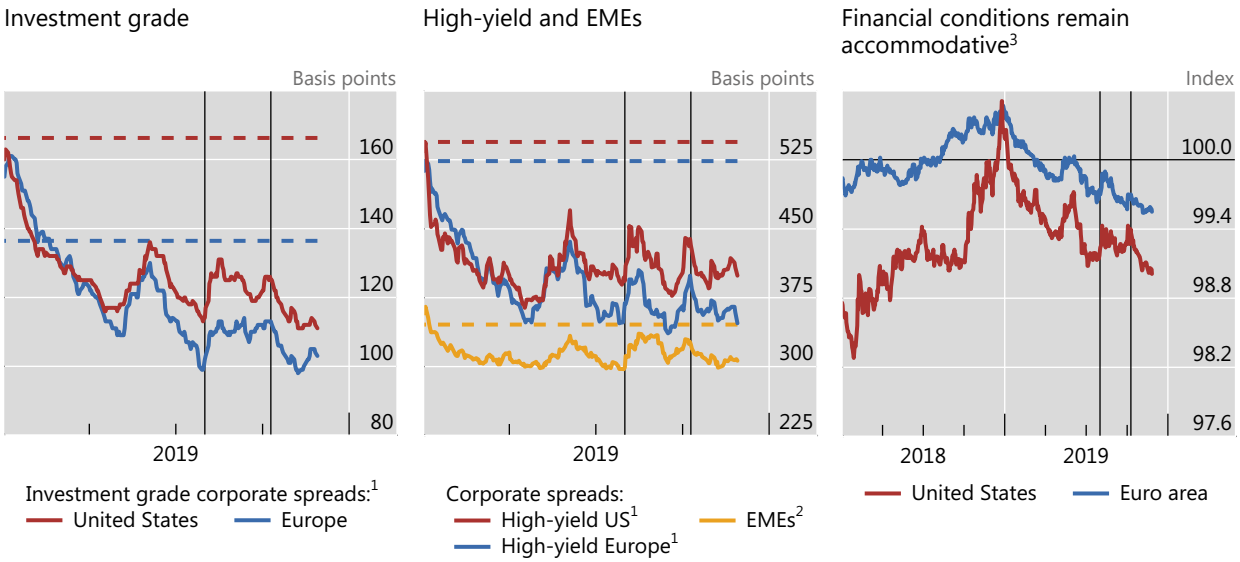
speculative positions on VIX futures also reached an all-time high, pointing to investors' renewed appetite for risk (third panel). Improved sentiment about EMEs carried over to option markets, where investors moved away from positions that would protect them from downside risk (fourth panel). Yet the contrast with the restrained response of Chinese stock markets and the still limited evidence of a rebound in global activity begged the question of whether stock prices might be running ahead of themselves in some markets.

Corporate spreads tightened across credit rating categories. Investment grade in the United States and Europe (Graph 4, left-hand panel) and EME corporate debt (centre panel, yellow line) rallied in October and their spreads also approached minima for the year. While it had been broadly stable over the past three years, corporate debt in EMEs remained relatively high, with credit to non-financial corporates around 100% of GDP. Corporate bond spreads continued to be sensitive to developments in trade tensions. In particular, US and European high-yield spreads tightened in October, after widening in September on still disappointing economic data and simmering trade tensions. That said, spreads stayed slightly above the troughs reached earlier in the year and clearly below long-term averages (centre panel, blue and red lines).

On balance, financial conditions eased further in both the United States and Europe (Graph 4, right-hand panel). In fact, with the exception of a temporary trade tension-induced deterioration in May, financial conditions had been improving since the beginning of 2019. In the United States, they were back to levels similar to those before market volatility spiked in the fourth quarter of 2018. In the euro area, financial conditions were more supportive than they had been since early 2018.

Corporate credit spreads remain tight, and overall financial conditions loose

Graph 4



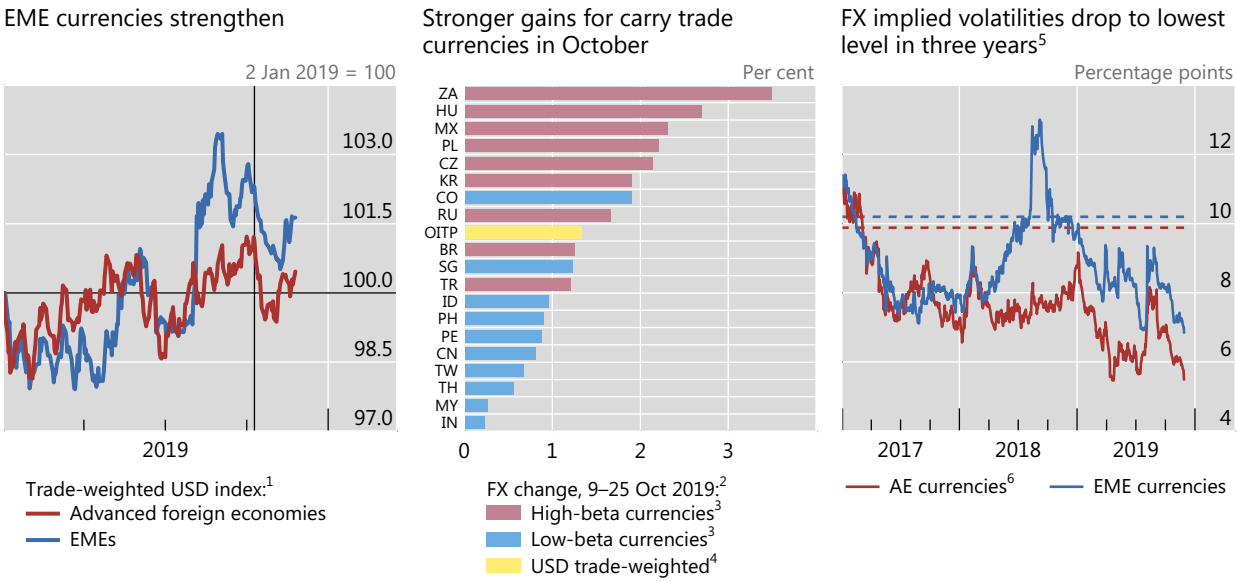
The vertical lines indicate 31 July (Shanghai trade talks break down) and 10–11 October 2019 (Johnson-Varadkar Brexit meeting and "phase one" trade deal between US and China).

The dashed horizontal lines in the left-hand and centre panels indicate long-term averages (2005–current).

[1] Option-adjusted spreads. [2] JPMorgan CEMBI index; stripped spread. [3] 100 indicates country-specific long-term averages; each unit above (below) 100 denotes financial conditions that are one standard deviation tighter (looser) than the average.

Sources: Bloomberg; Goldman Sachs; ICE BoAML indices; JPMorgan Chase; BIS calculations.

EME currencies strengthen vis-à-vis the dollar as risk appetite increases Graph 5



The vertical line in the left-hand panel indicates 10–11 October 2019 (Johnson-Varadkar Brexit meeting and "phase one" trade deal between US and China).

The dashed horizontal lines in the right-hand panel indicate long-term averages (2000–current).

[1] Goods and services. [2] A positive value indicates that the local currency has appreciated against the US dollar. [3] Beta of a univariate regression of the exchange rate vis-à-vis the US dollar and the Bloomberg Cumulative FX Carry Trade Index for eight EME currencies for the period 9 October 2016–9 October 2019. High = larger than the median. [4] Multiplied by –1. OITP = other important trading partners. [5] JPMorgan Chase implied volatility indices. [6] Based on JPMorgan Chase G7 currencies implied volatility index.

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

As the risk-on phase in markets gained momentum and safe asset demand retreated, the US dollar weakened. The greenback had lost some ground against EME currencies even before the announcement of the phase one trade deal between China and the United States. But the depreciation became broad-based – including against other AE currencies – after this announcement (Graph 5, left-hand panel). Other traditional safe haven currencies like the yen and the Swiss franc stayed flat or even depreciated vis-à-vis the US currency. In a further sign that risk appetite had turned, riskier EME currencies, which normally rise together with returns on carry trade strategies, gained in October more than the trade weighted benchmark (centre panel). Forward-looking gauges of FX volatility dropped to lows for the year, possibly reflecting the expectation of a sustained truce in US-China tensions (right-hand panel).

Asset valuations reflect a low term premium

As the risk-on phase set in and bond yields edged up, the term premium remained negative – something unique to the post-crisis period. The premium has been declining for about 30 years alongside bond yields. The current debate about the underlying drivers of this trend and likely persistence of the low level has heightened uncertainty about asset valuations.[5] A commonly used gauge of the compensation

[5] For a recent discussion of developments in the term premium, see R Clarida, "Monetary policy, price stability, and equilibrium bond yields: success and consequences", remarks at the High-Level Conference on Global Risk, Uncertainty, and Volatility, Zurich, November 2019. He stresses that, given

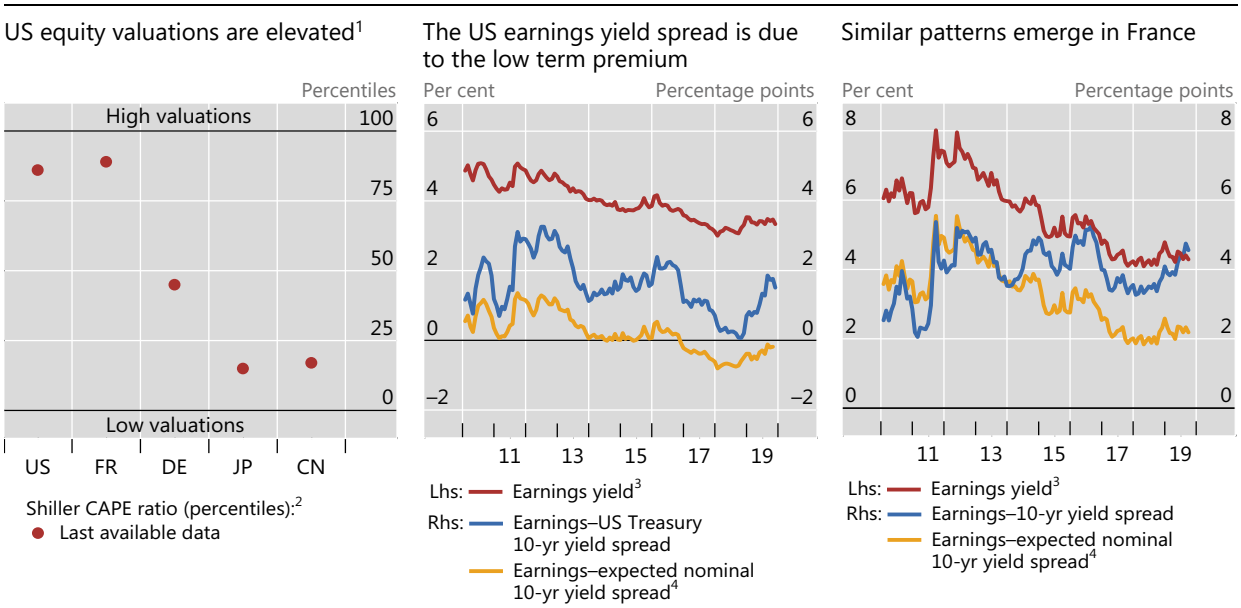
that investors earn for bearing risk compares the yield on risky assets with that on government bonds. A compressed term premium depresses government bond yields and thus, to the extent that the premium is unusually low, it may flatter valuations. If the term premium is removed, certain assets appear to offer limited risk compensation.

In equity markets, there were noticeable differences in valuations across countries. Valuations were elevated in France and the United States, where in late 2019 the cyclically adjusted price/earnings (CAPE) ratio was higher than in 89% and 86% of the months since 2010, respectively. In other countries, including Germany but particularly China and Japan, CAPE ratios were closer to the bottom of their respective post-GFC ranges (Graph 6, left-hand panel).

Equity valuations appear more subdued when accounting for low interest rates, in the sense that returns on equities appear to offer a sizeable compensation for risk. The earnings yield, or the inverse of the CAPE ratio, had declined steadily in the United States from the GFC until late 2017, indicating that investors paid increasingly higher prices for US equities given profitability levels (Graph 6, centre panel, red line). Since 2018, the earnings yield has slowly inched up, pointing to slightly decreasing valuations. However, the spread between the earnings yield and the 10-year Treasury yield – a valuation gauge that measures the compensation earned by investors for holding equity risk – stood at about the historical norm in late 2019 (centre panel, blue line). The level of this spread suggests that equities were not particularly expensive given the level of interest rates, and that investors were earning similar compensation for equity risk as in the past.

US equity valuations hinge on the compressed term premium

Graph 6



[1] For the US, Robert Shiller data until November 2019; for other countries, Barclays Shiller CAPE ratios until September 2019. [2] Relative to the distribution of country-specific monthly Shiller CAPE ratios between 2010 and present. [3] Inverted Shiller CAPE ratio. [4] Using expected nominal 10-year rate component of Hördahl and Tristani term premium.

Sources: P Hördahl and O Tristani, "Inflation risk premia in the euro area and the United States", *International Journal of Central Banking*, vol 10, no 3, 2014; R Shiller, www.econ.yale.edu/~shiller/data.htm; Barclays; Bloomberg; BIS calculations.

that the returns on bonds and stocks have become negatively correlated over the last two decades, the explanation for low and even negative term premia could be that bonds have become a hedge for stocks.

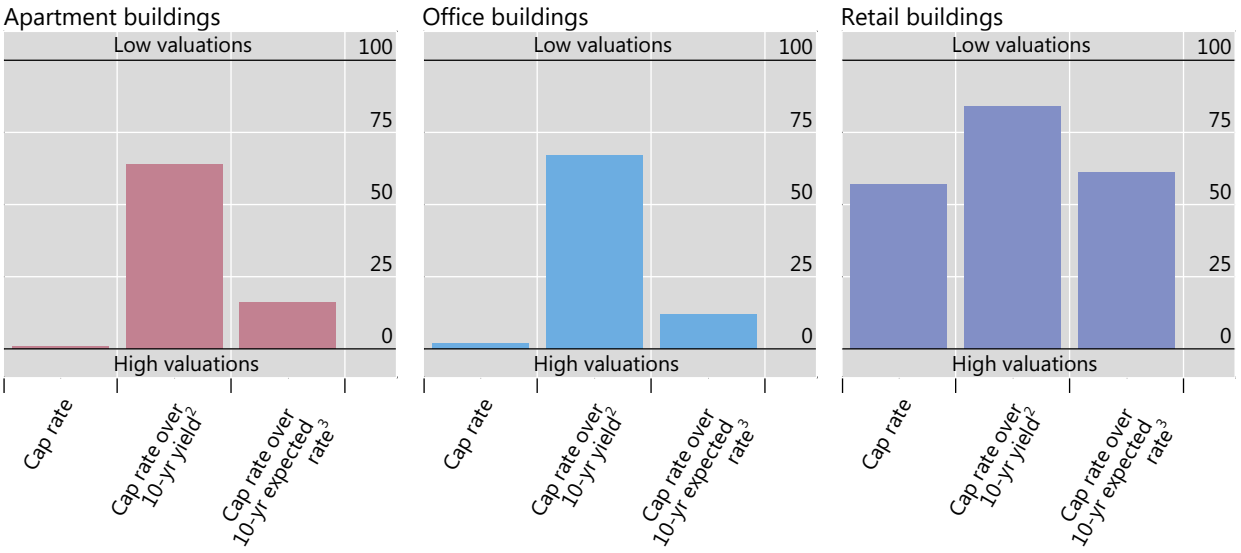
However, such compensation would be less benign if adjusted for the low level of the term premium. Not only was the improvement in valuations almost fully due to interest rates, it was largely driven by the decline of the term premium, which is a fairly volatile component of interest rates. The earnings yield spread relative to the expected nominal US Treasury rate – that is, after removing the term premium from interest rates – was quite low by historical standards (Graph 6, centre panel, yellow line). In fact, it suggested that investors were receiving little compensation for equity risk. Similar patterns could be observed for French equities (right-hand panel).

Valuations in US commercial real estate (CRE) markets also seem to hinge on the low level of the term premium. The capitalisation rate (cap rate), calculated as property income over purchase price, is a common measure of CRE valuations. In October, cap rates were compressed, indicating stretched valuations, with the exception of retail properties, whose prices reflected adverse shifts in shopping patterns in favour of online retail (Graph 7, all panels, left-most bars). Like the earnings yield spread for equities, the cap rate spread over the 10-year US Treasury yields suggested much lower valuations, somewhat below the historical norm (all panels, centre bars). As for equities, however, much of the difference in valuations was due to the low term premium, and cap rate spreads over expected nominal rates were compressed and close to the bottom of the post-GFC range, indicating that the recent decline of the term premium was driving valuations (all panels, right-most bars).

In corporate bond markets, various indicators pointed to higher than average valuations. One simple measure is the corporate yield spread relative to government bonds of similar maturity. In late 2019, AE spreads were lower than they had been 80% of the time since 2010 in the investment grade segment (Graph 8, first panel). Valuations were closer to the average for EME and for AE high-yield corporate bonds, with spreads lower than they had been 70% of the time since 2010.

Commercial real estate valuations also largely depend on the term premium

Capitalisation rates, as percentiles, October 2019[1] Graph 7



[1] Relative to a distribution of monthly values between 2010 and October 2019. [2] Spread of US market capitalisation rate to zero coupon US Treasury 10-year yield. [3] Spread of US market capitalisation rate to expected US Treasury 10-year yield.

Sources: P Hördahl and O Tristani, "Inflation risk premia in the euro area and the United States", *International Journal of Central Banking*, vol 10, no 3, 2014; Bloomberg; Real Capital Analytics; BIS calculations.

Furthermore, in recent quarters corporate bond valuations showed signs of diverging from their traditional economic drivers. For example, euro area and US valuations appeared rich in relation to the outlook for manufacturing activity. Corporate bonds are often used to finance working capital and investment, and their valuations had tracked manufacturing PMIs closely since the GFC. In particular, periods of relatively strong prospects for manufacturing (ie high PMIs) corresponded to elevated corporate bond valuations in the form of compressed spreads, with a stronger link for US corporate bond spreads between 2016 and 2018 (Graph 8, second panel).

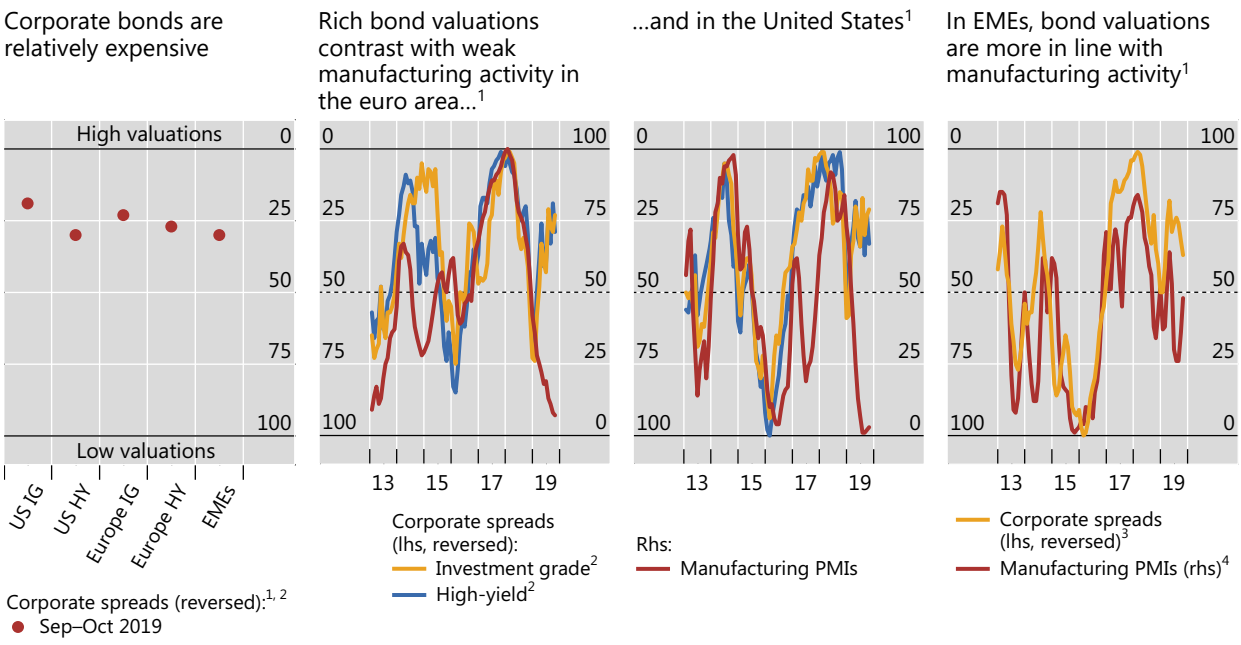
In early 2019, a gap had started opening between high corporate bond valuations and muted prospects for manufacturing activity. In November, this gap was the largest since 2013, indicating that corporate bond valuations were unusually buoyant relative to weak manufacturing. The divide was evident for investment grade and high-yield bonds in both the euro area and the United States (Graph 8, second and third panels).

The disconnect between corporate bond valuations and manufacturing activity was less pronounced in EMEs. While bond valuations were above their post-GFC midpoint, manufacturing PMIs were roughly at the middle of their range since 2010, instead of near the bottom as in the United States and euro area (Graph 8, fourth panel). As a result, corporate bond valuations in EMEs appeared more in line with the macroeconomic backdrop.

Corporate bond valuations were not driven by unusually low default risk. Global default rates for speculative grade bonds had been relatively steady for the past several years, picking up in 2016 but settling back in 2018 to levels similar to the

Corporate bond valuations are high globally

All variables expressed as percentiles — Graph 8



[1] Relative to a distribution of monthly values between 2010 and present. [2] For the United States and Europe, Bank of America Merrill Lynch corporate bond index, option-adjusted spread; for EMEs, JPMorgan Chase CEMBI index, stripped spread. [3] JPMorgan Chase CEMBI, stripped spread. [4] GDP and PPP exchange rates weighted average of BR, CN, IN, MX, RU and TR, three-month moving average.

Sources: IMF, *World Economic Outlook*; ICE BoAML indices; IHS Markit; JPMorgan Chase; BIS calculations.

2010–17 average (2.09% compared with 2.35%).[6] In September and October, expected default risk and downgrades for US high-yield issuers rose to levels last seen in 2016.[7]

In a further sign of strong risk appetite, investor demand for higher-risk bonds remained high. The US market for high-yield bonds saw issuance of $34 billion in September, exceeding all monthly totals since January 2018 and well above the $23 billion monthly average between 2010 and 2017. Similarly, in October bond investment funds that focus on countries classified as frontier markets saw the second highest inflow over the previous 12 months. The total assets managed by these funds rose from $3.7 billion in November 2018 to $5.4 billion in October.

[6] S&P Global Ratings, *2018 annual global corporate default and rating transition study*, 2019.

[7] Moody's Analytics, "Worsened fundamentals lift downgrades well above upgrades", 10 October 2019; Moody's Analytics, "Leading credit-risk indicator signals a rising default rate", 5 September 2019.

September stress in dollar repo markets: passing or structural?

Fernando Avalos, Torsten Ehlers and Egemen Eren

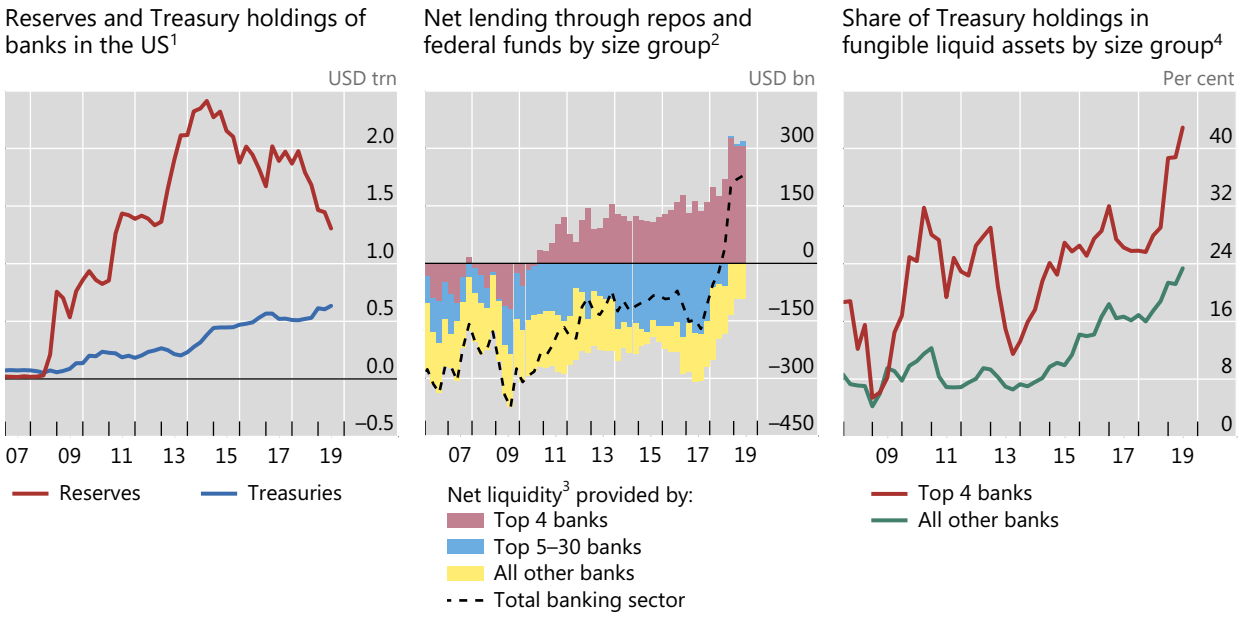
The mid-September tensions in the US dollar market for repurchase agreements (repos) were highly unusual. Repo rates typically fluctuate in an intraday range of 10 basis points, or at most 20 basis points. On 17 September, the secured overnight funding rate (SOFR) – the new, repo market-based, US dollar overnight reference rate – more than doubled, and the intraday range jumped to about 700 basis points. Intraday volatility in the federal funds rate was also unusually high.① The reasons for this dislocation have been extensively debated; explanations include a due date for US corporate taxes and a large settlement of US Treasury securities. Yet none of these temporary factors can fully explain the exceptional jump in repo rates.②

This box focuses on the distribution of liquid assets in the US banking system and how it became an underlying structural factor that could have amplified the repo rate reaction. US repo markets currently rely heavily on four banks as marginal lenders. As the composition of their liquid assets became more skewed towards US Treasuries, their ability to supply funding at short notice in repo markets was diminished. At the same time, increased demand for funding from leveraged financial institutions (eg hedge funds) via Treasury repos appears to have compounded the strains of the temporary factors. Finally, the stress may have been amplified in part by hysteresis effects brought about by a long period of abundant reserves, owing to the Federal Reserve's large-scale asset purchases.

A repo transaction is a short-term (usually overnight) collateralised loan, in which the borrower (of cash) sells a security (typically government bonds as collateral) to the lender, with a commitment to buy it back later at the same price plus interest. Repo markets redistribute liquidity between financial institutions: not only banks (as is the case with the federal funds market), but also insurance companies, asset managers, money market funds and other institutional investors. In so doing, they help other financial markets to function smoothly. Thus, any sustained disruption in this market, with daily turnover in the US market of about $1 trillion, could quickly ripple through the financial system. The freezing-up of repo markets in late 2008 was one of the most damaging aspects of the Great Financial Crisis (GFC).

The big four US banks turned into key lenders in the repo market

Graph A1



[1] All banks filing US Call Reports, including foreign banking operations in the US, but excluding credit unions. Excludes broker-dealer affiliates [2] Size = total assets. Aggregated across all bank entities of the same holding company. [3] Net lending = reverse repos (assets) – repos (liabilities) + fed funds (assets) – fed funds (liabilities). [4] Fungible liquid assets are defined as cash + fed funds + reserves + Treasury securities.

Sources: Federal Financial Institutions Examination Council, *Call Reports* 031, 041 and 002; BIS calculations.

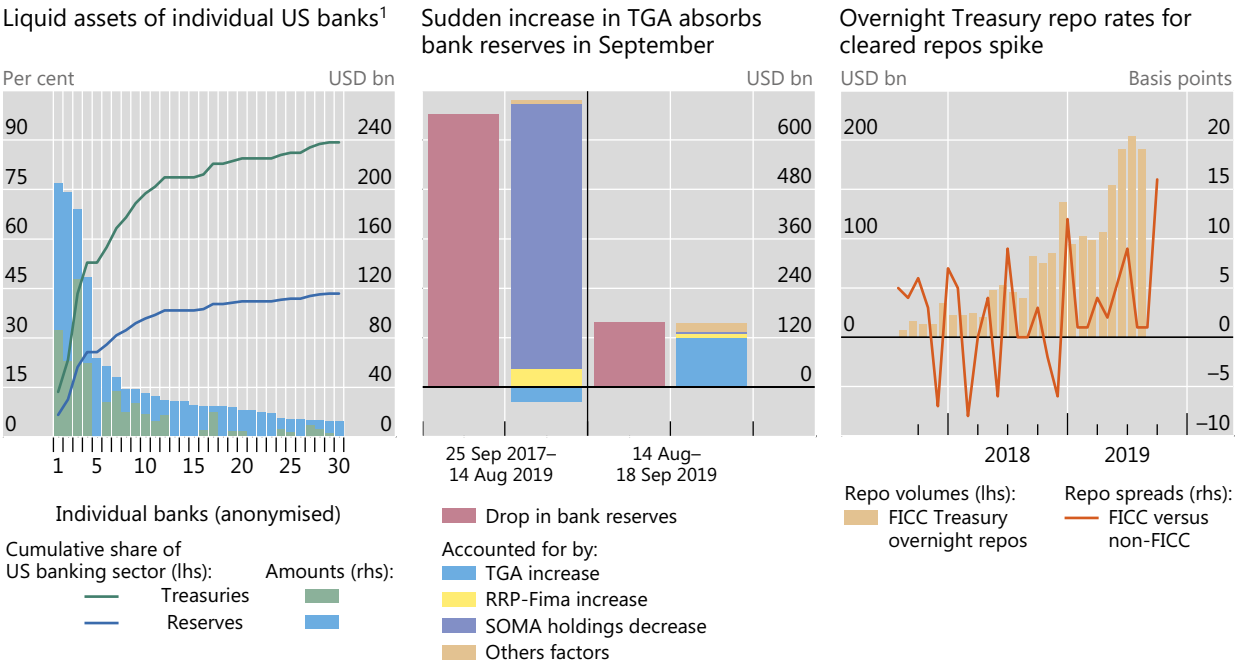
The liquid asset holdings of US banks and their composition have changed significantly since the GFC. Successive rounds of large-scale asset purchases reduced the free float of long-dated US Treasuries available to the market between the end of 2008 and October 2014. On the flip side, banks accumulated large amounts of reserve balances remunerated at the Fed's interest on excess reserves (IOER) (Graph A.1, left-hand panel, red line). After the Federal Reserve started to run down its balance sheet in October 2017, reserves contracted, quickly but in an orderly way as intended. Alongside, banks' holdings of US Treasuries increased, almost trebling between end-2013 and the second quarter of 2019 (blue line).

As repo rates started to increase above the IOER from mid-2018 owing to the large issuance of Treasuries, a remarkable shift took place: the US banking system as a whole, hitherto a net provider of collateral, became a net provider of funds to repo markets. The four largest US banks specifically turned into key players: their net lending position (reverse repo assets minus repo liabilities) increased quickly, reaching about $300 billion at end-June 2019 (Graph A.1, centre panel, red bars). At the same time, the next largest 25 banks reduced their demand for repo funding, turning the net repo position of the banking sector positive (centre panel, dashed line). The big four banks appear to have turned into the marginal lender, possibly as other banks do not have the scale and non-bank cash suppliers such as money market funds (MMFs) hit exposure limits (see below).

Concurrent with the growing role of the largest four banks in the repo market, their liquid asset holdings have become increasingly skewed towards US Treasuries, much more so than for the other, smaller banks (Graph A.1, right-hand panel). As of the second quarter of 2019, the big four banks alone accounted for more than 50% of the total Treasury securities held by banks in the United States – the largest 30 banks held about 90% (Graph A.2, left-hand panel). At the same time, the four largest banks held only about 25% of reserves (ie funding that they could supply at short notice in repo markets).

The big four banks hold more Treasuries, while the Treasury holds more cash

Graph A2



[1] All banks filing US Call Reports, including foreign banking operations in the US, but excluding credit unions. Excludes broker-dealer affiliates. Aggregated across all bank entities of the same bank holding company.

Sources: Federal Financial Institutions Examination Council, *Call Reports* 031, 041 and 002; Federal Reserve Bank of St Louis, FRED; Board of Governors of the Federal Reserve System; Office of Financial Research; BIS calculations.

Cash balances held by the US Treasury in its Federal Reserve account (the Treasury General Account, TGA) grew in size and became more volatile, especially after 2015. The resulting drain and swings in reserves are likely to have reduced the cash buffers of the big four banks and their willingness to lend into the repo market. After the debt ceiling was suspended in early August 2019, the US Treasury quickly set out to rebuild its dwindling cash balances, draining more than $120 billion of reserves in the 30 days between 14 August and 17 September alone, and half of this amount in the last week of that period. By comparison, while the Federal Reserve runoff removed about five times this amount, it did so over almost two years (Graph A.2, centre panel).

Besides these shifts in market structure and balance sheet composition, other factors may help to explain why banks did not lend into the repo market, despite attractive profit opportunities.③ A reduction in money market activity is a natural by-product of central bank balance sheet expansion. If it persists for a prolonged period, it may result in hysteresis effects that hamper market functioning. For instance, the internal processes and knowledge that banks need to ensure prompt and smooth market operations may start to decay. This could take the form of staff inexperience and fewer market-makers, slowing internal processes.④ Moreover, for regulatory requirements – the liquidity coverage ratio – reserves and Treasuries are high-quality liquid assets (HQLA) of equivalent standing. But in practice, especially when managing internal intraday liquidity needs, banks prefer to keep reserves for their superior availability.

Shifts in repo borrowing and lending by non-bank participants may have also played a role in the repo rate spike. Market commentary suggests that, in preceding quarters, leveraged players (eg hedge funds) were increasing their demand for Treasury repos to fund arbitrage trades between cash bonds and derivatives. Since 2017, MMFs have been lending to a broader range of repo counterparties, including hedge funds, potentially obtaining higher returns.⑤ These transactions are cleared by the Fixed Income Clearing Corporation (FICC), with a dealer sponsor (usually a bank or broker-dealer) taking on the credit risk. The resulting remarkable rise in FICC-cleared repos indirectly connected these players. During September, however, quantities dropped and rates rose, suggesting a reluctance, also on the part of MMFs, to lend into these markets (Graph A.2, right-hand panel). Market intelligence suggests MMFs were concerned by potential large redemptions given strong prior inflows. Counterparty exposure limits may have contributed to the drop in quantities, as these repos now account for almost 20% of the total provided by MMFs.

Since 17 September, the Federal Reserve has taken various measures to supply more reserves and alleviate repo market pressures. These operations were expanded in scope to term repos (of two to six weeks) and increased in size and time horizon (at least through January 2020).⑥ The Federal Reserve further announced on 11 October the purchase of Treasury bills at an initial pace of $60 billion per month to offset the increase in non-reserve liabilities (eg the TGA). These ongoing operations have calmed markets.

① On the same day, the effective federal funds rate increased only 5 basis points to 2.30% (above the upper limit of the federal funds target), but the intraday range spiked to almost 200 basis points, from a typical range of less than 10 basis points. ② J Williams, "Money markets and the federal funds rate: the path forward", speech 332, Federal Reserve Bank of New York, 17 October 2019. ③ Concerns about market functioning due to depressed interbank trading activity in an abundant reserves regime were an important consideration behind the Central Bank of Norway's switch to a quota-based system in 2011. ④ Markets Committee, *Large central bank balance sheets and market functioning*, October 2019. ⑤ See I Aldasoro, T Ehlers and E Eren, "Can CCPs reduce repo market inefficiencies?", *BIS Quarterly Review,* December 2017, pp 13–14. ⑥ On 18–20 September, it offered overnight repos to primary dealers of up to an aggregate amount of $75 billion against Treasury, agency debt and agency mortgage-backed securities collateral. From 15 November, at least $120 billion in daily overnight repos, in addition to at least $35 billion in two-week term repos, was offered twice a week and at least $15 billion for four- or six-week repos was offered weekly.

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FX and OTC derivatives markets through the lens of the Triennial Survey[1]

The 2019 BIS Triennial Central Bank Survey provided new insights about the boost that electronification gave to trading in FX and OTC derivatives markets, and the role of compression and clearing in containing the growth of outstanding derivatives exposures.

JEL classification: F31, G15, G23

This special issue of the *BIS Quarterly Review* analyses the results of the latest BIS Triennial Central Bank Survey of Foreign Exchange and Over-the-counter (OTC) Derivatives Markets (Triennial Survey). The collection of five articles explores what factors drove the recent growth of these markets and what those factors tell us about the evolution of the markets' structure. The message that emerges is that OTC markets are larger and more diversified than ever, owing in part to the rise of electronic and automated trading. Even as trading picked up, compression and clearing helped to contain the growth of outstanding derivatives exposures.

The Triennial Survey is the most comprehensive source of information on the size and structure of foreign exchange (FX) and OTC derivatives markets. The BIS coordinates it in cooperation with central banks worldwide under the guidance of the Markets Committee and the Committee on the Global Financial System. The survey has been conducted every three years since 1986. In 2019, almost 1,300 dealers (mainly banks) located in 53 countries participated. Data were collected in two stages: OTC trading of FX spot, FX derivatives and interest rate derivatives was surveyed in April 2019, and the outstanding notional amounts and gross market values of all OTC derivatives were surveyed at the end of June.[2]

Offshore markets propel trading growth

FX and OTC derivatives markets saw a marked pickup in trading between the 2016 and 2019 surveys. Following a dip in 2016, FX trading returned to its long-term

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

[2] For more information about the Triennial Survey and to explore the data, see www.bis.org/statistics/rpfx19.htm.

Key takeaways

- The 2019 BIS Triennial Central Bank Survey showed that FX and OTC derivatives markets were larger and more diversified than ever.
- Electronification propelled the growth of offshore trading and increased the diversity of market participants.
- In FX markets, the rise in trading was led by swaps, while settlement risk remains a major concern.

upward trend, rising to $6.6 trillion per day in April 2019. Interest rate derivatives trading departed sharply from its previous trend, soaring to $6.5 trillion.

The trading of short-term instruments grew faster than that of long-term instruments. This mechanically increased reported turnover because such contracts need to be replaced more often. Schrimpf and Sushko (2019a) emphasise that the trading of FX swaps, which is concentrated in maturities of less than a week, rose from $2.4 trillion in April 2016 to $3.2 trillion in April 2019 and accounted for most of the overall increase in FX trading. In interest rate derivatives markets historically, OTC contracts had mainly referenced long-term rates; contracts referencing short-term rates were traded on exchanges. Using overnight index swaps and forward rate agreements as a proxy for OTC derivatives referencing short-term interest rates, Ehlers and Hardy (2019) find that OTC trading of such derivatives probably surpassed that of derivatives on long-term rates in April 2019.

While globally trading continued to be dominated by the major currencies, in particular the US dollar and the euro, in FX markets the trading of emerging market currencies grew faster than that of major currencies. As discussed by Patel and Xia (2019), the share of emerging market currencies in global FX turnover rose to 23% in April 2019 from 19% in 2016 and 15% in 2013. In contrast, interest rate derivatives denominated in emerging market currencies saw their share of global activity decline. Aramonte and Huang (2019) highlight that the OTC derivatives exposures of dealers headquartered in emerging market economies were concentrated in FX instruments, whereas those of dealers from advanced economies were concentrated in interest rate instruments.

The pickup in turnover between 2016 and 2019 was especially marked in offshore markets. Trading tended to grow most for those currencies with greater increases in activity offshore than onshore. The Chinese renminbi illustrates this: subdued growth coincided with a decline in the share of offshore trading. The renminbi's rank as the eighth most traded currency was unchanged between 2016 and 2019 and, according to Packer et al (2019), turnover remained lower than expected, based on trade and GDP per capita.

Greater offshore trading went hand in hand with greater geographical concentration. In FX markets, London, New York, Singapore and Hong Kong SAR increased their collective share of global trading to 75% in April 2019, up from 71% in 2016 and 65% in 2010. Trading in OTC interest rate derivatives markets was also increasingly concentrated in a few financial centres, especially London. Schrimpf and Sushko (2019a) attribute this geographical concentration to network externalities. For example, it is more cost-effective to centralise counterparty and credit relationships, or technical and legal infrastructures, in a handful of hubs than to spread them across many countries. The faster pace of trading also increased the advantages of locating traders' IT systems physically close to those of the platforms on which they trade.

Even as trading became more concentrated geographically, it fragmented across platforms. Schrimpf and Sushko (2019b) explain how the distinction in FX markets

between the inter-dealer and dealer-customer segments is increasingly blurred. Principal trading firms (PTFs),[3] in particular, made inroads into market-making activities, and the ways in which customers could conduct trades proliferated.

Electronification is reshaping markets

Turning to what factors drove the recent growth of FX and OTC derivatives markets, one stood out: the rise in electronic and automated trading, also referred to as electronification. By reducing transaction costs, electronification has boosted trading and changed price formation and liquidity provision. FX spot was one of the first OTC markets to go electronic, and the FX forwards market is quickly catching up, especially the market for non-deliverable FX forwards (NDFs). In contrast, as Schrimpf and Sushko (2019b) point out, the electronification of FX swaps lags because of their large size, complex pricing and the credit risk involved. OTC interest rate derivatives markets, too, are shifting from voice brokers to electronic platforms. Ehlers and Hardy (2019) cite electronification as a key reason for the faster growth of OTC trading relative to exchange trading of interest rate derivatives.

Another notable driver of growth was the increased diversity of market participants. Greater heterogeneity in participants' transaction needs and investment horizons has enhanced market liquidity and facilitated risk transfers. To some extent, greater diversity was linked to electronification. Electronification has enabled automated trading, in particular high-frequency trading. This, in turn, has made OTC markets more attractive to those engaged in such strategies, mainly hedge funds and PTFs.

The market for NDFs shows how electronification has stimulated trading and increased the diversity of market participants. Currencies that are not freely convertible were among those recording the fastest growth in FX turnover between the 2016 and 2019 surveys, including the Indian rupee, Indonesian rupiah and Philippine peso. Patel and Xia (2019) highlight that this growth was led by forwards, particularly NDFs traded in offshore markets.

Changes in the size, investment objectives and strategies of asset managers have also served to increase the diversity of OTC market participants. Since the Great Financial Crisis (GFC) of 2007–09, assets managed by investment funds, exchange-traded funds and other non-bank investors have expanded substantially. At the same time, low interest rates have encouraged riskier investments. According to Patel and Xia (2019), this has raised non-bank financial institutions' demand for emerging market assets. Similarly, Ehlers and Hardy (2019) emphasise that non-bank financial institutions have made more active use of OTC interest rate derivatives.

In addition to such market-wide structural changes, other factors have contributed to the growth of specific market segments. As Schrimpf and Sushko (2019a) explain, trading in FX swaps was boosted by banks' liquidity management as well as their arbitraging of interest rate differentials for funding in different currencies. Another driver of FX trading was the recovery in prime brokerage activities[4] from the

[3] PTFs are firms that invest, hedge or speculate for their own account. PTFs include high-frequency trading firms as well as electronic non-bank market-makers.

[4] Prime brokerage refers to intermediation services that dealers provide to hedge funds, PTFs and other selected customers. Prime brokers are usually large highly rated banks. They enable selected

subdued levels of 2016, when losses on clients' trades following idiosyncratic events in FX markets had caused some banks to retrench. For OTC interest rate derivatives, Ehlers and Hardy (2019) highlight how changes in the level and volatility of US dollar interest rates boosted turnover in April 2019.

Compression and clearing mitigate exposures

The marked pickup in the trading of FX and OTC derivatives between the 2016 and 2019 surveys did not lead to an increase in outstanding exposures. To be sure, since 2015 the notional principal of outstanding OTC derivatives has trended upwards, and at end-June 2019 it reached its highest level since 2014. However, their gross market value – a more meaningful measure of amounts at risk than notional principal – has trended downward since 2012. As Aramonte and Huang (2019) highlight, the gross market value was $12 trillion at end-June 2019, close to its level immediately before the GFC.

Compression and clearing helped to slow the growth of outstanding exposures. Compression eliminates economically redundant derivatives positions and thereby reduces outstanding contracts. Compression first took hold in the market for credit default swaps (CDS), where even before the GFC it contributed to a sharp reduction in notional principal. While it took longer to penetrate OTC interest rate derivatives markets, Ehlers and Hardy (2019) document that the frequency and amount of compression has increased in recent years, making it now commonplace. Compression, coupled with electronification and other changes, is reshaping OTC markets along the lines of exchanges.

Compression has been greatly facilitated by the expansion of central clearing. Clearing rates for CDS and OTC interest rate derivatives rose steadily between 2010 and 2017, though they have since levelled off. By 2019, derivatives subject to mandatory clearing, mainly forward rate agreements, interest rate swaps and CDS indices, were almost all centrally cleared. Aramonte and Huang (2019) find that, among derivatives not subject to mandatory clearing, some have migrated to central clearing voluntarily. The decision whether to migrate contracts depends on the benefits of lower margin requirements, potential gains from netting positions within the same asset class and relative liquidity conditions.

In contrast to trends in other segments of OTC markets, in FX markets initiatives to mitigate risk exposures appear to have stalled. Most FX instruments are deliverable contracts, which involve an exchange of principal. Thus, settlement risk – the risk that one counterparty fails to deliver after the other has delivered – is a major concern. In the 2000s, a number of initiatives, most notably the establishment of Continuous Linked Settlement, a specialist institution that settles FX transactions on a payment-versus-payment basis, led to a big reduction in FX settlement risk. However, Bech and Holden (2019) conclude that FX settlement risk has risen since 2013. In particular, the proportion of trades using payment-versus-payment systems has declined. Encouraging use of these systems and opening them to fast-growing emerging market currencies would help to reverse this trend.

customers to conduct trades, subject to credit limits, with a group of predetermined counterparties in the prime broker's name.

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Sizing up global foreign exchange markets[1]

The latest BIS Triennial Survey shows that global foreign exchange trading increased to more than $6 trillion per day. Trading bounced back strongly following a dip in 2016, buoyed by increased trading with financial clients such as lower-tier banks, hedge funds and principal trading firms. Prime brokerage volumes recovered in tandem. These developments were driven in large part by the greater use of FX swaps for managing funding and greater electronification of customer trading. They led to further concentration of trading in a few financial hubs.

JEL classification: C42, C82, F31, G12, G15.

Turnover in global foreign exchange (FX) markets reached $6.6 trillion per day in April 2019. This is up from $5.1 trillion per day in April 2016 and marked a return to the long-term upward trend in turnover recorded in each BIS Triennial Central Bank Survey since 2001. In this article, we explore the recent evolution in the size and structure of global FX markets by drawing on the latest survey.

The global FX market is more opaque than many other financial markets because it is organised as an over-the-counter (OTC) market built upon credit relationships. In recent years, changes in market structure, such as the internalisation of trades in dealers' proprietary liquidity pools, further reduced the share of trading activity that is "visible" to other market participants (Schrimpf and Sushko (2019) in this issue). The Triennial Survey provides a comprehensive, albeit infrequent, snapshot of activity in this highly fragmented market.[2]

[1] We thank Sirio Aramonte, Claudio Borio, Alain Chaboud, Ying-Wong Cheung, Stijn Claessens, Torsten Ehlers, Ingo Fender, Brian Hardy, Wenqian Huang, Robert McCauley, Dagfinn Rime, Maik Schmeling, Olav Syrstad and Philip Wooldridge for helpful comments and suggestions. We also appreciate the feedback and insightful discussions with a number of market participants at major FX dealing banks, buy-side institutions, electronic market-makers and trading platform providers. We are also grateful to Yifan Ma and Denis Pêtre for compiling the data and Adam Cap 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] Central banks and other authorities in 53 jurisdictions participated in the 2019 survey, which collected data from close to 1,300 banks and other dealers. For information about the Triennial Survey, see www.bis.org/statistics/rpfx19.htm.

Key takeaways

- Trading in global FX markets reached $6.6 trillion per day in April 2019, up from $5.1 trillion in April 2016.
- Increased use of FX swaps for bank funding liquidity management and hedging of foreign currency portfolios, as well as growth in prime brokerage, boosted trading.
- Electronification of FX markets spurred an even greater concentration of trading in a few financial hubs.

FX trading volumes in April 2019 were buoyed by a pickup in trading with financial clients, such as smaller banks, hedge funds and principal trading firms (PTFs). FX prime brokerage – intermediation services provided by top-tier FX dealers to financial clients – recovered in tandem. Prime brokerage expanded across all instruments, but was particularly visible in spot trading. This was largely due to a more active presence of PTFs, some of which have gained a firm footing as non-bank electronic market-makers. It also offset the continued decline in spot trading in inter-dealer markets.

A pickup in trading of FX swaps, especially by smaller banks, was the largest single contributor to the overall FX turnover growth (Annex Table A1). It was mainly driven by the use of swaps in banks' funding management. Another noteworthy development was robust trading in forwards, particularly in the non-deliverable forward (NDF) segment attractive to hedge funds and PTFs. While the increase in the trading of FX swaps and forwards accounted for about 75% of the rise in global FX volumes since 2016, growth in spot was more muted due to a prolonged period of subdued volatility and a decline in inter-dealer spot trading.

Electronification in FX first took off in inter-dealer trading, but its trajectory has since changed. In recent years, the dealer-to-customer segment has seen the strongest rise in electronification. To the extent that electronic trading tends to be booked in a few major financial hubs, it also leads to a greater share of offshore trading.

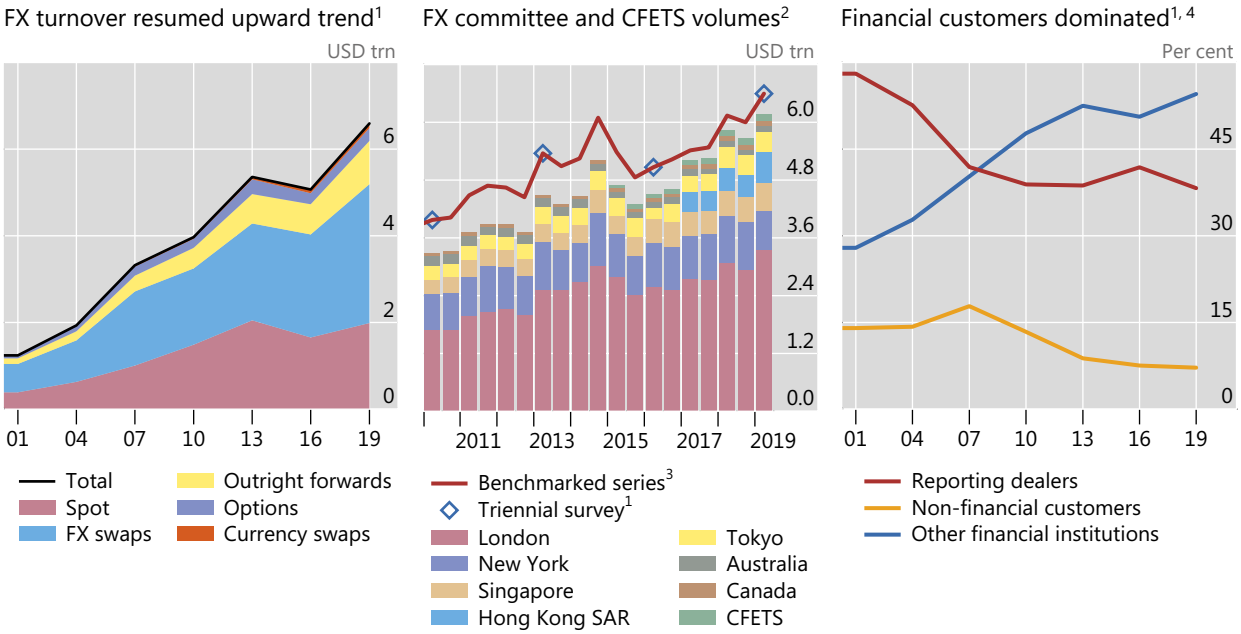
This article is organised as follows. The first section provides empirical evidence of financial drivers behind FX volumes. The second digs deeper into developments in FX swaps, with a particular focus on trading by banks. The third discusses broader trends in trading with financial clients and across instruments, as well as FX prime brokerage. The fourth takes stock of the degree of electronification in FX trading across key market segments. The fifth section focuses on the trend towards more concentration of trading in major FX hubs, and, by extension, increased offshore trading. The final section concludes.

FX trading volumes mostly reflect financial motives

The recovery in volumes recorded in the 2019 Triennial Survey follows some unusually subdued trading activity three years ago, when the survey had shown a decline for the first time since 2001 (Graph 1, left-hand panel). In 2016, the prime brokerage

FX turnover rises with more trading in FX swaps and by financials

Graph 1



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [2] Semiannual data, referring to April and October. Additional increase in stacked bars due to the inclusion of China Foreign Exchange Trade System (CFETS) turnover in April 2015 and the Hong Kong Treasury Markets Association survey in April 2017. [3] The benchmarking using the proportional Denton technique allows us to assess the evolution of FX trading volumes between Triennial surveys. For a description, see Bech (2012). [4] Expressed as a share of total turnover.

Sources: M Bech, "FX volume during the financial crisis and now". BIS Quarterly Review. March 2012. pp 33–43; foreign exchange committee surveys; Bloomberg; BIS Triennial Central Bank Survey; authors' calculations.

business had still not fully recovered from the 2015 Swiss franc shock,[3] the banking industry was adjusting to the new regulatory environment, and the composition of participants had changed in favour of more risk-averse players (Moore et al (2016)). Semiannual surveys by FX committees and other sources in the major centres confirm that 2019 represented a return to the long-term upward trend in FX trading (centre panel).[4]

The 2019 survey shows that the evolution of FX trading volumes continues to be dominated mostly by financial institutions' motives as opposed to needs arising directly from real economic activity. The customer segment most closely linked to global trade is non-financial corporations, and in 2019 its share of trading remained almost unchanged at less than 8% (Graph 1, right-hand panel). The long-term shift towards financial customers outside the dealer community resumed, with the share of trading with other financial institutions rising from 51% in 2016 to 55% in 2019. By contrast, trading among reporting dealers grew little, so that the inter-dealer share in overall FX volumes continued its downward trend.

Regression analysis confirms the dominance of financial motives. As shown in Table 1, trade in goods and services shows a positive link with FX turnover (column 1),

[3] The abandonment of the Swiss franc's floor regime with the euro on 15 January 2015 led to extreme currency moves. It shook the entire FX industry, especially prime brokerage, and exerted lasting effects on trading volumes (see Box A and Moore et al (2016)).

[4] Global FX turnover probably briefly surpassed $6 trillion already in September 2014, as discussed in Box A in Moore at al (2016).

Drivers of FX trading growth

Table 1

	(1)	(2)	(3)	(4)	(5)
Trade flows	0.16***	0.15***	0.09**	0.08**	0.07**
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
Corporate clients		–0.08**			
		(0.03)			
Financial flows			0.15***	0.16***	0.15***
			(0.04)	(0.03)	(0.03)
Financial clients				0.13***	0.08**
				(0.04)	(0.04)
Offshore share					0.11***
					(0.03)
Number of observations	194	188	154	151	151
R-squared	0.12	0.14	0.21	0.27	0.32

The following variables are specified as log differences: FX turnover (USD millions); trade flows = exports plus imports of goods and services (USD millions); corporate clients = share of non-financial counterparties in total turnover; financial flows = net acquisition of financial assets plus net incurrence of liabilities (USD millions). The following variables are specified as changes in integer percentage shares between surveys: financial clients = share of (non-dealer) financial counterparties; offshore share = share of offshore turnover (intra-euro area transactions are classified as offshore in the calculation of the EUR offshore share).

Panel data for 26 individual currencies in five survey periods (2007, 2010, 2013, 2016 and 2019). Coefficients and standard errors scaled by the standard deviation of each variable in order to infer economic magnitudes; standard errors in brackets. ***/**/* indicates p-values less than 0.01/0.05/0.1, respectively. Constant not shown.

Sources: IMF, *Balance of Payments Statistics* and *World Economic Outlook*; BIS Triennial Central Bank Survey; authors' calculations.

yet currencies featuring greater participation by corporates show sub-par growth (column 2). By contrast, FX turnover growth is better captured when financial flows (column 3) and the share of trading with financial clients (column 4) are accounted for. Furthermore, currencies featuring a higher share of trading offshore in financial centres have also seen higher FX turnover (column 5).[5]

Zooming in on FX swaps

Since 2013, FX swaps and forwards have been the main instruments behind the growth in overall FX trading (Graph 1, left-hand panel).[6] Their combined share of turnover rose from 54% in 2013 to 61% in 2016, and 64% in 2019. By contrast, the share of spot trading fell from 38% to 30% over this period.

The share of the US dollar in swaps is even higher than in spot, with USD on one side in more than 90% of FX swap turnover. The three most traded FX swap crosses

[5] These results extend the findings of McCauley and Scatigna (2011) and Chitu et al (2014). At the same time, these results may understate the importance of corporate clients in affecting FX flow. While large multinational corporations may trade directly with top-tier FX banks (captured as such in the Triennial), other corporates are more likely to be intermediated by smaller and more locally oriented (non-reporting) banks. Trading by the latter could hence effectively act as a conduit for real economy driven flows to reach the FX market.

[6] An FX swap is an OTC derivatives contract consisting of a spot and a forward leg. Effectively it is a term loan of one currency collateralised with another currency. While FX swaps constitute an off-balance sheet derivatives position from an accounting perspective, in many respects they fulfil a similar economic function to secured foreign currency debt (Borio et al (2017)). The pricing of the FX swap, ie the forward premium/discount, is linked to money market rates in the two currencies via a law of one price relation known as covered interest parity (CIP).

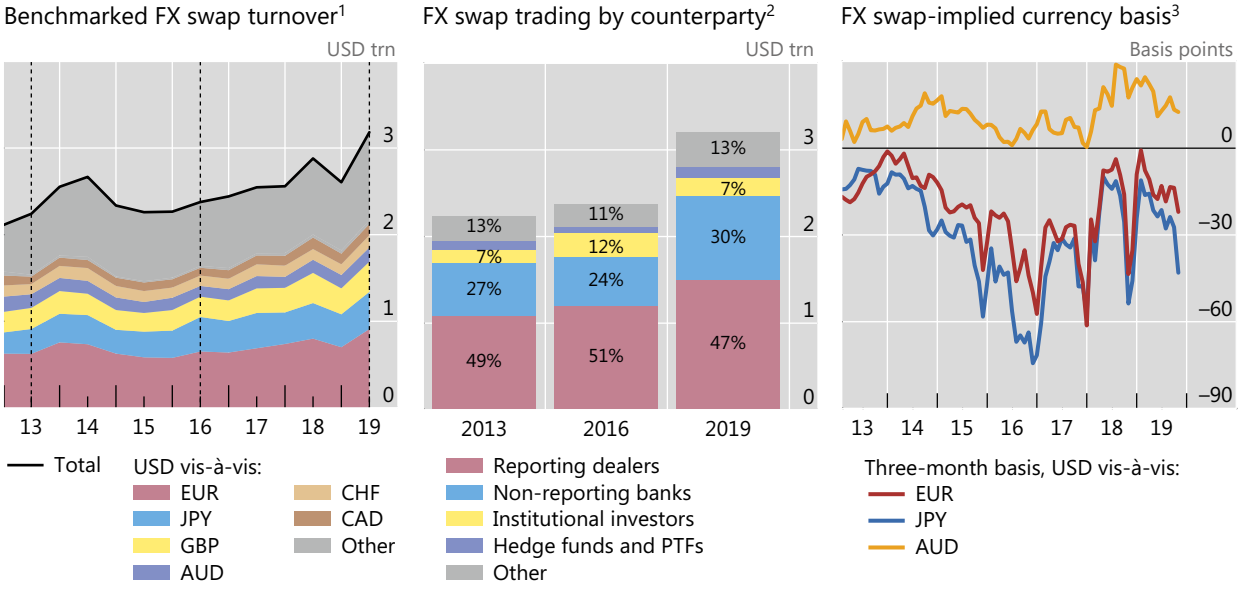
are USD/EUR, USD/JPY and USD/GBP (Graph 2, left-hand panel). Two factors explain the dollar's dominance. First, it is the international funding currency of choice, and second, it serves as the primary vehicle currency for trading FX instruments.

FX swap trading picked up significantly between 2016 and 2019 (Graph 2, centre panel). The market has been in the spotlight since about 2014 on the back of the resurgence in price "anomalies" (right-hand panel; Borio et al (2016), Du et al (2018)). The rise in FX swap volumes went hand in hand with the divergence of FX swap-implied funding costs from money market rates in the respective currencies, continuing a trend already observed in 2016 (Moore et al (2016)).

Banks dominate FX swap trading

Inter-dealer trading accounted for 47% of all FX swap turnover. FX dealers can trade swaps for their own banks' treasury unit for funding, or on behalf of clients for funding and hedging purposes. They can also use FX swaps to construct offsetting hedges for their positions in related instruments, such as forwards and (longer-dated) currency swaps. Smaller banks ("non-reporting banks" in the survey terminology) accounted for another 30% of FX swap turnover. They enter FX swap transactions with reporting dealers to manage their own funding or FX hedging needs, or in order to provide intermediation services to their own local customer base, such as smaller and medium-sized corporates.[7]

Trading in FX swaps boosted by trading with bank customers — Graph 2



[1] The vertical lines indicate April 2013, April 2016 and April 2019 (the dates of the BIS Triennial Survey). Benchmarked series are calculated using the proportional Denton technique. Based on breakdowns by currency pairs from the foreign exchange committees in London, New York, Singapore, Tokyo and Australia. The breakdown for USD/CHF and USD/CAD is not available from the Tokyo foreign exchange committee. [2] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [3] Difference between FX swap-implied US dollar three-month interest rate and US dollar three-month Libor. Negative values indicate that FX swap-implied US dollar rate exceeds US dollar Libor and vice versa.

Sources: Foreign exchange committee surveys; Bloomberg; BIS Triennial Central Bank Survey; authors' calculations.

[7] Market sources indicate that second-tier banks have also increased their own presence as FX swap intermediaries. Krohn and Sushko (2019) find evidence that smaller banks displaced larger dealers as market-makers in FX swaps at times when large banks managed down their balance sheets around regulatory reporting periods.

Funding liquidity management and hedging of FX assets

The renewed expansion in FX swaps in the 2016–19 period largely owed to the increasing participation of lower-tier banks. The trading of these smaller and regional banks outside the group of global FX dealers accounted for $404 billion (about half) of the total increase in swap turnover. These banks relied more heavily on FX swaps for funding because they have more limited direct access to US dollar funding.

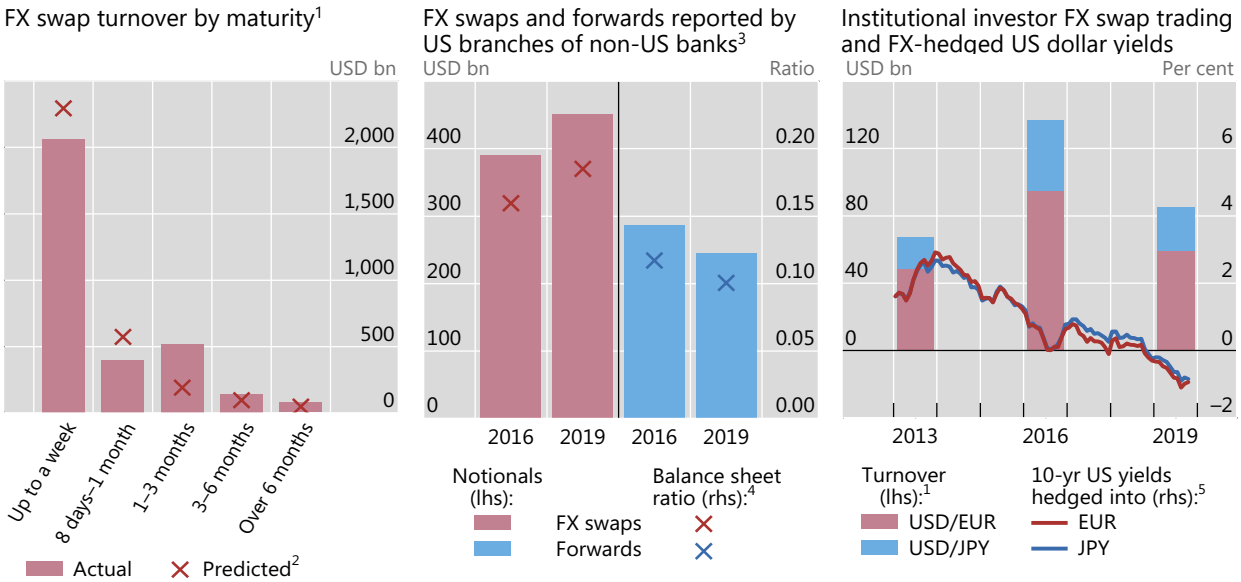
Major central banks' divergent balance sheet policies also affected banks' incentives to trade in FX swap markets. For instance, the abundant liquidity in the euro area strengthened European banks' incentives to swap excess euro liquidity into US dollars. Market sources indicate that this was driven by the demand to place abundant euro cash into a dollar-denominated safe and liquid asset, even if that meant paying up in the FX swap market to convert the currency. The actual need to fund longer-term dollar-denominated assets, by contrast, was reportedly a lesser consideration.

Banks' use of FX swaps for managing funding liquidity naturally favours shorter-term tenors. Indeed, $2.1 trillion, or 64%, of FX swap turnover was in maturities of seven days or less (Graph 3, left-hand panel). Over the 2016–19 period, the use of FX swaps relative to on-balance sheet funding by foreign bank affiliates in the US increased significantly (centre panel). This points to the importance of FX swaps in banks' funding liquidity management.

At the same time, asset managers and other investors also rely on FX swaps as rolling hedges for currency risk in international bond portfolios and passive investment fund vehicles. These have grown in both amounts and duration in recent

Maturity profile of FX swaps and importance for funding and hedging

Graph 3



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [2] Predicted distribution based on the assumption of an inverse relationship between turnover and maturity; using discrete maturities of one week, one month, three months, six months and one year for each maturity bucket; for example, daily turnover of one-week FX swaps is assumed to be four times that of one-month ones, daily turnover of one-month FX swaps is assumed to be three times that of three-month ones, etc. [3] Based on Federal Financial Institutions Examination Council, *Report of Assets and Liabilities of US Branches and Agencies of Foreign Banks* using Q1 data. [4] Calculated as the gross notional divided by total on-balance sheet liabilities. [5] Ten-year US Treasury yields adjusted for FX hedging cost by subtracting the forward premium of the respective currency pair.

Sources: US Federal Financial Institutions Examination Council; Bloomberg; BIS Triennial Central Bank Survey; authors' calculations.

years. FX swaps of one- to three-month tenors, which were popular maturities for such hedges, thus saw higher turnover compared with what one would expect solely on the basis of the inverse relationship between instrument maturity and trading frequency.

Opportunistic behaviour: arbitrage trades

Banks can also use FX swaps in order to exploit the pricing differentials implicit in them (the "cross-currency basis"), by varying their short-term borrowing and/or placement of funds across currencies. Specifically, financial institutions endowed with large amounts of US dollar reserve balances, or those with cheaper access to direct sources of dollar funding as well as access to central bank deposit facilities in different currencies, have been in a position to arbitrage dislocations in short-dated FX swaps (Rime et al (2017)). Opportunistic behaviour tends to intensify around regulatory reporting dates, and it goes both ways. Dealers of some of the largest banks reduce their FX swap intermediation around these dates (Krohn and Sushko (2019)), while some non-US banks face incentives to actively manage down their on-balance sheet funding by switching to off-balance sheet instruments, such as FX swaps. By contrast, others can take advantage of pricing dislocations by taking the other side and supplying the sought-after currency via FX swaps. Some central banks are also active in FX swaps, mostly as lenders of their US dollar reserves.

Other forms of arbitrage can also make use of FX swaps. For example, the linked exchange rate system of HKD/USD operates by capital flows arbitraging fluctuations in the Libor-Hibor interest rate differential (HKMA (2018)). Higher interest rate volatilities and divergence from US rates over the past three years have induced more arbitrage flows, with investors using FX swaps to synthetically create long/short positions in money markets in the two currencies. Such activity explains a good part of the doubling of HKD/USD turnover since the last Triennial Survey.

FX swap trading by institutional investors falls

In contrast to the increased FX swap trading by banks, trading by institutional investors has contracted since the last Triennial. This development was most visible in EUR/USD and JPY/USD – the two major crosses (Graph 3, right-hand panel). Institutional investors, such as insurance companies, typically use longer-dated FX swaps or forwards to hedge the currency risk of their foreign bond holdings.

The decline in swap trading by institutional investors in EUR/USD and JPY/USD since 2016 is explained by the evaporation of the pickup in yield from investing in long-term US Treasury bonds on an FX-hedged basis. In the past, with long-term yields compressed in conjunction with monetary easing by the ECB and the Bank of Japan, euro area and Japanese institutional investors sought higher yields by investing in US Treasury bonds. At the same time, they hedged the currency risk with FX swaps. A flattening of the yield curve since late 2016 made US Treasuries less attractive, once hedging costs (which are predicated on short-term rates in the two currencies) were factored in.[8]

[8] The relative steepness of the US yield curve (vis-à-vis investors' home country one) matters because FX hedging costs depend on the level of short-term rates while the investment returns are predicated on the level of long-term yields. More precisely, euro area or Japanese institutions effectively pay the short-end yield differential (via the FX swap transaction) and earn the long-end yield differential.

Trading with financial clients and FX prime brokerage

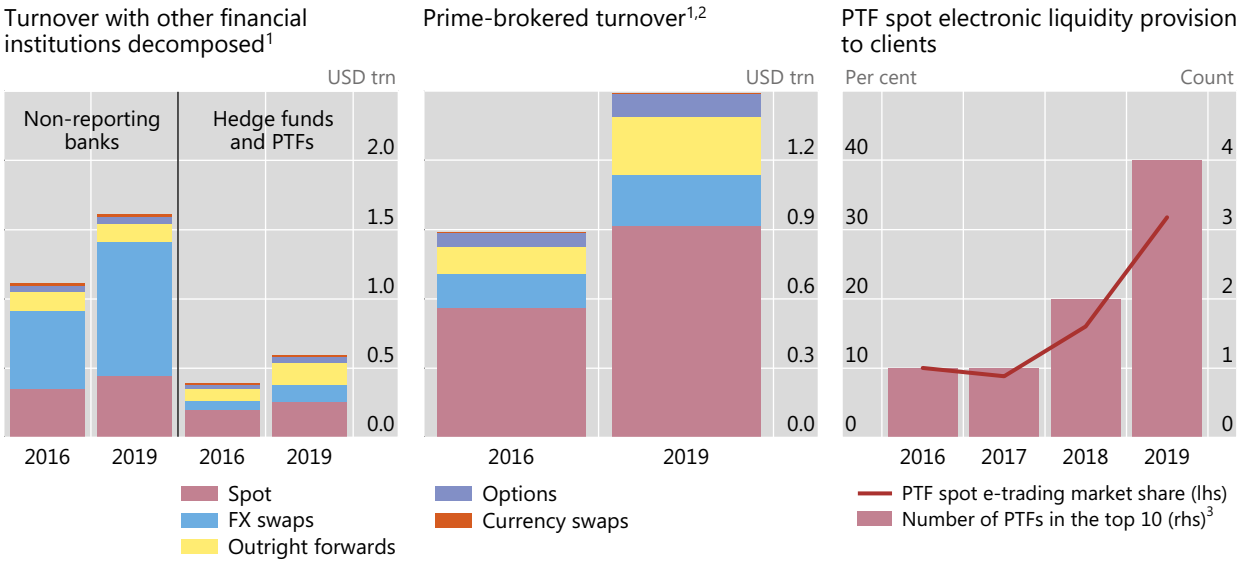
Dealers' trading with "other financial institutions" – a category that includes non-reporting banks, hedge funds and PTFs, institutional investors and official sector financial institutions – grew notably since 2016 by $1 trillion, to $3.6 trillion. As such, the share of this heterogeneous group of financial clients has reached 55% of global volumes. Non-reporting banks – typically smaller, regional banks that serve as clients of the large FX dealer banks – remained the largest counterparty category within "other financial institutions", accounting for $1.6 trillion in daily turnover (Graph 4, left-hand panel). As described above, most of the FX trading activity by these smaller banks is in FX swaps.

Trading with hedge funds and PTFs also increased significantly, to almost $600 billion. Hedge funds trade a variety of instruments, including FX swaps, forwards and options, which support their multi-asset trading strategies. By contrast, PTFs' algorithmic trading strategies employ instruments featuring a high degree of electronification, especially spot and, most recently, forwards.

Prime-brokered turnover recovers

Close to a third of trading by other financial institutions in 2019 was done via prime brokers, according to our estimates (see Box A). In a prime-brokered transaction, top FX dealers allow clients to trade directly in the bank's name with their established counterparties, subject to credit limits.[9]

FX trading by smaller banks, hedge funds and principal trading firms — Graph 4



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [2] Reporting dealers who act as prime brokers report both trades to which they are a counterparty as a result of their client trading on a prime-brokered basis: the "give-up" trade with the executing dealer and the value of the trade with the client. [3] Number of PTFs in the Euromoney list of top 10 spot electronic liquidity providers by market share.

Sources: Euromoney Foreign Exchange Survey; BIS Triennial Central Bank Survey; authors' calculations.

[9] This way, the client gains access to the deep liquidity of electronic trading venues.

Fuelled by greater demand from non-bank financial clients, the prime brokerage industry has largely recovered since 2015–16. Prime-brokered turnover rose to $1.5 trillion in April 2019, a 68% increase compared with the 2016 survey. While the growth mostly took place in spot (Graph 4, centre panel), it also exhibited a fairly large increase in FX swaps, outright forwards and options. At the same time, more conservative prime broker business models, tighter risk management practices and know-your-customer rules have favoured retaining only larger clients.

Non-bank electronic market-makers spur spot volumes

The 2019 Triennial points to an increased footprint of the so-called "non-bank electronic market-maker" community, which forms part of the broader group of PTFs. PTFs in general thrive on fast, algorithmic strategies and rely on speed instead of balance sheet to trade large volumes.[10] To gain access to the FX market, PTFs rely exclusively on prime brokers. The OTC FX trading activity by these firms is almost exclusively in spot and has contributed to the rise in spot turnover.

The broader set of PTFs has long engaged in both "aggressive" (initiating trades) and "passive" (serving as a willing counterparty to trades initiated by others) trading on anonymous electronic brokerage platforms. Passive trading effectively represents liquidity provision: it involves posting price quotes (limit orders) that can be hit by aggressive orders by a counterparty seeking to execute a trade at the prevailing market price. Yet the anonymity of such trading means that the counterparty does not know that it is trading with a PTF, nor can it count on being matched with the same liquidity provider in the future.

What sets non-bank electronic market-makers apart from their other PTF peers is the greater use of passive (ie liquidity-providing) strategies and disclosed liquidity provision via a network of client relationships. Not only does the counterparty on the other side, such as a smaller bank or an asset manager, know they are trading with a non-bank market-maker, but they also count on the same firm for their FX liquidity needs in the future as repeat customers.

Non-bank electronic market-makers have now penetrated deeply into the realm that, until about five years ago, was exclusive to bank dealers. The 2019 Euromoney survey indicates that the share of PTFs in spot e-trading with buy-side clients rose sharply to 32%, up from 10% three years earlier (Graph 4, right-hand panel).[11] What differentiates these new players from traditional bank dealers is that they substitute speed for balance sheet. As they have morphed into market-makers, alongside main FX dealing banks, they have become an integral part of FX intermediation and a key determinant of liquidity conditions, particularly in the spot market.

[10] In addition to market-making, PTF trading strategies can also include statistical arbitrage, latency arbitrage and momentum or trend-following. Many PTFs have their roots as high-frequency trading firms in equity and futures markets, but then ventured into OTC trading in deep and liquid FX spot markets. Electronic prime brokerage offers them access and anonymity for executing high-speed algorithmic strategies on electronic venues.

[11] The 2019 Euromoney rankings of top electronic spot liquidity providers include non-bank names such as XTX Markets, HC Tech, Jump Trading and Citadel Securities, alongside known bank dealers such as Deutsche Bank, JPMorgan, UBS, Citi, Goldman Sachs and Bank of America Merrill Lynch. Other PTFs with sizeable FX market footprints, many of which operate across other asset classes, include Flow Traders, GTS, Hudson Trading, Tower Research Capital and Virtu Financial.

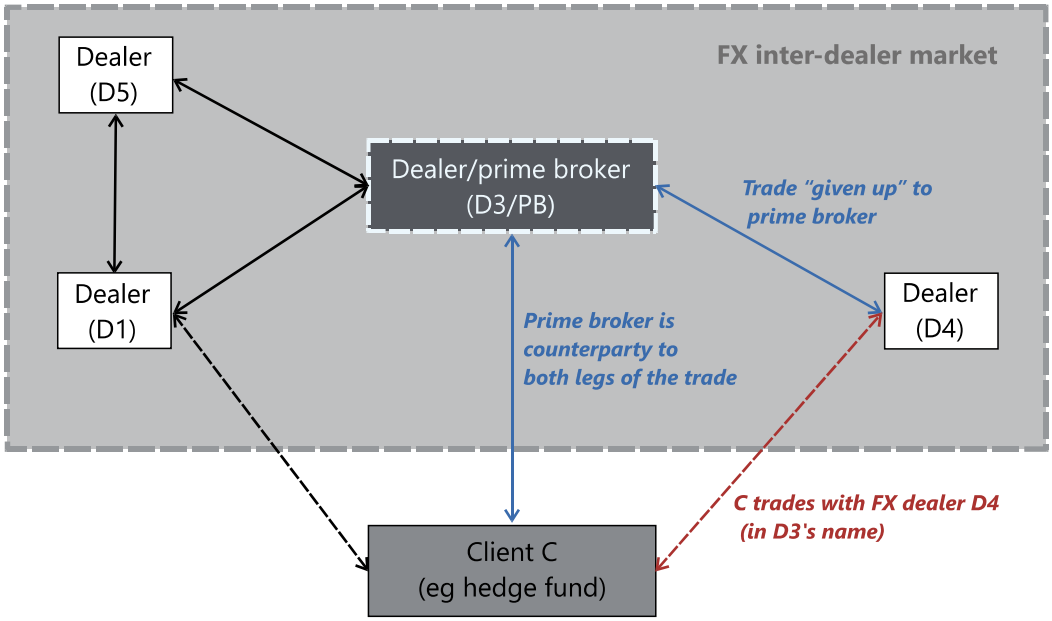
Box A

FX prime brokerage and its contribution to trading volumes

The biggest FX dealers in terms of volumes are also the biggest suppliers of prime brokerage (PB) services. PB enables clients to conduct trades with a group of predetermined third-party wholesale counterparties in the prime broker's name and using the prime broker's credit. This may also entail granting the client access to electronic platforms that once had been available only to major banks. By opening up the market and allowing greater participation by non-banks, PB has been an important catalyst of the move away from a clearly delineated two-tier market structure where dealers used to enjoy an exclusive role at the core.

FX prime brokerage

Graph A1



Dealers who act as prime brokers (D3) allow some of their customers (C) to trade with a set of third-party banks (eg executing dealer D4) in the prime broker's name and using the prime broker's credit lines.

Source: BIS elaboration.

In an FX PB relationship, the prime broker (D3/PB) guarantees the payment to the counterparty to the client's trade. As illustrated in Graph A1, the client (C) is granted credit to execute directly with another FX dealer (D4) in the prime broker's name (D3/PB). Upon execution, the client trade is normally "given up" to the prime broker. When the prime broker is informed and accepts the transaction between its client and another wholesale market participant (ie the so-called executing dealer, D4), it is the prime broker (rather than the client) which becomes the party to the transaction. The transaction between the prime broker and the executing dealer is defined by what is called a "give-up agreement".①

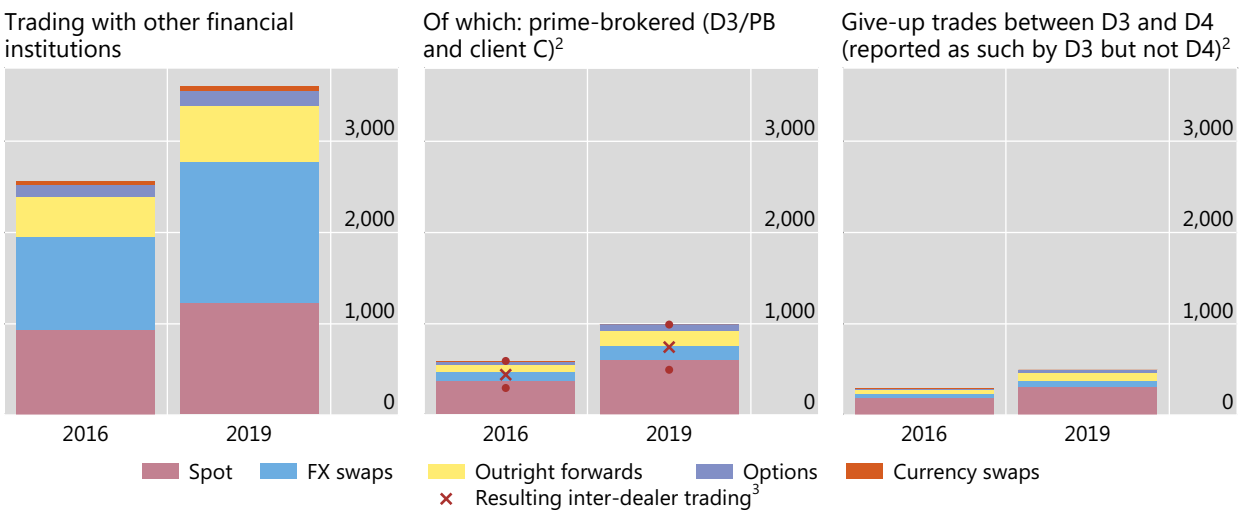
A key benefit that prime brokers provide to their customers is anonymity: the counterparty to the customer's trade (executing dealer D4) typically does not know that they are in fact dealing with a client (C) of a prime broker (dashed red arrow), as they only see the prime broker's identity (D3/PB). Prime brokers receive a fee for these services, which also include consolidated settlement, clearing and reporting.

In 2019, close to a third of turnover with financial customers was prime-brokered, as estimated from the corresponding breakdown in the Triennial Survey (Graph A2, left-hand and centre panels).② The rising prevalence of PB has implications for the turnover figures recorded by the Triennial. Even though effectively C trades with D4, there are actually two trades taking place which need to be recorded in the survey. In a scenario where two prime-brokered clients face each other directly, and their respective prime brokers each record another trade with their prime-brokered customer, a give-up trade executed by the two prime-brokered customers could create three times the turnover of a direct transaction. Hence, FX PB volumes to financial customers, which capture the amount of credit backing prime-

brokered customer trades, may exceed the associated give-up trades in the inter-dealer market (centre and right-hand panels).

FX prime brokerage implications for turnover volumes

Net-net basis,[1] in billions of US dollars — Graph A2



[1] Adjusted for local and cross-border inter-dealer double-counting; daily averages in April. [2] Prime-brokered turnover provided by reporting dealers is broken down into turnover between the reporting dealers and their prime brokerage customers (centre panel) versus the give-up trades with executing dealers (right-hand panel) under the assumption that all executing dealers are also reporting dealers to the Triennial Survey (but report the trade as a regular inter-dealer transaction), so that the inter-dealer leg entered the total after having been adjusted for double-counting. [3] If two prime-brokered clients face each other, then this volume will overstate the amount of give-up trades by a factor of two because of double-counting (bottom red dot). If prime-brokered clients always faced executing dealers as ultimate counterparties, then this volume would match the amount of give-up trades generated (top red dot). The cross is based on the assumption of equal likelihood for both scenarios.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

Given the central role played by credit, very large client trading losses can result in capital losses for prime brokers. The entire industry was jolted on 15 January 2015 when the Swiss franc moved by an intraday maximum of 39% against the euro after the Swiss National Bank abandoned its exchange rate ceiling. Although they recovered by the end of the day, key CHF exchange rate crosses against USD and EUR moved by as much as 12 standard deviations on that day. The shockwaves were felt in all corners of global FX markets. Prime brokers' risk management models were simply not set up to take into account such an extreme tail event. Individual losses to banks providing PB services to specialised retail FX margin brokers were in the hundreds of millions. Overall, the industry underwent a tightening of credit and risk management, more restrictive client onboarding requirements and consolidation. These developments were a key factor behind unusually depressed FX volumes as captured in the 2016 Triennial.③

Despite industry-wide changes, more recent examples show that prime brokers continue to face idiosyncratic risks from losses on client trades. According to media reports, in December 2018 a major FX dealer bank faced large losses stemming from a hedge fund client's trades in the Turkish lira, which experienced a bout of unusual volatility. As the client could not meet a margin call, the ensuing losses triggered a revision of the bank's entire approach to FX PB, including offboarding of large PTFs engaged in FX as non-bank market-makers.

① See Federal Reserve Bank of New York (2005) and Hasbrouck and Levich (2017) for a discussion. ② Prime-brokered turnover provided by reporting dealers is broken down into turnover between the reporting dealers and their prime brokerage customers (D3/PB with C) versus the "give-up" trades with executing dealers (D3 with D4) under the assumption that all executing dealers are also reporting dealers to the Triennial Survey, so that the inter-dealer leg entered the total after having been adjusted for double-counting. ③ Many prime brokers evaluated their business model and risk appetite after the Swiss franc shock, shedding certain types of clients (smaller hedge funds and retail brokers, who were pushed towards the so-called prime of prime model; see Moore et al (2016) for a discussion).

Electronification of trading across key market segments

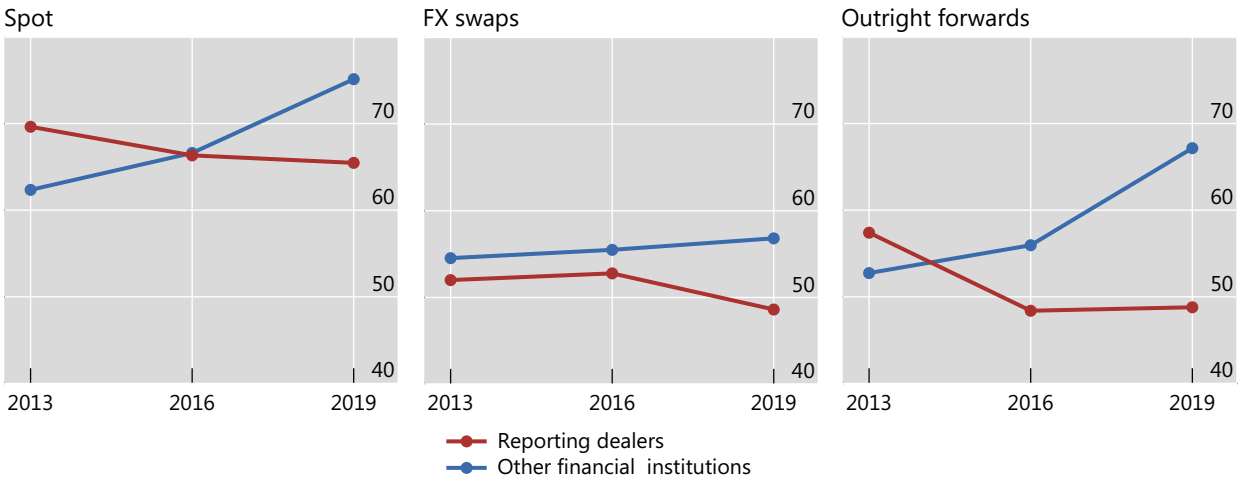
Electronic execution (e-trading) allows for fast trading and therefore contributes to overall FX turnover growth. In aggregate, the share of FX trading done electronically edged up only slightly to 56% in 2019. However, there are notable differences in the progress of electronification across instruments, and in inter-dealer versus dealer-to-customer market segments.

FX market electronification originally took off in the inter-dealer spot segment with the advent of centralised limit order books on electronic brokerage platforms such as EBS and Reuters (Refinitiv). However, this market segment no longer leads in electronification of FX trading. In fact, the share of e-trading in inter-dealer spot markets actually witnessed a decline (see Schrimpf and Sushko (2019) in this issue). It grew at a much faster pace in dealer-to-customer transactions with other financial institutions (Graph 5, left-hand panel). As discussed above, much of this increase owes to more active participation by PTFs as non-bank market-makers.

The divergence in the pace of electronification between the dealer-to-customer and dealer-to-dealer segments is also visible in other instruments, such as FX swaps and, especially, forwards (Graph 5, centre and right-hand panels). Trading in forwards between dealers and their financial customers exhibited the most rapid pace of electronification. Trading in NDFs constitutes a significant part of this activity (see Patel and Xia (2019) in this issue). In particular, making NDFs tradable on electronic platforms has attracted greater volumes from hedge funds and PTFs.[12]

Shares of electronic trading by market participant type and instrument

Percentage of total turnover[1] Graph 5



[1] Calculated as the share of both direct and indirect electronic execution method in the total turnover (electronic and voice) of each instrument, excluding turnover not distributed to any execution method. Turnover adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

[12] Discussions with market participants suggest that, while more than 90% of PTFs' turnover in OTC FX instruments is in spot, their trading in forwards has been growing rapidly and tends to be concentrated disproportionately in NDF currencies.

Concentration of FX trading in offshore hubs

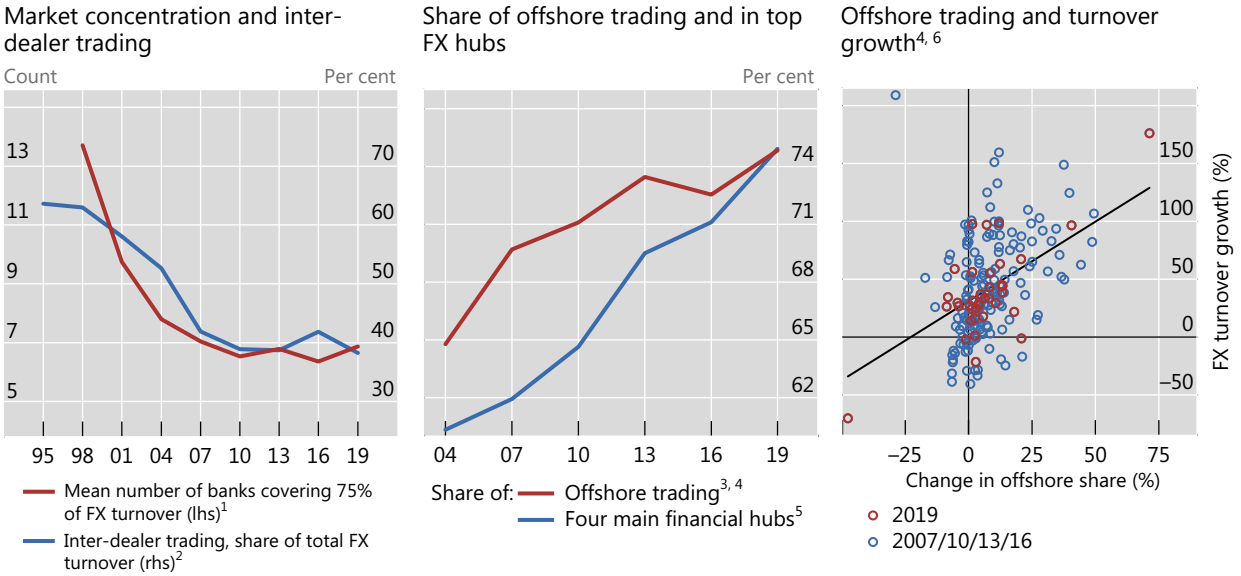
Even though FX trading is highly fragmented across numerous electronic venues and "liquidity pools", most activity passes through the desks of just a handful of top dealers (Graph 6, left-hand panel) in a few financial hubs. London alone accounts for 43%, while the combined share of the top four trading centres, which also include New York, Singapore and Hong Kong SAR, amounts to 75% of global FX turnover. Moreover, their combined share increased steadily (centre panel).

This concentration tendency has naturally gone hand in hand with a higher share of offshore trading, transactions where both counterparties are located outside the currency-issuing jurisdiction. In today's currency markets that trade around the clock, offshore trading is the norm. The share of offshore trading for the US dollar, euro and Japanese yen – the three most traded currencies – is 79%, 84% and 74%, respectively.

The economies of geographical concentration are the main force driving the rise of offshore trading. It is much less costly to build counterparty and credit relationships with dealers and clients in just a handful of centres than in each country separately. Placing FX desks within the same location as banks' other functions, such as money market and treasury units, also favours major financial centres. Differences in legal frameworks and IT infrastructures,[13] and the sheer number of business affiliates that would be required to run geographically dispersed FX trading, all speak in favour of

Concentration among a few dealer banks and FX hubs spurs offshore trading

Graph 6



[1] Across the following jurisdictions: Australia, Brazil, Denmark, France, Germany, Hong Kong SAR, Japan, Singapore, Sweden, Switzerland, the United Kingdom and the United States. [2] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [3] Turnover-weighted average. [4] Intra-euro area transactions are classified as offshore in the calculation of the EUR offshore share. [5] Hong Kong SAR, Singapore, the United Kingdom and the United States. [6] The FX turnover growth between each Triennial Survey is calculated in logarithmic terms.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

[13] Eichengreen et al (2016) argue that technology has implications for the distribution of FX transactions across financial centres, boosting the share of London in global turnover by as much as one third.

geographical concentration.[14] In particular, major dealers tend to consolidate their electronic trading business in one of the major FX hubs. This concentration thus partly compensates for the decentralised OTC structure of FX markets.

Hence, a rise in the share of offshore trading is associated with a rise in that currency's trading volume, and vice versa (Graph 6, right-hand panel, and in line with regression results reported in Table 1). For example, the decline in the turnover in the Malaysian ringgit between 2016 and 2019 is consistent with authorities effectively prohibiting offshore MYR trading. The relatively slow growth of renminbi trading is also in line with the fall in the share of offshore renminbi (CNH) trading (see Box B).

Conclusion

Global FX volumes recovered from the lows recorded in the previous BIS Triennial Survey. FX trading volumes were buoyed by a pickup in trading with financial clients, such as smaller banks, hedge funds and principal trading firms. Prime brokerage volumes thus saw a rebound across all instruments, which was particularly visible in spot. A strong pickup in trading of FX swaps, especially by smaller banks, was the largest single contributor to overall FX turnover growth, and largely owed to the crucial role of these instruments in banks' funding liquidity management.

The 2019 Triennial results also point to the increased footprint of non-bank electronic market-makers, a subset of the broader class of principal trading firms. These new players provide FX intermediation services by substituting speed for balance sheet. Their larger FX market presence, now also in direct relationship trading akin to that of bank dealers, has become vital to understanding liquidity conditions and market functioning.

The dominance of financial trading motives and further electronification of FX trading, particularly in the dealer-customer segment, has been conducive to further concentration of trading in a few financial hubs where e-trading is booked. Hence, more geographically concentrated trading, aided by technology, compensates to some extent for the otherwise highly fragmented nature of FX markets.

[14] For example, there are three main Equinix data centres and internet exchange sites: London (LD4), New York (NY4) and Tokyo (TY4). Major electronic brokers and FX dealers co-locate their servers in these locations, and so do the more sophisticated FX clients.

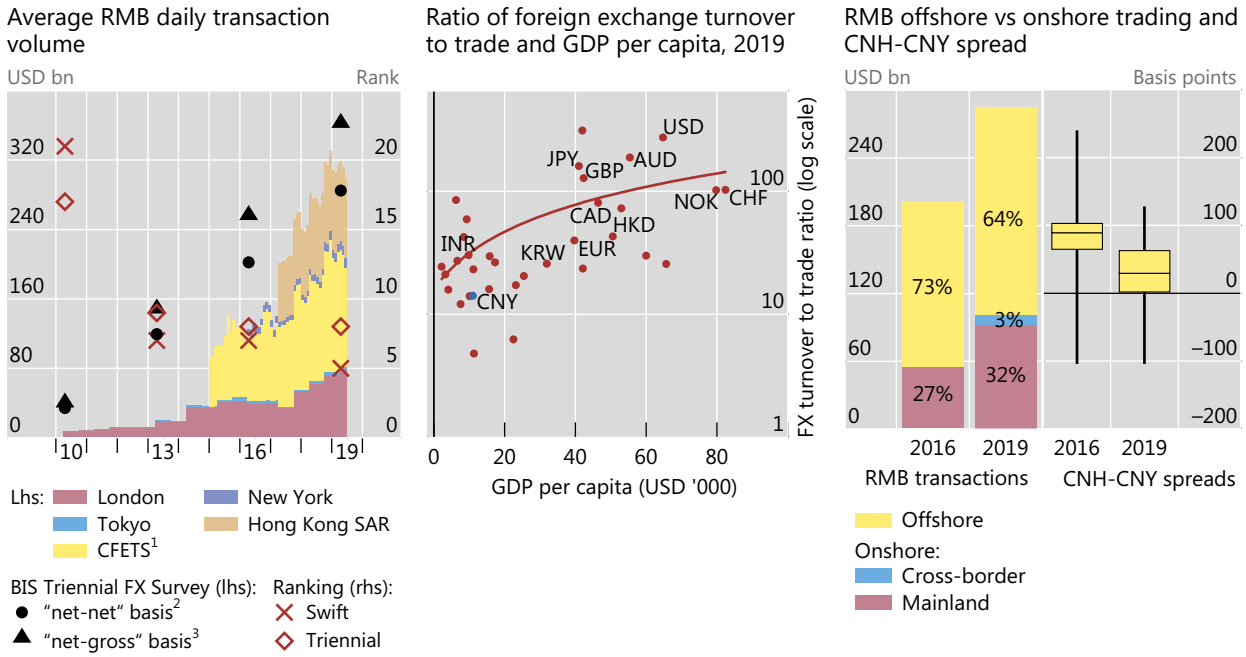
Renminbi turnover tilts onshore

Frank Packer, Andreas Schrimpf and Vladyslav Sushko

The average daily turnover of the Chinese renminbi (RMB) surpassed $280 billion per day in April 2019, yet it remained only the world's eighth most traded currency (Graph B1, left-hand panel). The share of RMB in global FX trading rose by less than between previous Triennial Surveys, to 4.3% in 2019, because of subdued growth in offshore RMB (CNH) trading.① RMB turnover remains lower than expected based on real economy indicators, such as trade volume and GDP per capita (centre panel). The deviation can be explained by financial drivers, such as restrictions on financial capital flows. For the first time in over a decade, the relative importance of onshore RMB trading on platforms such as CFETS increased, while the share of CNH turnover declined, from 73% in 2016 to 64% in 2019 (right-hand panel).②

Renminbi turnover and offshore trading

Graph B1



[1] Monthly volume is converted to average daily volume by dividing the monthly figures by the number of trading days each month. [2] Adjusted for local and cross-border inter-dealer double-counting. [3] Adjusted for local inter-dealer double-counting (ie "net-gross" basis); comparable with the sum of the semiannual FX committee turnovers, which is also "net-gross".

Sources: IMF, *World Economic Outlook;* London Foreign Exchange Joint Standing Committee; Federal Reserve Bank of New York Foreign Exchange Committee; Tokyo Foreign Exchange Market Committee; Bloomberg; FOW TRADEdata; Futures Industry Association; SWIFT, *RMB Tracker*; Treasury Markets Association; Wind; BIS Triennial Central Bank Survey; authors' calculations.

The offshore share of RMB activity declined for a few reasons. First, several liquidity squeezes in the CNH market in 2016–17 deterred speculative activity. CNH-CNY spreads were lower in 2019 than in 2016 (Graph B1, right-hand panel). Second, returns on offshore deposits were low, making them less attractive than those in other currencies and weighing on their growth (Graph B2, left-hand panel). Third, tighter controls by the mainland authorities reduced issuance of RMB bonds offshore (dim sum bonds) by Chinese corporates. The total stock of dim sum bonds declined between late 2016 and mid-2019, which had a negative impact on CNH liquidity. Fourth, Chinese authorities began to offer more direct ways for foreign investors to access onshore RMB markets. They opened more channels, such as Stock Connect, Bond Connect and CFETS Connect, and increased the quota for foreign institutional investors. These initiatives resulted in net investment flows from Hong Kong SAR to the mainland in excess of RMB 350 billion between Q2 2018 and Q1 2019.③

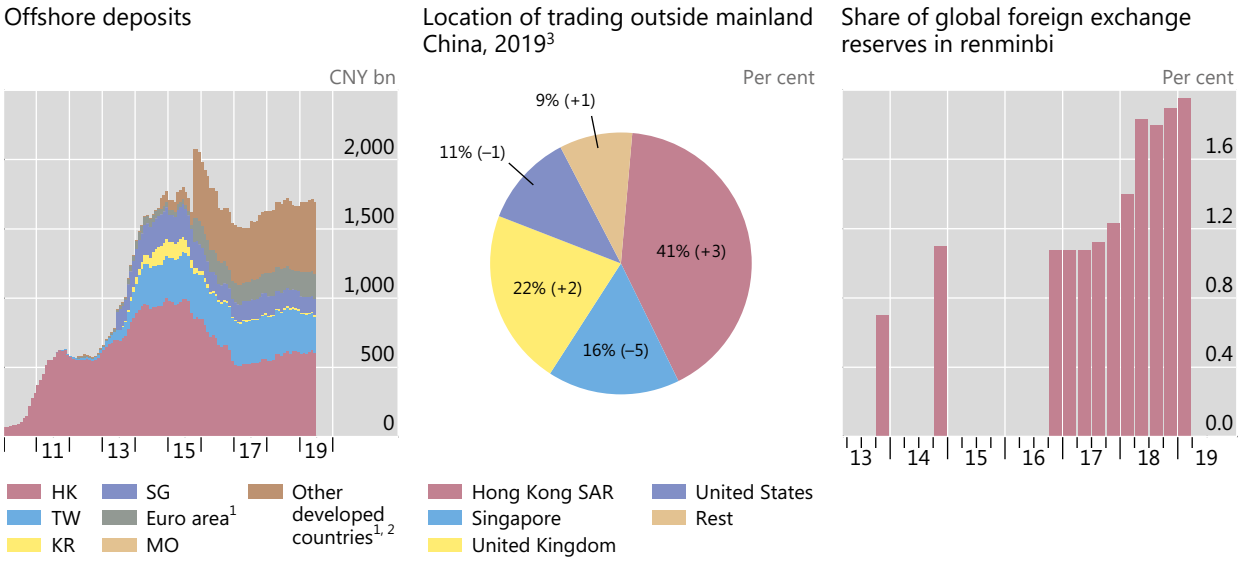
Over the past three years, offshore RMB activity saw an important shift in terms of location of trading, with the shares of Hong Kong and London rising to 41% and 22%, respectively (Graph B2, centre panel). As hedge fund interest in CNH has waned, due to the factors listed above, offshore trading in RMB has favoured banking and clearing centres

with direct onshore links, most notably in Hong Kong. Hence, in April RMB ranked fifth in SWIFT (Graph B1, left-hand panel), which captures bank-to-bank payment flows. London has also continued to increase its status as a leading offshore hub for RMB, having displaced Singapore as the largest trading centre for RMB outside greater China.④

In contrast with the decelerating growth in overall RMB turnover, central bank reserves held in RMB rose significantly in recent years, with official institutions accounting for 51% of total turnover by foreign institutional investors by Q3 2018.⑤ RMB turnover involving official sector counterparties grew from a daily average of $1.1 billion to $2.0 billion over the last three years. At the same time, the RMB's share in total FX reserves almost doubled from 1% in 2016 to nearly 2% in 2019, equivalent to about $200 billion (Graph B2, right-hand panel), further evidence of the increased attention of the public sector to investment opportunities in RMB. RMB reserve allocations have benefited from the authorities' stepwise process of opening up onshore markets, as well as relatively high returns compared with other fixed income instruments and good diversification properties relative to other reserve currencies.

Offshore RMB deposits, trading by location and share in official reserves

Graph B2



[1] Data are available from Q2 2012 (as a part of CGFS enhancements) and the coverage is partial. [2] Australia, Canada, Denmark, Japan, Norway, Sweden, Switzerland, the United Kingdom and the United States. [3] As a total of CNY trading excluding mainland China.

Sources: People's Bank of China; CEIC; BIS locational banking statistics by residence and Triennial Central Bank Survey.

① CNH is used to refer to offshore RMB activity, CNY onshore activity. In addition to intervention in the market, the People's Bank of China also imposed a reserve requirement on the offshore renminbi in 2016. ② See eg Ehlers et al (2016). ③ Citi Research (2019). ④ This is consistent with the prediction of Cheung et al (2019). ⑤ Rigaudy (2019).

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Annex table

Global FX market turnover in April 2019, by counterparty and instrument

Net-net basis,[1] daily averages in April 2019 — Table A

	Turnover in 2019	2016–19 change	2016–19 change	Contribution to 2016–19 change
	USD bn		In per cent	
Global FX market	6,595	1,529	30%	100%
By counterparty				
Reporting dealers	2,523	403	19%	26%
Other financial institutions	3,599	1,034	40%	68%
Of which:				
Non-reporting banks	1,616	502	45%	33%
Institutional investors	777	–21	–3%	–1%
Hedge funds and principal trading firms	593	204	52%	13%
Official sector financial institutions	89	15	21%	1%
Other[2]	499	317	174%	21%
Non-financial customers	474	92	24%	6%
By instrument				
Spot	1,987	335	20%	22%
Outright forwards	999	300	43%	20%
FX swaps	3,203	825	35%	54%
Currency swaps	108	26	32%	2%
Options	298	43	17%	3%

[1] Adjusted for local and cross-border double-counting. Turnover and absolute change rounded. Undistributed volumes omitted from the table. [2] This category can include various other financial counterparties, such as securities firms, financial arms of corporates, retail aggregators or institutions performing the role of so-called prime of prime (see Moore et al (2016)).

Sources: BIS Triennial Central Bank Survey; authors' calculations.

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FX trade execution: complex and highly fragmented[1]

The 2019 Triennial Survey shows that trade execution has undergone rapid change, with more diverse participants, new technologies and increasing complexity. Electronification advanced the fastest in dealer-to-customer trading. Dealers and customers navigated a highly fragmented market by leveraging technology to trade across electronic venues. Aspects of FX intermediation tilted more towards non-banks as new market-makers, albeit brokered by top dealers. Bank dealers continued to attract large flows to their own proprietary liquidity pools. Consequently, even though the market grew bigger as a whole, the share of trading activity `visible´ to the broader market declined.

JEL classification: C42, C82, F31, G12, G15.

For many years, the BIS Triennial Central Bank Survey[2] has chronicled changes in the structure of foreign exchange (FX) markets and the way trades are executed, meaning where and how orders are filled. The latest survey shows that trade execution has undergone rapid change. FX trading is turning more electronic, participants are becoming more diverse, and trading venues are multiplying. These innovations have enhanced the speed of trading, offered participants more choices and facilitated a greater variety of trading strategies.

This special feature first describes how FX markets have become increasingly complex and fragmented. It then analyses recent developments in trade execution in different market segments in general, and the growth of electronic trading in particular. The concluding section discusses the possible implications of these changes for the resilience of FX markets. A box takes a close look at a crucial element of the post-trade ecosystem – how market participants mitigate FX settlement risk.

[1] The authors would like to thank Benjamin Anderegg, Sirio Aramonte, Morten Bech, Claudio Borio, Alain Chaboud, Yin-Wong Cheung, Stijn Claessens, Jenny Hancock, Brian Hardy, Henry Holden, Wenqian Huang, Thomas Maag, Robert McCauley, Dagfinn Rime, Takeshi Shirakami, Hyun Song Shin, and Philip Wooldridge for input. We also greatly appreciate the feedback and insightful discussions with numerous market participants at major FX dealer banks, buy-side institutions, electronic market-makers and trading platforms. We are also grateful to Yifan Ma and Denis Pêtre for compiling the underlying data and Adam Cap 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] For information about the Triennial Survey, see www.bis.org/statistics/rpfx19.htm.

Key takeaways

- Electronification advanced most rapidly in dealer-to-customer trading, while the electronic share of inter-dealer trading decreased.
- A rise in intermediation within dealers' proprietary liquidity pools contributed to a decline in the share of "visible" FX trading in spot markets.
- Customers and dealers responded to market fragmentation by executing trades across a large number of electronic venues.

The feature complements the analysis of the main drivers of recent growth in global FX turnover in Schrimpf and Sushko (2019) in this issue.

An increasingly complex and fragmented market structure

FX trading has become more complex and fragmented over the years.[3] FX markets were long characterised by a two-tier structure, with clearly delineated inter-dealer and dealer-customer segments. This structure has blurred somewhat over the years (Graph 1). Financial institutions outside the bank dealer community have taken on important intermediation functions, and a plethora of electronic trading venues have emerged. These developments have led to ever greater choice in how to execute trades but also to a highly fragmented market structure.

An important catalyst of these developments was prime brokerage, whereby top FX dealers allow clients to trade directly in the bank's name with its established counterparties. Principal trading firms (PTFs) are some of the heaviest users of prime brokerage services. PTFs employ algorithmic trading strategies and have been active in FX for quite some time. What is new in recent years is that some have built a business model around making markets and thus have deeply penetrated the realm that previously was exclusive to dealers (see Schrimpf and Sushko (2019) in this issue). Prime brokered trading now accounts for a large fraction of volumes on platforms that historically catered to interbank trading, such as electronic brokers.[4]

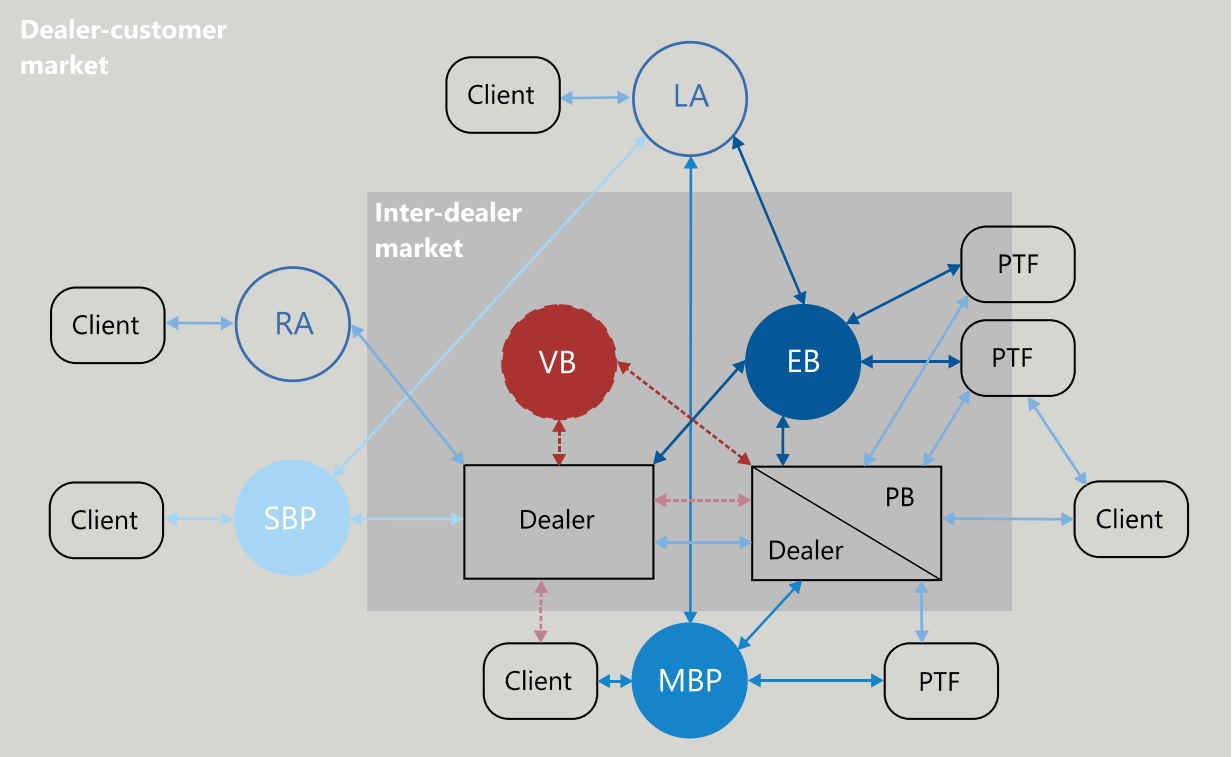
The proliferation of alternative ways to conduct trades has been spurred by customers "shopping around" for best execution and by technology providers facing lower costs to set up such platforms. Another trend has been the use of liquidity aggregators that bundle access to different trading venues or liquidity providers (Oomen (2017)). Countering this tendency, FX dealer banks, in turn, have sought to build stronger relationships with their customers. They have invested heavily in improving the technology and functionality of their proprietary trading platform offerings, known as single-bank platforms.

[3] King et al (2012) illustrate the gradual build-up of complexity of the market from the 1980s through the first decade of the 2000s. We add a layer to capture further developments over the past decade.

[4] Another set of players, not discussed further in this article, are retail clients (eg individuals, family offices or smaller hedge funds). Their trading needs are served by retail brokerage platforms or retail aggregators (denoted by RA in Graph 1). Their market access has become one-step removed from wholesale FX markets because of their reliance on so-called "prime-of-prime", as discussed by Moore et al (2016).

Stylised structure of the FX market

Graph 1



EB = electronic broker; LA = liquidity aggregator; MBP = multi-bank platform; PB = prime broker; PTF = principal trading firm; RA = retail aggregator; SBP = single-bank platform; VB = voice broker. Dashed lines indicate voice execution; solid lines indicate electronic execution.

Source: King et al (2012), augmented by adding LA to depict liquidity aggregators and PTFs in their roles as both clients and intermediaries.

The resulting fragmentation of the FX market has made it harder to assess market conditions at any given point in time. Market participants wishing to trade FX have more than 75 different FX venues at their disposal (Sinclair (2018)).[5] At the same time, greater internalisation of customer flow by banks (explained below) reduced the amount of inter-dealer trading via the main electronic brokers. Thus, while the market as a whole grew bigger, the share of trading activity that is "visible" to the broader market declined. Against this background, the execution methods data collected in the Triennial Survey provide a unique and rare perspective on how the structure of this crucial, yet inherently opaque, market has evolved.

Mapping out trade execution using the Triennial Survey

The taxonomy used in the Triennial Survey to capture data on execution methods is aligned with the main features of the market structure sketched above. At the broadest level, it distinguishes between "voice" and "electronic" execution. Within each, it further differentiates between "direct" (bilateral) and "indirect" (brokered) trading. "Direct" includes relationship-based trading by phone, trades through a chatting system, via a proprietary single-bank platform, or a direct electronic price

[5] These venues differ in terms of the pool of participants (eg composition of fast (algorithmic) vs slow (human) traders, or banks vs non-bank players), microstructural aspects affecting latency, the order queuing or cancellation process of the platform's matching engine, "last-look" (ability of liquidity providers to reject the trade even after their price quotes are hit) policies, as well as the suite of different trading protocols.

stream. "Indirect" refers to the involvement of a third party in the matching process. This can, for instance, be a traditional voice broker, an electronic broking platform or a multi-bank platform.

The 2019 Triennial Survey data on execution methods corroborate the picture of great diversity in trade execution choices. Electronic trading dominates, although voice remains significant in some market segments (Graph 2, left-hand panel and Annex Table A). Electronic trading was roughly equally split between "direct" and "indirect" trading in 2019, whereas "direct" electronic trading had a significantly higher market share three years earlier. Drilling down further into various forms of electronic trading, direct forms of electronic execution were about equally split between single-bank platforms and other direct forms of electronic trading, such as price streams (Graph 2, right-hand panel). When it comes to indirect electronic trading, "anonymous" venues, where counterparty identities are only revealed post-trade, attracted a slightly higher market share than "disclosed" venues, where counterparties know each other's identity before they decide to trade.

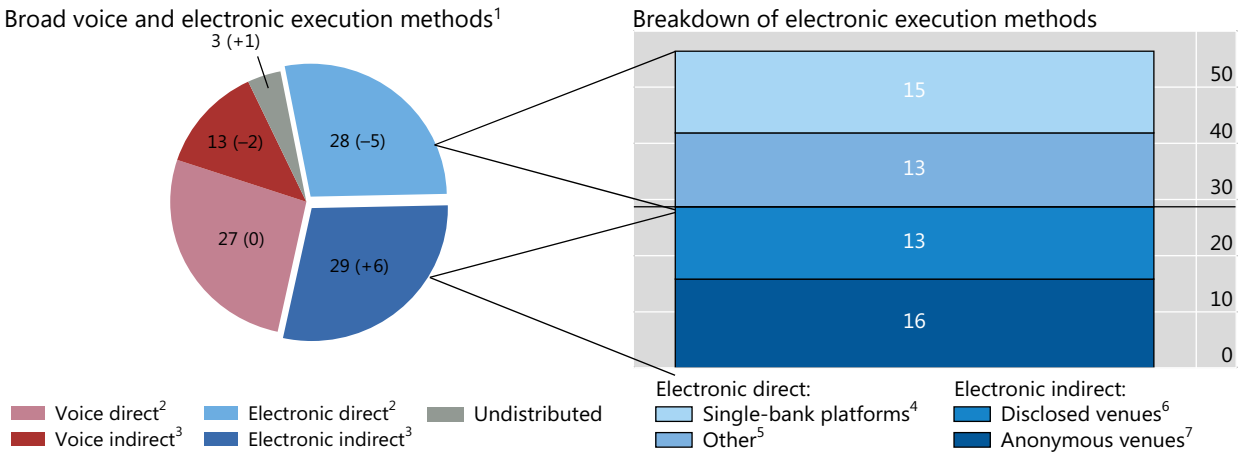
How is the landscape of FX trade execution evolving?

The main trend in FX trade execution has been increased "electronification"– deeper penetration of the market by electronic and automated trading. Electronification comes in a variety of forms, catering to the needs of a diverse set of players (fast and slow traders, banks and non-banks etc). It enables automated and continuous trading, bringing together participants with diverse trading interests so that they can more seamlessly adjust and redistribute financial exposures.

The 2019 Triennial Survey shows that the share of FX trading executed electronically edged up only slightly since the previous survey (Graph 3, left-hand

How were FX trades executed in April 2019?

Percentage shares in total turnover — Graph 2



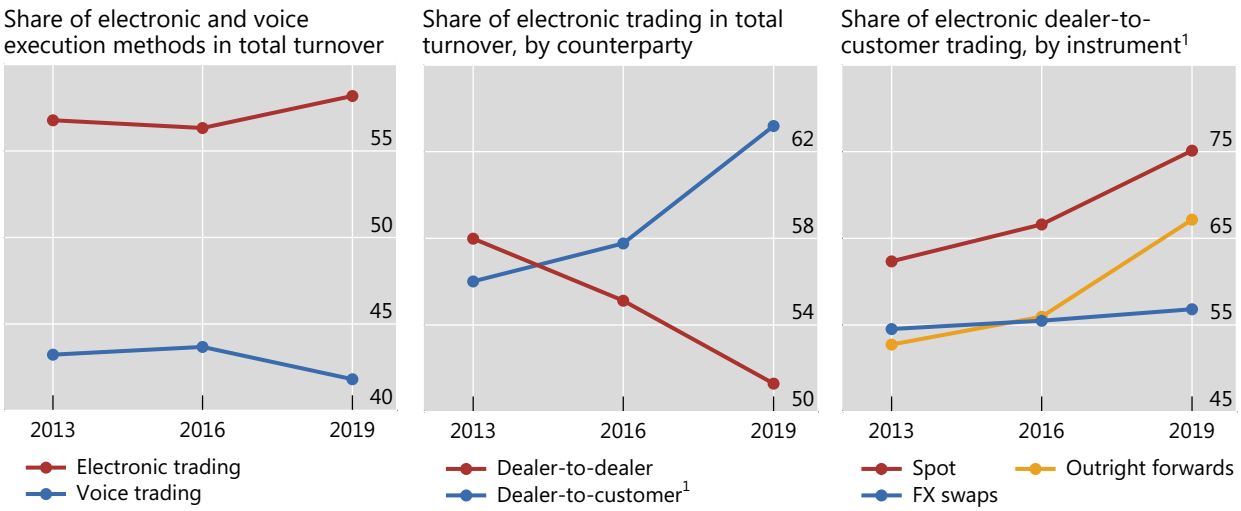
[1] Change in percentage points since the 2016 Triennial Survey indicated in brackets. [2] "Direct" refers to trades not intermediated by a third party. [3] "Indirect" refers to trades intermediated by a third party – either a voice broker or a third-party electronic platform. [4] Single-bank trading systems (eg Barclays BARX, Citi Velocity, Deutsche Bank Autobahn, UBS Neo). [5] Other direct electronic trading systems (eg direct electronic price streams). [6] Multi-bank dealing systems that facilitate trading on a disclosed basis or that allow for liquidity partitioning using customised tags (eg 360T, EBS Direct, Currenex FXTrades, Fastmatch, FXall OrderBook, Hotspot Link). [7] Electronic trading platforms geared to the non-disclosed inter-dealer market (eg EBS Market, Hotspot FX ECN, Reuters (Refinitiv) Matching).

Sources: BIS Triennial Central Bank Survey; authors' calculations.

Uneven pace of foreign exchange market electronification

In per cent

Graph 3



[1] Based on dealer trading with other financial institutions.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

panel), rising by 2 percentage points to 58% by 2019. Yet the market-wide average masks notable differences across key instruments and market segments.

Electronification progresses fastest in the dealer-customer segment

The segment where electronification progressed the fastest was dealer-to-customer transactions (Graph 3, centre panel). This rise also reflects the changing composition of market participants, with financial customers, such as hedge funds and PTFs, and lower-tier banks playing a more active role (see Schrimpf and Sushko (2019) in this issue). The dealer-customer segment has arguably also been the place where technological innovation has been the fastest, as witnessed by a greater range of trading venues featuring a diversity of execution protocols.

Spot remains the instrument with the highest electronic trading share, which stood at 75% of dealer-to-client transactions (Graph 3, right-hand panel). That said, electronic trading in forwards has been catching up at an accelerating pace.[6] Non-deliverable forwards (NDFs), which are typically used for EME currencies, in particular witnessed a rapid rise in electronic trading (see Patel and Xia (2019) in this issue, Box B). Platform trading and prime-brokered access, in turn, have attracted hedge funds and PTFs to trade NDFs electronically.

Interbank electronic trading in spot declines

In contrast to its rise in dealer-to-customer markets, electronic spot trading in inter-dealer markets saw a decline in both relative and absolute terms, falling by 7% since 2016 to $368 billion per day in the latest Triennial Survey. As a result, inter-dealer

[6] The leading platform provider, EBS, introduced electronic prime brokerage for NDFs in 2016, and Reuters (Refinitiv) announced plans to introduce electronic matching for NDFs in 2020.

trading accounted for less than a third of the total electronic spot market in 2019, 10 percentage points lower than in 2016 (Graph 4, left-hand panel).

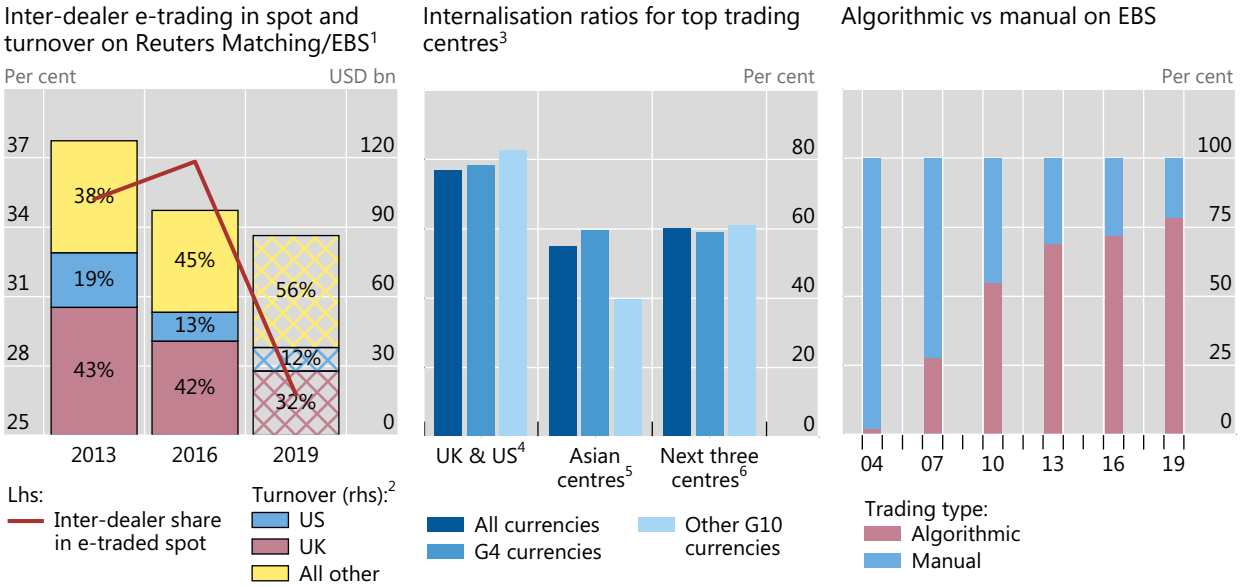
This decline in electronic inter-dealer trading was driven principally by internalisation, whereby dealers temporarily warehouse risk arising from client transactions until it is offset against opposing client flow. This practice, in turn, reduces the need to offload any imbalances in inter-dealer markets. Data showed dealers reporting in the United Kingdom and the United States had some of the largest declines in electronic trading on anonymous inter-dealer venues (Graph 4, left-hand panel) and also posted some of the highest internalisation ratios for spot trades (Graph 4, centre panel).

As a consequence, electronic inter-dealer brokerage systems, which have long constituted the main locus of electronic inter-dealer trading, now only account for a small fraction of the entire market. As Evans and Rime (2019) highlight, order book depth on these platforms also declined in tandem. A likely factor has been greater algorithmic trading (Graph 4, right-hand panel), especially by PTFs (on a prime brokered basis), which tends to involve greater activity at the top of the order book. Despite this, these so-called primary venues (eg EBS Market and Reuters (Refinitiv) Matching) are still vital for FX market functioning. Primary venues still serve as an important point of price discovery (Markets Committee (2018)), and when volatility rises, internalisation becomes more challenging and dealers need these venues to manage inventory imbalances (Moore et al (2016)).

More internalisation also means that fewer trades are visible in the broader marketplace, resulting in less information leakage (Butz and Oomen (2019)). It likely

Inter-dealer spot e-trading stagnates due to internalisation

Graph 4



[1] The 2019 data also include turnover on other anonymous venues and hence are not directly comparable with the 2016 figures for this data breakdown. [2] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [3] Volume-weighted averages using total customer spot turnover. [4] For the United States, same share of customer spot turnover in total spot turnover as in the United Kingdom is assumed to calculate the volume-weighted average. [5] Hong Kong SAR, Japan and Singapore. [6] France, Germany and Switzerland.

Sources: EBS; BIS Triennial Central Bank Survey; authors' calculations.

led to an increase in "on-us" settlement across the books of the dealers.[7] Internalisation may also partly explain why the FX industry remains highly concentrated among a few very large dealers. It may contribute to a market structure in which concentration begets more concentration: given that dealers with large flows from a diverse set of clients find it easier to internalise and can price more competitively, letting them attract ever greater customer flows. Indeed, the falling share of inter-dealer trading has gone hand-in-hand with a handful of banks coming to dominate FX volumes.[8] By contrast, banks finding it hard to compete turn to other niches to retain an edge (eg providing execution algorithms to clients).

The ability of dealers to internalise benefits greatly from electronification and the ability to attract customers to trading via single-bank platforms or direct price streams. Subdued FX volatility in recent years was also conducive to internalisation. This is because there have been fewer instances of large imbalances in order flow that are difficult to match internally, thus requiring hedging on inter-dealer venues.

FX swaps still rely heavily on voice intermediation

The 2019 Triennial Survey confirms that, despite the overall trend, electronic trading is not progressing uniformly across all instruments and market segments. Most prominently, inter-dealer trading of FX swaps has remained heavily voice-reliant, while dealer-to-customer trading has moved towards greater use of electronic execution methods.

There are several interrelated reasons for voice retaining a higher share in FX swaps. First, swap trades vary greatly in size, with inter-dealer transactions at times involving particularly large notional amounts. Second, FX swaps are more difficult to price, with internal and balance sheet considerations playing a relatively larger role. The largest dealers use internal models to set their prices (eg relying on their money market desk and taking funding rates in different currencies as inputs) as opposed to sourcing price signals from wholesale venues. This means that inter-dealer FX swap trading still often relies on intermediation via voice brokers. Third, FX swap trading entails management of credit risk because it involves exchanging principal in two different currencies, at the spot rate at contract inception and at the forward rate at contract maturity. This risk needs to be managed and allocated across counterparties which, at least so far, still requires some manual processes.

By contrast, electronic trading continues to make inroads into dealer-to-customer FX swap trading. When quoting bid or ask prices to customers, dealers can rely on inter-dealer mid-prices as input. Such trading with customers is more amenable to electronification, eg by streaming prices on a single-bank platform or responding to a request-for-quote on a multi-dealer-platform.

[7] On-us settlement is where both legs of a FX transaction are settled across the books of a single institution. It is not a payment-versus-payment settlement method (see box).

[8] On average, desks belonging to seven reporting banks account for 75% of FX turnover in each jurisdiction. Schrimpf and Sushko (2019) in this issue also show the inverse relationship between concentration and inter-dealer trading.

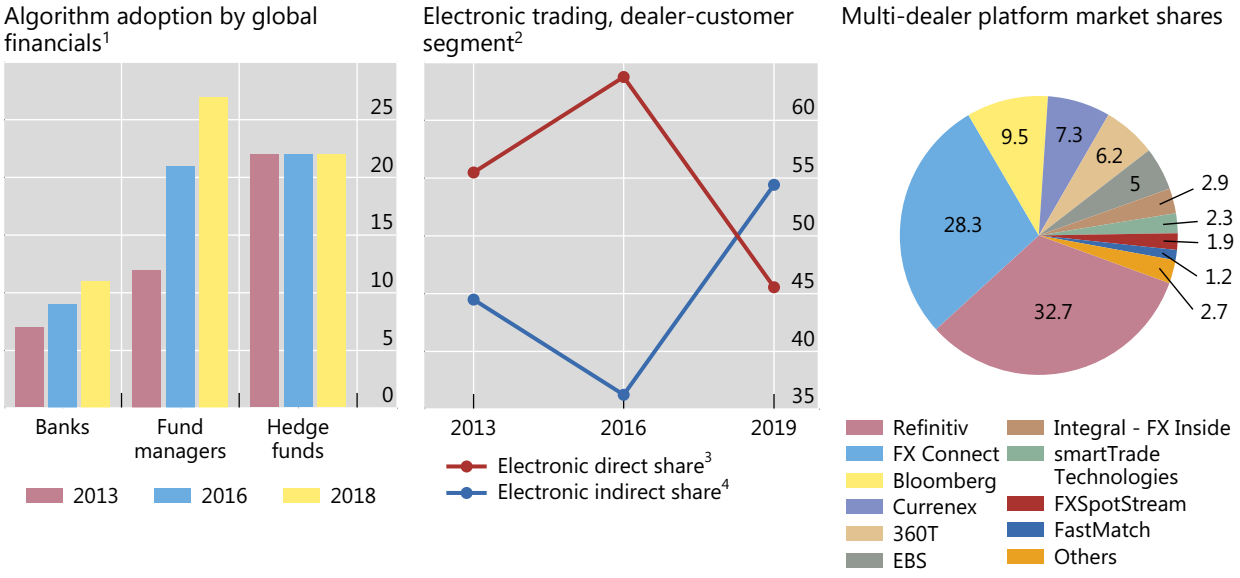
Further fragmentation as execution spreads across secondary venues

The 2019 Triennial Survey shows that trading on multi-bank platforms (sometimes referred to as "secondary venues" to contrast them with electronic brokers, which are referred to as "primary venues") constitutes the fastest growing execution method over the past three years. Some of these secondary venues operate anonymous limit order books, akin to those on primary venues. Others cater to disclosed forms of electronic trading, where identities are known to the counterparties before they decide to engage in a trade. This allows some aspects of relationship trading to be retained, while also matching with a broader pool of potential counterparties.

The trend towards greater reliance on methods where end users can choose from a range of liquidity providers and various ways to implement the trade is reinforced by increased attention to best execution. Sophisticated clients increasingly rely on execution algorithms to spread large orders over time and across multiple electronic venues.[9] Hedge funds have been the early adopters of execution algorithms, although fund managers have followed suit (Graph 5, left-hand panel).[10] As an indication of clients becoming more cost-conscious, trading on multi-bank platforms, or via liquidity aggregators bundling various venues and providers, has surpassed single-bank platform volumes and other direct forms of electronic trading (Graph 5,

Sophisticated customers spread their electronic trading across venues

In per cent — Graph 5



[1] Based on responses from 710 top-tier financial FX users. [2] Based on dealer trading with other financial institutions. [3] Trading executed via single-dealer platforms or other direct electronic execution methods, such as API. [4] Electronic trading intermediated by a third party such as via an electronic broking system or electronic communication network.

Sources: Euromoney Foreign Exchange Survey 2019; Greenwich Associates 2018 Global Foreign Exchange Study; BIS Triennial Central Bank Survey; authors' calculations.

[9] The cost-efficient execution of large volumes is the primary driver of execution algorithm use. With automated execution, it is the customers who bear market risk instead of dealer banks.

[10] Financial clients, such as money managers, are also under considerable pressure to demonstrate best execution, with an additional push from regulatory reforms such as MiFID II. Although MiFID II is a European regulation, its global impact is highlighted in the JP Morgan *Electronic Trading Trends for*

centre panel).[11] For example, according to the 2019 *Euromoney* survey, buy-side customers trade using over a dozen different platform providers (Graph 5, right-hand panel).[12] It is also common for top-tier liquidity providers (including non-bank market-makers) to cater to this demand by quoting simultaneously on a wide range of venues (Markets Committee (2018)).

Conclusion

FX trading has evolved rapidly over recent years. It has seen further electronification and increasing variety in trading venues and protocols. In spot, FX intermediation has tilted towards non-bank electronic market-makers, who substitute speed for balance sheet. Activity has also gravitated more to dealers' proprietary liquidity pools and away from primary inter-dealer venues. Clients can use algorithms to enhance execution and navigate a fragmented market, albeit in exchange for taking on more market risk themselves. All these developments have led to more choice for tech-savvy clients, but also to some important risk-shifting and greater market fragmentation.

Yet there are signs that fragmentation may be reaching its peak. Some customers are reportedly questioning the cost of connecting to so many venues. Dealers, too, have been re-assessing whether it is beneficial to quote prices on a large number of third-party systems. For example, a top-tier bank recently announced plans to slash the number of systems it uses, from 45 to 15. Similarly, some PTFs focused on market-making have reportedly also cut down on the number of electronic communication networks where they post prices.

Furthermore, the current market configuration has emerged largely during a prolonged period of low volatility, and its resilience might be tested if the volatility regime were to change. For example, during periods of stress, FX dealers might ration liquidity and favour clients with whom they have a strong relationship, such as those using their single-bank platform. Thus, customers who spread execution across venues could face a sharp evaporation of liquidity. The question of whose risk-bearing capacity to rely on under such circumstances could become a pertinent one. In the event of stress, the resilience of FX markets could be further challenged by the declining use of payment-versus-payment systems to reduce FX settlement risk (see box).

2018 survey: while 73% of respondents in EMEA believe it will have an impact, 47% of respondents in the Americas and 45% in Asia-Pacific also hold the same view.

[11] Academic research indicates that clients face less price discrimination when trading FX derivatives through multilateral trading platforms (Hau et al (2019)).

[12] Some of the technology providers shown offer more than one platform for customer trading.

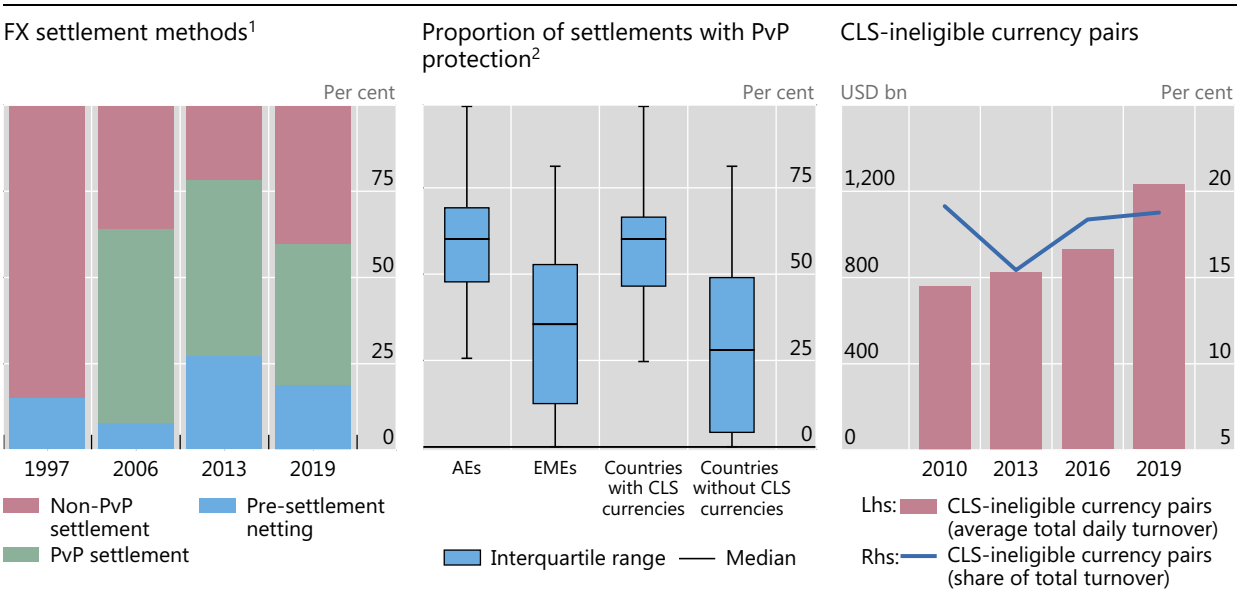
FX settlement risk remains significant

Morten Bech and Henry Holden

The settlement of FX trades can lead to significant risk exposures when one counterparty to a trade sends a currency payment to the other and needs to wait before receiving the currency it is buying. Over the past two decades, market participants have made significant progress in reducing FX settlement risk. Nevertheless, due in part to higher trading activity, the 2019 Triennial Survey indicates that close to $9 trillion of payments remain at risk on any given day.

The bankruptcy of Bankhaus Herstatt in 1974 demonstrated how FX settlement risk can undermine financial stability.① Herstatt was a medium-sized German bank active in FX markets. At 15:30 CET on 26 June 1974, the German authorities closed the bank down. While Herstatt had already received Deutsche marks from its counterparties, it had not yet made the corresponding US dollar payments in New York. Herstatt's failure to pay led banks more generally to stop outgoing payments until they were sure their countervalues had been received. The international payment system then froze, and the erosion of trust caused lending rates to spike and credit to be curtailed.

FX settlement risk: increasing and global — Graph A.1



[1] "PvP settlement" includes settlement through systems such as CLS and Hong Kong CHATS. [2] The median value is represented by a horizontal line, with 50% of the values falling in the range shown in the box. The highest and lowest values are represented by the upper and lower end points of the vertical lines.

Sources: Committee on Payment and Settlement Systems, "Progress in reducing foreign exchange settlement risk", *CPMI Papers*, no 83, May 2008; D Kos and R Levich, "Settlement risk in the global FX market: how much remains?", *SSRN*, October 2016; BIS Triennial Central Bank Survey; authors' calculations.

In 1996, G10 central banks endorsed a strategy to reduce FX settlement risk.② The strategy involved actions to be taken by banks to control their exposures, actions to be taken by industry groups to provide services and actions to be taken by central banks to induce progress. In response, in 2002 market participants set up Continuous Linked Settlement (CLS), a specialist institution that settles FX transactions on a payment-versus-payment (PvP) basis. PvP eliminates FX settlement risk by ensuring that a payment in a currency occurs if and only if the payment in the other currency takes place. The establishment of CLS and other actions led to a big reduction in FX settlement risk. Even at the height of the Great Financial Crisis, FX markets remained resilient. However, FX settlement risk appears to have increased since 2013 in both relative and absolute terms (Graph A.1, left-hand panel).

To help assess progress in reducing FX settlement risk, the Triennial Survey was expanded in 2019 to collect data on FX settlement. Different FX instruments give rise to different numbers of payments. For example, spot and outright forwards result in two payment obligations, whereas swaps result in four payments of principal (two at inception and

two at repayment). Some FX transactions, such as non-deliverable forwards, are settled with a single payment and are therefore not subject to FX settlement risk. FX trades can also be bilaterally netted, which eliminates a need for settlement.

After taking account of the number of payments for each instrument, in April 2019 daily global FX trading of $6.6 trillion translated into gross payment obligations worth $18.7 trillion (Table A.1). Bilateral netting reduced the payment obligations to $15.2 trillion. About $6.3 trillion was settled on a PvP basis using CLS or a similar settlement system. This left an estimated $8.9 trillion worth of FX payments at risk on any given day. The proportion of trades with PvP protection appears to have fallen from 50% in 2013 to 40% in 2019, although available data are not fully comparable across time (Graph A.1, left-hand panel).

One reason for the relative decline in PvP protection is the growth of trading in currencies not eligible for CLS settlement. In absolute terms, 90% of FX settlement risk is in the top 10 jurisdictions. However, these advanced economies settle a higher proportion of their FX with PvP protection than emerging market economies (EMEs) do, many of which have currencies that are not included in CLS (Graph A.1, centre panel). Nonetheless, CLS-eligible currency pairs still make up about 80% of total global trading activity (Graph A.1, right-hand panel). To reduce global risk, it may therefore be necessary to both encourage FX market participants to use PvP where available and widen that availability to include EME currencies. The task of reducing global risk is now firmly on the agenda of bank supervisors.③

Trading activity and payments — Table A.1

Description		Trades/payments
Trading activity		USD billions
A.	Spot	1,987
B.	Deliverable forwards	741
C.	FX and currency swaps	3,311
D.	NDFs and options[1]	556
E.	Total (= A + B + C + D)	6,595
Settlement		
F.	Gross payment obligations (= 2 × (A + B) + 4 × C)	18,701
G.	Bilateral netting[2]	(3,516)
H.	Net payment obligations (F – G)	15,185
I.	Of which: settled with PvP[3]	6,311
J.	Of which: settled without PvP protection[4]	8,874

[1] NDFs and some options are settled with a single payment and are therefore not subject to FX settlement risk. [2] Bilateral netting reduces the amount of payment obligations to be settled; it is calculated by applying the proportion of netting shown in the Triennial Survey. [3] Calculated using the CLS settlement data for April 2019 and the "Other PvP" proportion in the Triennial Survey. [4] "Without PVP protection" is the residual.

Sources: CLS; BIS Triennial Central Bank Survey; authors' calculations.

① G Galati, "Settlement risk in foreign exchange markets and CLS Bank", *BIS Quarterly Review*, December 2002, pp 55–65. ② Committee on Payment and Settlement Systems, "Settlement risk in foreign exchange transactions", *CPMI Papers*, no 17, March 1996. ③ Basel Committee on Banking Supervision, "Basel Committee discusses policy and supervisory initiatives and approves implementation reports", press release, October 2019.

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Execution method by instrument and counterparty in 2019, percentage shares

Net-net basis,[1] daily averages in April 2019, in per cent

Annex Table A

		Voice			Electronic						
						Electronic direct				Electronic indirect	
Counterparty sector	Instrument	Voice total	Direct[2]	Indirect[3]	Electronic total	*Electronic direct total*	Single-bank platforms[4]	Other direct[5]	*Electronic indirect total*	Anonymous venues[6]	Disclosed venues[7]
All counterparties	Spot	28	25	3	69	*32*	17	15	*37*	26	11
	FX swaps	46	24	21	52	*26*	14	12	*26*	12	14
	Outright forwards	38	31	7	57	*29*	13	16	*28*	13	15
	Currency swaps	77	63	14	19	*13*	3	9	*7*	1	6
	Options	65	50	15	31	*21*	19	2	*10*	3	7
Reporting dealers	Spot	33	28	5	62	*34*	20	14	*28*	15	14
	FX swaps	50	26	25	48	*23*	12	10	*25*	12	13
	Outright forwards	48	37	11	46	*28*	15	13	*18*	9	9
	Currency swaps	80	66	15	18	*9*	2	8	*8*	1	7
	Options	60	44	16	33	*21*	19	2	*12*	5	7
Other financial institutions	Spot	24	23	1	73	*29*	14	15	*44*	34	11
	FX swaps	42	23	19	55	*28*	14	14	*27*	12	15
	Outright forwards	31	26	6	64	*29*	12	17	*35*	17	18
	Currency swaps	76	62	14	22	*16*	4	12	*6*	1	5
	Options	69	54	16	29	*19*	18	1	*10*	3	7
Non-financial customers	Spot	35	31	3	64	*45*	21	24	*19*	9	10
	FX swaps	39	27	11	60	*36*	21	15	*24*	4	20
	Outright forwards	52	45	7	45	*30*	13	17	*15*	3	12
	Currency swaps	51	47	4	18	*15*	8	7	*3*	0	3
	Options	63	54	9	33	*28*	24	5	*5*	1	4

Percentage shares of total FX volumes for each counterparty segment and instrument; totals do not total 100 due to incomplete reporting.

[1] Adjusted for local and cross-border inter-dealer double-counting. [2] "Direct" refers to trades not intermediated by a third party. [3] "Indirect" refers to deals intermediated by a third party, ie either a voice or an electronic broker. [4] Single-bank trading systems (eg Barclays BARX, Citi Velocity, Deutsche Bank Autobahn, UBS Neo). [5] Other direct electronic trading systems as well as direct electronic price streams. [6] Electronic trading platforms geared towards the non-disclosed inter-dealer market (eg, EBS Market, Hotspot FX ECN, Refinitiv Matching). [7] Multi-bank dealing systems that facilitate trading on a disclosed basis or that allow for liquidity partitioning using customised tags (eg 360T, EBS Direct, Currenex FXTrades, Fastmatch, Refinitiv FXall Order Book, Hotspot Link).

Sources: BIS Triennial Central Bank Survey; authors' calculations.

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Offshore markets drive trading of emerging market currencies[1]

FX markets for the currencies of emerging market economies grew more rapidly than those for major currencies between 2016 and 2019, rising from 19% to almost 25% of global turnover. At the same time, these currencies attracted a wider range of participants and saw a rapid increase in offshore trading activity. Offshore markets tended to drive onshore markets during times of global market stress.

JEL classification: F31, G12, G23.

In foreign exchange (FX) markets, the trading of emerging market economy (EME) currencies outgrew that of major currencies between 2016 and 2019. While global turnover rose by 33%, the turnover of EME currencies rose by almost 60% over this period, to $1.6 trillion. This article highlights recent trends in the trading of EME currencies and discusses the main drivers of their recent growth.

One notable trend in EME currency trading was an increase in the share of trading generated by hedge funds, proprietary trading firms (PTFs) and other financial customers. A second trend was a surge in offshore trading. An important driver here was the growing appetite of global investors for EME assets. In addition, the electronification of FX trading enabled smaller players to participate in a market traditionally dominated by inter-dealer trading among large banks. Finally, activity continued to be influenced by restrictions on currency convertibility.

The remainder of this article is organised as follows. The next section describes the growth in FX markets for EME currencies between 2016 and 2019, drawing on data from the BIS Triennial Central Bank Survey.[2] We then detail changes in the composition of market participants, instruments and trading venues and analyse their drivers. The last section summarises the key policy implications.

[1] The authors would like to thank Claudio Borio, Michael Chui, Stijn Claessens, Mathias Drehmann, Bryan Hardy, Robert McCauley, Benoît Mojon, Denis Pêtre, Andreas Schrimpf, Hyun Song Shin, Vladyslav Sushko, Christian Upper and Philip Wooldridge for helpful comments and Samuel Carrasco for excellent research assistance and comments. The views expressed here are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

[2] For information about the Triennial Survey, see www.bis.org/statistics/rpfx19.htm.

Key takeaways

- Markets for EME currencies grew faster than those for major currencies between 2016 and 2019.
- Global demand for emerging market assets and the electronification of trading drove recent growth.
- During times of FX market stress, offshore markets for EME currencies tend to drive onshore prices.

Growth of FX trading in EME currencies

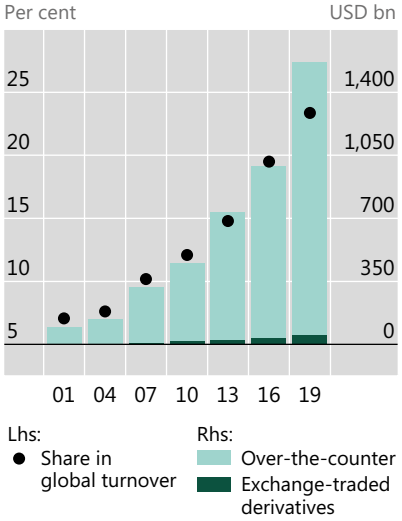
For many years, FX trading in EME currencies has outgrown that of advanced economy (AE) currencies. The average daily turnover of EME currencies rose by almost 60% between April 2016 and April 2019, to almost $1.6 trillion (Graph 1, left-hand panel). This boosted the share of EME currencies in global turnover to 23%, up from 19% in 2016 and 15% in 2013.

The increase in FX turnover was particularly pronounced in many Asian currencies (Graph 2). The Chinese renminbi was the most traded EME currency, at $289 billion per day in April 2019, but its 48% growth between 2016 and 2019 was moderate when compared with that of many other currencies (see Packer et al (2019) in this issue).

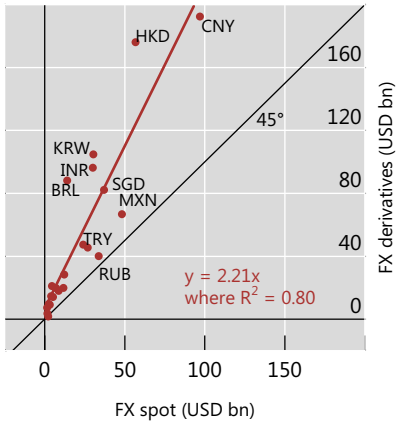
Trading in the Indian rupee, Indonesian rupiah and Philippine peso more than doubled, despite continued restrictions on their convertibility. In contrast, many of the more freely convertible EME currencies, such as the Mexican peso, Singapore dollar and South African rand, experienced below average growth. The Hong Kong

Turnover in EMEs FX markets continued to rise — Graph 1

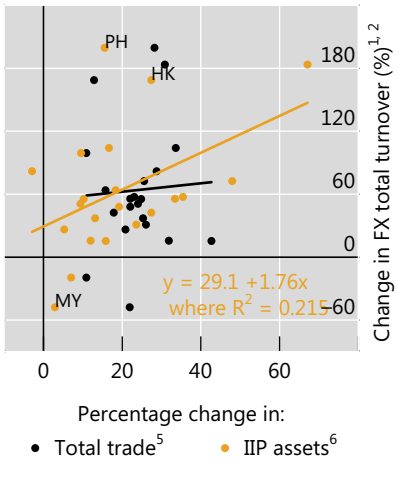
Total FX turnover in EME currencies[1, 2]



FX derivatives vs spot in EME currencies in 2019[1, 3]



Change in FX turnover vs international trade and external assets between 2016 and 2019[4]



[1] OTC data are adjusted for local and cross-border inter-dealer double-counting. EME currencies = ARS, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, INR, KRW, MXN, MYR, PEN, PHP, PLN, RUB, SAR, SGD, THB, TRY and ZAR. Turnover at constant exchange rate in April 2019. [2] FX data include OTC (spot, outright forwards, FX swaps, currency swaps and options) and exchange-traded transactions (futures and options). [3] FX derivatives = Total OTC turnover minus spot transactions for each currency plus exchange-traded transactions. Slope is statistically significant at 1% level. [4] ARS excluded from the sample. [5] Sum of merchandise exports and imports over 12 months to April of each year. [6] External assets (from the international investment position) as of Q1; for Malaysia, Q4 2018. Slope is statistically significant at the 5% level.

Sources: IMF, *Balance of Payments* and *Direction of Trade Statistics*; national data; BIS Triennial Central Bank Survey; authors' calculations.

dollar stood out with one of the largest increases in turnover, due probably to temporary factors in April 2019 related to local funding conditions.

A notable exception to the rapid increase in EME currencies' turnover was the Malaysian ringgit, which experienced a 48% decline in turnover between 2016 and 2019. New administrative restrictions contributed to the sharp decline in ringgit turnover. The Malaysian authorities banned offshore trading of non-deliverable forwards (NDFs) by domestic entities.[3] As a result, offshore trading in the ringgit collapsed between 2016 to 2019. While measures were also introduced to promote onshore trading, the rise in onshore trading could not outweigh the decline in offshore trading.

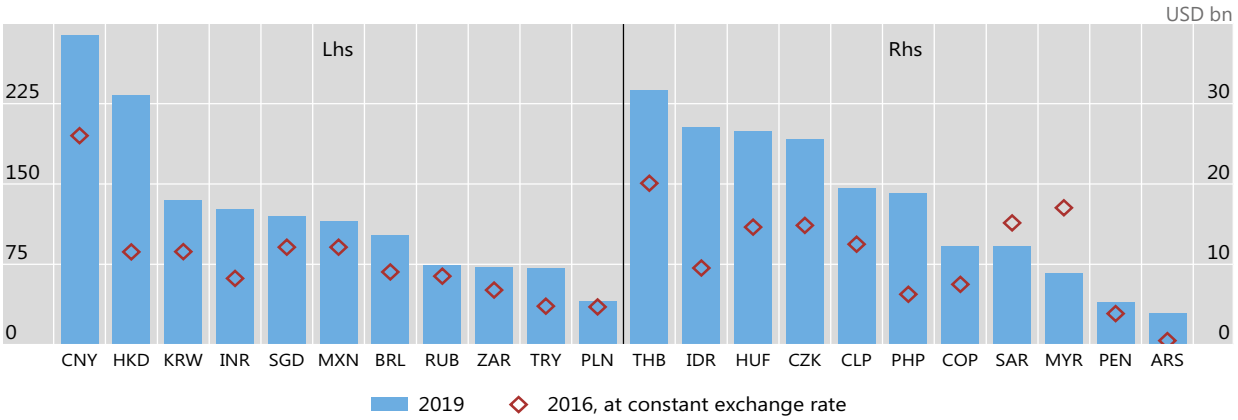
For EME currencies, as for AE currencies, the turnover of FX derivatives greatly exceeded spot transactions. Derivatives trading in EME currencies approached $1.1 trillion per day in April 2019, whereas spot trading was less than $0.5 trillion. The volume of derivatives trading was, on average, double that of spot trading for both EME and AE currencies (Graph 1, centre panel).[4] Notable exceptions included the Mexican peso and Russian rouble, where derivatives trading in April 2019 was low relative to spot trading, and the Hong Kong dollar, where derivatives trading was relatively high. For most EME currencies, the FX derivatives markets were larger and more developed than those for interest rate derivatives (see Box A).

In line with global patterns, trading on over-the-counter (OTC) markets greatly exceeded that on exchanges. For EME currencies, OTC FX derivatives accounted for 95% of the total turnover, slightly below their 98% global share.[5] In April 2019, exchange-traded derivatives accounted for a substantial share of activity in only two currencies: the Brazilian real (36%) and the Indian rupee (13%).

Turnover in most EME currencies grew, particularly in emerging Asia

Total FX turnover by currency, daily average turnover in April[1]

Graph 2



[1] OTC transactions are adjusted for local and cross-border inter-dealer double-counting. Data include OTC (spot, outright forwards, FX swaps, currency swaps and options) and exchange-traded transactions (futures and options).

Sources: BIS derivatives statistics and Triennial Central Bank Survey; authors' calculations.

[3] NDFs are forward contracts that do not involve an actual exchange of currencies. Instead, they entail a settlement of the difference between the actual and a pre-agreed exchange rate in a single US dollar payment at maturity.

[4] The ratio understates spot trading because, in the Triennial Survey, the spot leg of FX swaps is not reported. This bias is more sizeable for AE currencies, given their larger share of FX swaps trading.

[5] The dominant share of OTC markets is partly explained by the greater flexibility that OTC deals offer to meet special demands, such as for specific maturities and trading currency pairs not involving the US dollar (Wooldridge and Xia (2019)). While the US dollar remained dominant, as the currency on one side of 99% of all trades on exchanges in April 2019, its share in OTC markets was lower, at 90%.

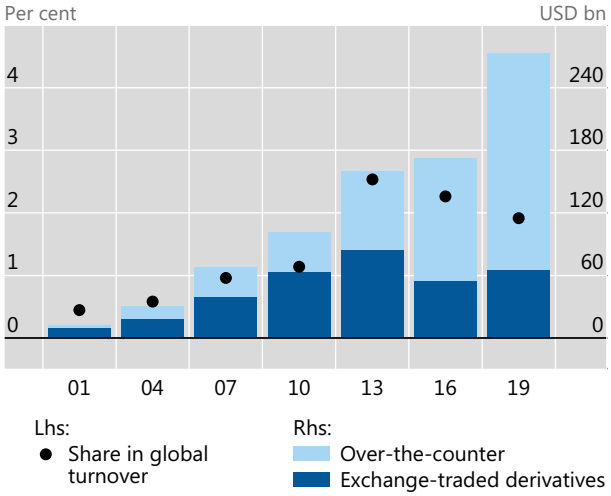
FX instruments dominate derivatives markets in EMEs

The relative size of FX and interest rate derivatives markets differs markedly between EMEs and AEs. The turnover of interest rate derivatives in EMEs rose significantly between April 2016 and April 2019, increasing from $173 billion to $273 billion (Graph A1, left-hand panel).① Nevertheless, in April 2019, the turnover of FX derivatives denominated in EME currencies was still more than four times greater than that of interest rate derivatives. This was in stark contrast to AE currencies, where trading in the two asset classes was on a more equal footing. In the right-hand panel of Graph A1, the red line suggests that the ratio of interest rate to FX derivatives turnover is much smaller than one for EME currencies on average, indicating that FX instruments predominate in EME derivatives markets. In comparison, the blue line, for AEs, revealed more activity in interest rate derivatives than in FX derivatives.

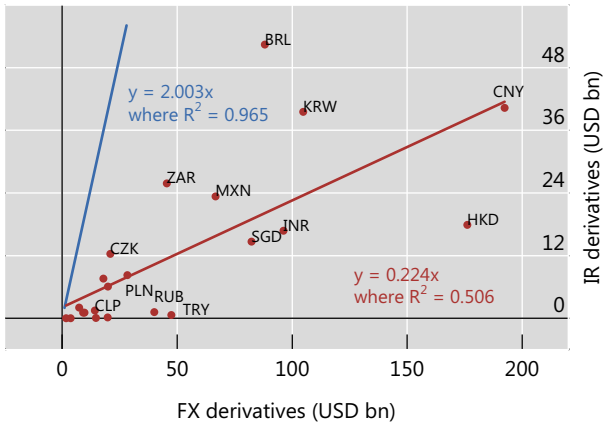
FX outweighs interest rate instruments in EME derivatives trading

Graph A1

Interest rate derivatives turnover in EME currencies[1]



FX and IR derivatives turnover in EME currencies in 2019[2]



[1] EME currencies = ARS, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, INR, KRW, MXN, MYR, PEN, PHP, PLN, RUB, SAR, SGD, THB, TRY and ZAR; AE currencies = AUD, CAD, CHF, EUR, GBP, JPY, NOK, NZD, SEK and USD. Interest rate derivatives include OTC (forward rate agreements, options, overnight indexed swaps, other interest rate swaps and other instruments). OTC derivatives are adjusted for local and cross-border inter-dealer double-counting. Turnover at constant exchange rate in April 2019. [2] FX derivatives = OTC and XTD excluding spot transactions. IR derivatives = OTC and XTD transactions. Blue line corresponds to AEs; red line corresponds to EMEs.
Sources: BIS derivatives statistics and Triennial Central Bank Survey; authors' calculations.

The notional amounts outstanding painted a similar picture. For EME currencies, FX and interest rate derivatives markets were similar in size, whereas for AE currencies interest rate derivatives volumes exceeded those of FX derivatives by a large margin (see Aramonte and Huang (2019) in this issue).

The smaller scale of interest rate derivatives activity in EMEs, as compared with AEs, reflected several factors. Less-developed bond markets and benchmark rates in EMEs meant more limited demand for interest rate derivatives. In addition, tighter control of capital markets in EMEs further curbed demand, by restricting the investor base. The EMEs that stood out in terms of interest rate derivatives activity were Mexico and South Africa, which have better developed bond markets than most other EMEs, as well as freely convertible currencies.

Changes in the turnover of interest rate derivatives varied considerably across currencies (Annex Table A1, second and third columns). Most Asian currencies witnessed significant increases. In particular, renminbi interest rate derivatives increased more than threefold, overtaking the Mexican peso as the most actively traded EME instrument in this category. On the other side of the spectrum, interest rate derivatives trading declined in several Latin American currencies (Argentine peso, Chilean peso, Colombian peso and Peruvian sol).

① See Ehlers and Hardy (2019) in this issue for an overview of recent trends in global interest rate derivatives markets.

Evolving market structure

Two notable trends have characterised the FX market for EME currencies in recent years; first, the increased presence of non-bank financial institutions; second, the rapid growth in forwards, in particular NDFs, and the related increased role of offshore transactions.

Rising prominence of non-bank financial institutions

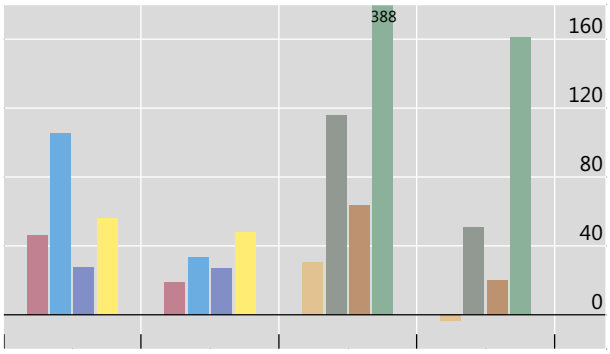
In general, the growth of FX trading is linked more strongly to financial motivations than to trade in goods and services. In the right-hand panel of Graph 1, the orange line shows a positive relationship across EMEs between the growth in gross external financial assets and FX turnover. By contrast, the black line shows that the relationship between trade in goods and services and FX turnover was much weaker.[6] These results accord with the dominant role of financial factors in driving activity in FX markets, as documented elsewhere (eg Schrimpf and Sushko (2019a) in this issue).

Consistent with the dominant role of financial factors, the recent growth in FX turnover for EME currencies was led by trading with non-bank financial institutions (NBFIs). This contrasts with AE currencies, where smaller (non-dealer) banks played

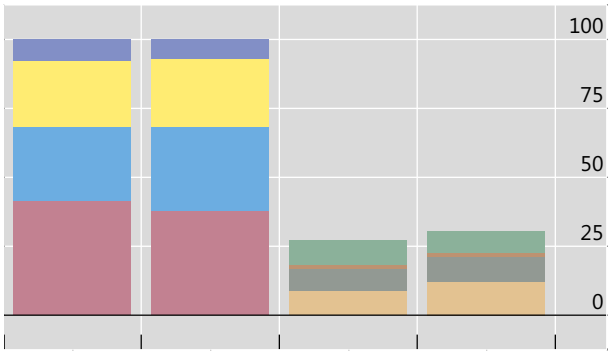
Growth of EME currencies trading was driven by non-bank financial institutions[1]

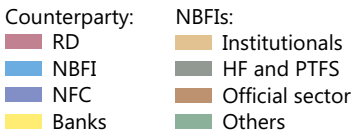
In per cent — Graph 3

OFIs are increasingly important counterparties for EME currencies[2]



Market ecosystem for EME currencies becomes more like that in AEs[3]





EME currencies = ARS, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, INR, KRW, MXN, MYR, PEN, PHP, PLN, RUB, SAR, SGD, THB, TRY and ZAR; AE currencies = AUD, CAD, CHF, EUR, GBP, JPY, NOK, NZD, SEK and USD.

Counterparty: RD = reporting dealers; Banks = non-reporting banks; NBFI = non-bank financial institutions; NFC = non-financial customers; HF & PTFs = hedge funds and proprietary trading firms; Others = others and undistributed.

[1] FX OTC daily average turnover in April adjusted for local and cross-border inter-dealer double-counting. [2] Growth rate in FX turnover in April 2019 with respect to April 2016 at constant exchange rate for EME and AE currencies. Spot transactions included. [3] FX OTC turnover in 2019 by counterparty as percentage of turnover by all counterparties. Spot transactions included.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

[6] Interestingly, growth in gross external financial liabilities plays a less significant role, probably reflecting that EME liabilities consist mainly of equity and foreign direct investments, which generate less turnover owing to both their longer term and lower hedging requirements.

the leading role (Graph 3, left-hand panel). Among NBFIs, the rise of "other" financial institutions (those not categorised as institutional investors, hedge funds, property trading firms or the official sector) was especially pronounced. This category includes retail aggregators.

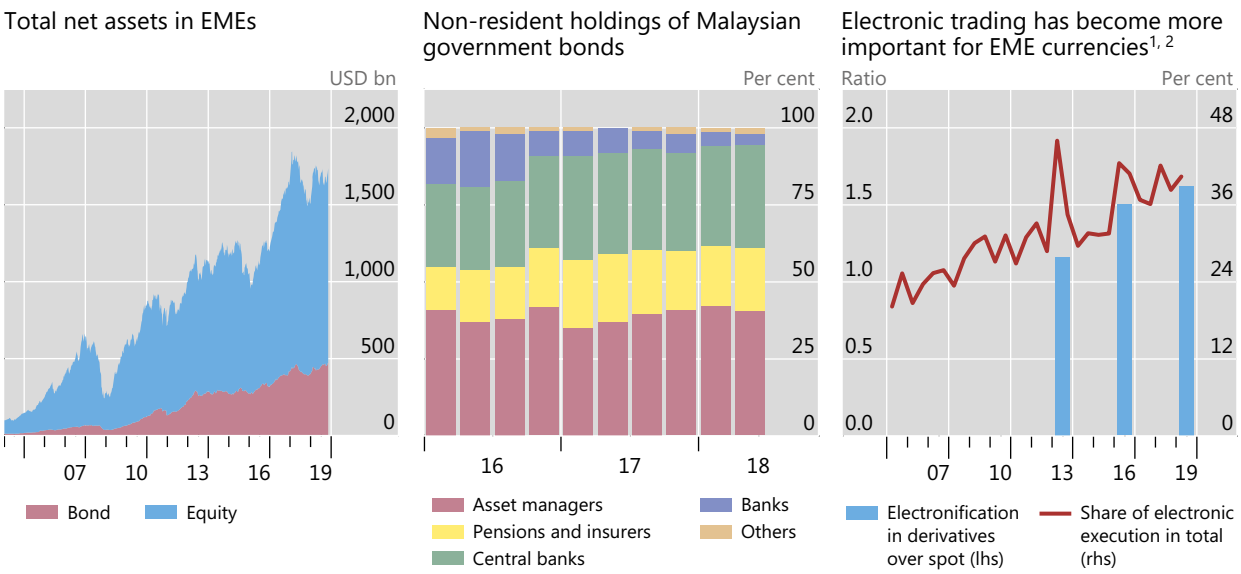
These developments brought the composition of market participants more into line with that of AE currencies (Graph 3, right-hand panel). However some differences remained. For example, despite growing at a faster rate over the past three years, the share of institutional investors continued to be smaller in EME currencies than in AE currencies.

The rising share of NBFIs reflects increased non-bank and foreign demand for EME assets as financial intermediation shifts from banks to capital markets in EMEs. For example, the participation of foreign investors in local currency bond markets in EMEs has increased (BIS (2019)). Assets under management by dedicated EME equity and bond funds have doubled over the past decade (Graph 4, left-hand panel). In contrast, bank demand for EME assets has moderated. The share of banks in the Malaysian government bond market, for example, has fallen markedly over the last three years (Graph 4, centre panel).

Hedge funds and PTFs, which are active in algorithmic trading, also saw swifter increases, as compared with their activity in AE currencies. This rise is attributable in large part to the continuing electronification of global FX markets (see Holden et al (2019) in this issue). As shown by the blue bars in the right-hand panel of Graph 4, electronic trading of EME currencies grew at a faster pace in derivatives than in the spot market.

Rising demand for non-bank EME assets and growing electronification

Graph 4



[1] Trading of USD/Latin American currency pairs (ARS, BRL, CLP and MXN) in North America. Data for April and October. [2] Total FX OTC turnover that involves all electronic execution methods in derivative instruments (FX swaps and outright forwards) over the total FX turnover that involves spot transactions.

Sources: Federal Reserve Bank of New York; EPFR; national data; BIS Triennial Central Bank Survey; authors' calculations.

Rapid growth in forwards and offshore trading

Outright forwards saw the sharpest increase in turnover in FX markets for EME currencies, followed by FX swaps and options (Graph 5, left-hand panel). On the other hand, turnover in currency swaps declined. This pattern was in sharp contrast to that seen in AE currencies, where currency swaps increased more than other instruments. As a result, the differences between EME and AE currencies in terms of forwards vis-à-vis FX swaps became more pronounced (Graph 5, centre panel).

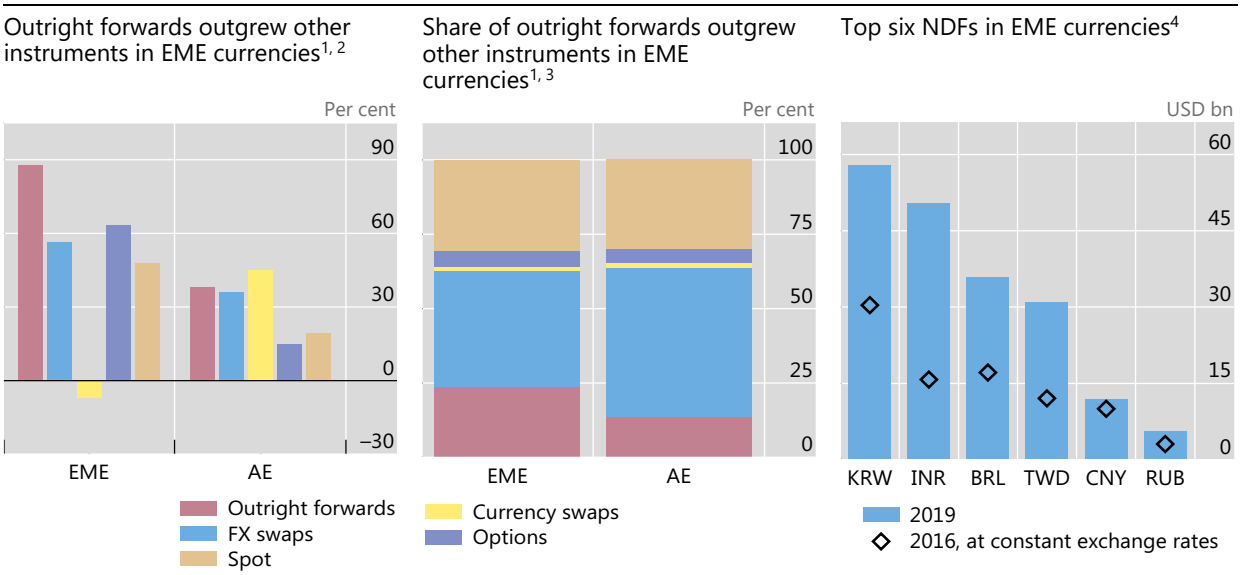
NDFs contributed most to the increase in outright forwards. Driven in large part by increased market electronification, NDF turnover almost doubled (see Box B). Historically, NDFs have been used to meet hedging demands involving currencies that are not fully convertible because they allow for payoffs related to a currency's performance without requiring funding in the underlying currency. This trend continued for some currencies, even where controls on non-residents participating in onshore markets were relaxed.

The increase in NDF turnover was broad-based; most of the top six most traded NDFs in EME currencies saw a marked increase (Graph 5, right-hand panel). The renminbi saw more modest growth, of less than 20%, probably reflecting authorities' initiatives to encourage hedging in the onshore deliverable forwards market.

Led by the robust growth in NDFs, the share of offshore trading in FX turnover increased for most EME currencies (Graph 6, left-hand panel). In April 2019, the volume of offshore trading in EME currencies exceeded that of onshore trading in all major regions. Latin American currencies had the highest share of offshore trading. In contrast, the offshore/onshore ratio for Asian EME currencies has stalled since 2016, due largely to a sizeable shift to onshore trading of the renminbi.[7]

Rapid growth in forwards led by NDFs

Graph 5



[1] Daily average turnover in April adjusted for local and cross-border inter-dealer double-counting. EME currencies = ARS, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, INR, KRW, MXN, MYR, PEN, PHP, PLN, RUB, SAR, SGD, THB, TRY and ZAR; AE currencies = AUD, CAD, CHF, EUR, GBP, JPY, NOK, NZD, SEK and USD. [2] Growth rate in FX turnover in April 2019 with respect to April 2016 at constant exchange rates for EME and AE currencies. [3] FX turnover by instrument as a percentage of turnover by all instruments in 2019 [4] At constant exchange rates in 2019.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

[7] The ratio for EM Asia excluding China continued to increase between 2016 and 2019.

Strictly offshore trades (where both counterparties are located offshore) dominate the market for FX turnover in EME currencies (Graph 6, centre panel). By the location of a trade, defined as the location of the sales desk of the reporting dealer, a trade can be classified as either "strictly domestic" (between two parties located onshore), "onshore-offshore" (between one party located onshore and the other offshore) or "strictly offshore" (both parties located offshore).

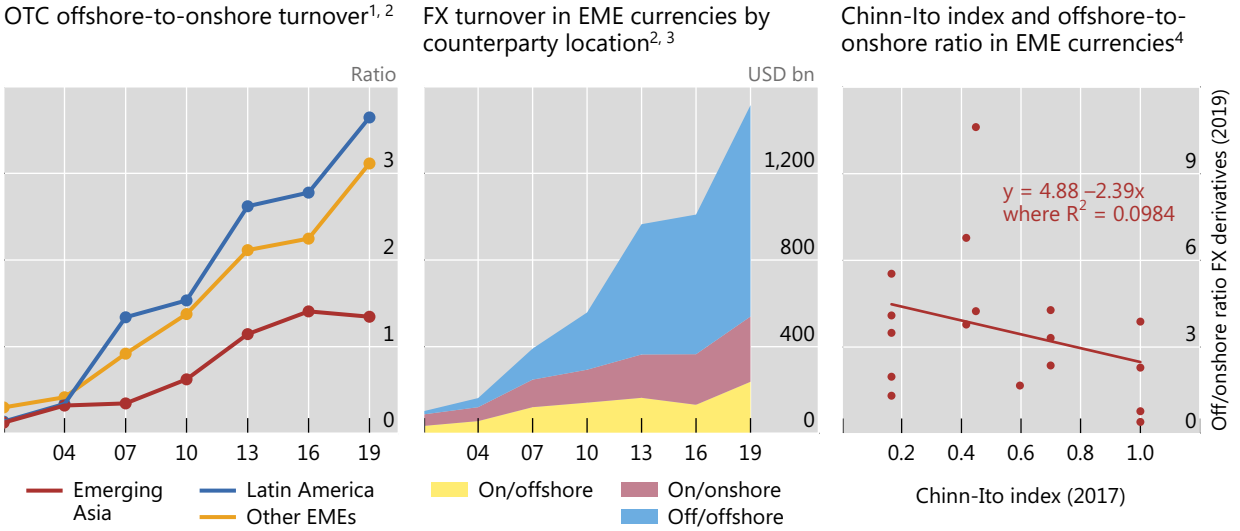
The rapid expansion of strictly offshore trading was broad-based (Annex Table A2).[8] Except for the Hong Kong dollar and the Malaysian ringgit, all other EME currencies were traded mainly between two parties located outside the domestic jurisdiction as of April 2019.

The vast majority of offshore FX transactions in EME currencies took place in a handful of locations. London played the most notable role, followed by New York, Singapore and Hong Kong SAR.

The prominence of offshore trading is not specific to EME currencies. It reflects the network effects that have led to a highly concentrated market structure within a handful of global financial centres. For EME currencies, capital account and currency convertibility restrictions represent an additional factor behind the higher share of offshore trading. In particular, jurisdictions with heavier capital account restrictions tend to have a higher share of offshore trading of derivatives (Graph 6, right-hand panel). In other words, capital controls appeared to boost the offshore trading of derivatives – NDFs in particular – at the expense of onshore trading.

Share of offshore transactions increased in most regions

Graph 6



[1] Emerging Asia = CNY, HKD, IDR, INR, KRW, MYR, PHP, SGD and THB; Latin America = ARS, BRL, CLP, COP, MXN and PEN; Other EMEs = CZK, HUF, PLN, RUB, SAR, TRY and ZAR. [2] Onshore transactions are defined as the turnover in the corresponding currency in the issuing jurisdiction (on a net-gross basis). Offshore transactions are defined as the difference between the total turnover of a currency on a net-net basis and the onshore transactions in the issuing jurisdiction. Includes total OTC derivatives and spot transactions. Excludes exchange-traded transactions. [3] EME currencies = ARS, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, INR, KRW, MXN, MYR, PEN, PHP, PLN, RUB, SAR, SGD, THB, TRY and ZAR. [4] Offshore-to-onshore turnover in OTC FX derivatives in 2019. ARS, CZK, HUF, MYR, and PLN excluded from the sample. The p-value of the slope coefficient equals 0.11 in a one-sided t-student distribution with 15 degrees of freedom.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

[8] The Triennial Survey might overstate "strictly offshore" trading. Dealers report whether a trade is local, with a resident counterparty, or cross-border, with a non-resident. Therefore, trades between dealers located offshore and customers located onshore are included with offshore trades.

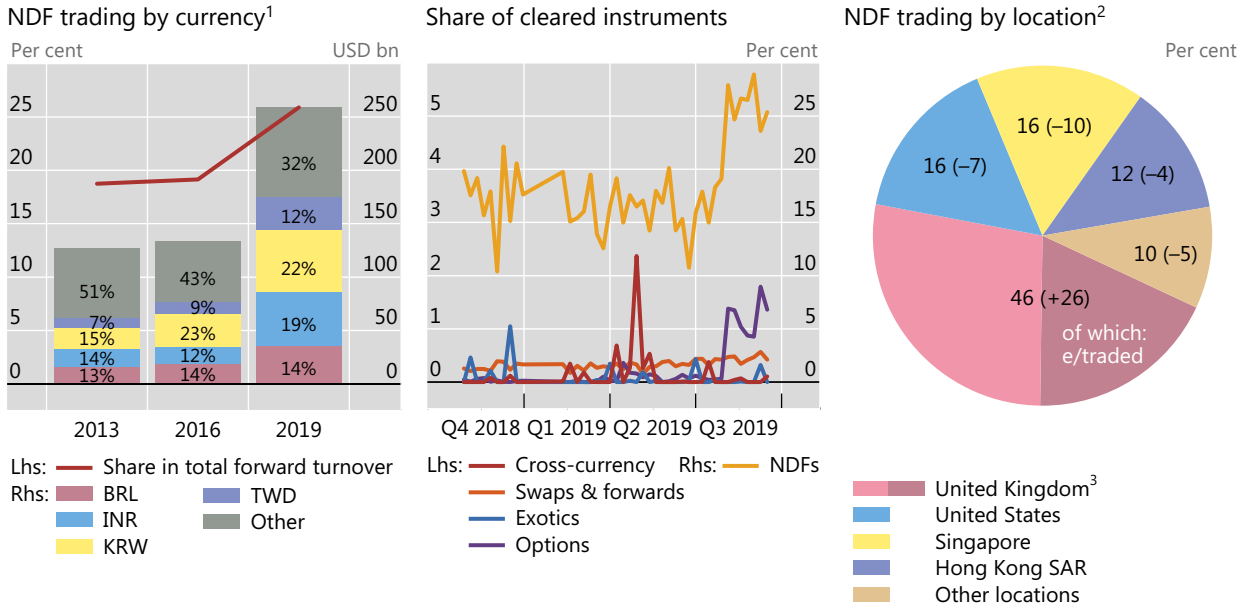
NDF markets thrive on the back of electronification

Andreas Schrimpf and Vladyslav Sushko

Trading of NDFs has almost doubled over the past three years, contributing significantly to the substantial increase in the trading of forwards recorded in the 2019 Triennial Survey. NDFs are contracts that, unlike their deliverable counterparts, settle in the *same* currency (typically the US dollar) at maturity, based on the movement of the underlying exchange rate. NDFs are particularly popular for trading non-convertible currencies. The key currencies behind the NDF surge include the Korean won, Brazilian real, Indian rupee and New Taiwan dollar (Graph B1, left-hand panel).

Evolution of NDF trading by currency and location, and central clearing

Graph B1



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis; daily averages in April. [2] Change since the 2016 Triennial Survey in brackets, in percentage points. [3] For the United Kingdom, the share of electronic trading (electronic broking and trading systems) is calculated based on FXJSC April 2019 survey data.

Sources: London Foreign Exchange Joint Standing Committee Survey (FXJSC); US Commodity Futures Trading Commission Swap Reports; BIS Triennial Central Bank Survey; authors' calculations.

Hedge funds and PTFs can trade NDFs to arbitrage or take directional bets. In the process, they serve as natural counterparties to market participants who need to hedge currency exposures. NDFs exemplify two main trends in the structure of global FX markets, as highlighted in the main text: (i) electronification of trading with other financial institutions, and (ii) concentration of trading activity in the largest FX centres.

The trend towards electronification in NDF markets rides on the inclusion of these instruments among those traded on the main electronic broking platforms: EBS emerged as the electronic venue for NDF trading, while Reuters (Refinitiv) Matching plans to launch NDF trading in 2020. Electronification has also benefited from central clearing, which enables multilateral netting and reduces the need to post margins. As highlighted in McCauley and Shu (2016), the NDF market microstructure has started evolving rapidly on the back of global legal and regulatory reforms for derivatives markets. Since 2015, NDFs have started the transition from a decentralised, bilateral microstructure to one characterised by centralised trading, disclosure and clearing. The gradual phase-in of uncleared margin rules, requiring firms to post initial margins for certain uncleared derivatives, has incentivised greater central clearing of NDFs. To date, NDFs represent the only type of FX derivative with any meaningful share of centrally cleared transactions (Graph B1, centre panel).

These forces have naturally led to a further concentration of trading in the main FX hubs, with the share of NDF trading in the United Kingdom more than doubling from 20% in 2016 to 46% in 2019 (Graph B1, right-hand panel). Given the popularity of NDF trading in Asian currencies, London's overlap with the trading hours of Hong Kong SAR and Singapore puts the city in an advantageous position.

Policy implications

The rapid expansion of offshore trading in EME currencies presents both opportunities and challenges. On the one hand, offshore trading can increase liquidity and cut transaction costs. Electronification can encourage trading by a wider range of market participants, while overlapping time zones allow round-the-clock trading. Increased FX liquidity can in turn boost foreign investment and trade in goods and services.

On the other hand, offshore trading can influence the price discovery process for exchange rates, in markets that are more difficult than onshore centres for central banks to monitor. Estimates for the four largest NDF currencies suggest that, while a bidirectional relationship exists between the onshore and offshore markets during normal times, offshore venues tend to drive movements in the onshore markets during times of global market stress (Box C). This raises challenges for central banks, which have historically limited their market monitoring and intervention policies to the onshore market.

Many central banks have responded to the challenges posed by offshore markets by expanding their monitoring activities. They can expand their coverage of fast-paced electronic markets by tapping larger volumes of data from more diverse sources. They can also enhance the scope and coverage of their market intelligence-gathering efforts (Markets Committee (2016, 2018)). The Korean authorities, for instance, have encouraged domestic entities to play a greater role in offshore markets, with the aim of increasing their monitoring capabilities for offshore markets via these entities. The move has also served to integrate the on- and offshore markets, reducing price discrepancies between the two.

Other central banks, such as those in Indonesia, Malaysia and Turkey, have taken steps to deepen their nascent onshore derivatives markets, often acting as the primary providers of liquidity. Initiatives such as extending onshore trading hours and providing more flexibility for foreign investors to hedge their positions in the domestic markets have also been considered (Reserve Bank of India (2019)).

Furthermore, while spot interventions still remain the dominant intervention tool, some central banks have reacted to the increasing weight of offshore derivatives in the FX market by increasing the use of derivatives in their FX intervention frameworks, including in offshore markets (BIS (2019)).

Box C

How onshore and offshore markets interact: an empirical investigation

Understanding the information flow between onshore and offshore markets is of prime importance, particularly for policymakers. It sheds light on the price formation process and reveals the venue of price discovery, which is critical for informing a central bank's FX intervention strategy and market monitoring efforts.

Policymakers often see spillovers from hard-to-monitor offshore markets as an area of concern (Central Bank of Malaysia (2018)). Indeed, the empirical analysis below shows that, while a bidirectional relationship exists between the onshore and offshore markets during normal times, it turns unidirectional during times of market stress, when offshore markets tend to drive onshore price developments.

In the absence of permanent frictions between the onshore and offshore markets, prices across venues are cointegrated, as confirmed by our empirical estimates. Short-run fluctuations and lead-lag relationships can then be studied using a vector error correction model for onshore spot and forward rates and offshore non-deliverable forward (NDF) rates. This represents the information flow between the onshore and offshore markets, and shows how it varies over time.① The model consists of two sets of equations, the first of which captures the long-run relationship between spot and NDF rates. The second set examines how deviations from the long-term relationship affect the short-term dynamics of these rates, an "error correction" mechanism in the spirit of Engel and Granger (1987). This provides information about the direction of the linkage between onshore and offshore markets. The analysis focuses on five currencies with large NDF markets, namely the Brazilian real, Chinese renminbi, Indian rupee, Korean won and New Taiwan dollar.

The long-run equations are as follows:

$$\log(spot)_t = \beta_0^{spot} + \beta_1^{spot} \log(NDF)_t + e_t^{spot}$$

$$\log(NDF)_t = \beta_0^{NDF} + \beta_1^{NDF} \log(spot)_t + e_t^{NDF}$$

β_1^{spot} and β_1^{NDF} quantify the strength of the long-run relationship between the two exchange rate measures, with a value close to 1 indicating a complete pass-through and the absence of permanent frictions between the two markets.

The short-run equations are as follows:

$$\Delta \log(spot)_t = \alpha_0^{spot} + \alpha^{spot}\left(e_{t-1}^{spot}\right) + \sum_{i=1,\dots n} \alpha_{11,i}(\Delta \log(spot)_{t-i}) + \sum_{i=1,\dots n} \alpha_{12,i}(\Delta \log(NDF)_{t-i}) + \epsilon_t^{spot}$$

$$\Delta \log(NDF)_t = \alpha_0^{NDF} + \alpha^{NDF}(e_{t-1}^{NDF}) + \sum_{i=1,\dots n} \alpha_{21,i}(\Delta \log(spot)_{t-i}) + \sum_{i=1,\dots n} \alpha_{22,i}(\Delta \log(NDF)_{t-i}) + \epsilon_t^{NDF}$$

α^{spot} and α^{ndf} are the coefficients of interest. They reveal the rate of adjustment when the system departs from equilibrium. We use them as a measure of the direction of influence. For example, when α^{spot} is negative and statistically significant, it indicates that NDF rates will affect the dynamics of spot rates in the next period.

The analysis reveals, first, that most currencies show a bidirectional relationship: spot prices affect subsequent NDF rates and vice versa.② For the Chinese renminbi, Indian rupee and Korean won, this bidirectional relationship holds when the model is estimated over the full sample from January 2005 to October 2019 (Table C1, first row). The New Taiwan dollar stands out as the only currency with unidirectional spillovers from the NDF rates to spot rates. This could reflect the fact that offshore branches of local banks are allowed to participate in the NDF market, which brings additional information to the NDF rates.③ Unlike the other currencies in the sample, the Brazilian real shows no significant evidence of spillovers from one market to the other. This may reflect the important role that exchange trading plays for the Brazilian real, with price discovery taking place largely in the futures market rather than in the offshore NDF or spot market.④

Second, during times of global market stress, it is more likely that the offshore NDF markets will drive onshore prices (Table C1, second to fourth rows). For example, during the Great Financial Crisis (GFC) and the "taper tantrum", the Indian rupee saw spillovers from the NDF rates to the spot rates but not vice versa. Similar dynamics were also observed for the renminbi and New Taiwan dollar during the GFC, and for the Korean won during the taper tantrum and recent trade tensions. The pattern also manifests itself between the offshore NDF rates and the onshore forward rates (fifth to seventh rows).

The unidirectional influence from offshore to onshore markets during global market stress for Asian currencies likely reflects a number of factors. For one, the onshore and offshore markets span different time zones. As a result, news related to Europe and the United States that arrives during prime trading hours in London and New York is too

late for Asian trading hours. Thus, this news affects NDF rates first, before subsequently affecting the onshore prices the following morning. However, this is probably not the only reason, as the case of the Indian rupee shows. Here Reserve Bank of India (2019) finds the unidirectional flow to hold during market stress episodes, even though the NDF and spot prices are recorded at exactly the same time (the closing time of the onshore market). Other factors, such as different degrees of risk aversion and changes in the wealth of offshore investors during global market stress episodes, could contribute to the unidirectional influence.

Spillovers between onshore rates (spot/forward) and offshore rates (NDF) Table C1

	BRL	CNY[1]	INR	KRW	TWD
Spot and NDF					
Full sample (January 2005–October 2019)	×	⇔	⇔	⇔	⇐
GFC (September 2008–July 2009)	⇔	⇐	⇐	⇒	⇐
Taper tantrum (May 2013–August 2013)	⇔	⇒	⇐	⇐	×
Trade tensions (May 2018–December 2018)	×	×	×	⇐	×
Forward and NDF					
GFC (September 2008–July 2009)	⇒	⇐	⇐	⇐	⇐
Taper tantrum (May 2013–August 2013)	×	⇒	⇐	⇐	×
Trade tensions (May 2018–December 2018)	⇐	×	×	⇐	×

⇔ indicates two-way causality between spot or forward and NDF; ⇐ indicates NDF causes spot or forward; × indicates no relationship.

[1] One-month forward data start in 2007.

Sources: Bloomberg; authors' calculations.

In a few cases, spot rates have led the NDF rates during global stress episodes. One example is the Korean won during the GFC. This likely reflects the central bank's interventions in the onshore markets, which then become the primary venue of price discovery.⑤

The finding that offshore centres tend to lead price discovery during times of stress presents central banks with both opportunities and challenges. The challenge lies in the fact that interventions are primarily restricted to the onshore spot markets, whereas the venues for price discovery during times of stress tend to be the offshore derivatives markets (Cavalino and Patel (2019)). However, the results also indicate that proactive interventions at such times could nevertheless help to counter trends originating in the offshore markets.

① The approach is similar to the one used in Reserve Bank of India (2019). See also Behera (2011). ② These results are consistent with prior studies, including McCauley et al (2014). ③ See Annex A in Tsuyuguchi and Wooldridge (2008). ④ For details of price discovery in Brazilian FX markets, see Garcia and Santos (2014). ⑤ See Garcia and Santos (2014) for how central bank interventions relate to the price discovery process. See Ryoo et al (2013) for the role of the Bank of Korea's interventions during the GFC.

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Annex tables

Growth in FX was broader-based than for interest rate derivatives[1]

Table A1

	Turnover		
	FX spot and derivatives	Interest rate derivatives	
	2019 level (USD bn)	2019 level (USD bn)	% change from 2016
CNY	289	40	167.4
HKD	233	18	241.5
KRW	135	40	56.5
INR	126	17	179.3
SGD	119	15	23.9
MXN	115	23	–8.6
BRL	102	52	11.4
RUB	74	1	838.7
ZAR	72	26	55.2
TRY	72	1	1,135.3
PLN	41	8	50.6
THB	32	6	183.5
IDR	27	0	–23.2
HUF	27	8	–0.6
CZK	26	12	815.2
CLP	19	1	–64.4
PHP	19	0	61.2
COP	12	1	–25.1
SAR	12	1	41.6
MYR	9	2	–35.1
PEN	5	0	–84.0
ARS	4	0	–80.6

[1] Considers FX and IR OTC including spot and exchange traded transactions. Changes are computed at current exchange rates. Sources: BIS Triennial Central Bank Survey; authors' calculations.

FX turnover in most EME currencies is dominated by offshore trading[1]

Table A2

	Strictly onshore (on-/onshore)[2]		Strictly offshore (off-/offshore)[3]		On-/offshore[4]	
	2019 level (USD bn)	% change from 2016	2019 level (USD bn)	% change from 2016	2019 level (USD bn)	% change from 2016
BRL	7	–40.7	57	55.4	7	195.9
CNY	92	68.4	184	25.3	9	1279.6
HKD	43	161.4	87	176.3	102	158.9
INR	31	14.9	79	178.8	4	35.2
KRW	34	5.5	84	96.9	14	54.0
MXN	7	37.5	94	20.8	12	–10.5
RUB	20	–26.7	40	84.4	12	38.0
SGD	22	9.3	62	21.2	35	74.8
TRY	5	87.5	59	–3.4	8	–19.4

[1] Total OTC turnover, including spot and excluding exchange-traded derivatives. Onshore transactions = turnover in the corresponding currency in the issuing jurisdiction (on a net-gross basis). Offshore transactions = the difference between the total turnover of a currency on a net-net basis and the onshore transactions in the issuing jurisdiction. [2] Onshore-onshore = transactions between two counterparties located onshore. [3] Offshore-offshore = transactions between two counterparties located offshore; data about the specific location of customers is not reported in the Triennial Survey, and therefore offshore-offshore may include transactions between offshore dealers and onshore customers. [4] Onshore-offshore = transactions between dealers located onshore and customers offshore.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

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The evolution of OTC interest rate derivatives markets[1]

The trading of interest rate derivatives in over-the-counter (OTC) markets more than doubled between 2016 and 2019, significantly outpacing the growth of trading on exchanges. This rapid expansion was driven by three factors. First, non-market facing trades, such as back-to-back deals and compression trades, increased and were more comprehensively reported in the BIS Triennial Survey. Second, technological developments reduced transaction costs in OTC markets and spurred trading, including more trading by investment funds. And third, changing expectations about US short-term interest rates fuelled hedging and speculative activity. In general, structural developments like clearing, compression and automation remade OTC markets so that they more closely resembled exchanges and led to a relative shift in trading from exchanges to OTC markets. Further market changes due to benchmark rate reforms may be on the horizon.

JEL classification: E43, G15, G18, G21, G23.

In recent years, the trading of interest rate derivatives (IRDs) in over-the-counter (OTC) markets has surged. Between April 2010 and April 2016, average daily OTC turnover trended steadily upwards from $2.1 trillion to $2.7 trillion, and then in April 2019 it jumped sharply to $6.5 trillion – an increase of 143% compared with 2016. Trading on exchanges also rose, but not as much (53% between 2016 and 2019). Consequently, whereas OTC trading accounted for only 21% of IRD trading in 2010, it accounted for 46% in 2019.

The increase in OTC trading was driven by a combination of factors. First, the amount and coverage of non-market facing trades expanded, specifically back-to-back and compression trades. Second, the proliferation of electronic trading platforms reduced transaction costs, which in turn incentivised greater trading, especially by investment funds and other asset managers. Third, greater uncertainty around US short-term interest rates fuelled hedging and speculative activity.

These developments were enabled by important structural changes in OTC markets. Regulatory changes incentivised an increase in the use of central clearing,

[1] The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements. We thank Yifan Ma for excellent research assistance, Giulio Cornelli for help with the Lipper data, and LCH Ltd and ClarusFT for providing data. We thank Sirio Aramonte, Claudio Borio, Christian Cabanilla, Stijn Claessens, Wenqian Huang, Patrick McGuire, Denis Pêtre, Vladyslav Sushko, Christian Upper and Philip Wooldridge for helpful comments. We benefited from discussion with numerous market participants and individuals at central banks.

Key takeaways

- The daily turnover of OTC interest rate derivatives more than doubled between 2016 and 2019 to $6.5 trillion, taking OTC markets' share to almost half of total trading.
- Asset managers increased their trading of interest rate derivatives.
- Structural changes including clearing, compression and automation made OTC markets more closely resemble exchanges.

electronic trading platforms and portfolio compression services. OTC markets thus acquired many of the same benefits as exchanges, leading to a relative shift in trading from exchanges to OTC markets.

In this feature, we use data from the 2019 BIS Triennial Central Bank Survey of Foreign Exchange and OTC Derivatives Markets to explore the evolution of OTC IRD markets.[2] The first section describes the key findings of the 2019 survey. The second discusses the main factors contributing to the increase in IRD turnover. The third section explores how structural developments have affected the relative importance of OTC and exchange trading of IRDs. The final section looks forward to potential future structural changes. A box discusses the shift to central clearing in IRD markets.

A broad-based rise in turnover

Average daily turnover in OTC interest rate derivatives markets more than doubled between the BIS Triennial Surveys in April 2016 and April 2019 (Graph 1, left-hand panel). The 143% increase to $6.5 trillion per day was the highest growth rate since the inception of the surveys in 1995.[3] In contrast, between 2007 and 2016, growth between surveys averaged just 17%. Turnover for exchange-traded interest rate derivatives also exhibited high growth between 2016 and 2019, but at 53% was outpaced by OTC turnover. This continued the trend shift in turnover from exchanges to OTC markets that started around 2010.

The surge in OTC turnover was broad-based across instruments and currencies (Graph 1, centre and right-hand panels).[4] Interest rate swaps as a whole, which include overnight index swaps (OIS) and basis swaps, remained the most traded instruments, accounting for 64% of the total global turnover (compared with 69% in 2016). Turnover of dollar- and euro-denominated contracts grew by 141% and 148%, respectively, maintaining their global share of OTC turnover (50% and 24%, respectively).

[2] The Triennial Survey provides comprehensive information on the size and structure of OTC derivatives markets. The survey captures, among other things, the aggregate turnover of OTC interest rate derivatives from nearly 1,300 dealers in 53 different jurisdictions. In complement with BIS exchange-traded derivatives (ETD) statistics, they capture activity for interest rate derivatives globally.

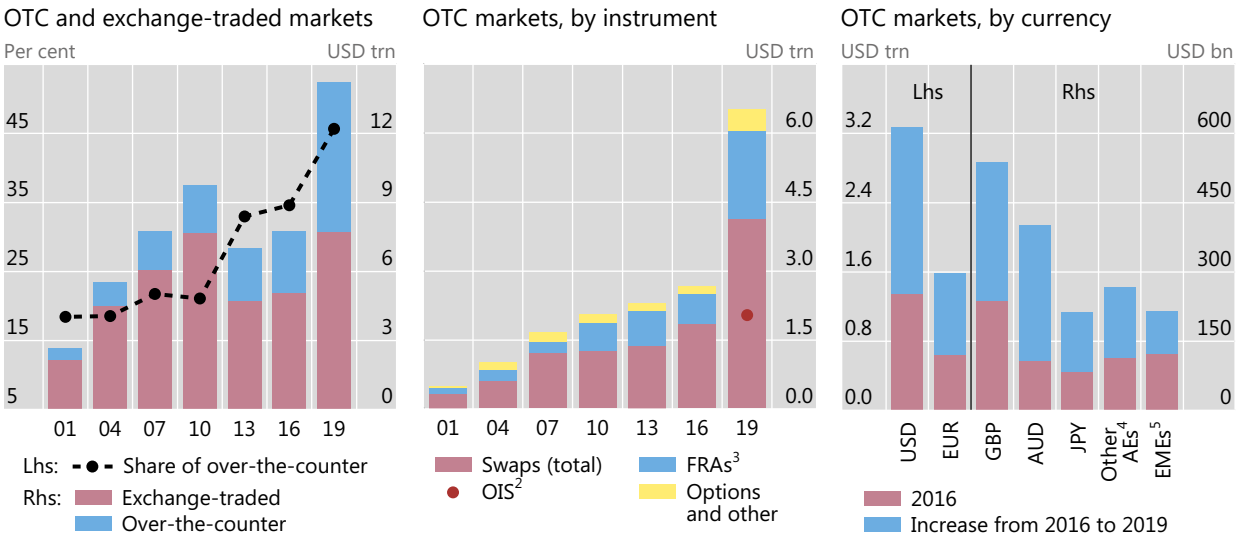
[3] Compared with monthly data from other sources, April 2019 does not appear to be an exceptional month in terms of OTC turnover. Also, exchange rate movements played a minor role in determining this growth rate. After adjusting for them, the increase was actually a little larger at 147%. Turnover with central counterparties also rose at a very high rate over the same period (115%; see Box A).

[4] See also Patel and Xia (2019) in this issue.

Turnover and composition in interest rate derivatives markets

Notional amounts, daily averages in April[1]

Graph 1



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis. [2] OIS are included in total swap turnover. Data available only from 2019. [3] Forward rate agreements. [4] CAD, CHF, DKK, NOK, NZD and SEK. [5] AED, ARS, BGN, BHD, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, ILS, INR, KRW, MXN, MYR, PEN, PHP, PLN, RON, RUB, SAR, SGD, THB, TRY, TWD and ZAR.

Sources: BIS derivatives statistics and Triennial Central Bank Survey.

The large increase in dollar and euro IRD turnover was driven by trading in the United States and especially the United Kingdom (Graph 2). In April 2019, sales desks in the UK accounted for over half of all OTC IRD turnover and 86% of euro turnover, up from 39% and 73%, respectively, in 2016 (centre panel). The UK also strengthened its role as the key offshore trading location for emerging market currency contracts (right-hand panel). The United States remained the dominant location for US dollar turnover, expanding from $1.1 trillion to $2 trillion in turnover, though its share of the global amount fell from 80% to 61% between surveys. Dealers in the UK took a substantially larger share in 2019 (left-hand panel).

What drove the increase in turnover?

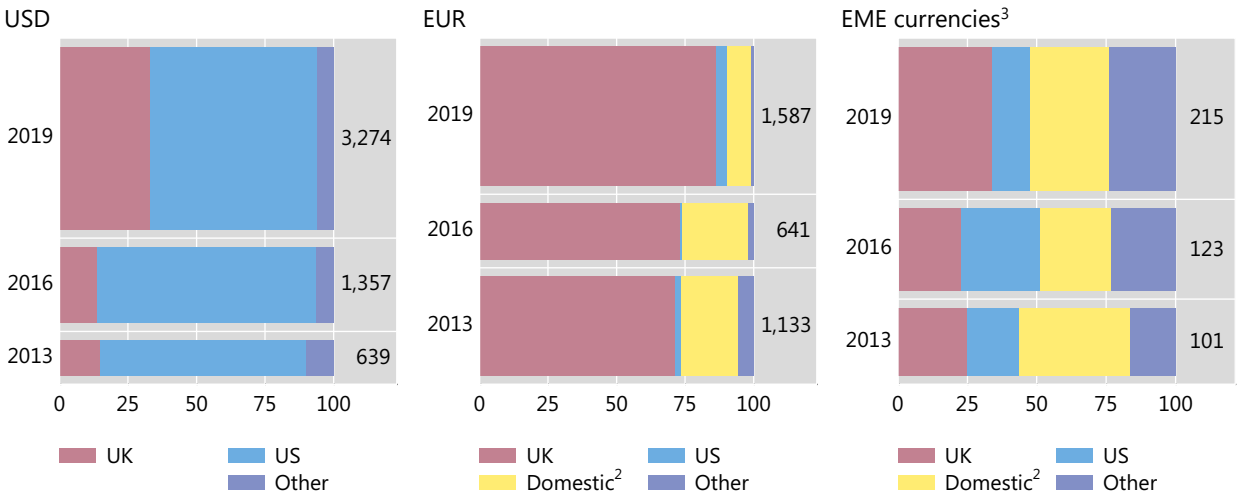
The increase in turnover was driven by a combination of factors. One factor was more turnover and more comprehensive reporting of non-market facing trades (sometimes referred to as administrative trades), such as back-to-back trades and portfolio compression trades. Yet market-facing trades also increased substantially, boosted by cyclical developments as well as structural shifts in OTC derivatives markets.

More comprehensive reporting and the rise in related party trades

Dealers in several trading jurisdictions noted an increase in related party trades in the 2019 Triennial Survey, in particular back-to-back trades. Related party trades are those between a reporting dealer's own offices and subsidiaries, or between the dealer and its parent or other affiliated entities. Back-to-back deals are linked deals where the liabilities, obligations and rights of the second deal are exactly the same as those of the original one. They are normally conducted between affiliates of the same consolidated group to facilitate either internal risk management or internal bookkeeping. Back-to-back trades should only be reported to the Triennial Survey if

OTC interest rate derivatives turnover – by currency and trading location

Daily averages in April,[1] in billions of US dollars — Graph 2



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net". [2] Currency of legal tender used in the jurisdiction. For the euro, trading in the euro area is considered as domestic. [3] AED, ARS, BGN, BHD, BRL, CLP, CNY, COP, CZK, HKD, HUF, IDR, ILS, INR, KRW, MXN, MYR, PEN, PHP, PLN, RON, RUB, SAR, SGD, THB, TRY, TWD and ZAR.

Sources: BIS Triennial Central Bank Survey; authors' calculations.

they transfer risk away from the reporting dealer. Feedback from central banks participating in the survey suggests that many reporting dealers that did not fully include these trades in the 2016 survey were able to report them in 2019 (in line with the survey guidelines).[5]

Related party trades, reported as an "of which" item (without a breakdown by counterparty sector, instrument or currency), jumped significantly, from 15% of total turnover in the 2016 survey to 24% in the 2019 one (Graph 3, left-hand panel). These trades grew by nearly 300% between surveys (centre panel). This boosted positions between reporting dealers (which grew by 124% since the last survey), but also positions between dealers and "other financial institutions" (which grew by 156%).

The pickup in related party trades accounted for about 30% of the OTC increase, or 43 percentage points out of the 143% of total turnover growth. Excluding related party trades, average daily turnover was up 117% since the 2016 survey. This still substantial growth rate is broadly in line with trends evident in other data sources, such as turnover growth at central counterparties (CCPs) (Graph 3, right-hand panel).

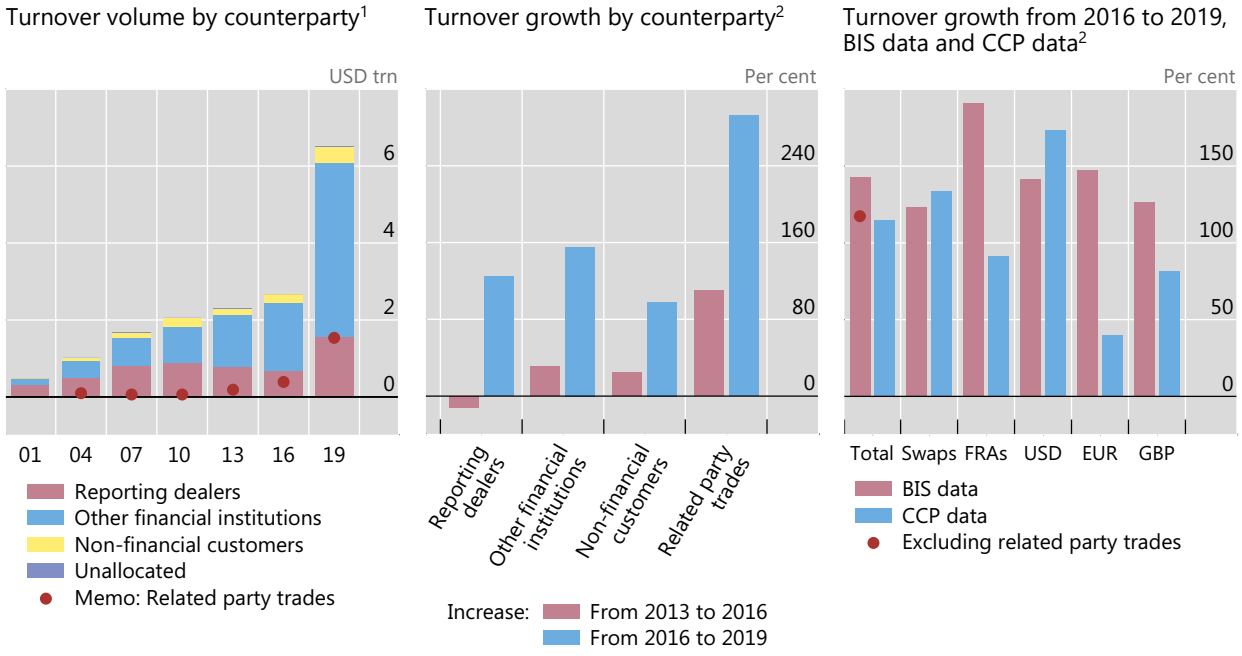
In addition to the increased reporting of back-to-back trades, the volume of such trades appears to have gone up. Conversations with dealers and reporting central banks suggest that banks engaged in relatively fewer trades in the inter-dealer market and kept more of their trades within their consolidated group.[6] This internalisation would lead to a generic increase in back-to-back trades and contribute to the large amount of related party trades in the 2019 survey.

[5] Many dealers began reporting these trades for the first time in 2019. The increased reporting may be due in part to greater use of electronic trading platforms. The move from voice to electronic booking improved the recording of the details of each trade and made it easier to flag and report back-to-back trades in line with the survey guidelines. Greater emphasis in the reporting guidelines themselves on how such trades should be reported may also have spurred better reporting.

[6] This is not to say that inter-dealer trades declined, just that the propensity to internalise a given trade increased. Turnover with other reporting dealers also exhibited high growth (Graph 3, centre panel).

Increased turnover with all counterparties

OTC interest rate turnover, by counterparty, instrument or currency — Graph 3



[1] Net-net basis, daily averages in April 2019. [2] Turnover in April in respective years is compared.

Sources: Clarus Financial Technology; BIS Triennial Central Bank Survey.

Portfolio compression usage expands

Portfolio compression trades were another important contributor to the large OTC turnover increase. A compression trade replaces two or more offsetting positions with a single new trade representing the net position that leaves the economic exposure materially unchanged. While the survey data exclude post-trade transactions (such as the novation of contracts to CCPs), compression trades can involve pre-existing trades and may take place well after the initial trades were booked.[7]

Compression has been steadily increasing in recent years (Graph 4, left-hand panel). Discussions with reporting dealers suggest that including compression trades can boost reported turnover by 40–60% for some dealers. Compression trades may thus account for a good portion of the increased turnover, though there are no hard data to provide a precise figure.[8]

Compression trades themselves can be large for two reasons. First, compression cycles are not always fully efficient in offsetting all possible positions. Second, compression trades can be applied to the entire stock of outstanding derivatives

[7] The reporting guidelines do not specifically mention compression trades. Thus some dealers added those trades to the turnover they reported, while others did not. Not all reporting dealers had compression trades to report.

[8] Based on compression data from LCH, we estimate that compression explains no more than one quarter of the overall increase in turnover between 2016 and 2019 and probably less. In other words, a generous estimate of compression trades would lower the growth of IRD turnover between 2016 and 2019 from 143% to around 110%.

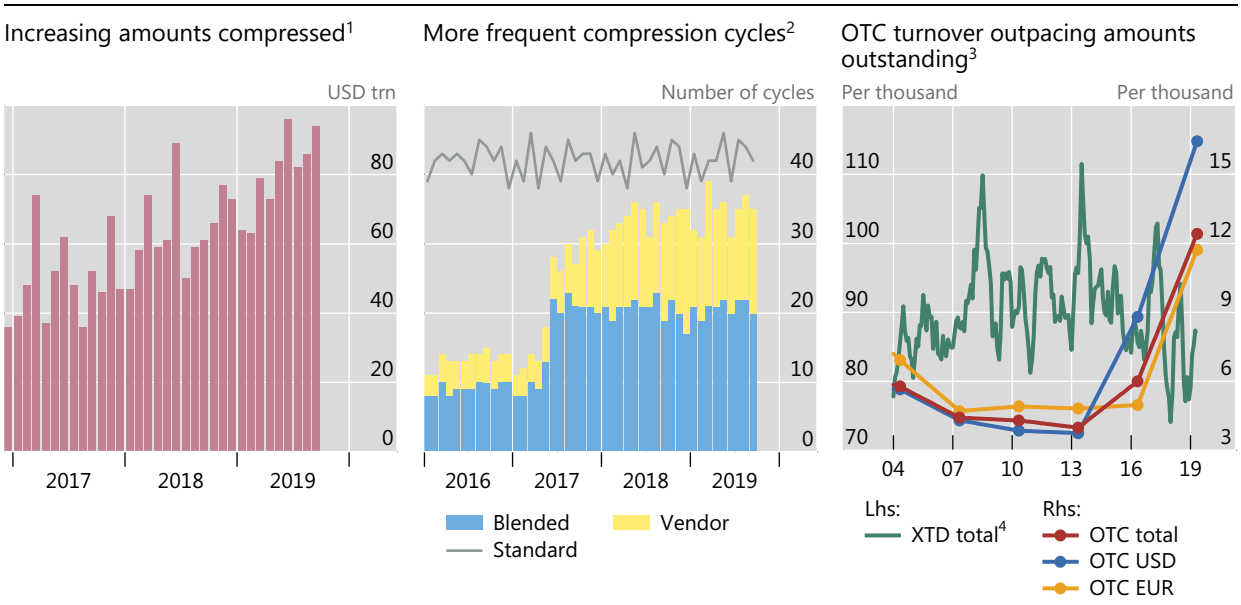
positions, not just the most recent trades. Thus, the resulting compression trade may have a large notional value.

Regulation and other drivers led to an increase in portfolio compression for IRD contracts.[9] Some regulations explicitly require institutions to compress trades periodically. Others, such as Basel III, base some regulatory requirements on gross notional positions rather than net positions, so firms are incentivised to reduce their gross derivatives position via portfolio compression. The drive to central clearing also facilitated an acceleration in compression. Central clearing channels liquidity in standardised OTC contracts, bringing many of the large players together (see box). These changes drove more firms to engage in portfolio compression, thus potentially contributing to greater turnover in the data.

An increase in the frequency of compression cycles also boosted turnover between surveys. Compression services for IRDs have been around since 2008, but compression cycles for OTC IRDs were somewhat infrequent.[10] Cycle frequency has risen strongly in recent years, going from 13 to 35 per month just between the last

Increase in portfolio compression trades

OTC interest rate derivatives — Graph 4



[1] Monthly amount compressed with LCH, including third-party vendors. [2] Number of compression runs per month with LCH. Blended = blended rate compression; vendor = compression runs done using a third-party vendor; standard = LCH's solo compression service. [3] Ratio of the daily average turnover to the gross notional amounts outstanding. [4] Exchange-traded turnover-to-outstanding ratio; six-month moving averages used.

Sources: Clarus Financial Technology; LCH Ltd; BIS derivatives statistics and Triennial Central Bank Survey.

[9] The Dodd-Frank Act in the United States (Title VII implemented in July 2011) requires dealers and other major swap participants to engage in periodic bilateral and multilateral compression. The European Market Infrastructure Regulation (EMIR, implemented in September 2013) requires European institutions which trade more than 500 contracts with each other to compress their trades at least twice per year. The Basel III leverage ratio requirements (which became mandatory in 2018) account for derivatives on a gross rather than a net basis, further incentivising banks to reduce the size of their balance sheets via compression.

[10] For cleared swaps, there were nine cycles in 2010 and 10 in 2011. See https://newsroom.nex.com/contents/pressrelease/press_release_973591527086833.pdf.

two Triennial Surveys (Graph 4, centre panel).[11] Runs by third-party vendors, including for multilateral compression,[12] went from five to 14 per month, while those for blended rate compression increased from eight to 21. Blended rate compression replaces multiple contracts "with different fixed rates into a single contract with one blended rate".[13] This is particularly notable because this type of flexibility is a relative advantage of OTC markets over the automatic reduction of gross positions (via contract cancellation) possible on exchanges. As more compression cycles are run during the month, turnover of these trades rises.

More compression boosts the turnover-to-outstanding ratio by adding more trades and reducing the notional amounts outstanding. In recent years, turnover in OTC IRD markets has dramatically outpaced the change in notional amounts outstanding (Graph 4, right-hand panel). In contrast, the trend turnover-to-open interest for exchange-traded derivatives (ETDs) has remained essentially flat, with some fluctuations, over the same period. ETDs cancel offsetting positions, which (like compression) keeps the outstanding positions down, though without any additional compression trades.

The changing interest rate environment

The evolution of policy rates and the uncertainty around possible future changes naturally affects activity in interest rate derivatives markets – in particular for short-term instruments (Upper (2006)). Turnover tends to rise if policy rates change, due to both demand for hedging against potential changes in short-term rates and speculation. In particular, if there is uncertainty around expected changes, it is more likely that speculators are willing to take positions on both sides of (typically a short-term) interest rate derivative trade. Analogously, stable and predictable rates imply low turnover (Gyntelberg and Upper (2013)).

Turnover of short-term instruments rose particularly strongly between the 2016 and 2019 Triennial Surveys. OIS and forward rate agreements (FRAs), instruments of typically short maturity, accounted for 61% of the total turnover in all instruments in 2019. Turnover of OIS was reported separately for the first time in this survey, but data from CCPs show that the turnover increase was particularly marked for shorter-term instruments (Graph 5, left-hand panel). This was to a large extent driven by OIS and FRAs denominated in US dollars (right-hand panel).

The change and increasing volatility in short-term rates in the US during April 2019 was conducive to the increase in turnover of short-term US dollar derivatives (Graph 6, left-hand panel). US monetary policy tightened gradually starting from December 2015. Over the next few years, while the timing of further expected rises probably caused some uncertainty around short rates, the expected path of future rates was clear: gradual increases. But the outlook for monetary policy changed in early 2019. April 2019 marked a turning point, as short-term rates started

[11] This excludes unilateral netting done for clearing members by LCH. These standard compression cycles have held roughly constant over the past three years at around 42 per month (about twice per day). See also the centre panel of Graph 4. Bilateral compression is probably also important, though data on frequency and size are not available.

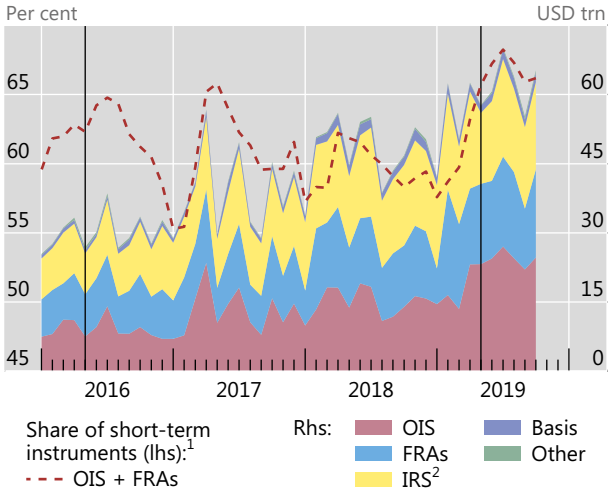
[12] Offsetting trades become more likely and more effective with a larger pool of traders with similar products. Multilateral compression is more complicated, but can be more efficient at reducing the gross notional exposures of the parties involved.

[13] https://www.lch.com/services/swapclear/enhancements/compression.

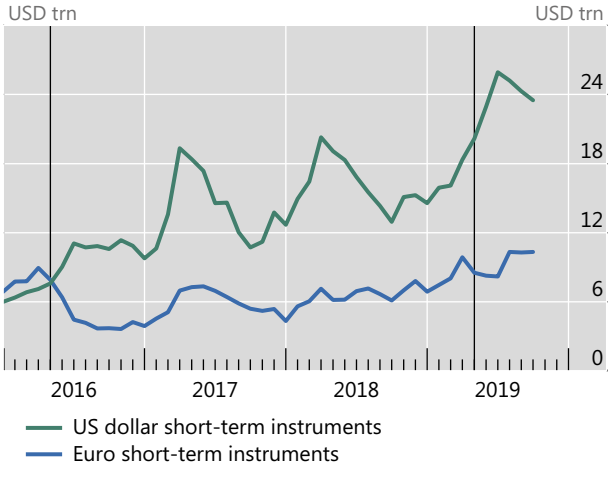
Turnover share of shorter-term OTC IRD contracts has been rising

Aggregate monthly turnover in cleared OTC derivatives — Graph 5

Share of short-term instruments has been increasing



Turnover for US dollar and euro contracts[3]



The vertical lines indicate April 2016 and April 2019 (the dates of the last BIS Triennial Central Bank Surveys).

[1] Three-month moving averages. [2] Interest rate swaps. [3] OIS and FRAs included.

Sources: Clarus Financial Technology; authors' calculations.

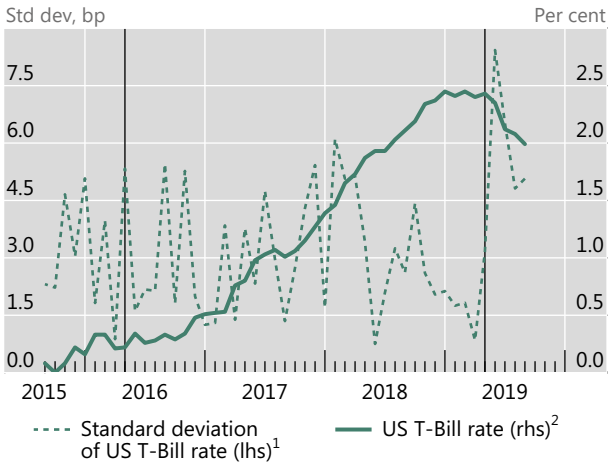
to decline from then on and the volatility of short rates started to rise markedly. This is indicative of both a changing and an increasingly uncertain interest rate environment.

In the euro area, on the other hand, the continued accommodative monetary policy in the currency zone kept shorter-term rates low and more stable, with subdued short-term rate volatility during both April 2016 and April 2019 (Graph 6, right-hand panel). This is consistent with the much smaller level and increase in activity in short-term euro contracts (Graph 5, right-hand panel).

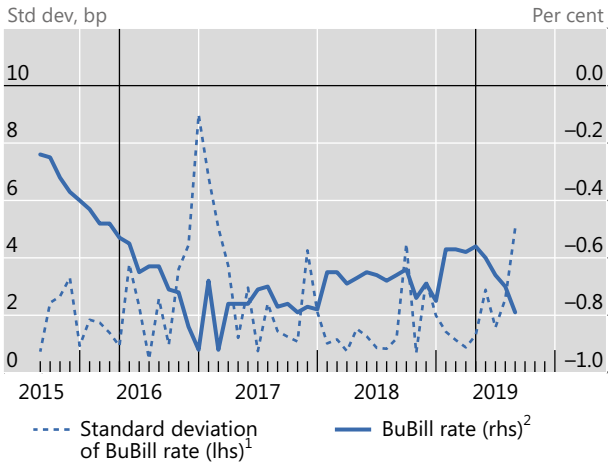
Short-term rates and volatility since 2016 in the major currency areas

Graph 6

US dollar short-term rates and volatility



Euro short-term rates and volatility



The vertical lines indicate April 2016 and April 2019 (the dates of the last BIS Triennial Central Bank Surveys).

[1] End-of-month rates; three-month T-bill rate for the US dollar and six-month BuBill (German government bills) rate for the euro. [2] Historical standard deviation of daily prices during the past month.

Sources: Board of Governors of the Federal Reserve System; Deutsche Bundesbank; authors' calculations.

The shift to central clearing of OTC interest rate products

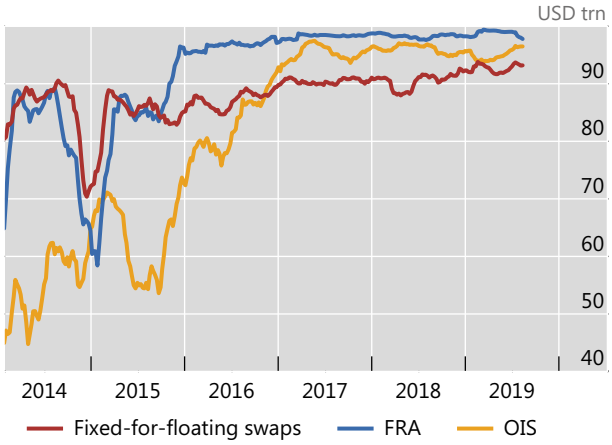
The shift to central clearing has been an important structural change for OTC interest rate derivatives markets. The move was spurred in large part by a concerted regulatory push in response to the 2007–09 financial crisis (Domanski et al (2015)). The strong regulatory incentives developed led to a surge in IRD trades cleared with central counterparties.① These include clearing requirements for some products, preferential capital treatment for cleared derivatives and higher margin requirements for uncleared derivatives. The move to clearing also brought other benefits, such as reduced counterparty risk, more netting opportunities for cleared contracts and increased compression opportunities (BCBS et al (2018), Bellia et al (2019)).

The rise in central clearing can be self-reinforcing, as liquidity shifts to CCPs and incentivises other traders to move likewise. As a result of both the regulatory push and more incentives to clear, clearing rates have increased substantially (Graph A, left-hand panel). In the US market, over 90% (in terms of notional turnover) of fixed-for-floating swaps, forward rate agreements (FRAs) and OIS transactions are now cleared, up from 79% for OIS and 86% for fixed-for-floating swaps in April 2016.

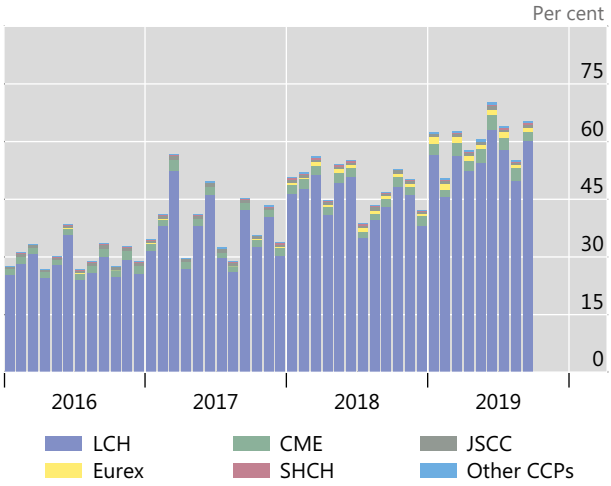
The inherent network effects of clearing lead to a high concentration in CCP activity.② Concentration helps to deepen liquidity and facilitates portfolio compression, which in turn incentives even more trades to move to the core CCPs. The London Clearing House (LCH) is the dominant CCP for clearing interest rate derivatives (Graph A, right-hand panel). Other CCPs play larger roles for currencies other than the dollar, the euro or sterling (eg JSCC for the Japanese yen, or Shanghai Clearing House for the Chinese renminbi).

Concentration of CCPs in the OTC interest rate derivatives market — Graph A

Transaction clearing ratio,[1] by instrument



Monthly notional turnover cleared by CCPs[2]



[1] Share of transactions centrally cleared, by product; three-month moving averages. [2] LCH = London Clearing House; CME = Chicago Mercantile Exchange; JSCC = Japan Securities Clearing Corporation; Eurex = Eurex Exchange; SHCH = Shanghai Clearing House; other CCPs = Asigna MexDer, ASX Clear, BME Clearing, The Clearing Corporation of India (CCIL), Hong Kong Exchanges and Clearing (HKEX), Central Securities Depository of Poland (KDPW), Korea Exchange (KRX), Nasdaq OMX Clearing and Singapore Exchange (SGX).

Sources: US Commodity Futures Trading Commission; Clarus Financial Technology.

① See Aramonte and Huang (2019) in this issue for a more general discussion of clearing in derivative markets. ② A network effect refers to the effect that an additional participant in the network has on others in the network. In the case of central clearing, each additional clearing participant increases the benefit of central clearing by increasing the liquidity of the products cleared, enabling multilateral compression opportunities and allowing any common counterparties to remove counterparty risk by novating their contracts to the CCP.

New players and automated trading

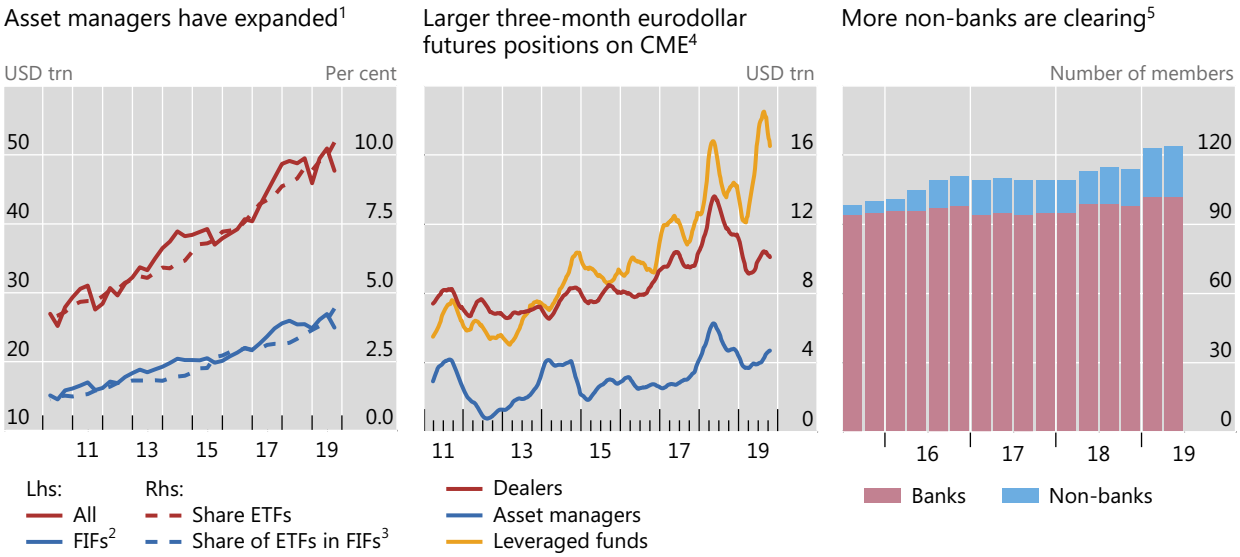
Investment funds and other asset managers have become more and more important as sources of demand for interest rate derivatives.[14] They have substantially increased their assets under management (AUM) in the past decade (Graph 7, left-hand panel). This was especially the case for exchange-traded funds (ETFs), which accounted for 10% of AUM in the third quarter of 2019, up from 4% in 2010.

Some asset managers use derivatives to manage their risk or replicate a portfolio. For instance, ETFs may use derivatives to help their return track a particular target.[15] Funds which invest in fixed income securities may naturally have use for IRD products. Such funds have also been expanding in terms of AUM, with an increasing share of them in the form of ETFs.

Gross derivatives positions for asset managers and leveraged funds are increasing faster than those of dealers. They were 37% larger from April 2016 to April 2019 for three-month eurodollar contracts on the Chicago Mercantile Exchange, as compared with 18% for dealers (Graph 7, centre panel). This trend indicates greater demand by funds for IRDs more broadly, which implies a rise in demand for OTC IRDs as well. This increase in demand contributed to the growth in OTC turnover with "other financial institutions" (Graph 3, centre panel), as well as the rise seen in the exchange-traded data.

Increased derivatives activity by non-banks

Graph 7



[1] Fund value of funds in the Lipper database. [2] Fixed income funds (FIFs), which invest in bond, money market and mixed assets. [3] Share of ETFs within the FIF category. [4] Gross positions on the Chicago Mercantile Exchange, defined as a sum of short positions plus long positions plus spreading positions. A spreading position occurs when the trader holds both long and short contracts which have not offset each other. The spreading position is the lesser of the long and short values, and the remainder is attributed to the larger value (eg a trader with 10 long contracts and five short contracts which have not yet offset each other would have their positions recorded as five spreading contracts and five long contracts). [5] IRD clearing members of LCH.

Sources: US Commodity Futures Trading Commission; Clarus Financial Technology; Lipper; LCH.

[14] Due to their size, their dynamics can be important for how IRD markets behave (Kreicher and McCauley (2016)).

[15] Note that synthetic ETFs typically use total return swaps (TRS) to generate many of their positions. TRS derivatives are classified as credit derivatives in the BIS derivatives statistics, so their developments are not captured in the IRD turnover discussed in this article. The use of IRDs by synthetic ETFs would be reflected in the turnover increase observed in the Triennial data.

Participation in central clearing highlights the importance of OTC IRD products for the overall strategies and business models of asset managers and other non-dealers. Many asset managers access CCP clearing services through affiliated banks or as clients to CCP members. Some non-banks have also started to directly clear their own positions by becoming clearing members with CCPs (Graph 7, right-hand panel). At end-March 2016, 96 bank members and five non-bank members cleared IRDs with LCH. By end-June 2019, the number of non-bank members jumped to 22 (with 102 bank members).

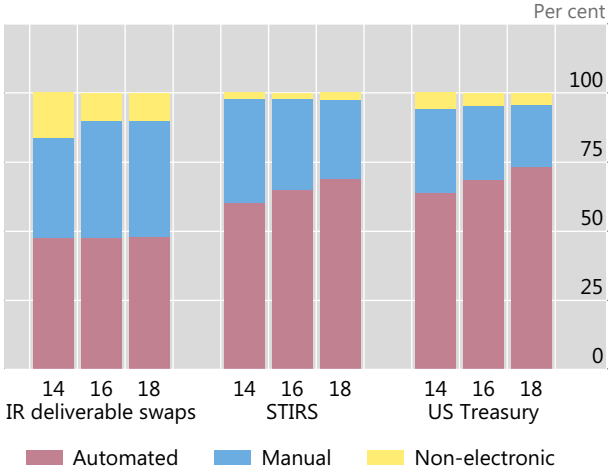
Another factor that bolstered the presence of asset managers and other new players in derivatives markets was a fall in transaction costs. Technological advances, including electronification, automation and algorithmic trading, have reduced these costs for trading in both OTC and exchange derivatives markets. They have also facilitated new investment strategies, in particular those using algorithmic trading.[16]

Automated trading has been on the rise across all derivatives markets in recent years. A trade is considered automated if it is "generated and/or routed without human intervention" (Haynes and Roberts (2015)).[17] Its adoption has been steadily increasing on exchanges (Graph 8, left-hand panel). The implementation of swap execution facilities (SEFs) in the US (spurred in part by mandatory execution requirements for swap trades in the Dodd-Frank Act) indicates that automated trading is generally spreading through the OTC market as well (right-hand

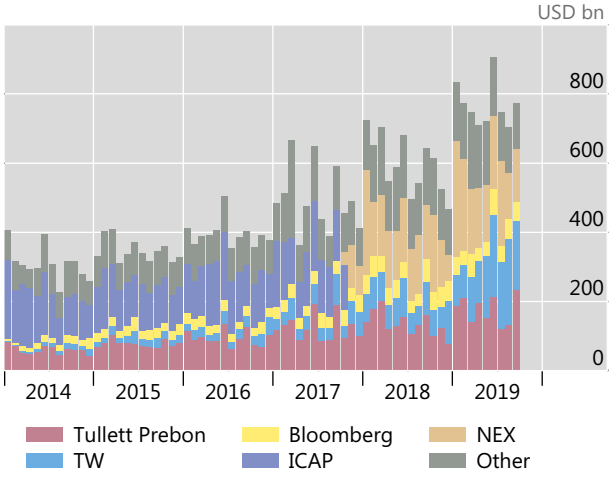
Automated trading has increased

Graph 8

More automated trading for IRD futures[1]



Turnover with swap execution facilities rising[2]



[1] Futures contracts traded on the Chicago Mercantile Exchange. 14 = contracts executed between 12 November 2012 and 31 October 2014; 16 = contracts executed between 1 November 2014 and 31 October 2016; 18 = contracts executed between 1 November 2016 and 31 October 2018. [2] Turnover with swap execution facilities in the United States. TW = Trade Web; other = BGC SEF, DW SEF, GFI Group, ICAP Global Derivatives Limited SEF (IGDL SEF), Javelin SEF, LatAm SEF, Tradition SEF and trueEX.

Sources: Haynes and Roberts (2015, updated); Financial Industry Association.

[16] Hedge funds and proprietary trading firms (PTFs) have led the increase in turnover in foreign exchange OTC markets. PTFs often utilise centralised electronic trading platforms and algorithmic trading strategies. See Schrimpf and Sushko (2019b) in this issue for a discussion.

[17] This is a broader set of trades than just those generated by algorithms, also including "those which are generated manually but make use of automated spreading functionality, or even those where manual traders use the order submission management of third-party trading systems" (Haynes and Roberts (2015)).

panel).[18] By providing the infrastructure, SEFs make it easier to engage in algorithmic trading strategies in OTC markets. IRD turnover via SEFs increased from $391 billion in April 2016 to $710 billion in April 2019.

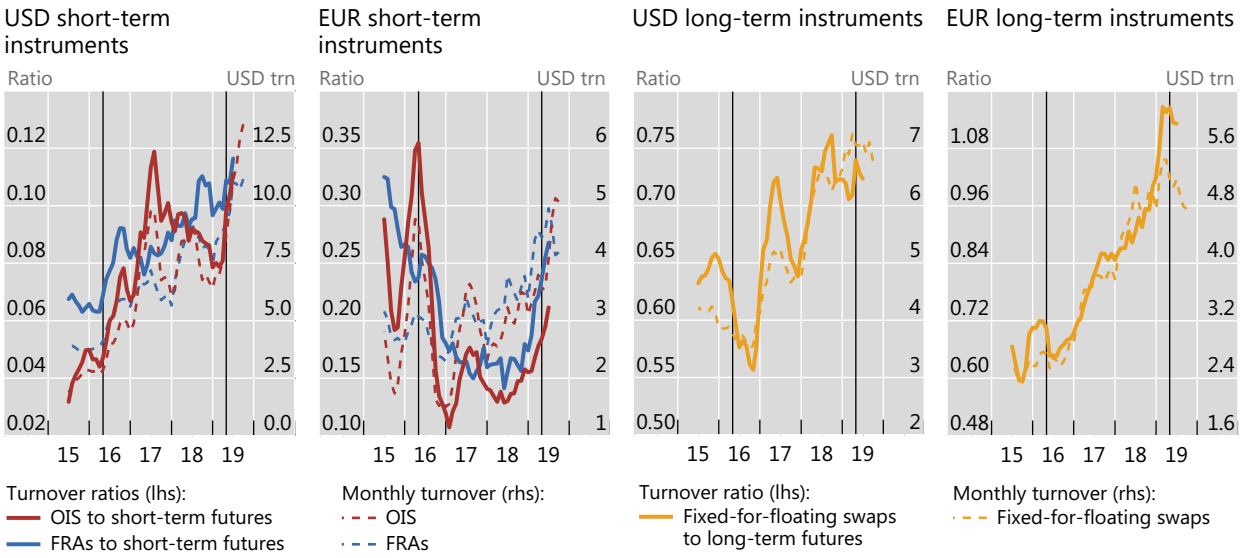
The increasing importance of OTC markets

While the factors discussed above help to explain the rise in turnover in IRD markets, they cannot fully explain the significant structural shift towards OTC markets from exchanges. Graph 9 highlights that the shift has been broad-based across the major currencies and both short-term and long-term instruments. The graph is based on turnover data from CCPs, which are not affected by the increase in related party trades or portfolio compression discussed above.

The relative attractiveness of OTC markets can – at least partly – be ascribed to the fact that OTC markets now yield many of the benefits of exchanges (Ehlers and Eren (2016), Hull (2014)). The move to central clearing and electronic trading platforms – two key pillars of the OTC derivatives market reforms promoted by the G20 – resulted in a decline in counterparty risks, a reduction in transaction costs and increased speed of trading. More effective and speedy compression on OTC markets minimises the notional amounts of outstanding contracts and thereby regulatory costs. These benefits appear to have outweighed the costs related to margining and

The structural shift towards OTC markets in recent years

Turnover ratios of OTC to exchange-traded derivatives, six-month moving averages — Graph 9



The vertical lines indicate April 2016 and April 2019 (the dates of the last BIS Triennial Central Bank Surveys).

Sources: Clarus Financial Technology; BIS exchange-traded derivatives statistics; authors' calculations.

[18] The EU is also developing similar infrastructure in the form of organised trading facilities (OTFs).

collateral requirements for cleared and uncleared derivatives, implemented in most jurisdictions including the United States and the European Union (FSB (2019)).

Exchanges have attempted to lure activity back from OTC markets by offering new instruments, such as swap futures. Zazzara (2019) dubs this the "futurisation of OTC markets". While swap futures have been launched at various points in time, in part to capture increasing demand for longer-term IRDs referencing private benchmark rates (Kreicher et al (2017)), their success thus far has been limited. The dedicated futures exchange Eris, for instance, introduced a deliverable swap future in February 2013. Even though turnover in these contracts picked up in recent months as trading moved to CME in December 2018, it is still less than 0.5% of turnover in US dollar OTC swaps.

Conclusion

Turnover in interest rate derivatives markets has increased substantially over the last three years, particularly in OTC markets. A rise in non-market facing trades, such as compression and back-to-back trades, helped boost turnover in OTC markets. The change in the US monetary policy outlook and the move to shorter-maturity instruments also played a role. Further, continuing structural changes have been important in driving up IRD turnover, especially in OTC markets. Automated trading has expanded access and reduced transaction costs, as new players have moved into the market.

The regulatory push towards central clearing and electronic trading, as well as the evolution of compression services, has led to a relative shift from exchanges to OTC markets. OTC markets now offer many of the attractive features that exchanges held, while also maintaining a wider range of products and contracts and the ability to meet customised demands. These factors have led turnover growth in OTC markets to significantly outpace that in exchanges.

Looking forward, more structural changes may be on the horizon. The prospect of the United Kingdom leaving the European Union may influence the structure of OTC markets, especially with so much activity based in London. Moreover, the transition of benchmark rates to new overnight risk-free rates (RFRs) foreshadows significant changes in both the type of traded instruments and the relative importance of OTC versus exchange-traded markets. The range of derivative instruments will expand as debt contracts start to reference the new RFRs. Term benchmarks beyond overnight rates are needed to, for instance, determine interest obligations in cash instruments (eg bonds). Therefore, new instruments, such as OIS with RFRs as the floating rate or longer-term RFR futures, are likely to be developed. Depending on which instruments prevail, this could again shift trading between OTC markets and exchanges. Whether these new contracts will gain a significant market share or even replace existing ones is unclear, as multiple benchmarks may emerge to serve different purposes and fulfil different market needs (Schrimpf and Sushko (2019a)).

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OTC derivatives: euro exposures rise and central clearing advances[1]

The composition of amounts outstanding in over-the-counter derivatives shifted towards the euro and cleared instruments. Since the Great Financial Crisis, increases in central clearing rates have helped shape growth in amounts outstanding. Derivatives subject to regulatory clearing mandates were approaching full clearing, while clearing rates were low for certain products, including some with short maturities or liquid bilateral markets.

JEL classification: G10; G18; G23.

Over-the-counter (OTC) markets are increasingly important for many types of derivative. This article examines how the composition of outstanding OTC derivatives has changed as they have become increasingly prevalent in financial markets. To explore the currency composition of outstanding OTC derivatives and trends in clearing, we draw on data from the combined BIS semiannual derivatives statistics and Triennial Central Bank Survey of OTC derivatives markets.[2]

The combined surveys show that interest rate derivatives still accounted for the largest share of the OTC derivatives recorded by dealers in advanced economies (AEs), while FX derivatives predominated in the outstanding positions of dealers from emerging market economies (EMEs). The euro's share rose globally, accounting for 44% of AE dealers' outstanding contracts by market value at end-June 2019, compared with 24% in US dollars. The euro became more relevant for dealers from emerging Europe in particular. Nevertheless, the US dollar remained the pre-eminent currency for EME dealers.

Since the Great Financial Crisis (GFC) of 2007–09, the dynamics of amounts outstanding in OTC derivatives markets have been shaped, in part, by regulatory reforms agreed at the 2009 G20 summit. Central clearing is a key element in authorities' efforts to reform OTC derivatives markets and reduce systemic risk. The

[1] The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements. We thank Kristina Micic for valuable assistance with the data.

[2] Since 1998, the BIS has collected two sets of statistics on outstanding positions in OTC derivatives markets: semiannual data from large derivatives dealers in 12 jurisdictions, and triennial data from smaller dealers in more than 30 jurisdictions. Both sets of data cover the worldwide consolidated positions of reporting dealers. According to the latest Triennial Survey, which captured positions at end-June 2019, smaller dealers accounted for about 8% of notional amounts outstanding (BIS (2019)). Between Triennial Surveys, the BIS uses the triennial data to scale up the semiannual data, thereby providing a more accurate estimate of the global size of OTC derivatives markets.

Key takeaways

- The management of interest rate risk continued to dominate global OTC derivatives activity, although FX derivatives were more important among dealers from emerging market economies.
- Among dealers from emerging market economies, the share of interest rate derivatives cleared rose to the high levels reported by dealers from advanced economies.
- After increasing substantially following the GFC, clearing rates have levelled off recently, with mandated products approaching full clearing.

data on outstanding positions show that clearing rates increased substantially from 2010 to 2017. By 2019, contracts subject to mandatory clearing were cleared almost entirely by central counterparties (CCPs).[3] For OTC derivatives not subject to mandatory clearing, clearing rates varied across products, even though margin requirements incentivised central clearing.

The next section of this article discusses recent trends in outstanding positions. The second section focuses on clearing, and the final section concludes.

Trends across countries and currencies

The notional amount of OTC derivatives, which determines contractual payments, rose to $640 trillion at end-June 2019 (Graph 1, left-hand panel). This was its highest level since 2014, continuing an upward trend that started in 2015. Over the same period, the global sovereign and non-financial corporate bond markets expanded at a similar pace. The turnover of OTC derivatives rose even more rapidly than notional amounts, probably because (i) trade compression limited notional growth and (ii) turnover rose mainly for shorter-maturity instruments that are rolled over frequently (Ehlers and Hardy (2019) in this issue).

In contrast to the notional amount, gross market value, which is a better gauge of amounts at risk, has trended downward since 2012 (left-hand panel). It totalled about $12 trillion in mid-2019, compared with $15 trillion in mid-2015 and $26 trillion in mid-2012. Netting agreements reduced dealers' credit exposure to $2.7 trillion at end-June 2019, equivalent to 22% of gross market value. In OTC derivatives markets, these credit exposures are typically covered by collateral.[4]

OTC derivatives referenced mainly interest rates. At end-June 2019, interest rate derivatives represented 73% of outstanding contracts by gross market value (Graph 1, right-hand panel). FX derivatives came a distant second, with 18%. Other derivatives, mostly in the form of equity and credit derivatives, accounted for 9% of gross market

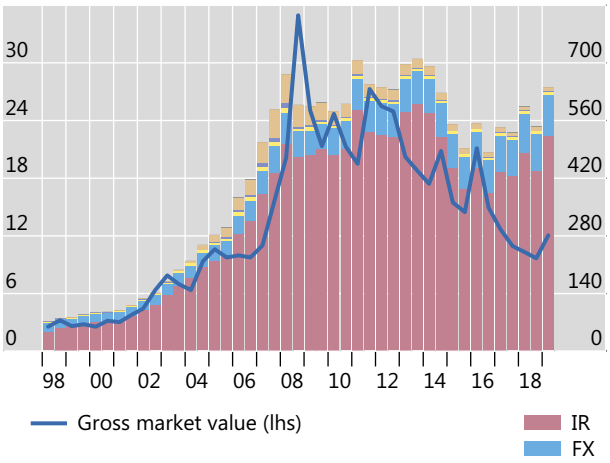
[3] The report of the Derivatives Assessment Team of the Financial Stability Board (FSB) recently found that regulations provided impetus for central clearing (BCBS-CPMI-FSB-IOSCO (2018)).

[4] In the BIS OTC derivatives statistics, gross credit exposure takes into account legally enforceable bilateral netting agreements but not collateral. Gross credit exposure is reported only by dealers who participate in the semiannual survey.

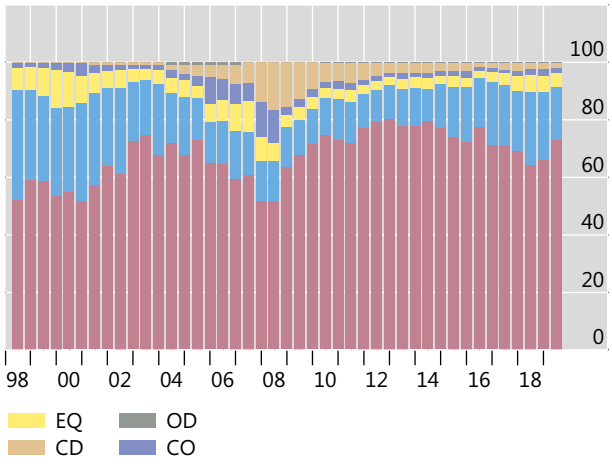
Global trends in OTC derivatives outstanding

At half-year end — Graph 1

Notional amounts outstanding (USD trillions)



Gross market values (%)[1]



CD = credit derivatives; CO = commodity derivatives; EQ = equity-linked derivatives; FX = foreign exchange derivatives; IR = single-currency interest rate derivatives; OD = other derivatives.

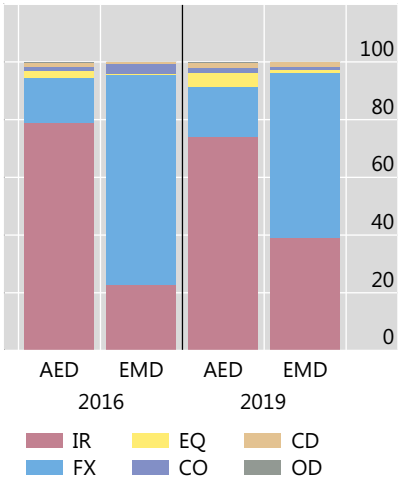
[1] As a percentage of the gross market value of all outstanding OTC derivatives.

Source: BIS derivatives statistics.

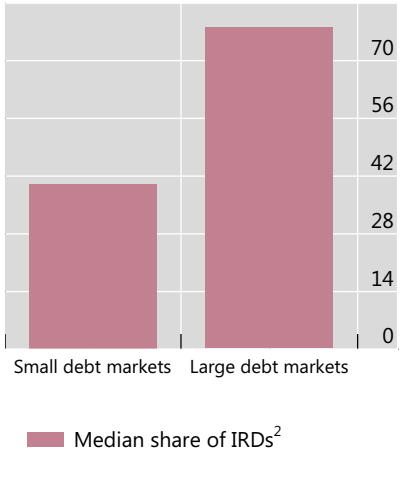
Composition of AE and EME dealers' OTC derivatives exposure

Share of gross market value of all outstanding OTC derivatives at end-June, in per cent — Graph 2

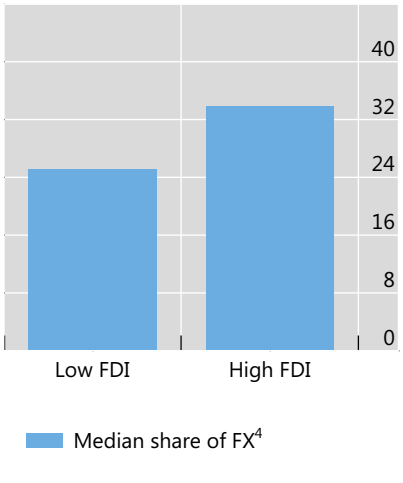
By underlying risk



Share of IRDs depending on debt securities market size[1]



Share of FX depending on FDI[3]



AED = advanced economy dealers (AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, LV, NL, NO, PT, SE and US); CD = credit derivatives; CO = commodity derivatives; EMD = emerging market dealers (ie dealers from countries that participate in the Triennial Survey, excluding those listed under AE); EQ = equity-linked derivatives; FDI = foreign direct investment; FX = foreign exchange derivatives; IR(Ds) = single-currency interest rate derivatives; OD = other derivatives.

[1] Small (large) debt markets are countries whose share of debt securities markets in the total (ie global debt market estimate) is below (above) the median share. [2] Share in the total amount based on gross market values at end-June 2019. [3] The low (high) FDI categories include countries whose foreign direct investment as a share of GDP is below (above) the median. As at December 2018. [4] Share in the total amount based on gross market values at end-June 2019.

Sources: Dealogic; Euroclear; Thomson Reuters; Xtrakter Ltd; World Bank; national data; BIS derivatives statistics; BIS calculations; authors' calculations.

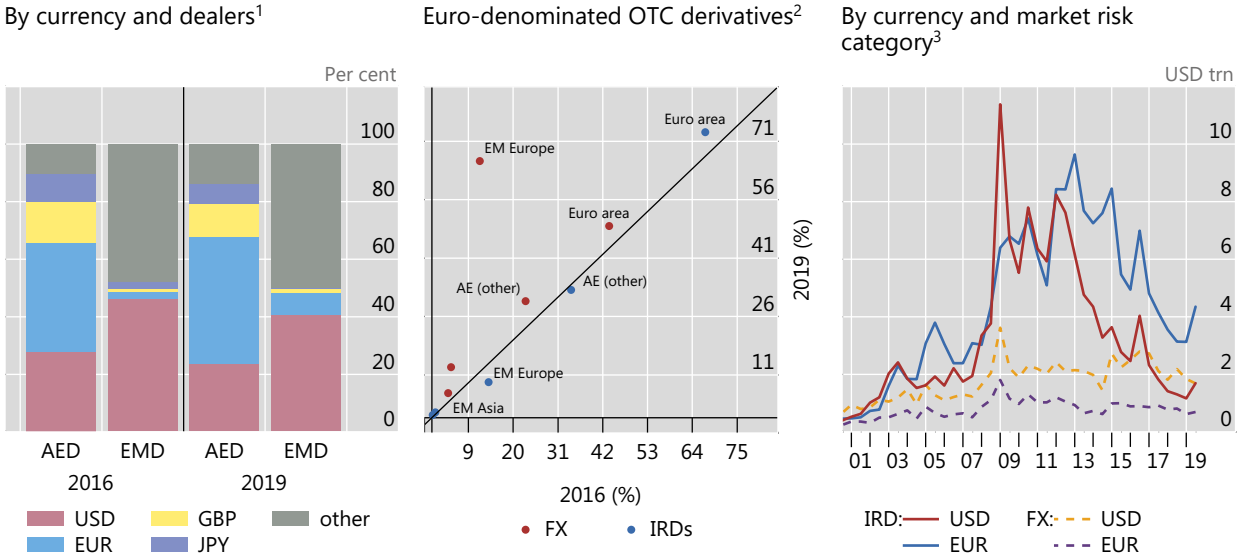
value. For AE dealers, exposures were concentrated in interest rate derivatives (74%); for EME dealers, they were mainly in FX derivatives (57%) (Graph 2, left-hand panel).[5]

Differences in exposures reported by AE and EME dealers reflected structural economic differences across countries. In particular, exposure to interest rate derivatives was higher for dealers from countries with larger debt securities markets, while FX derivatives were more significant for dealers from countries receiving relatively more foreign direct investment (Graph 2, centre and right-hand panels). The balance sheet composition of AE and EME dealers also differed in terms of currencies. AE dealers reported that their exposures consisted mainly of derivatives referencing the euro and the US dollar: 44% and 24%, respectively, at end-June 2019. For EME dealers, the US dollar was the key reference currency, representing 41% of their exposures (Graph 3, left-hand panel).

The euro's share of outstanding market value has increased appreciably over the past three years. Among dealers from AEs, the share of euro-denominated derivatives increased by 6 percentage points from 38% at end-June 2016. Over the same period, the share of euro-denominated derivatives in market value terms rose by 6 percentage points in EMEs, from 2% in 2016 to 8% in 2019. Dealers in emerging Europe drove the increase in euro exposure for EME dealers. While the share of euro-denominated OTC derivatives rose for euro area dealers and those in other AEs, it was considerably more pronounced for dealers in emerging Europe (Graph 3, centre panel).

Euro share expands, especially in FX derivatives

Gross market values — Graph 3



AED = advanced economy dealers (AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, LV, NL, NO, PT, SE and US); AE (other) = advanced economies excluding euro area economies; EM Asia = developing Asia and Pacific (see EMEs); EMD = emerging market dealers (ie those from countries that participate in the Triennial Survey excluding AEs); EM Europe = developing Europe (see EMD); FX = foreign exchange derivatives; IRDs = single-currency interest rate derivatives.

[1] Interest rate and foreign exchange derivatives only. As at end-June. [2] The share of euro-denominated interest rate and foreign exchange derivatives in the total of all currencies. As at end-June. [3] Dealers headquartered in AEs only. As at half-year end.

Source: BIS derivatives statistics.

[5] In the following discussion, exposures are defined in terms of gross market value. For comparisons of AE and EME derivatives markets in terms of size, instrument type and currencies, see eg Patel and Xia (2019), Upper and Valli (2016) and Wooldridge and Xia (2019).

A further breakdown of dealers' currency exposures by asset class shows that the US dollar dominated FX derivatives, while the euro surpassed other currencies in interest rate derivatives. In the latter case, euro and US dollar exposures were roughly similar until end-2011, when a gap opened rapidly, only stabilising after end-2014 (Graph 3, right-hand panel). The opening of this gap coincided with the ECB's introduction of longer-term refinancing operations to support bank lending and liquidity in the euro area money market.

In addition to hedging portfolio currency risk, FX swaps are used to cover US dollar financing needs, for both financial institutions (Baba and Packer (2009)) and non-financial corporates (Borio et al (2017)). In recent years, banks' use of FX swaps to manage funding liquidity has also increased (Schrimpf and Sushko (2019)).

Central clearing shaped patterns in derivatives outstanding

Rising central clearing rates, spurred by the post-crisis regulatory framework agreed at the 2009 G20 summit, have shaped the evolution of outstanding derivatives amounts since the GFC. This section reviews broad central clearing trends, highlights key channels through which central clearing can affect outstanding derivatives amounts and discusses central clearing rates in key market segments in the light of regulatory initiatives.

Clearing rates levelled off overall, rose for EME dealers

There were marked differences in central clearing rates across derivative types.[6] For interest rate and credit derivatives, substantial increases in the early years after the GFC levelled off recently. In particular, clearing rates rose from 55% in 2010 to 75% in 2017 for interest rate derivatives. Over the same period, the increase for credit default swaps (CDS) was also remarkable, from 10% to 55%. However, clearing rates barely inched up between 2018 and 2019 (Graph 4, left-hand panel).

For FX derivatives, the share of notional amounts for which CCPs are dealer counterparties was just 4% at end-June 2019 (right-hand panel). Low clearing rates for FX derivatives probably reflected the fact that most of these derivatives are deliverable contracts, which are not particularly suited for central clearing because they involve the exchange of notional principal, thus requiring CCPs with large balance sheets and access to funding in multiple currencies.

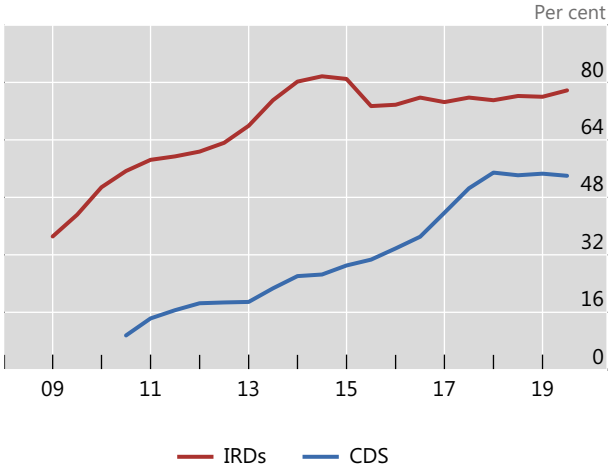
The clearing rates of EME dealers caught up with those of AE dealers over the past three years. AE dealers generally reported higher rates than those from EMEs and were approaching full clearing, while rates increased substantially for EME dealers (Graph 5, left-hand panel). AE currencies had higher clearing rates, while EME ones exhibited more substantial growth in central clearing (right-hand panel).

[6] The proportion of outstanding positions against CCPs is typically larger than the proportion of trades cleared through CCPs because the former counts trades between dealers twice. In the BIS OTC derivatives statistics, whereas inter-dealer positions are adjusted to eliminate double-counting, inter-dealer trades that are subsequently novated to a CCP are not adjusted. For further discussion, see Wooldridge (2016).

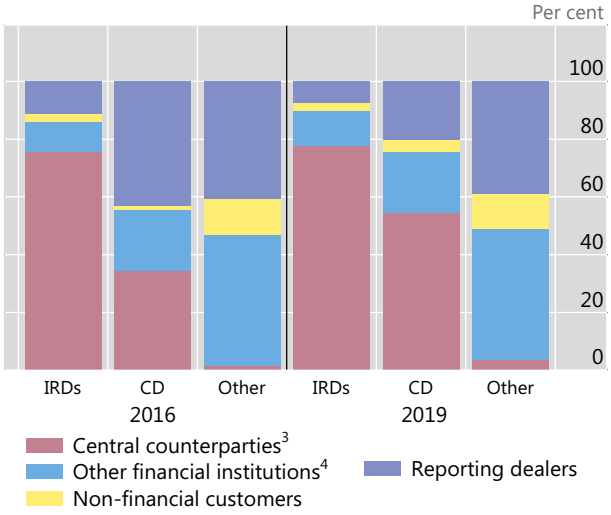
Central clearing advances after the Great Financial Crisis

Notional amounts outstanding — Graph 4

Clearing rates[1]



Notional amounts outstanding,[2] by counterparty and underlying risk



CD = credit derivatives; CDS = credit default swaps; IRDs = interest rate derivatives; other = foreign exchange and equity derivatives.

[1] Calculated as a share of notional amounts outstanding reported vis-à-vis CCPs in the total notional amounts outstanding. For IRDs, 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. At half-year end. [2] As a percentage of the notional amount of all outstanding OTC derivatives. As of end-June. [3] Contracts between reporting dealers that are subsequently novated to CCPs are recorded twice. [4] Excluding central counterparties and reporting dealers.

Sources: LCH.Clearnet Group Ltd; BIS derivatives statistics.

Rising clearing rates can reduce outstanding notional and gross market value in three main ways. First, offsetting positions can be netted across multiple parties. Second, CCPs have a complete view of the positions of their clearing members, facilitating trade compression.[7] Since the clearing mandate took effect in 2012, the notional amount of compression trades increased substantially (Ehlers and Hardy (2019) in this issue). Third, central clearing allows settled-to-market (STM), in which traders take ownership of variation margins and the market value of the derivatives is reset to zero frequently. Some dealer banks indicated that gross derivatives market value in their public reporting dropped because of STM.[8]

Clearing rates for mandated versus non-mandated contracts

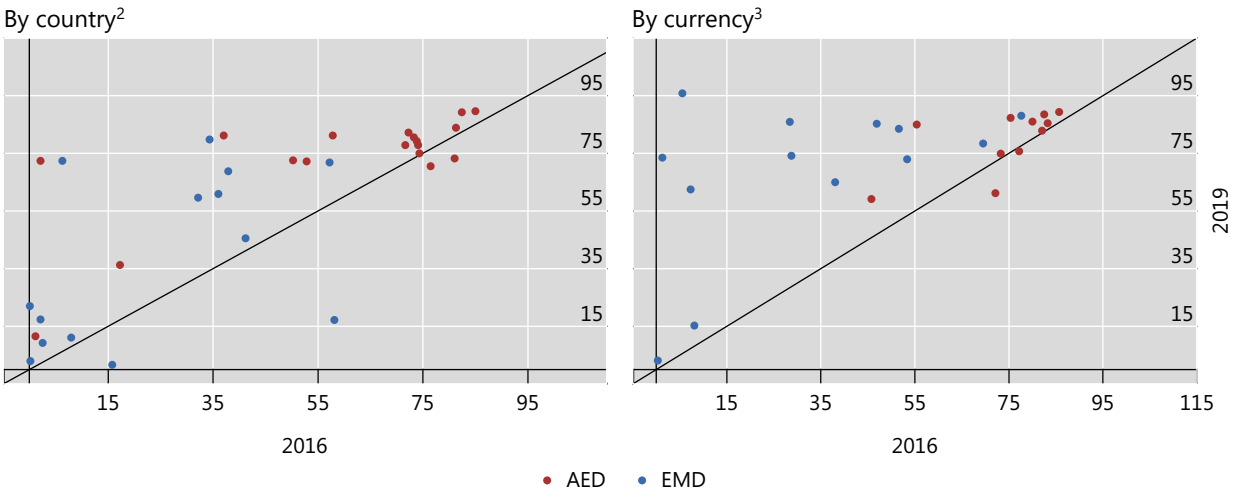
In the aftermath of the GFC, regulatory initiatives promoting central clearing were two-pronged. First, central clearing was mandated for a set of standardised contracts – including forward rate agreements (FRAs), interest rate swaps (IRS) and CDS indices. Second, uncleared contracts were to face higher capital and margin requirements, primarily to better reflect their risk profiles but also to promote central clearing.

[7] Compression is a process whereby two or more counterparties tear up existing derivatives contracts and replace them with a smaller number of new ones that leave the economic exposures materially unchanged. The elimination of economically redundant derivatives positions reduces the number of contracts and gross notional amounts.

[8] See eg the annual reports of Goldman Sachs (2016) and Wells Fargo (2017).

Clearing rates[1] increase substantially for emerging markets

Interest rate derivatives at end-June, in per cent — Graph 5



AED = advanced economy dealers (AT, AU, BE, CA, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, JP, LV, NL, NO, PT, SE and US); EMD = emerging market dealers (ie those from countries that participate in the Triennial Survey excluding AEs).

[1] Calculated as a share of notional amounts outstanding reported vis-à-vis CCPs in the total notional amounts outstanding. [2] Share of derivatives reported vis-à-vis CCPs in 2016 and in 2019 by dealers headquartered in a country, as a percentage of notional amount reported vis-à-vis all counterparties by those dealers. Contracts between reporting dealers that are subsequently novated to CCPs are recorded twice. [3] Share of derivatives reported vis-à-vis CCPs in 2016 and in 2019 in the currency of the "home" country of the dealer (ie that of the country where the parent group of the dealer is headquartered), as a percentage of the total reported vis-à-vis all counterparties in that currency. Contracts between reporting dealers that are subsequently novated to CCPs are recorded twice.

Source: BIS derivatives statistics.

Together, these regulatory requirements laid the foundation for the increase in central clearing rates among OTC derivatives.

Central clearing rates for mandated contracts approached 100% in mid-2019.[9] Based on transaction data, most mandated FRA and IRS contracts were already centrally cleared by end-2013, with clearing rates close to or above 90% (Graph 6, left-hand panel). The clearing rate for mandated CDS indices grew steadily from 48% at end-2013 to 92% at end-June 2019. As a result, virtually all mandated contracts were centrally cleared by mid-2019, limiting the scope for future increases.

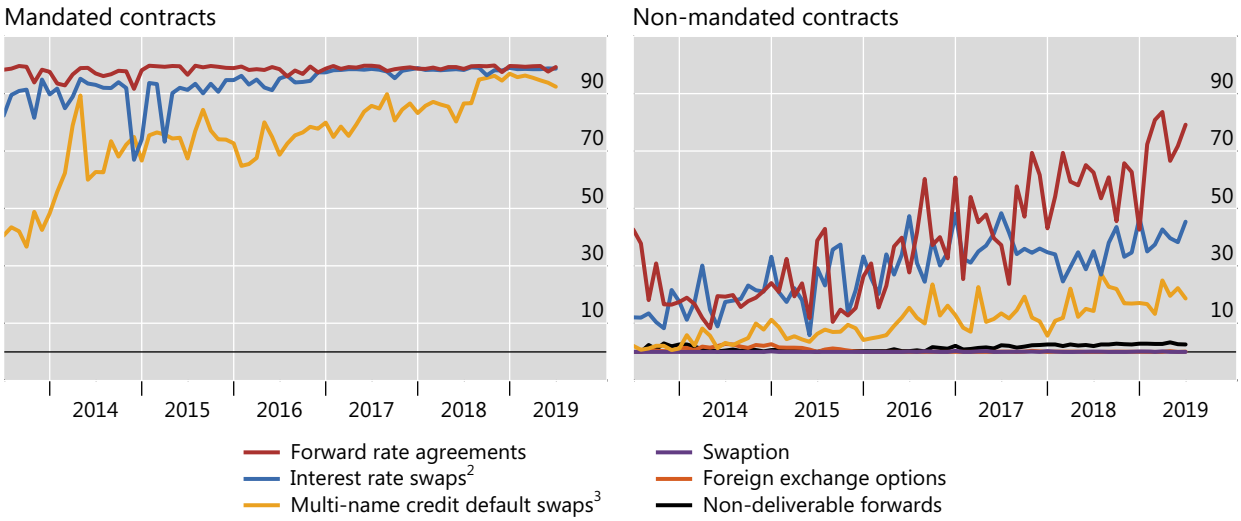
Moreover, clearing rates for non-mandated FRAs, IRS and CDS indices increased substantially over the past six years. Clearing of non-mandated FRA contracts rose the most, from 17% at end-2013 to 79% in June 2019 (Graph 6, right-hand panel). The clearing rate for non-mandated IRS also went up, from 18% to 45%, and that for non-mandated CDS indices climbed from 1% to 19%.

The upward trend in clearing rates for non-mandated contracts can arguably be traced to the multilateral netting benefits of central clearing, together with the higher capital and margin requirements applicable to non-cleared contracts (Ghamami and Glasserman (2017)). The phasing-in of margin requirements on uncleared contracts (known as uncleared margin rules, UMR), which started in September 2016, provides an opportunity to examine the effects of margin requirements on central clearing rates.

[9] Transactions of small clients are exempted from the clearing mandates.

Clearing rates[1] for mandated and non-mandated contracts

Transactions, monthly data, in per cent — Graph 6



[1] Calculated as a share of notional amounts traded vis-à-vis CCPs in total notional amounts traded. [2] Includes basis swaps, OIS and fixed/floating swaps. [3] CDS index.

Sources: Depository Trust and Clearing Corporation Swap Data Repository; authors' calculations.

Margin requirements rose markedly after UMR were implemented. They were first applied to financial firms with month-end notional derivatives exposure greater than €3 trillion ("phase 1 firms"), followed by firms with smaller notional exposure.[10] UMR led to significantly higher margin requirements, with phase 1 firms collecting $84 billion and posting $83 billion in initial margin at end-2018 for non-centrally cleared derivatives subject to UMR (Graph 7, left-hand panel). These figures were roughly 80% higher than in March 2017 and represented about 40% of total initial margins with CCPs for interest rate and credit derivatives.

We can gauge the impact of UMR on central clearing by linking the staggered implementation of UMR to the evolution of clearing rate differences between products subject to early or late UMR implementation. In particular, phase 1 firms in Japan and the United States were required to post margin from 1 September 2016, while those in the European Union had to do so only after 1 February 2017.

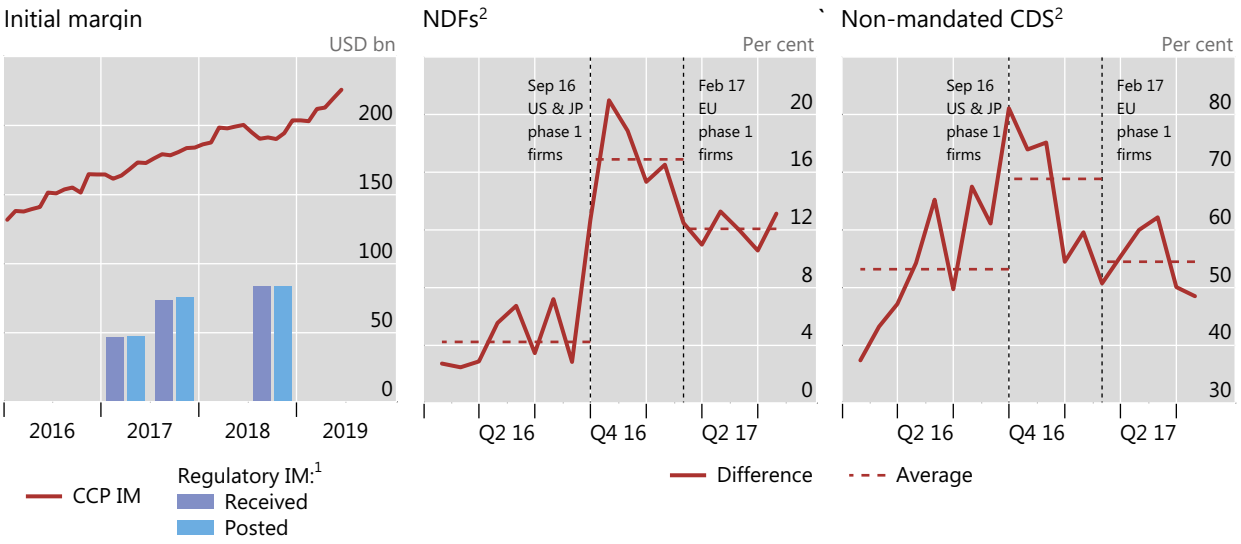
Our analysis suggests that UMR incentivised central clearing for non-deliverable forwards (NDFs) and non-mandated CDS.[11] For both products, traders in the US dollar- and Japanese yen-denominated segments moved to central clearing in the run-up to 1 September 2016, while those in the euro-denominated segment migrated gradually between late 2016 and early 2017. As a result, the clearing rates of the dollar-/yen-denominated and euro-denominated segments diverged just before the first implementation deadline and converged again as the second deadline approached (Graph 7, centre and right-hand panels).

Although post-crisis regulatory reforms promoted central clearing, clearing rates for non-mandated contracts remained low for some products. The box discusses why central clearing became common for some products but not for others. Since moving from bilateral to central clearing can be costly, migration takes place only if there are

[10] Physically delivered FX derivatives and small entities are exempted.

[11] We focus on NDFs and non-mandated CDS because they are representative of relatively simple products that can potentially be centrally cleared.

Margin requirements for uncleared trades incentivised central clearing Graph 7



[1] The regulatory initial margin (IM) is the margin pledged by 20 phase 1 financial firms that are surveyed by the ISDA. [2] The difference in the clearing rates between the USD/JPY and the EUR segments, where the clearing rate is defined as the share of notional amounts outstanding reported vis-à-vis CCPs in the total notional amounts outstanding subject to margin requirements (ie the fully collateralised segment).

Sources: Clarus Financial Technology; Depository Trust and Clearing Corporation Swap Data Repository; International Swaps and Derivatives Association (ISDA); authors' calculations.

substantial net benefits from central clearing. All else equal, migration is less likely for products with more modest netting benefits, such as those with shorter maturity. Likewise, higher liquidity in the bilateral segment can increase the costs of switching to central clearing.

Conclusion

In recent years, the composition of outstanding OTC derivatives has shifted. First, the Triennial Survey shows that balance sheet composition differed considerably across AE and EME dealers. In terms of market value outstanding, exposure was mostly to interest rate derivatives for AE dealers and to FX derivatives for EME dealers. As for currencies, exposure was mostly to the US dollar for EME dealers and more evenly split between the euro and the US dollar for AE dealers. With significant US dollar credit to EMEs (McCauley et al (2015)), FX derivatives referencing the US dollar could be used to hedge currency risk, but could also be a source of US dollar financing (Borio et al (2017)).

Second, the euro made inroads globally. In particular, its share of outstanding market value rose in interest rate derivatives for AE dealers and in FX for EME dealers. As has been the case since end-2011, the euro overshadowed other currencies in terms of market value for interest rate derivatives reported by AE dealers.

Last but not least, central clearing rates increased in EMEs but grew less quickly overall, as mandated contracts approached full clearing. As a natural result of the regulatory reforms spurred by the 2009 G20 summit, the prominent role of CCPs makes their resilience and appropriate recovery and resolution planning essential for financial stability (BCBS-CPMI-FSB-IOSCO (2017)).

Costs and benefits of switching to central clearing

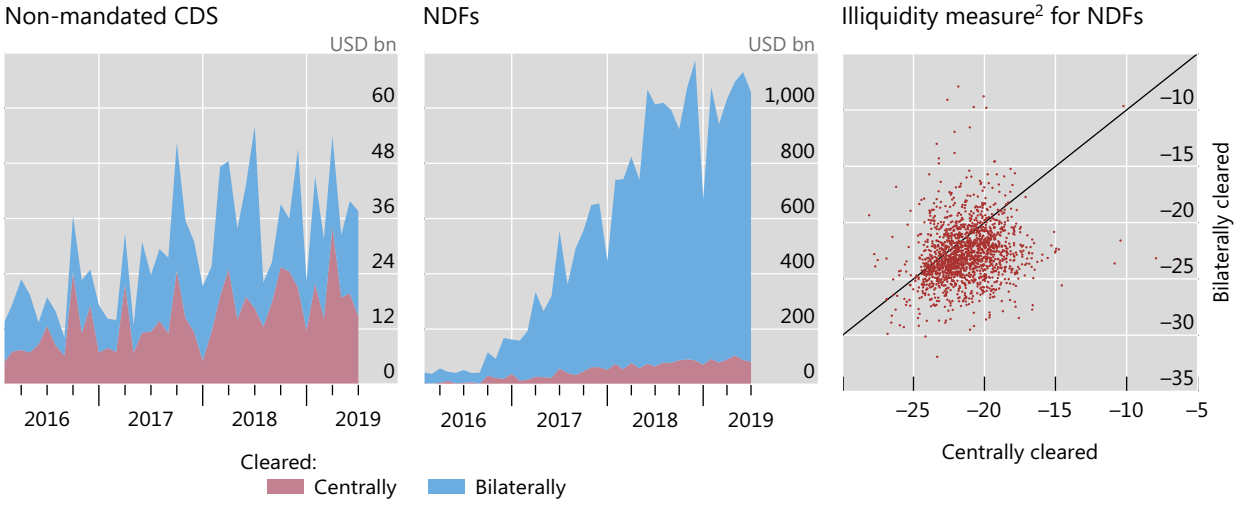
Why did trading in some derivatives migrate to central clearing, while staying with bilateral clearing for others? Among derivatives not subject to mandatory clearing, the rate of voluntary clearing differed substantially. In particular, the clearing rate for non-deliverable forwards (NDFs) was much lower than that for non-mandated credit default swaps (CDS). Such divergence can be explained, in part, by structural differences across the two products.

A substantial share of CDS trading has moved to central clearing over time, even in the absence of an official requirement. In June 2019, the monthly volume of centrally cleared CDS was, at $15 billion, comparable with the $23 billion of CDS that was cleared bilaterally each month (Graph A, left-hand panel). In comparison, the monthly volume of bilaterally cleared NDFs stood at $975 billion in June 2019, dwarfing that of centrally cleared NDFs (centre panel).

The decision to switch from bilateral to central clearing depends on a cost-benefit analysis that takes account of several elements. Among the potential benefits, lower capital or margin requirements certainly play a role, but so does the comparative ease of trade, or trading liquidity, in the bilaterally cleared and centrally cleared venues. These benefits vary across products, meaning that migration to central clearing might be cost-effective for some but not for others.①

Structure and liquidity of two major non-mandated contracts[1]

Graph A



[1] Only DTCC trades that are subject to the margin requirement for uncleared trades, ie trades that are fully collateralised including centrally cleared trades and bilaterally cleared but fully collateralised ones. [2] Log Amihud illiquidity measure.

Sources: Amihud (2002); Depository Trust and Clearing Corporation (DTCC) Swap Data Repository; authors' calculations.

First, gains from margin netting in central clearing are higher if similar products are subject to clearing mandates. The reason is that CCPs generally allow for netting within the same asset class and initial margin is calculated at the portfolio level. Unlike NDFs, standardised CDS contracts are subject to the central clearing mandate, and non-mandated CDS can benefit from margin netting under central clearing.

Second, CDS generally have longer maturities than NDFs. Maturity is a key determinant of margin requirements for uncleared products. It is often less than one year for NDFs and typically five years for CDS. All else equal, the longer the maturity, the higher the margin requirement. Given the multilateral netting benefits of central clearing, the potential for margin reduction is greater for CDS than for NDFs.

Third, significantly lower liquidity in centrally cleared markets can reduce the incentive to switch away from bilaterally cleared venues. Coordination among traders plays an important role in this instance, because liquidity in centrally cleared markets could improve rapidly if enough traders opted out of bilateral clearing at the same time. Such coordination can be difficult to achieve when other advantages from switching, such as gains from netting, are small. For NDFs, the relatively small margin netting benefits provided little incentive for enough traders to migrate, and liquidity remained concentrated in bilaterally cleared markets, further discouraging migration to centrally cleared venues (Graph A, right-hand panel).

① For a discussion of the effect of counterparty credit risk on traders' decisions to clear through CCPs rather than bilaterally, see P Fiedor, "Clearinghouse-Five: determinants of voluntary clearing in European derivatives markets", European Systemic Risk Board, *ESRB Working Paper Series*, no 72, March 2018; M Bellia, R Panzica, L Pelizzon and T Peltonen, "The demand for central clearing: to clear or not to clear, that is the question", European Systemic Risk Board, *ESRB Working Paper Series*, no 62, December 2017.

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Euro repo market functioning: collateral is king[1]

Repo markets play a major role in redistributing liquidity and collateral between financial institutions. A unique transaction-level database reveals how the euro-denominated repo market has performed since the mid-2000s. We find that the market recovered strongly from periods of intense stress, even though it remains segmented according to the home country of the collateral used. In recent years, signs of segmentation have increased as the main motivation of repo market participants has shifted from funding to the trading of collateral.

JEL classification: E40, E58, G15, G23.

As a key component of the money market, the repo market is a major channel for circulating cash and collateral through the financial system. Since the mid-2000s, repos have grown to become the predominant source of short-term funding in euro-denominated markets. In this period, the market has weathered stress during the Great Financial Crisis (GFC) of 2007–09 and the European sovereign debt crisis of 2011–12, and has coped with changes such as the ECB's introduction of unconventional monetary policy and the advent of new financial sector regulation. This article tracks the repo market's functioning in the face of these developments.

We use a unique transaction-level data set for centrally cleared euro-denominated repos to examine the market's liquidity and pricing efficiency. We find signs that the market is persistently segmented according to the home country of the collateral used. This may impede the redistribution of liquidity. Yet, despite this segmentation, we find that the repo market remained functional during periods of stress: transaction costs stayed low and prices themselves adjusted smoothly to changing fundamentals.

We also find increasing signs that, in recent years, the market has been driven by investors in search of specific collateral rather than investors seeking funding. This feature has strengthened segmentation along collateral lines. Consistent with segmentation, individual participants have "preferred habitats", in the sense of systematically borrowing and lending against collateral of a given country.

The following section outlines trading activity in the euro repo market over the 2006–18 period. We then discuss how different segments performed in terms of

[1] The authors thank Claudio Borio, Stijn Claessens, Jörg Diener, Andreas Schrimpf, Egon Zakrajšek and, especially, Philip Wooldridge for helpful comments and suggestions. The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank for International Settlements.

Key takeaways

- The euro repo market is a key channel for redistributing liquidity between financial institutions.
- The market shows signs of persistent segmentation according to the home country of the collateral.
- In recent years, demand for collateral has replaced funding considerations as the main driver of activity, further emphasising segmentation.

liquidity and pricing efficiency. The third and fourth sections examine the intensity of arbitrage trades across segments and the tendency of market participants to specialise in individual collateral segments. The final section concludes.

Trends in transaction volumes

A repurchase agreement (repo) is a two-legged transaction that resembles a collateralised loan. A borrower of cash sells securities (the collateral) to the lender and agrees to buy them back later at a pre-specified price.[2] Typical borrowers of cash are asset managers, pension funds and insurance companies. Typical lenders of cash are money market funds and corporate treasurers. Repos are intermediated by large broker-dealers, who are also significant repo users in their own right, to finance market-making inventory, source short-term funding or invest cash. Repo transactions can be either bilateral trades or cleared through a central counterparty.[3]

Repo markets fulfil two key functions. The first is to facilitate the borrowing and lending of cash. Repos are an attractive option for lenders seeking to place cash, because the collateral they receive (including haircuts and margin calls) mitigates credit risk. The second function is to facilitate the circulation of collateral or the exchange (swap) of collateral. Lenders of cash can obtain specific securities (for speculation, to cover short positions etc) for the repo's duration, while lenders of the securities improve their portfolio liquidity without an outright sale.

These two functions represent the main motivations for investor participation in the repo market: the search for funding and the search for collateral. They are also roughly echoed in the two main market segments: *general collateral* (GC) repos and *specific collateral* (SC) repos. In the GC segment, the borrowing and lending of cash is the primary motivation for the transaction, the only requirement for the underlying collateral being that it offers sufficient credit quality. The SC segment is better suited to trades driven by collateral needs, because transactions specify the particular security that is exchanged in the two legs (Mancini et al (2016)).

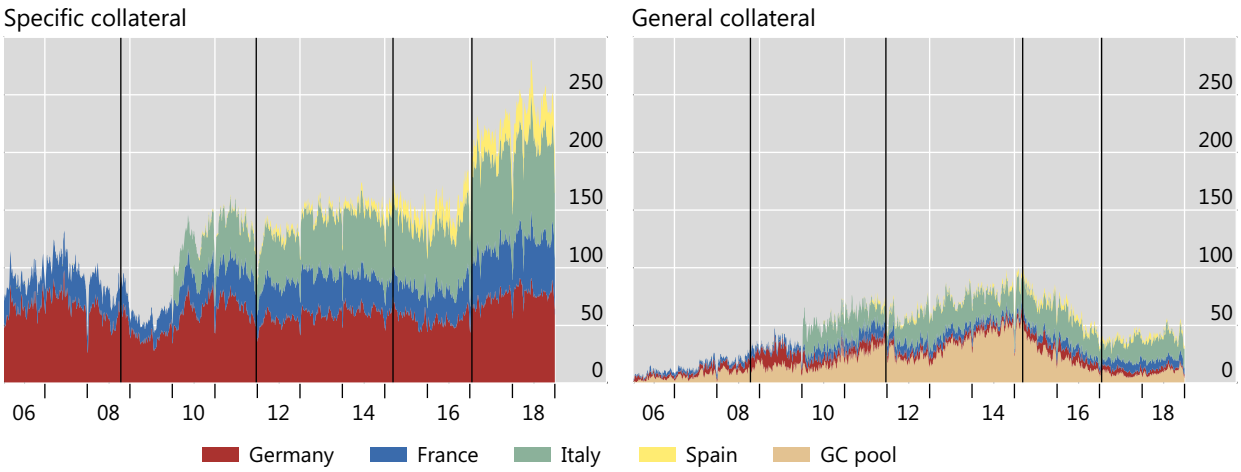
The outstanding volume of euro-denominated repos exceeded €500 billion at end-2018. In the absence of comprehensive data on the euro repo market, our analysis focuses on cleared trades. Our database pools transaction data from three electronic platforms: BrokerTec, Eurex Repo and MTS Repo. These platforms cover

[2] A repo transaction from the point of view of the seller of the securities is a reverse repo when seen from the point of view of the lender (the buyer of the securities).

[3] We classify tri-party repos as bilateral since credit risk remains between buyer and seller.

Trading activity

Turnover,[1] in billions of euros — Graph 1



The vertical lines indicate 15 October 2008 (switch to fixed rate full allotment), 21 December 2011 (LTRO), 9 March 2015 (PSPP) and 19 January 2017 (relaxation of eligibility requirements). Data from MTS Repo – which handles most of the Italian repos – are only available from 2010 onwards.

[1] Nominal amount of the cash leg of transactions settled on that day against the collateral and contract type that define the segment.

Sources: BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

the near-universe of centrally cleared repos denominated in euros, which in turn account for more than two thirds of overall activity (ECB (2015)). To analyse potential differences across segments, we consider only transactions using German, French, Italian or Spanish government bonds as collateral (SC and GC), as well as those using the GC Pooling basket, which encompasses securities eligible as collateral in the ECB's framework. This results in nine collateral segments, which account for more than 75% of the centrally cleared market and about 50% of the total market.[4] Thus, our sample is broadly representative of the overall market.

The euro repo market has grown significantly since the mid-2000s. Graph 1 shows the daily trading volumes for each collateral segment between 2006 and 2018.[5] The total volume of transactions in our data increased from about €200 billion in late 2011 to about €300 billion in late 2018. This growth has been most evident in the Italian and Spanish collateral segments, especially in SC, even when activity in the German segment slowed, as in late 2011.[6] Below we discuss other patterns of differential dynamics across collateral segments.

One feature of the market that comes through clearly in Graph 1 is the preference of traders for specific over general collateral. Turnover has been significantly higher in SC segments than in GC segments, and trends in the two

[4] We cover repos with a one-day maturity (overnight, tomorrow-next, spot-next). These make up 95% of centrally cleared transactions. Over 75% of repos with one-day maturity are centrally cleared. We use figures in ECB (2015) to compute market shares.

[5] The trading volume of a given segment equals the nominal amount of the cash leg of transactions settled on that day against the collateral and contract type that define the segment. Repo dynamics depend on when cash and collateral are exchanged, rather than when the repo was negotiated.

[6] As data from MTS Repo are available from 2010, our sample includes repos against Italian collateral only from 2010 onwards.

segments have diverged after 2015. Indeed, in 2015–18, turnover in the SC segment almost doubled, to €250 billion, whereas that in GC halved, to €50 billion. This divergence is consistent with a shift in the euro repo market towards transactions that are more securities-driven and less funding-driven (Brand et al (2019)).

The trends in market activity since the GFC are linked to the conduct of monetary policy. In late 2011, trading volumes dropped temporarily after the ECB introduced its longer-term refinancing operations (LTRO), which gave banks an alternative source of liquidity. In March 2015, turnover dropped after the ECB started to buy government bonds under its public sector purchase programme (PSPP). Collateral scarcity from the central bank's purchases boosted activity in SC segments and reduced it in GC segments (especially the GC pool).[7] SC segments received a further boost around the end of 2016, when the ECB enhanced its Securities Lending Programme (SLP) and relaxed the rules for eligible securities.

Liquidity and pricing efficiency

In a well functioning market, prices adjust promptly to shifts in underlying economic drivers, and do so smoothly. In this section, we analyse metrics of liquidity and pricing efficiency for the various collateral segments of the euro repo market. The metrics confirm the differences in the behaviour of these segments and point to the enhanced importance of collateral demand as a driver of the euro repo market.

Market liquidity

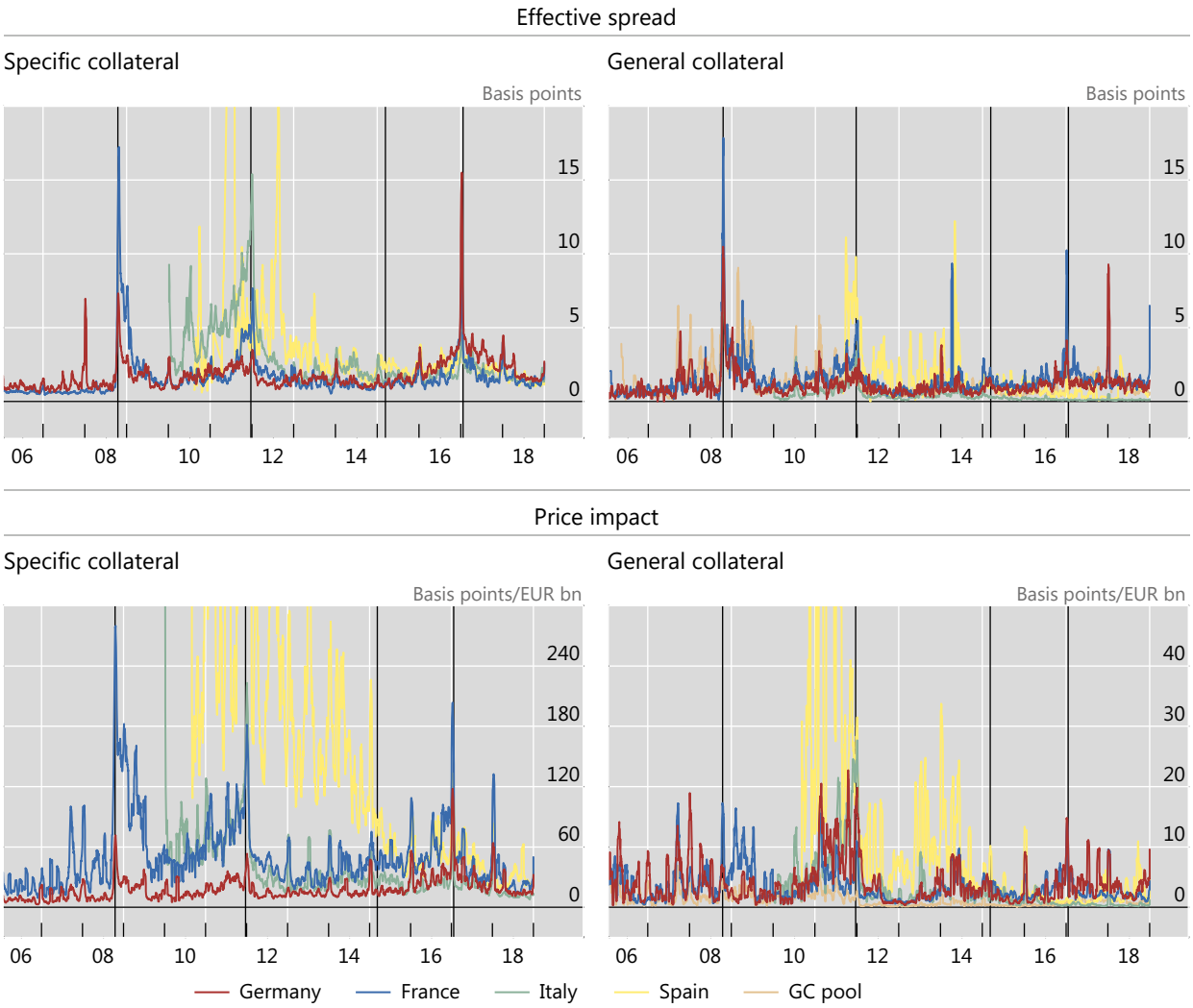
Liquidity generally refers to the market's capacity to smoothly absorb traders' orders (CGFS (1999)). We consider two measures of market liquidity: the effective spread and the price impact (see box). The *effective spread* uses the covariance between price changes in successive transactions to gauge the (unobserved) effective bid-ask spread. Transaction costs, such as the effective spread, are low in liquid markets. The *price impact* is calculated as the ratio of price changes to trading volume, with a low value indicating a liquid market. We use the repo rate as the relevant price.

Liquidity in the euro repo market was high on average over the period, but deteriorated at times in response to specific factors. Effective spreads were generally low, between 1 and 3 basis points (Graph 2, top panels), and so too was the price impact of trades, usually remaining below 10 basis points per billion euros in transaction volume (bottom panels). However, indicators across all segments deteriorated markedly but to varying extents in 2010–11 during the European sovereign debt crisis. They improved after the LTRO made its debut in December 2011. The introduction of the PSPP in 2015 had a moderately negative impact on repo liquidity, although its influence is confounded by the phasing-in of regulatory reforms that increased the capital requirement for banks' repo market activities, lifting banks'

[7] The effect of ECB purchases on bond scarcity came on top of higher demand from banks for high-quality liquid assets, which was related to changes in liquidity regulations.

Market liquidity[1]

Graph 2



The vertical lines indicate 15 October 2008 (switch to fixed rate full allotment), 21 December 2011 (LTRO), 9 March 2015 (PSPP) and 19 January 2017 (relaxation of eligibility requirements).

[1] Ten-day moving averages.

Sources: BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

demand for high-quality liquid assets (HQLA). Finally, the indicators point to regular spikes of illiquidity in repo markets around the turn of the year, owing to window-dressing by banks (see below).

Within this general picture, liquidity differed between segments. GC segments were more liquid than SC segments, despite the lower transaction volumes in the former. The difference was starkest for the price impact indicator (Graph 2, bottom panels), which indicated that trading in SC repos had a price impact that was often 10 times that of an equivalent GC repo trade. The greater liquidity of GC segments is partly explained by the fact that GC repos bundle many different collateral securities into one large order book. Yet, despite their lower liquidity, SC segments have registered increases in trading volume in recent years, which suggests that investors' demand for specific collateral has gained importance as a driver of repo market activity.

Measures of market liquidity and pricing efficiency

We measure market liquidity using two estimates of transaction costs: the effective spread (Roll (1984)) and the price impact measure proposed by Amihud (2002), which is related to order book depth (Kyle (1985)). Pricing efficiency is measured by realised volatility. All measures are calculated at a daily frequency by averaging across transactions that took place on a given collateral segment and tenor, and then weighting by transaction volume.

The *effective spread* is calculated on the basis of executed transactions (as opposed to market order book) using the following formula: $Roll_{t,c} = 2\sqrt{max(0, -Cov(\Delta r_{i+1}, \Delta r_i))}$, where Δr_{i+1} denotes the difference in the repo rate between two consecutive transactions using collateral *c* on day *t*. The Roll measure assumes that subsequent transactions originate from the same order book. Hence, in adapting it to the repo market, we use transactions involving the same specific security as the collateral, and then compute the weighted average within the segment: $ES_{t,s} = \frac{1}{TV_{t,s}} \sum_{c \in C_{t,s}} TV_{t,c} \cdot Roll_{t,c}$, where $C_{t,s}$ denotes the set of securities traded within segment *s* on day *t*. $ES_{t,s}$ can be interpreted as the average transaction cost paid in segment *s* on day *t*.

The *price impact* is given by $Amihud_{t,c} = |\Delta r_{t,c}|/TV_{t,c}$, where $|\Delta r_{t,c}|$ denotes the absolute value of the interest rate change on repos with collateral *c* during day *t* (ie the difference in closing rates from day *t-1* to *t*). In a similar way to the effective spread, the Amihud measure is computed for each individual security used as collateral and is averaged across all securities in the segment: $PI_{t,s} = \frac{1}{TV_{t,s}} \sum_{c \in C_{t,s}} TV_{t,c} \cdot Amihud_{t,c}$

The *realised volatility* is computed as $RV_{t,c} = \sum_i (\Delta r_i)^2$, where Δr_i denotes the change in the rate from one repo transaction to the next. Again, rate changes must be computed between repos using the same collateral. So the subscript *c* denotes a specific security and the sum is over all transactions using this security that are settled on day *t*. We then average across all securities in the segment: $Volatility_{t,s} = \frac{1}{TV_{t,s}} \sum_{c \in C_{t,s}} TV_{t,c} \cdot RV_{t,c}$

Within the SC and GC segments, liquidity varied according to the home country of the collateral. The relative liquidity of national collateral in GC segments was similar to their ranking by trading volume. However, in SC segments this was not the case from 2015 onwards. The most traded SC repo was German, yet it was among the less liquid ones (red line in Graph 2). French collateral had a very low effective spread in the SC segment. However, in the GC segment it exhibited pronounced spikes and after 2015 incurred the widest effective spread. The Spanish and Italian collateral segments demonstrated lower and more volatile liquidity on average.

Pricing efficiency

A market with an efficient pricing mechanism is one that adjusts smoothly and rapidly to underlying fundamentals. In a short-term funding market, this shows up as a low dispersion of rates across time and across collateral segments (spreads). We compute three measures of pricing efficiency. The first is the realised volatility of the repo rate (see box) in line with Krishnamurthy and Duffie (2016), which captures the variability of rates in the time dimension. The other two capture the idea that, in an efficient repo market, funding rates against different collateral should move closely with each other. However, when a specific security is in high demand, lenders of cash may accept a lower rate for the corresponding SC repo than they would for a GC repo (where they do not know what security they will receive). We calculate a repo *specialness premium* as the spread between the SC and GC repo rates of the same collateral segment (Duffie (1996)). This premium should normally be negative, and its size should reflect the importance of collateral scarcity. Short-maturity repo rates should move in parallel with the policy rate. We compute the *scarcity premium*, defined as the average rate in a given GC segment minus the policy rate, as another measure that gauges the intensity of collateral scarcity spilling over to GC rates.

Rate volatility measures show a pattern similar to the effective spread. Realised volatility was low on average but elevated in particular periods (Graph 3, top panels).

Volatility was lower in the GC segment than in the SC segment, despite the lower transaction volumes in the former.

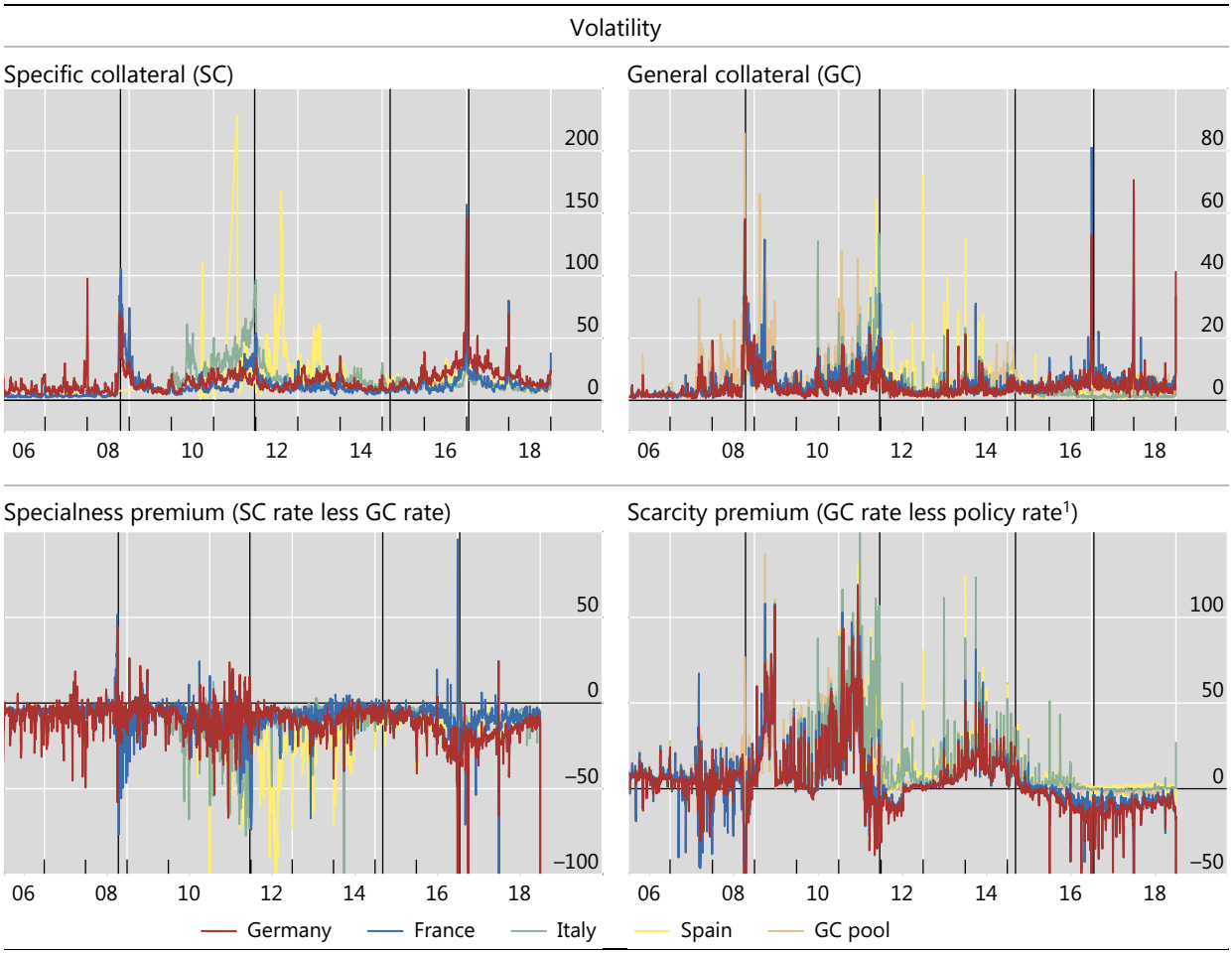
Over the 2006–18 period, repo rate volatility spiked higher on three occasions. The first was during the GFC. After the crisis, volatility never returned to the lows seen previously. Then, during the period of strain in euro area government bond markets in 2011–12, rates in the Italian and Spanish SC segments became several times more volatile than in their German and French counterparts. This divergence arguably reflected elevated sovereign credit risk embedded in the collateral (Mancini et al (2016)) and possibly the counterparty risk of the clearing houses (Boissel et al (2017)). The dispersion of volatility across segments rapidly declined after the ECB injected liquidity and, in December 2011, introduced the LTRO.

A third period of high volatility followed the introduction of the PSPP in March 2015. Volatility began to rise gradually, with the safest collateral showing the highest volatility. This probably reflected a scarcity of collateral due to the combined effect of the ECB purchases and higher demand for HQLA. The pressure on rates from collateral demand eased partially when the securities lending facility was introduced

Pricing efficiency

In basis points

Graph 3



The vertical lines indicate 15 October 2008 (switch to fixed rate full allotment), 21 December 2011 (LTRO), 9 March 2015 (PSPP) and 19 January 2017 (relaxation of eligibility requirements).

[1] In the light of changes to the ECB's operating framework, we use the interest rate on the main refinancing operations as the policy rate prior to September 2008 and the deposit facility rate thereafter.

Sources: ECB; BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

in December 2016 and the eligibility requirements for bonds purchased under the PSPP were relaxed in January 2017. These patterns also show how collateral-driven forces have intensified in the repo market.

Turning to the cross-sectional dispersion of rates, the specialness premium was mostly negative, indicating that SC rates were usually below GC rates, as expected (Graph 3, bottom left-hand panel). The premium and its dispersion across segments were higher on average after the GFC, rising to particularly elevated levels when volatility was also high. The deeply negative premia in the Italian and Spanish collateral segments during the period of sovereign bond market stress may reflect short-selling by speculators. After 2015, as the ECB purchased bonds, the German SC segment exhibited the highest and most volatile premium, consistent with the scarcity of collateral.

The pattern of the scarcity premium was driven by changes in the ECB's monetary policy framework, as well as by funding stress in sovereign debt markets around 2012. The ECB deposit rate represents a natural floor to repo rates, as banks looking for funding can always borrow from the central bank against collateral. Funding problems pushed the premium higher in all segments, while concerns about sovereign credit risk boosted demand for German bonds in 2011, lowering the corresponding spread (red line). It remained positive for other collateral segments, indicating that any scarcity pressures were confined to the SC segments. The introduction of the PSPP, however, pushed the scarcity premium into negative territory for all GC collateral segments. A negative scarcity premium indicates that banks are willing to lend against GC repos at rates below those of the ECB deposit facility, although GC repos do not specify which security the cash lender will receive. This collateral scarcity effect was present even in the large GC Pooling basket encompassing all European securities eligible in the ECB's collateral framework. The impact of the PSPP has been strongest in the German collateral segment, with the decline in pricing efficiency reflected in the rising dispersion of rates across all segments.

As for market liquidity, pricing efficiency measures spiked at year-ends. After 2015, these spikes became larger and premia were predominantly negative (see below).

Window-dressing

The market liquidity and pricing efficiency measures point to a seasonal deterioration in market functioning at the end of each quarter, especially at year-ends. This is when banks prepare their annual financial statements and calculate regulatory ratios and other charges, giving them an incentive to *window-dress* their balance sheet (Munyan (2015), CGFS (2017), Aldasoro et al (2018)).[8] Scaling back the repo book makes sense

[8] The balance sheet size is a key element in the calculation of the leverage ratio. It is also an input to the score that determines the capital surcharge for systemically important banks, as well as the basis for the calculation of contributions to deposit protection schemes and other levies, depending on the jurisdiction. In many European jurisdictions, banks can report their balance sheet size as of the last day of the quarter rather than on a period-average basis.

for banks, because repos are a volume-driven, low-margin business that swells their balance sheets (and associated charges).[9]

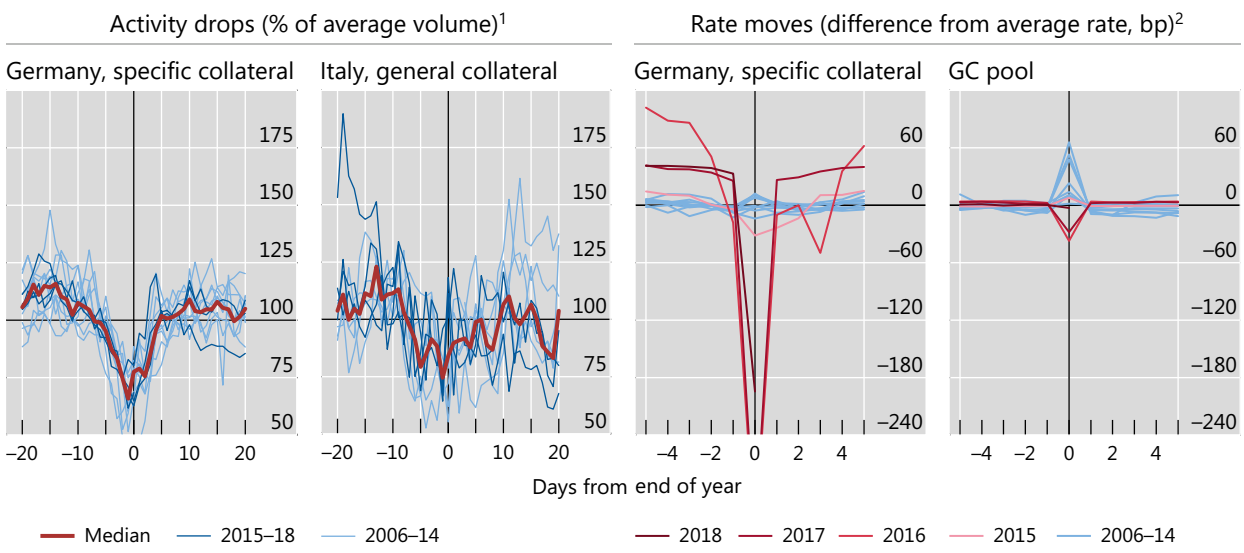
Year-end disruptions in repo market functioning are evident throughout the period we investigate. They manifest themselves as rate spikes and declines in trading activity (Graph 4). Interestingly, while turnover starts to decline at least 10 days before the end of the year, rate spikes are confined to the last day of the year. This indicates that rate disruptions are probably associated with unexpected liquidity needs of individual participants that happened to coincide with a shallow market (Graph 3).

The market strains due to year-end window-dressing are not uniform across collateral segments. For instance, the median turnover in the German SC segment at year-end was about 60% of the average volume during a window of 40 business days around the turn of the year (Graph 4, left-hand panel). By contrast, the Italian GC segment shows a more moderate decline. The French SC segment and the GC pool segment show the largest declines in activity, while other GC segments register smaller drops.[10]

Year-end rate spikes show heterogeneity across collateral segments and over time (Graph 4, right-hand panels). Prior to 2015, GC market rate spikes were, on average, larger than those in SC segments and were also mostly positive, indicating that funding from repos was becoming more expensive. In the period since the PSPP was introduced, rate spikes switched direction and became more pronounced in the SC segment, in particular for transactions using higher-quality (German and French) collateral. Spikes for investors offering Spanish or Italian collateral went negative (funding became cheaper) only at year-end 2016.

Year-end window-dressing: activity and rates

Graph 4



[1] Forty-day window average turnover = 100. [2] Ten-day window average rate = 0.

Sources: BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

[9] Financial reporting standards specify that the borrower of cash through a repo cannot derecognise the securities it offers as collateral because of its obligation to buy them back in the second leg of the contract, while it has also to recognise the cash it receives.

[10] Statistics for different collateral segments are available from the authors upon request.

These observations provide further evidence of the greater role of collateral-driven motives in shaping market dynamics. Window-dressing removes intermediation capacity from the repo market. Prior to the PSPP, when funding motives were more important, this reduction in capacity translated into higher borrowing rates. When the ECB engaged in large-scale bond purchases, it supplied reserves but created a scarcity of collateral. When intermediation capacity becomes constrained at year-ends, collateral does not circulate as freely, translating into lower borrowing rates against scarce collateral.

Arbitrage across segments

In the previous section, we highlighted how market segmentation manifests itself in a persistent dispersion of rates across collateral segments. In an efficient market, differences in rates should incentivise arbitrageurs to engage in *collateral swaps*. The transactions can exploit rate spreads by lending cash against any collateral that attracts the higher rate and borrowing cash by offering the collateral that attracts the lower rate. This puts pressure on the rate gap, but may stop short of eliminating it, given transaction costs and convenience yields (ie when investors' preference for a particular collateral manifests itself as a lower rate).[11] Below we examine the extent to which rate dispersion leads to collateral swaps. We find that it does, but not in volumes sufficient to eliminate rate differences.

We construct a measure of traders' arbitrage positioning by following Agueci et al (2014) in calculating the swap ratio that measures the extent to which a trader takes offsetting positions across collateral segments.[12] The metric takes values between unity and zero. If a trader is a net borrower in one segment and simultaneously a net lender in another (but balanced overall), then the metric will be close to unity. By contrast, if a trader is either a net borrower or a net lender in each segment they participate in, the metric will be zero. We then construct two market-wide statistics based on the swap ratio (which is calculated for each trader). The first is the *average swap ratio* for all active traders on a given day. The second is the proportion of traders who have a non-zero swap ratio (ie those with portfolios that are consistent with collateral swap trade activity).

Regression analysis confirms a relationship between the two market-wide statistics of traders' positioning and the rate dispersion (Table 1, first two columns).[13] The coefficients are positive and statistically meaningful, indicating that

[11] In principle, the credit risk associated with the collateral can also contribute to the gap but, for the data we analyse, this is unlikely to be an important factor. All repo trades in our data are centrally cleared, mature after one day and are collateralised with securities classified by regulators within the top category of high-quality liquid assets. Given that coupon payments during the transaction's lifetime are passed back to the borrower (even though legal ownership rests with the lender), any convenience yield must consist of non-pecuniary benefits (eg the security's eligibility for the collateral framework of the central bank, CCP or exchange).

[12] More concretely, for every trader we compute the net borrowing volume in each market segment and divide the absolute total net borrowing volume by the sum of each market segment's absolute borrowing volume. To facilitate interpretation, we use the difference between unity and this fraction.

[13] We define rate dispersion as the absolute spread between average rates in one segment and average rates in the whole repo market.

Arbitrage positions and repo rate dispersion Table 1

	Average swap ratio of active traders (%)	Active traders with collateral swap positions (%)	Adjusted swap volume (EUR bn)
Constant	9.68***	24.67***	0.992***
Effective spread	–0.24**	–0.65***	–0.126**
Rate dispersion	0.11***	0.27***	
Spread			0.035***
Fixed effects for each collateral pair			Yes
Number of observations	3,126	3,126	14,461
Adjusted R-squared	2.4%	4.1%	30%

***/**/* indicates statistical significance at the 1/5/10% level.

Sources: BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

equilibrating arbitrage forces are at work in the repo market. As expected, arbitrage activity is deterred by transaction costs (negative estimated coefficients for the effective spread). The economic relationship between spreads and arbitrage trades is not strong enough to eliminate the rate dispersion. The average swap ratio increases by only one tenth of a percentage point per basis point of rate dispersion. Similarly, the share of traders with non-zero swap ratios increases by only three tenths of a percentage point. Given the price impact of trades estimated earlier, these positions are too small to significantly reduce the gap in rates.[14]

The swap ratio indicates the extent to which collateral swaps take place, but it does not take into account whether swaps are in the same direction as rate differentials. To sharpen our analysis, we look at the trading volume that satisfies this condition and compute a daily *adjusted swap volume* measure for each collateral pair and every trader, which measures the amount of j-collateral exchanged for i-collateral.

$$swap_{i,j} = \min(|nb_i|, |nb_j|) \frac{sgn(nb_j) - sgn(nb_i)}{2}$$

In the above expression, nb_i denotes the net borrowing volume in segment i. The first part computes the maximal volume that could correspond to a swap, given the trader's positions, whereas the second part ensures that we measure only positions in opposite directions.[15] We aggregate all traders' adjusted swap volumes in a given segment and run a regression pooling the data across collateral pairs over the entire period. Transaction costs are measured as the sum of the two effective spreads corresponding to the given pair.

The panel regression using the adjusted volume gives results that are consistent with those for the aggregate swap ratio metrics (Table 1, third column). Traders do trade against the gaps in repo rates, as indicated by the positive and significant coefficient on the bilateral spread, but the volume is about 35 million for each basis

[14] We estimate the average price impact in the German collateral segment to be 18 basis points per billion volume of transactions and that in the Italian segment to be 37 basis points per billion. This means that a swap of €15–20 million would be required to reduce the rate differential by 1 basis point.

[15] A negative value for the adjusted flow metric implies that i-collateral is swapped for j-collateral. The metric is set to zero when the sign of net borrowing does not match that of the rate spread (ie when the swap direction is not consistent with arbitrage trades).

point in rate differentials. Spreads rarely exceed 30 basis points. This means that less than one billion of collateral swaps per country pair are driven by repo spreads. This is a small amount compared with the overall market turnover of €200–300 billion. Importantly, given our estimates of the price impact of trades, these positions are too small to eliminate rate differentials. This suggests either that spreads reflect important drivers of collateral heterogeneity (ie convenience yield) or that there is insufficient activity by traders that crosses national collateral segments.

Specialisation of market participants

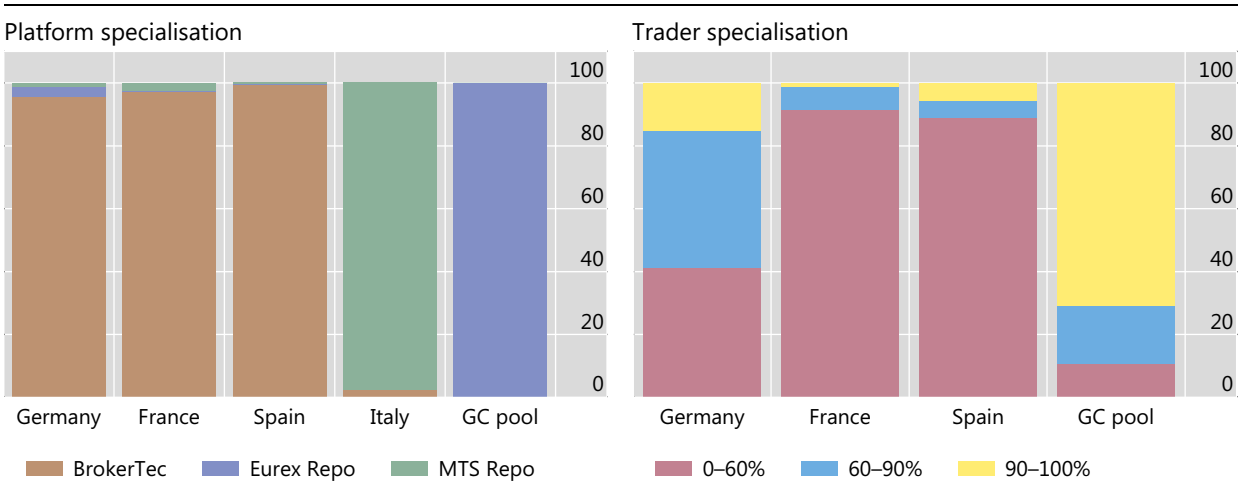
In this section, we look into two potential drivers of repo market segmentation. One is the segmentation of market activity into different trading platforms, which may hinder arbitrage activity across collateral segments. The other is specialisation by traders, who might exhibit a strong preference for trading only in specific segments.

Trading platforms for euro-denominated repos show a clear pattern of specialisation. Different collateral segments trade on different platforms, and only a very small share of transactions crosses over to other platforms (Graph 5, left-hand panel). For instance, almost all German collateral transactions are traded on BrokerTec, while MTS Repo clears practically all repos using Italian collateral. Platform segmentation can complicate the transfer of collateral across clearing houses.

Individual repo market participants do not spread their trading activity evenly across collateral segments, but they tend to specialise. We measure the extent of specialisation by the share of each segment's activity that is accounted for by traders that conduct most of their repo activity in that segment. More concretely, we first aggregate the trading positions of each participant by exploiting the anonymised counterparty identities in the data and calculating the share of their total turnover

Trade platform and trader specialisation

Share of total volume, in per cent — Graph 5



Sources: BrokerTec; Eurex Repo; MTS Repo; authors' calculations.

accounted for by transactions in a given segment.[16] We classify each trader as having a low (0–60%), medium (60–90%) or high (90–100%) specialisation score in the particular segment. The right-hand panel of Graph 5 shows the proportion of total turnover in a collateral segment that is accounted for by traders with different specialisation scores. More than 55% of repo transactions using German collateral involve traders who themselves conduct at least 60% of their repo business in this segment. The same statistic for the GC pooled segment is almost 85%. By contrast, transactions in the French and Italian segments are conducted by participants who are much less specialised.

The specialisation of repo traders is consistent with evidence that euro area bond investors, including banks, have a pronounced home bias in favour of bonds issued by their domestic sovereign (Boermans and Vermeulen (2018)). Domestic government bonds account for 55% of the average European bank's sovereign portfolio and 84% of the sovereign portfolio of banks from riskier countries (Koijen et al (2016)).[17] This home bias in bond holdings translates into a preference for conducting repos in the corresponding collateral segment. The evidence we present in this article is also consistent with the more general observation that money markets in the euro area are fragmented (Cœuré (2019)).

Conclusion

The euro repo market proved resilient to both the GFC and the ensuing stress in the euro area sovereign market. That said, it shows signs of segmentation along the lines of the collateral used, with individual traders (banks) tending to specialise in one or just a few collateral segments. This segmentation manifests itself in the way that repos behave differently against the various types of national collateral. It is further reflected by differences in the metrics that gauge market quality: liquidity and pricing efficiency. These market quality characteristics tend to be more fragile in some segments than in others, depending on circumstances. The differing response of the various market segments to year-end window-dressing also reflects this segmentation.

A consistent message across the different parts of our analysis is that, in recent years, the euro repo market has been driven more by the needs of investors seeking particular securities as collateral rather than by investors seeking to trade liquidity. This trend has gained force from the ECB's purchases of government bonds as it seeks to provide additional monetary stimulus. While this shift has had no significant impact on the market's overall functioning, it has affected that of individual segments. It remains unclear whether the importance of collateral demand in reshaping the repo market's dynamics is a permanent shift or only a consequence of the central bank's balance sheet expansion, as it simultaneously increased funding liquidity and removed collateral through securities purchases. In either case, these efforts have amplified the trend towards market segmentation.

[16] We are unable to perform this exercise for the MTS Repo data, which cover most of the repo activity using Italian collateral.

[17] Euro area banks also tend to assign lower risk weights to their holdings of bonds issued by their home government than do other banks that hold the same bonds.

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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

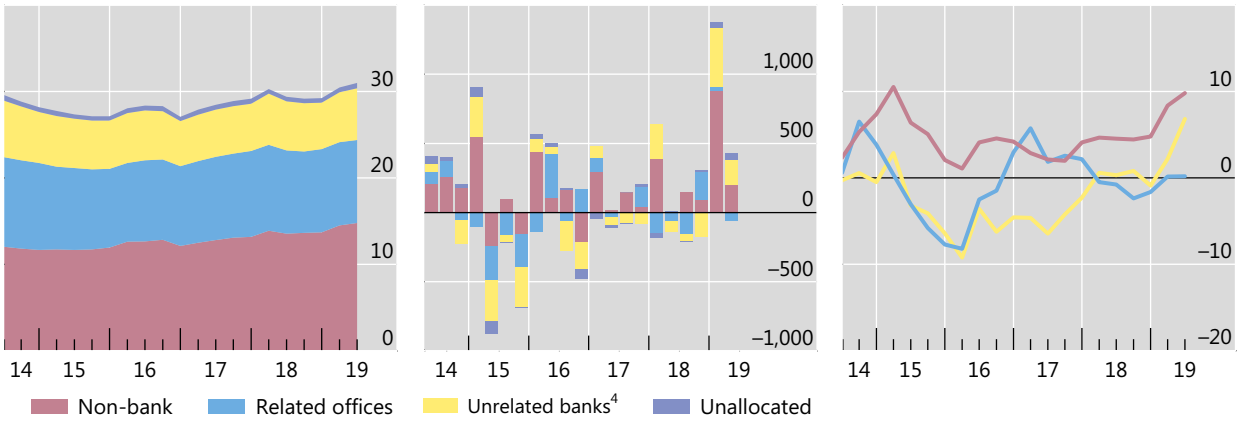
A Locational banking statistics

Cross-border claims, by sector, currency and instrument

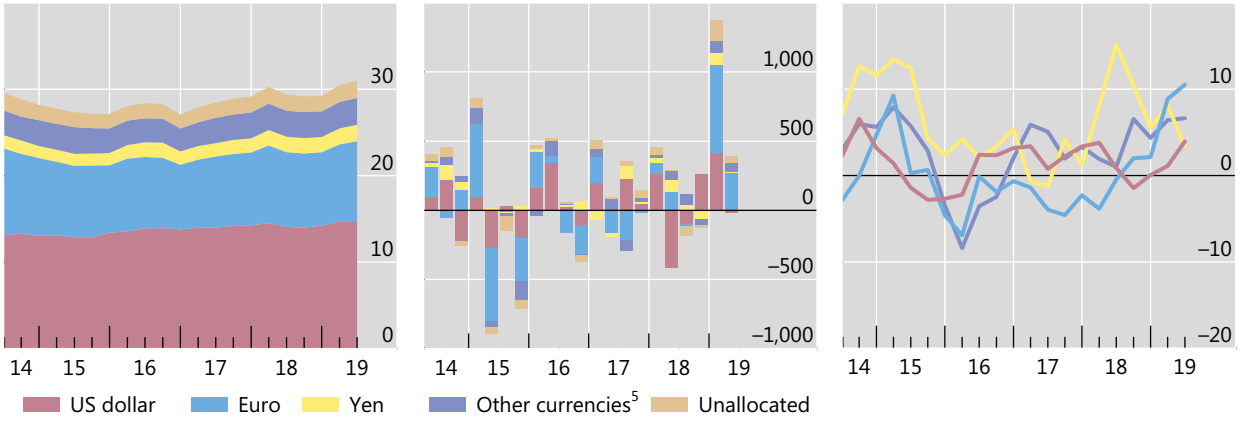
Graph A.1

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

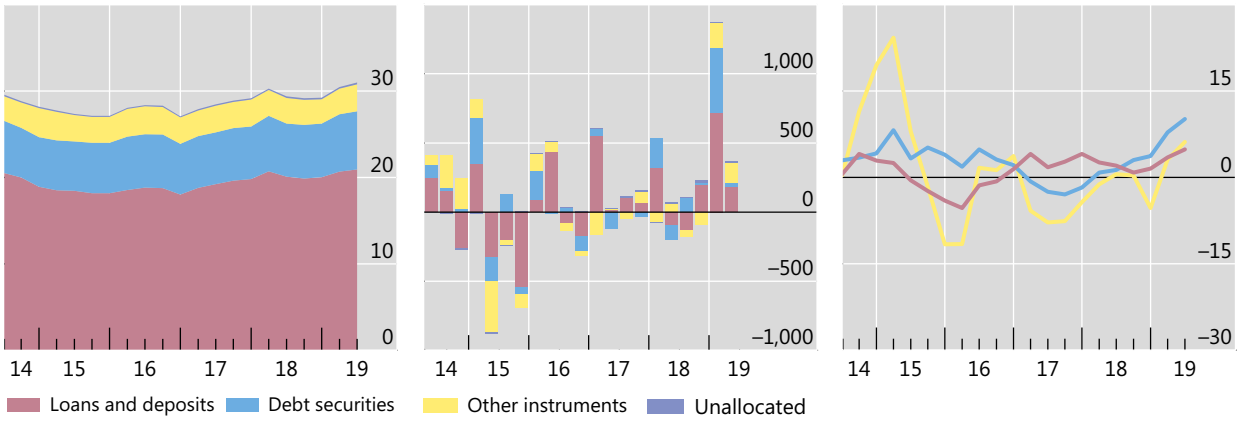
By sector of counterparty



By currency



By instrument



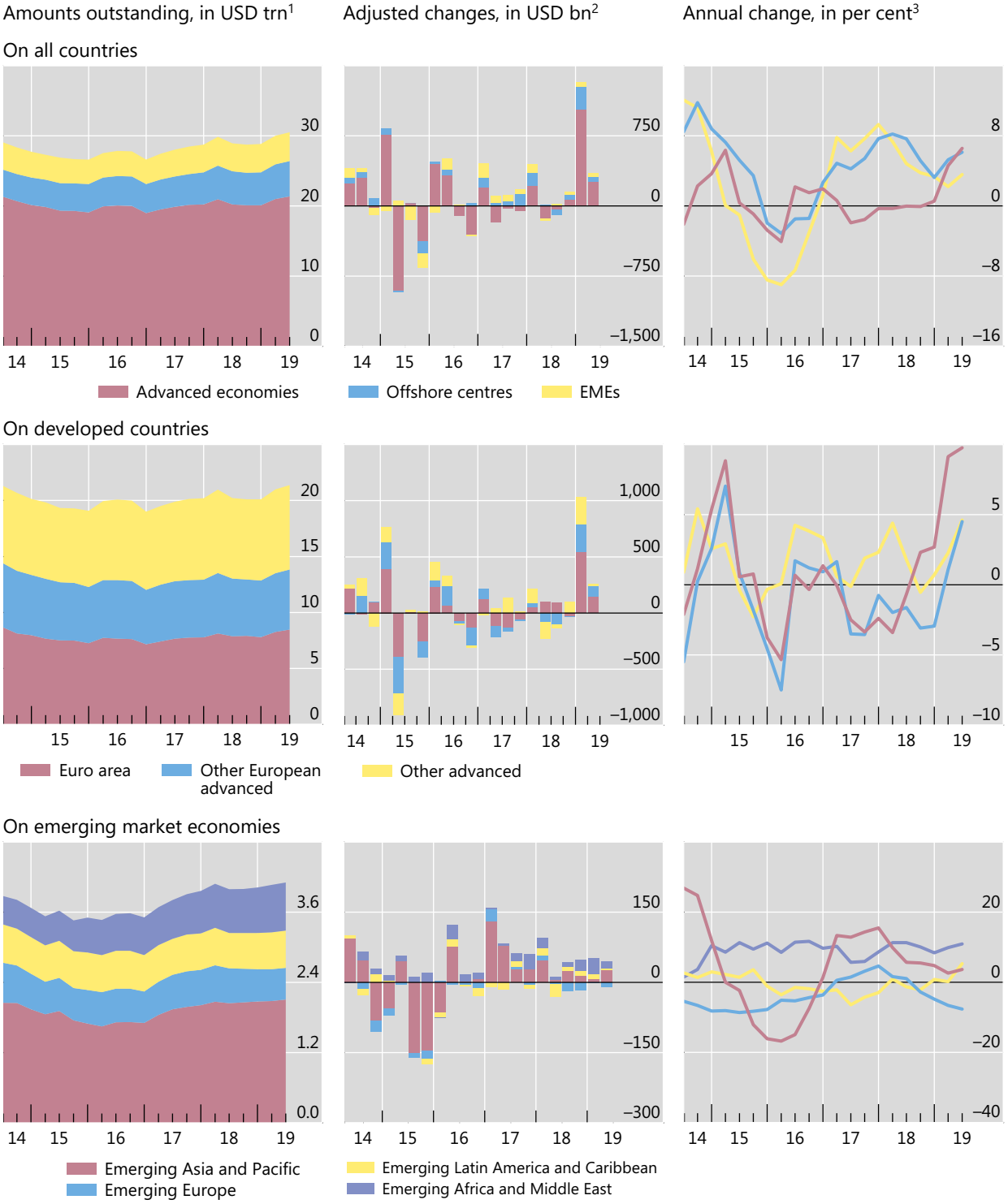
Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[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



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.

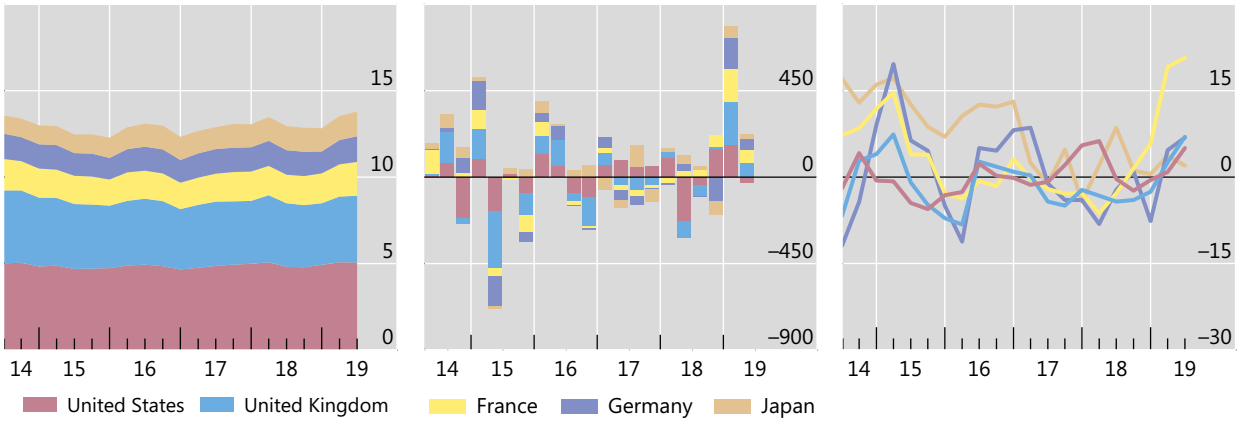
Source: BIS locational banking statistics.

Cross-border claims, by borrowing country

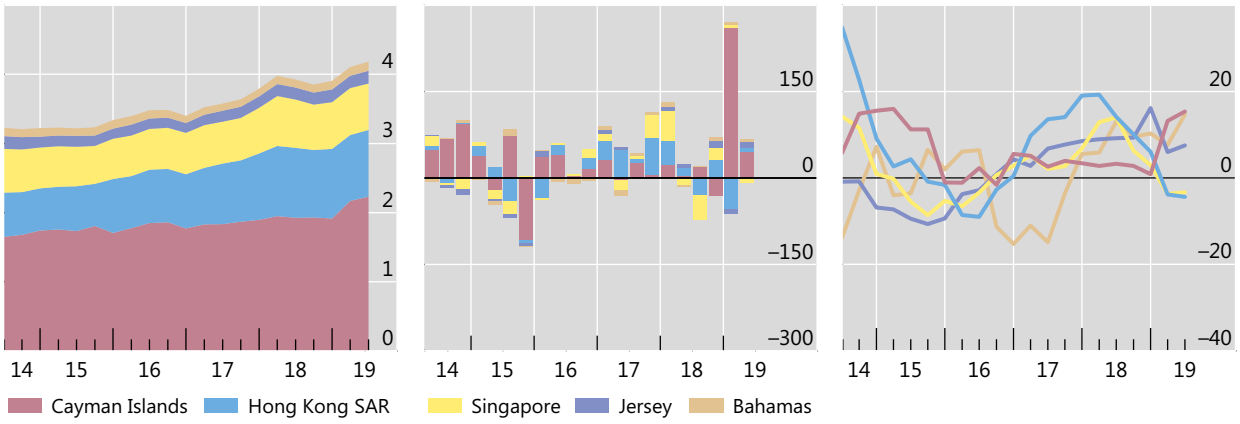
Graph A.3

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

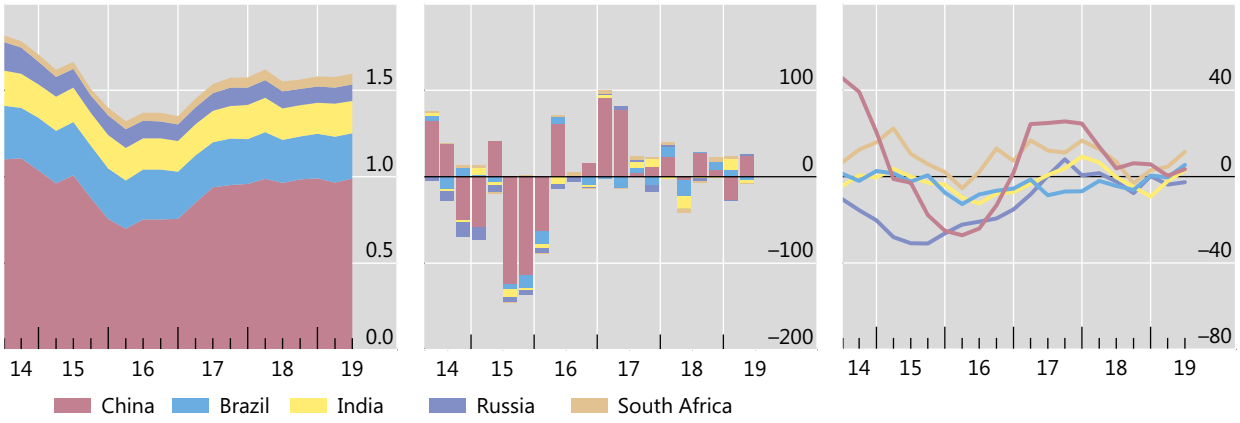
On selected advanced economies



On selected offshore centres



On selected emerging market economies



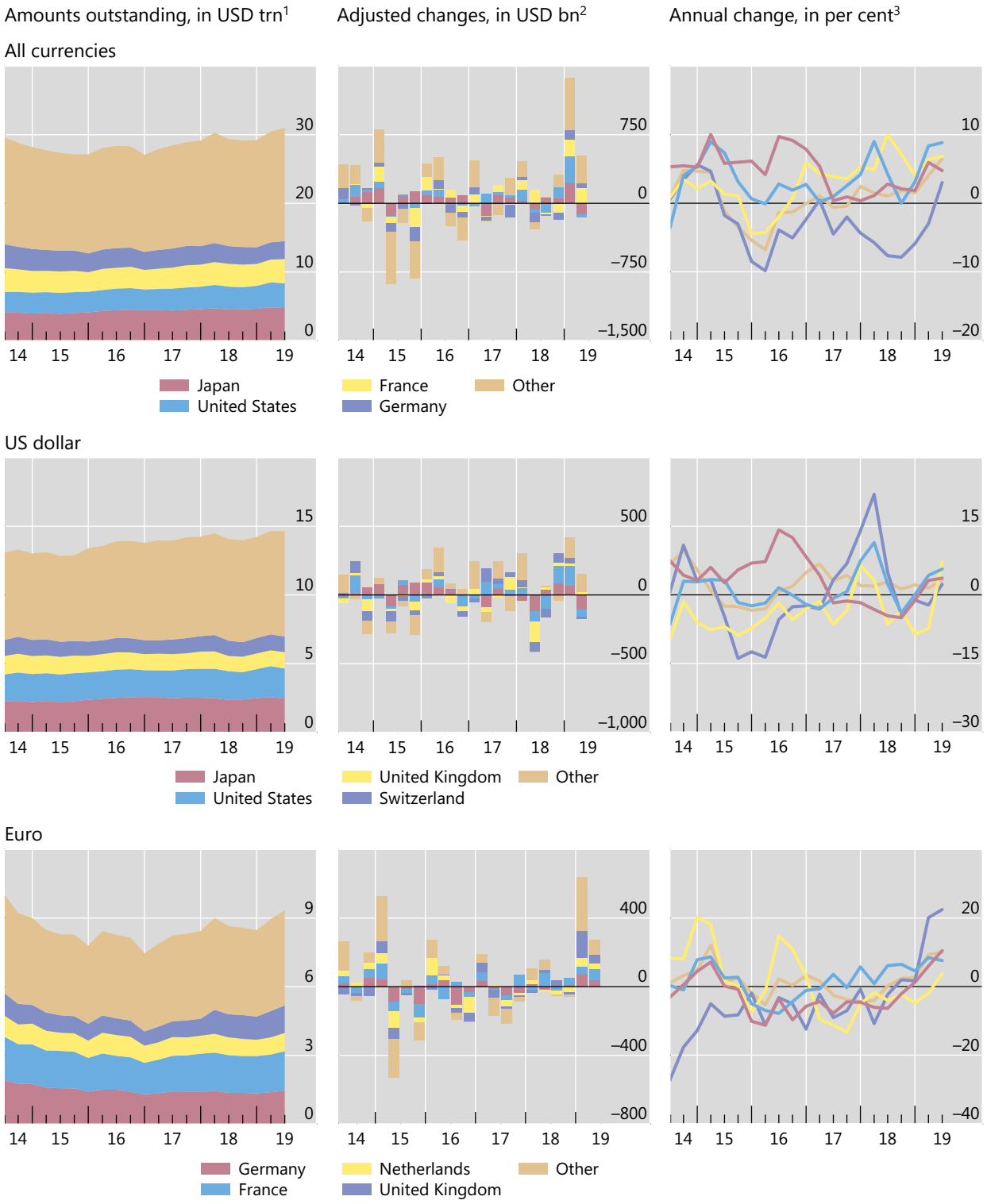
Further information on the BIS locational banking statistics is available at www.bis.org/statistics/bankstats.htm.

[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.

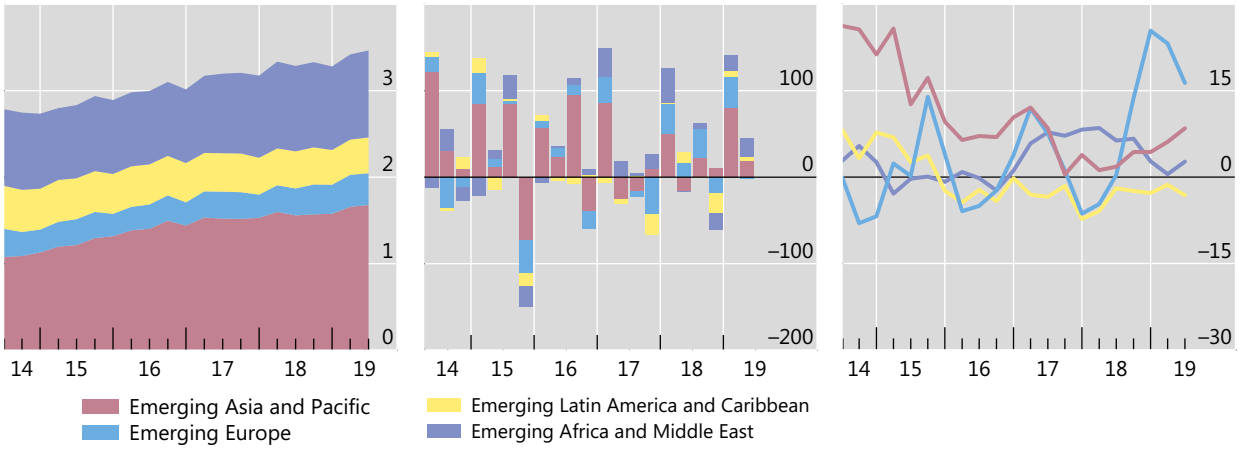
Source: BIS locational banking statistics.

Cross-border liabilities of reporting banks

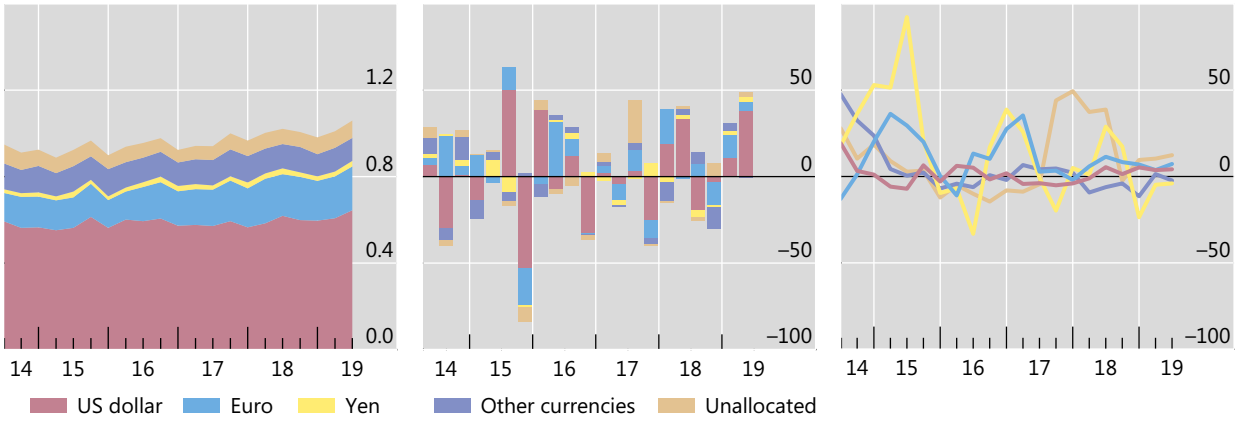
Graph A.5

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

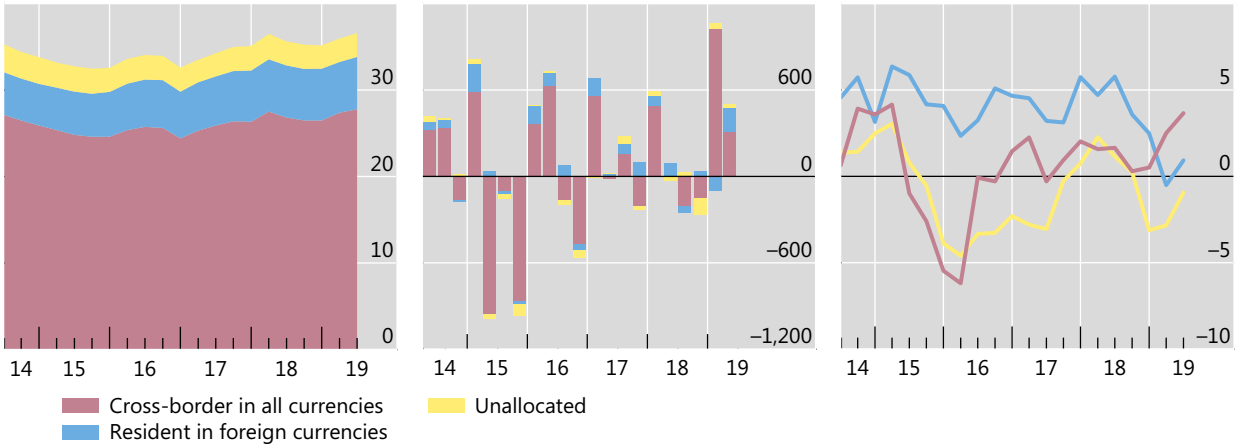
To emerging market economies



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

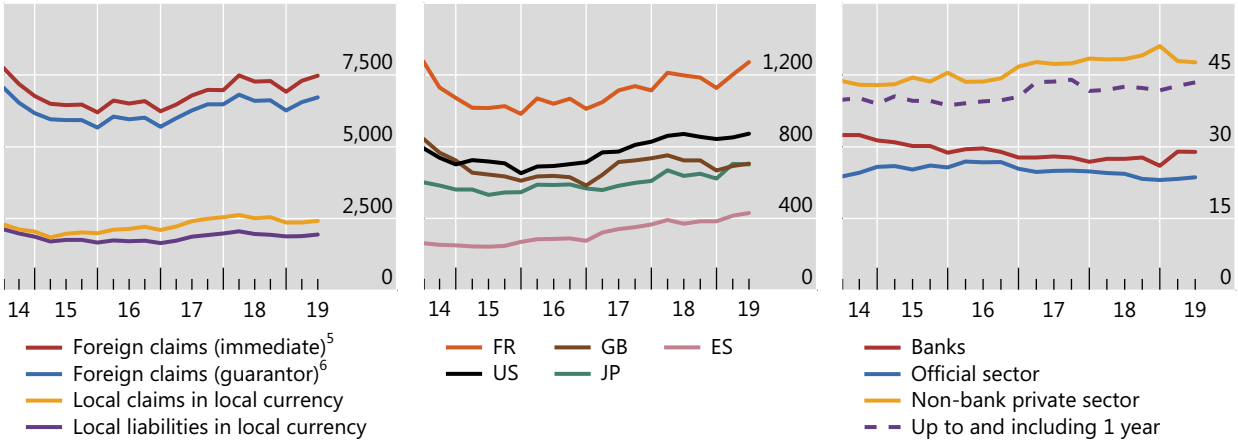
Graph B.1

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

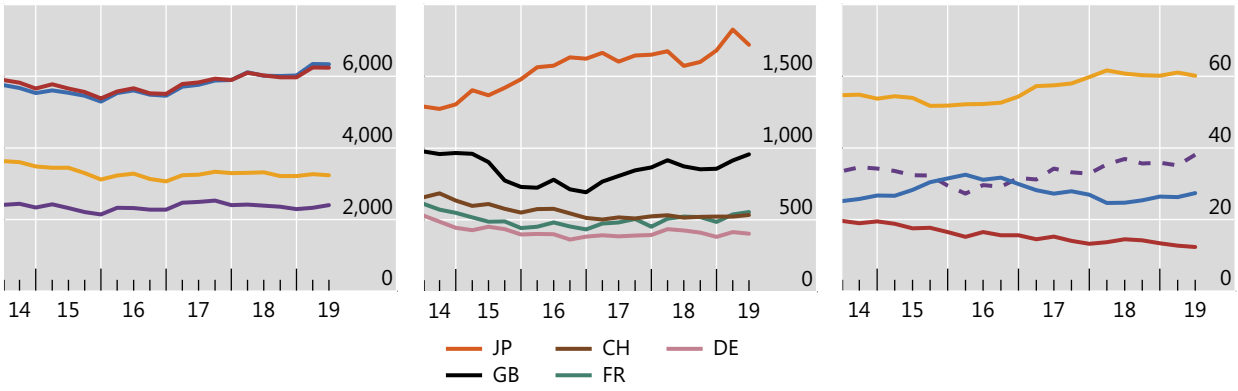
Foreign claims of selected creditors, in USD bn[1, 3]

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

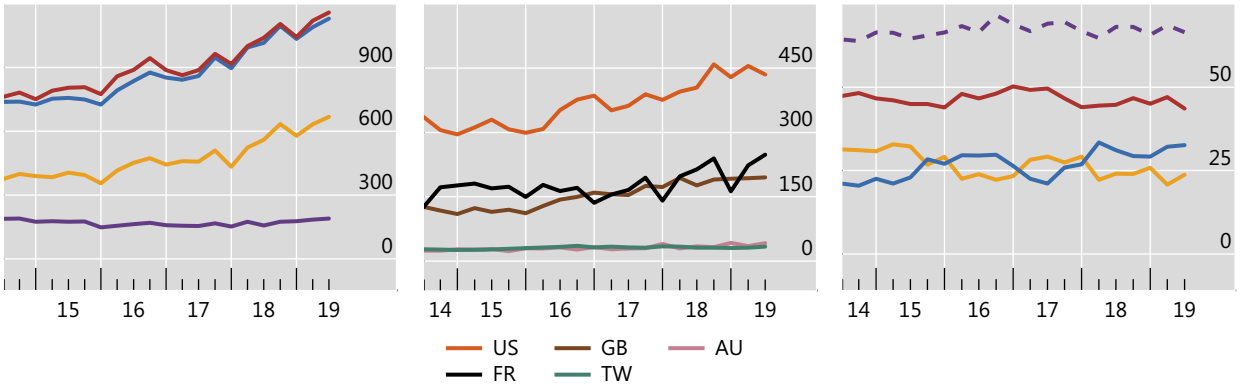
On the euro area



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

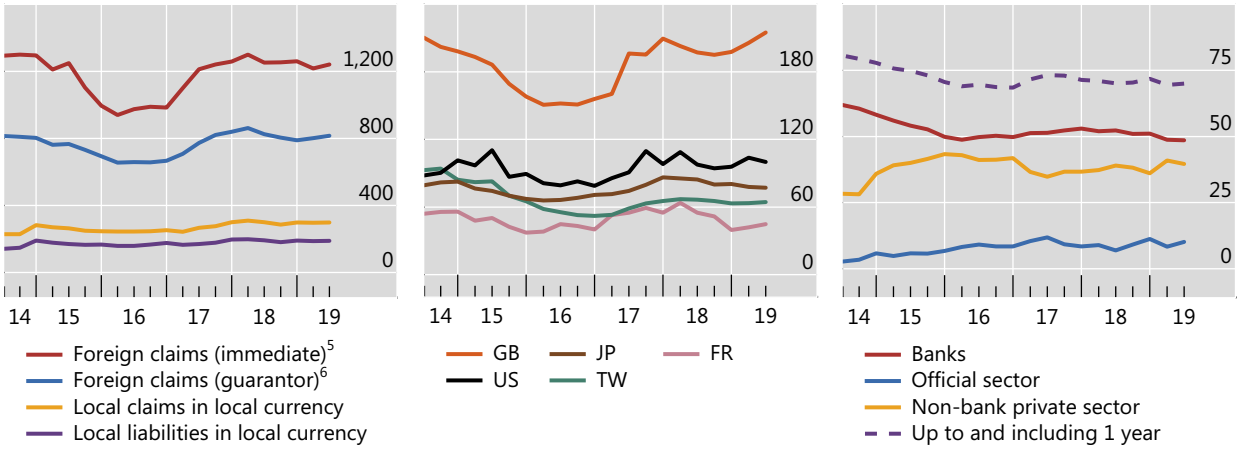
Graph B.2

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

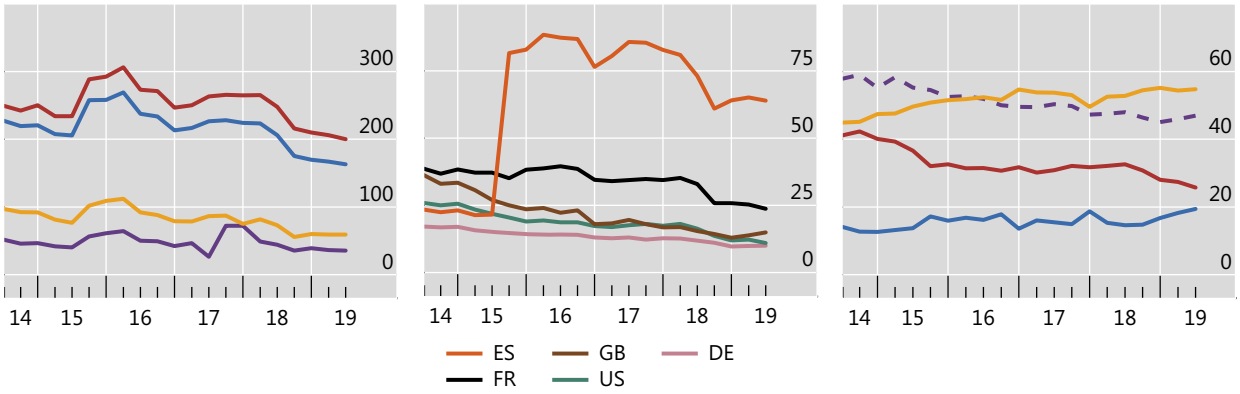
Foreign claims of selected creditors, in USD bn[1, 3]

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

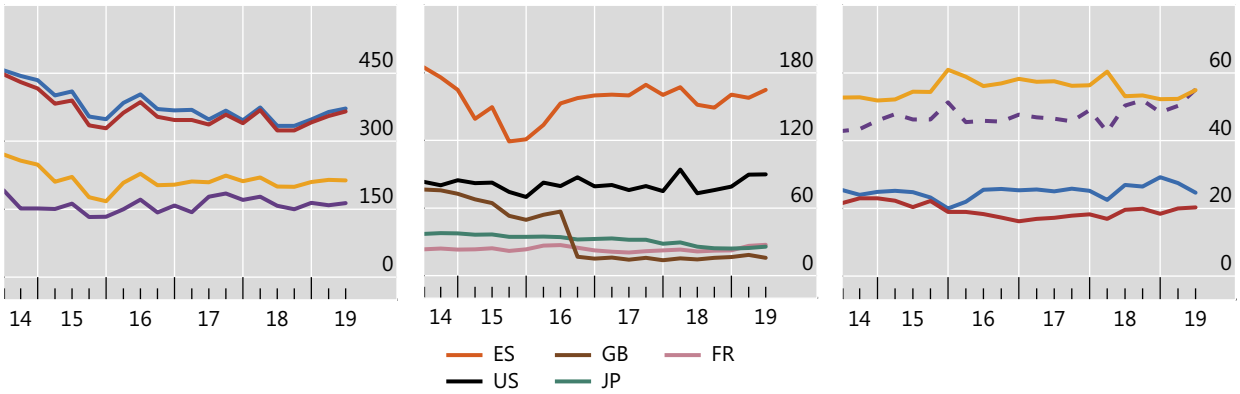
On China



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 .

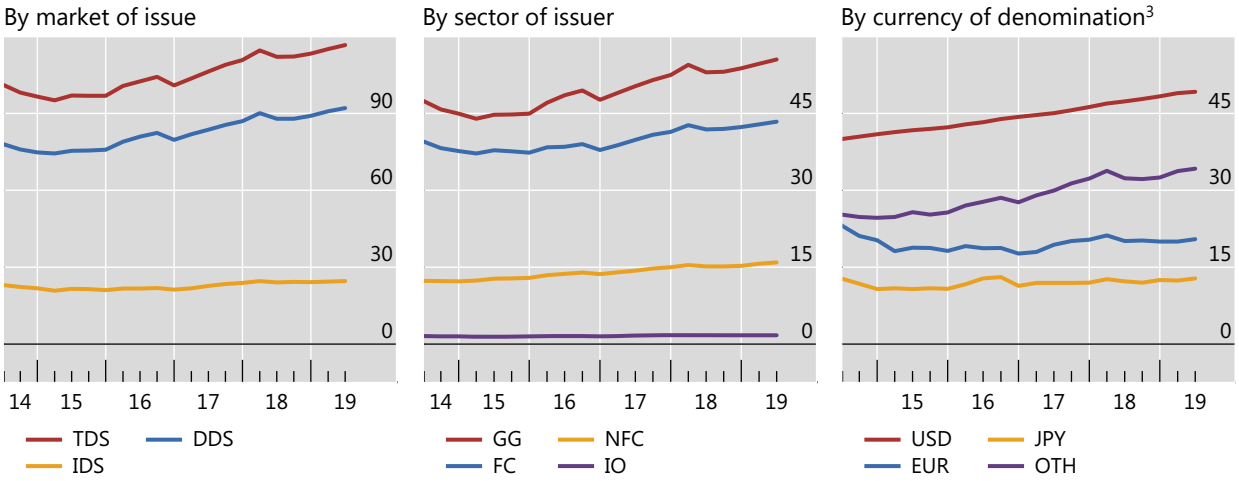
Source: BIS consolidated banking statistics (CBS).

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.

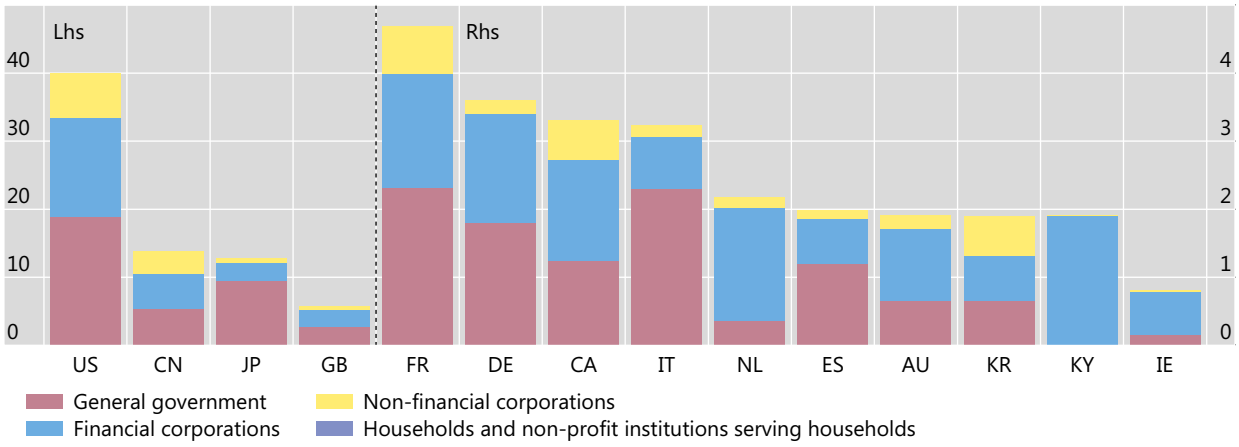
[1] Sample of countries varies across breakdowns shown. For countries that do not report TDS, data are estimated by the BIS as DDS plus IDS. For countries that do not report either TDS or DDS, data are estimated by the BIS as IDS. [2] At quarter-end. Amounts denominated in currencies other than the US 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



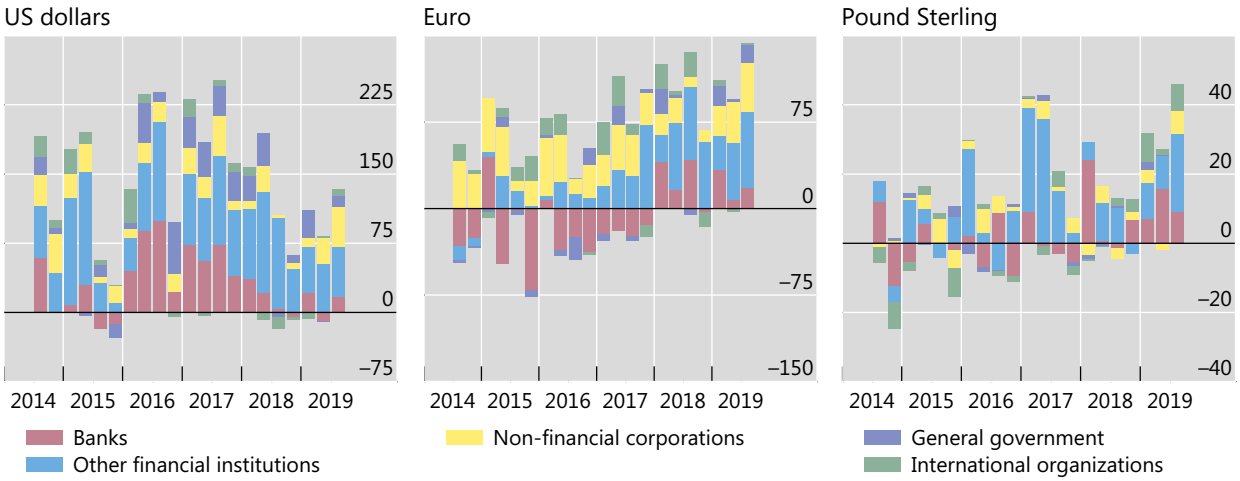
Further information on the BIS debt securities statistics is available at www.bis.org/statistics/secstats.htm.

[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

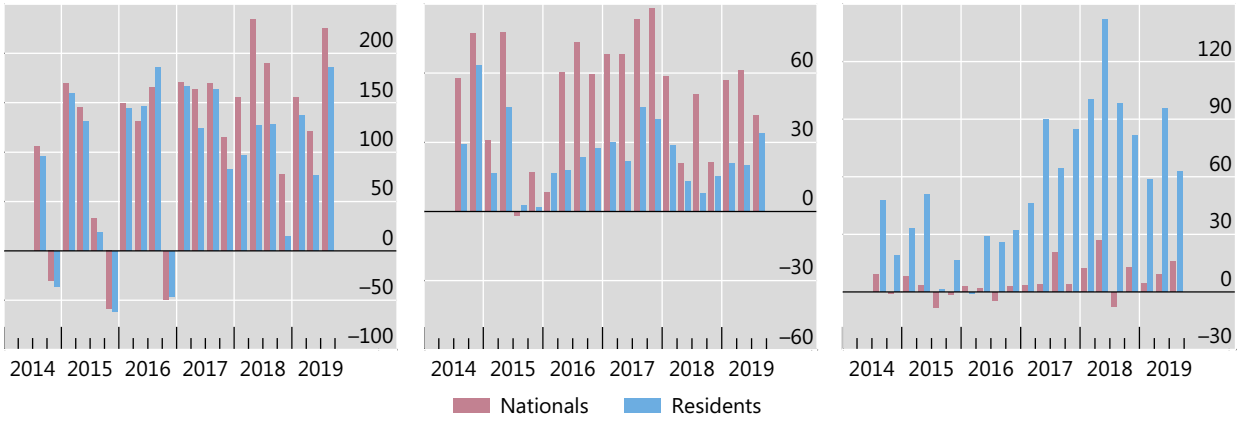


Further information is available at www.bis.org/statistics/secstats.htm.

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

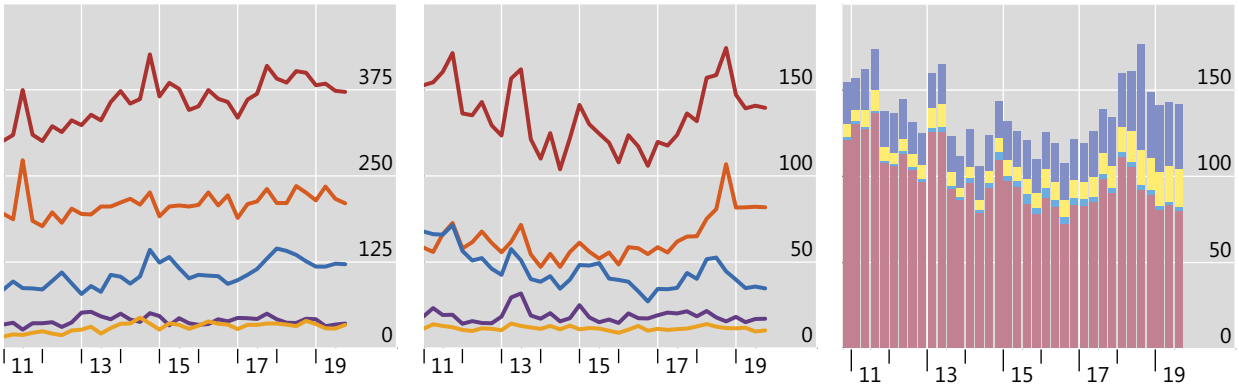
Graph D.1

Open interest, by currency[1]

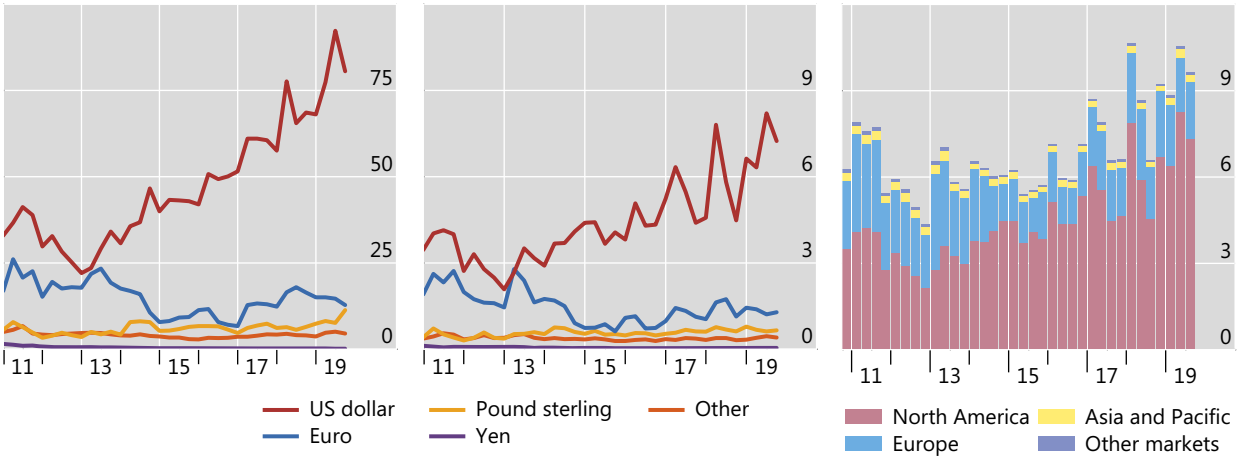
Daily average turnover, by currency[2]

Daily average turnover, by location of exchange[2]

Foreign exchange derivatives, USD bn[3]



Interest rate derivatives, USD trn[3]



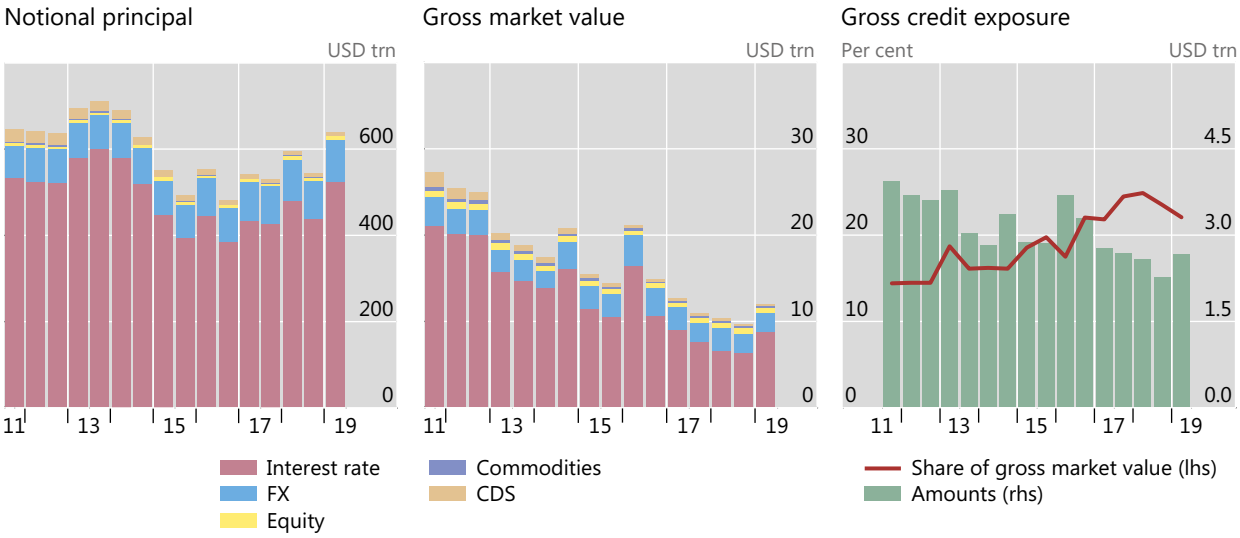
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/extderiv.htm. For definitions, see the online glossary.

[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.

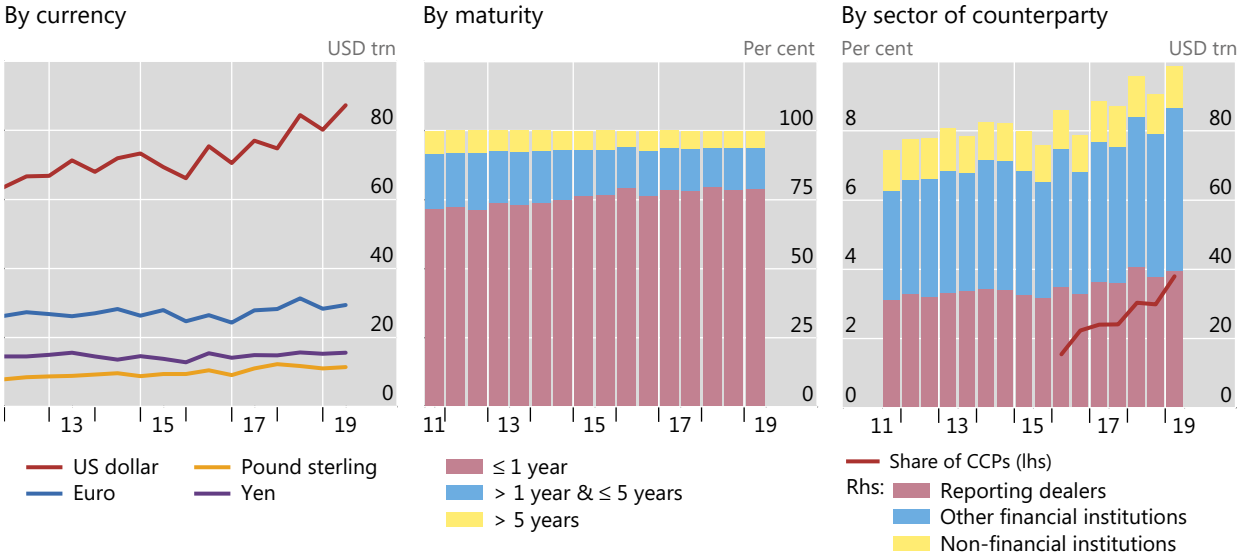
[1] At half-year end (end-June and end-December). Amounts denominated in currencies other than the US dollar are converted to US dollars at the exchange rate prevailing on the reference date.

Source: BIS derivatives statistics.

OTC foreign exchange derivatives

Notional principal[1]

Graph D.3



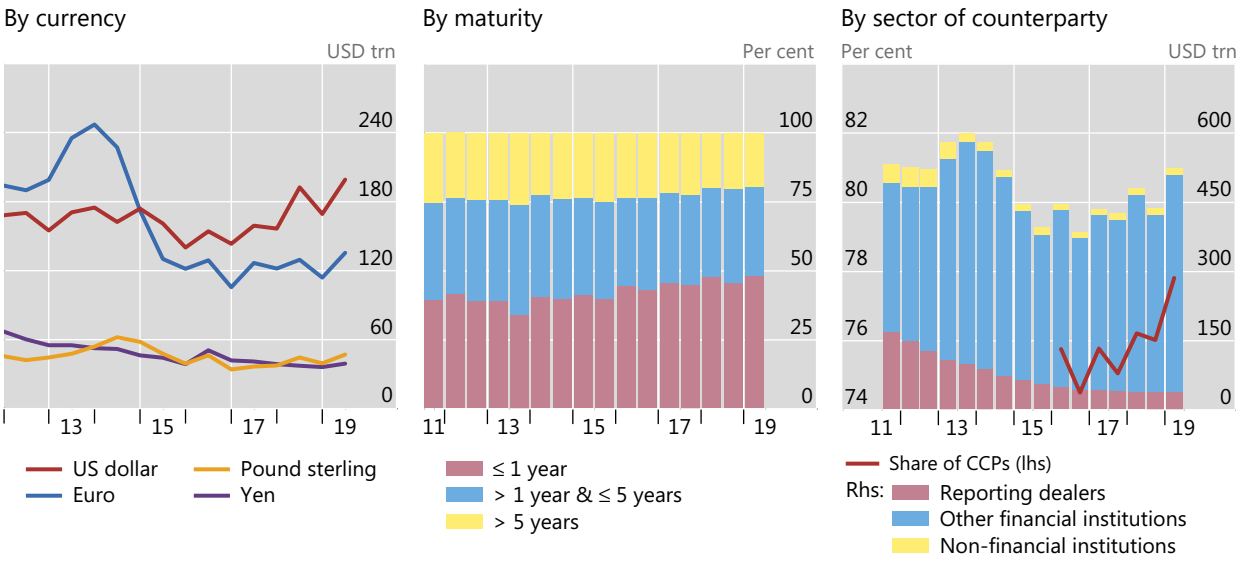
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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



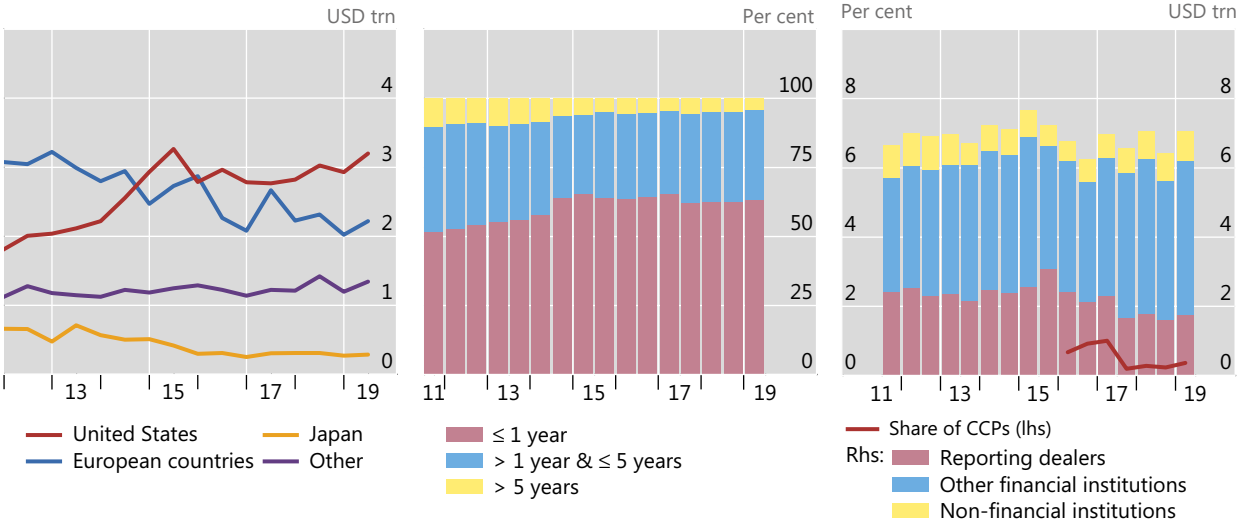
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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



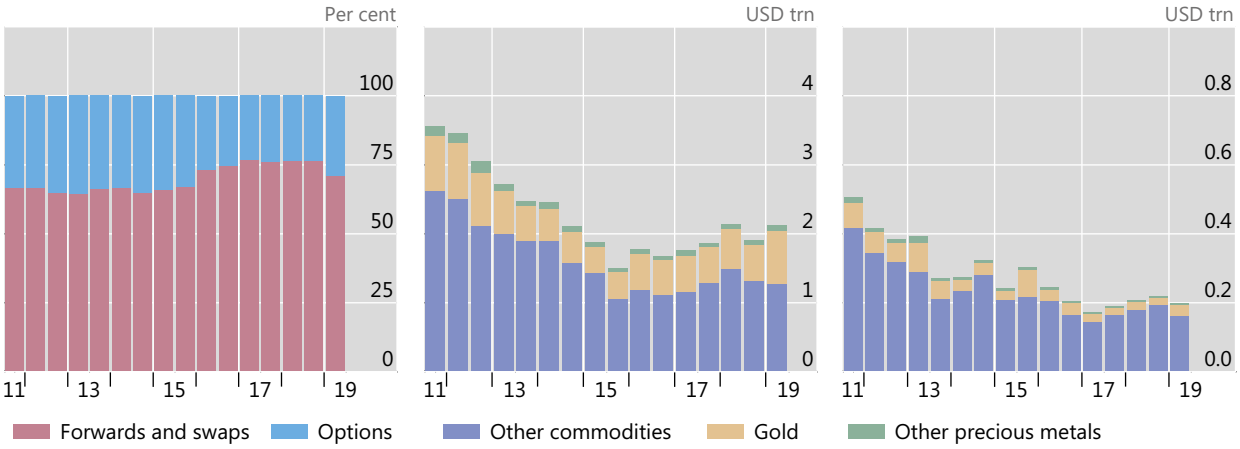
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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



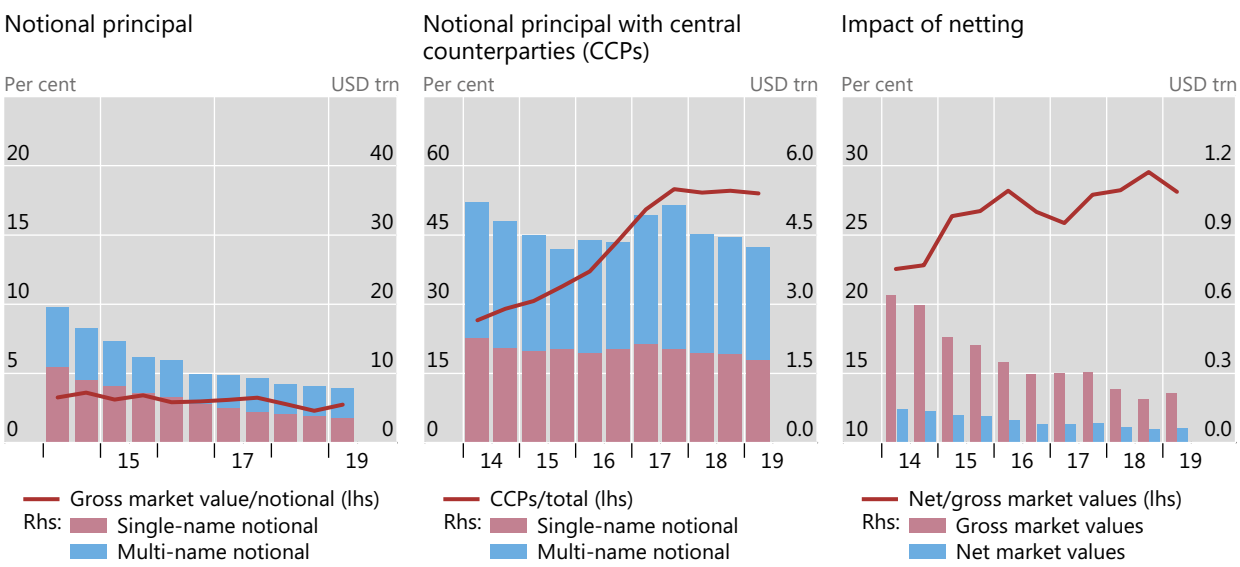
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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



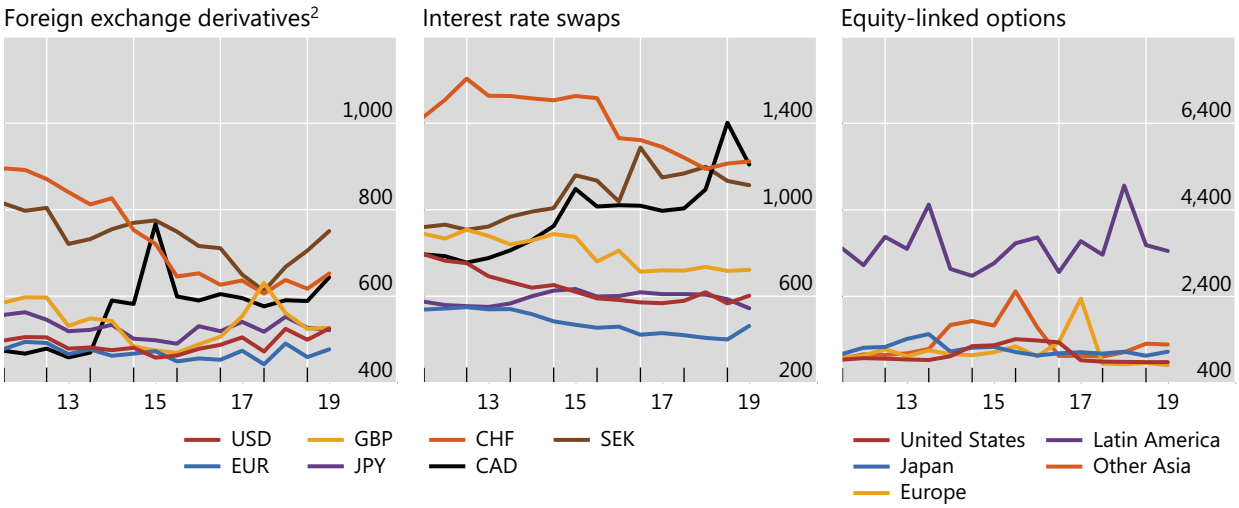
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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



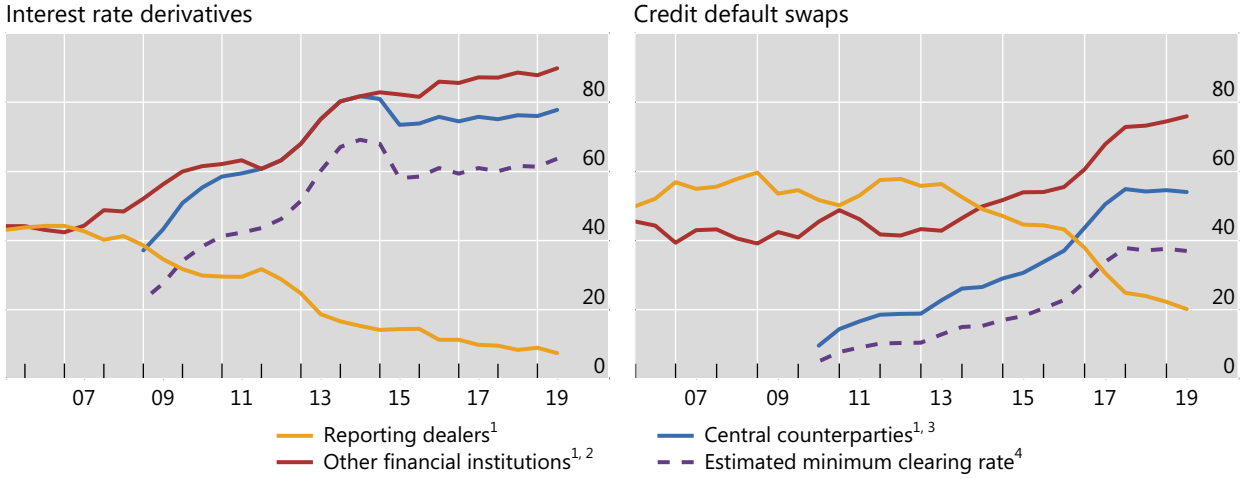
Further information on the BIS derivatives statistics is available at www.bis.org/statistics/derstats.htm. For definitions, see the online glossary.

[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.

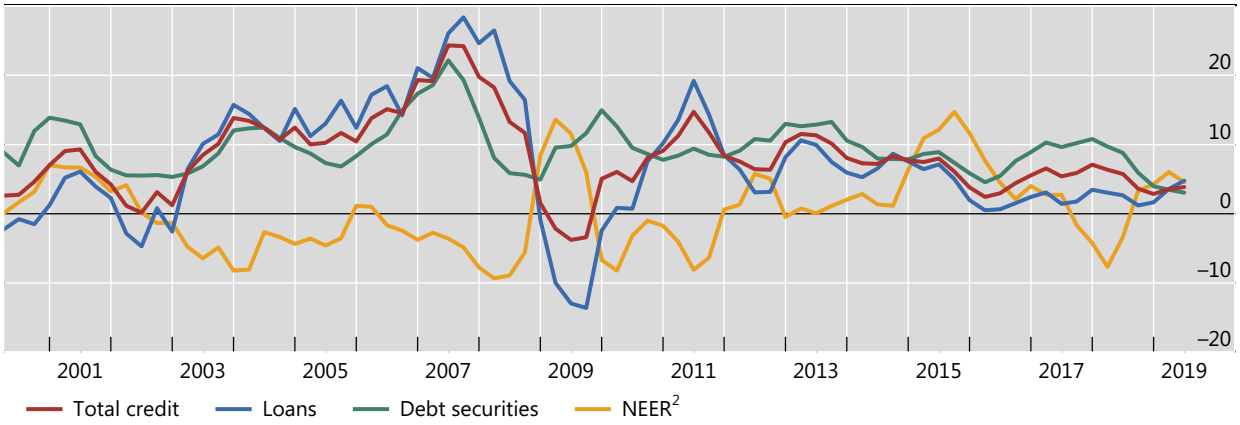
[1] As a percentage of notional amounts outstanding against all counterparties. [2] Including central counterparties but excluding reporting dealers. [3] For interest rate derivatives, data for CCPs prior to end-June 2016 are estimated by indexing the amounts reported at end-June 2016 to the growth since 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



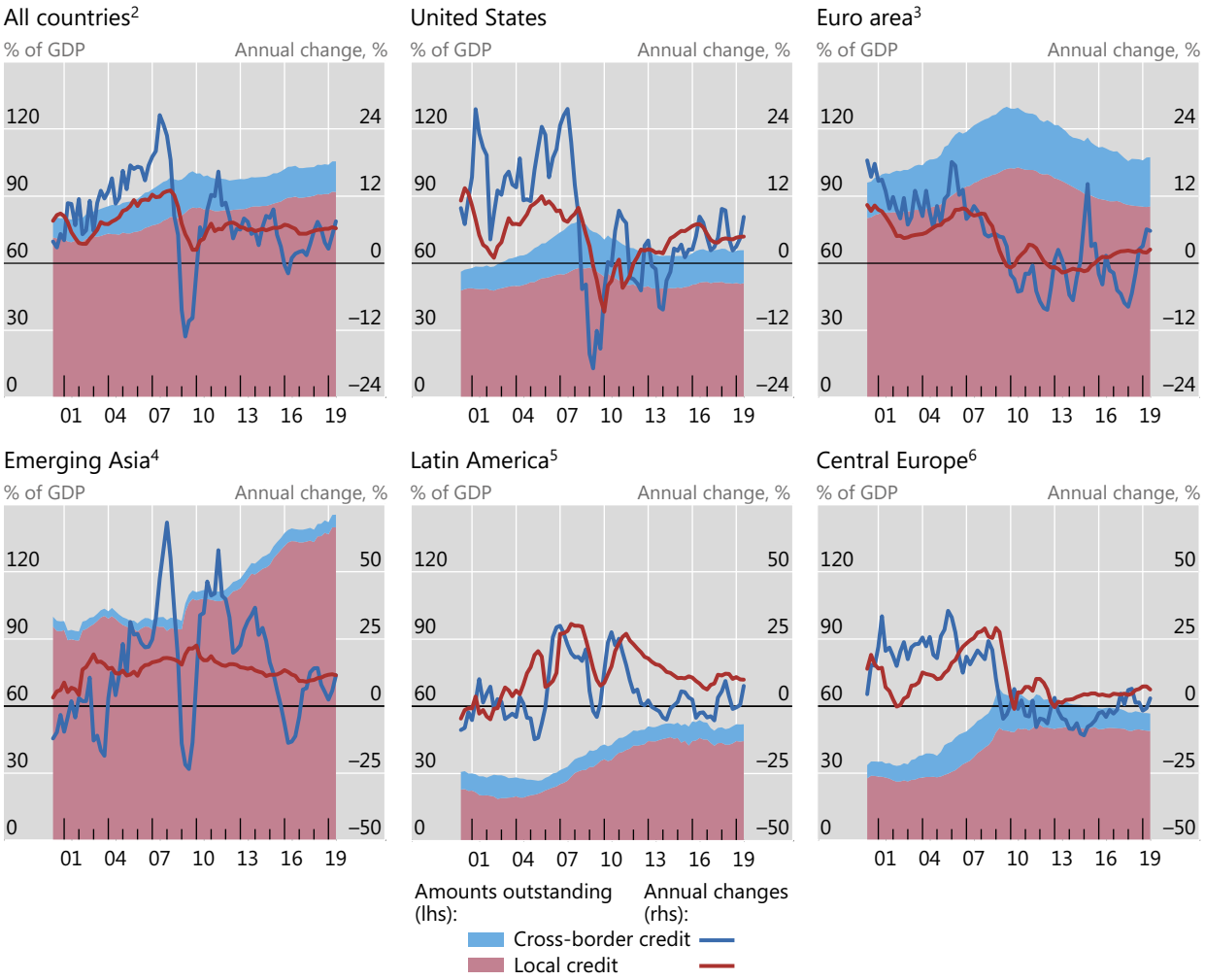
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[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.

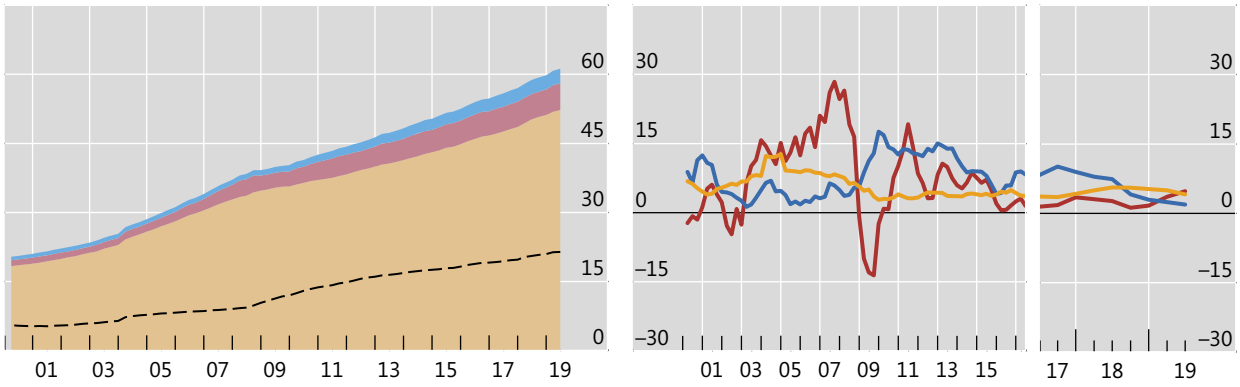
Global credit to the non-financial sector, by currency

Graph E.3

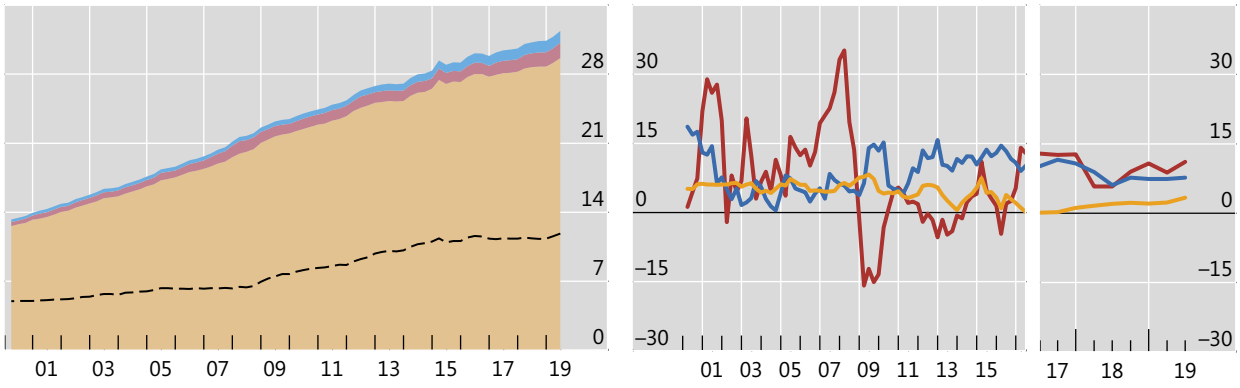
Amounts outstanding, in trillions of currency units[1]

Annual change, in per cent[2]

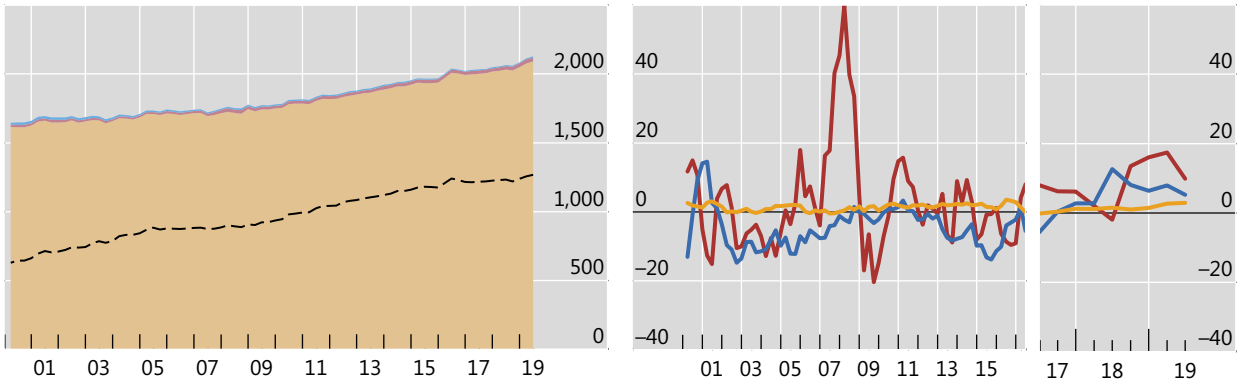
Credit denominated in US dollars (USD)



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]

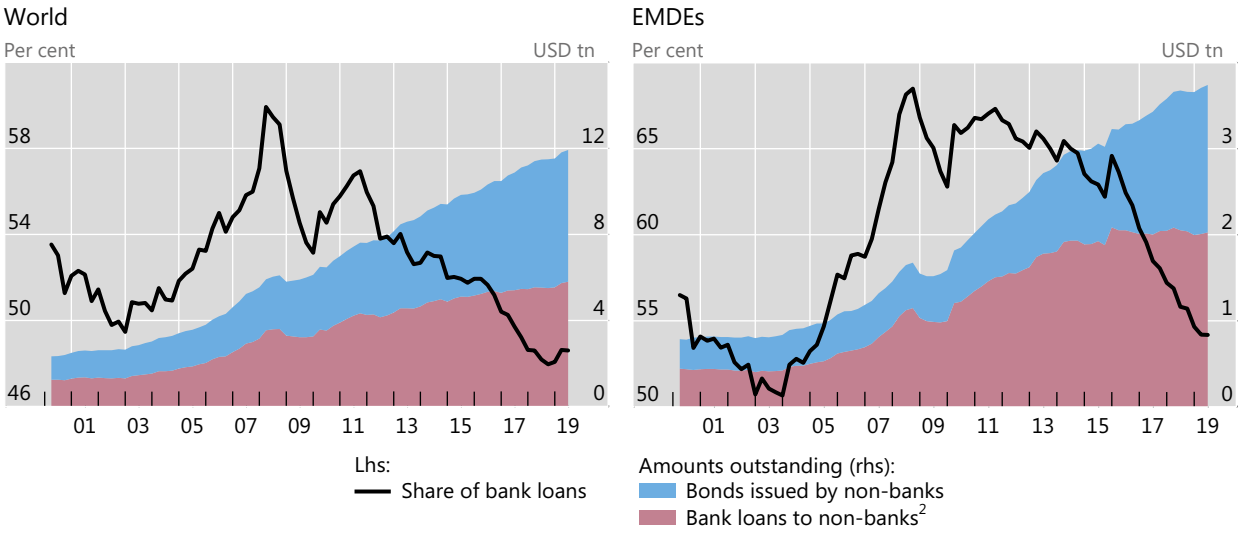
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[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



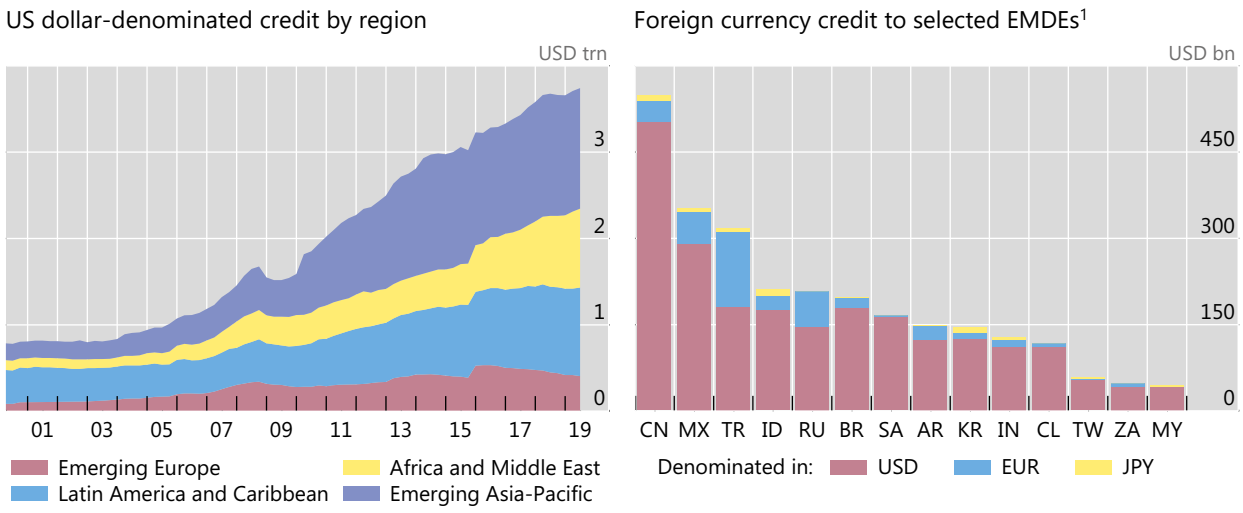
Further information on the BIS global liquidity indicators is available at www.bis.org/statistics/gli.htm.

[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.

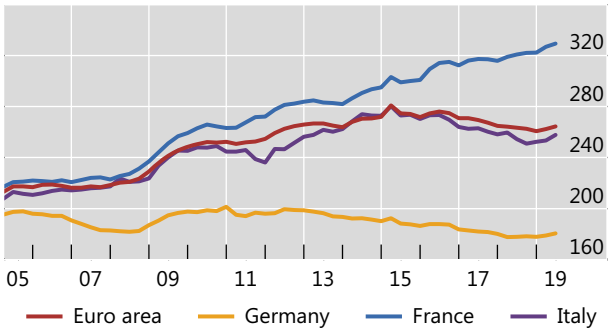
Sources: Datastream; Dealogic; Euroclear; Refinitiv; Xtrakter Ltd; national data; BIS locational banking statistics (LBS); BIS calculations.

F Statistics on total credit to the non-financial sector

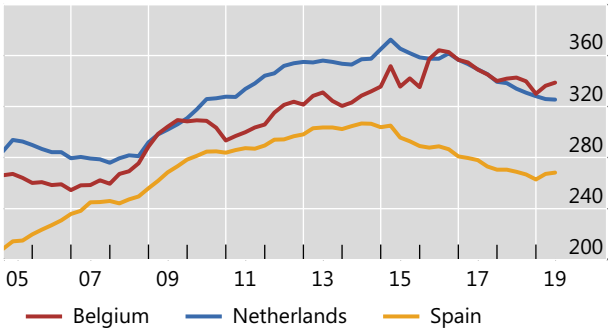
Total credit to the non-financial sector (core debt)

As a percentage of GDP — Graph F.1

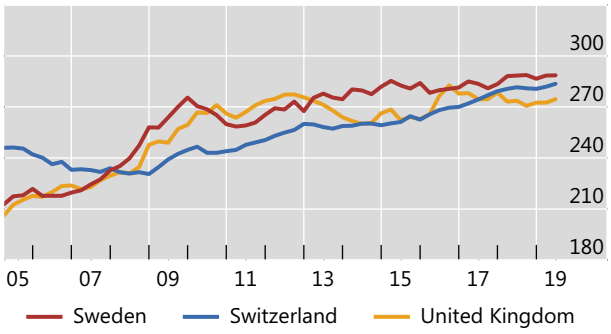
Euro area: aggregate and major countries



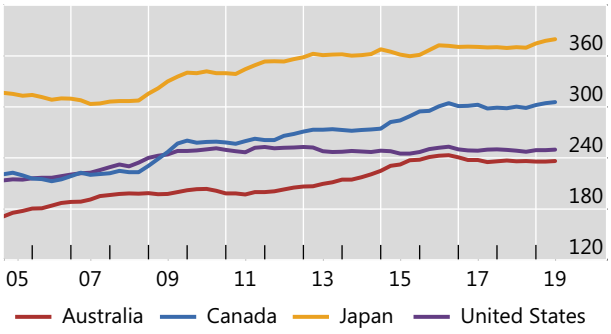
Euro area: other countries



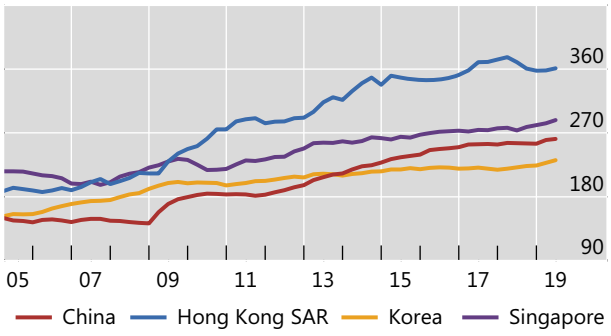
Other European countries



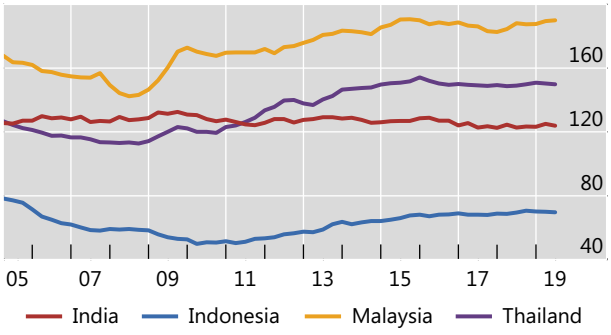
Major advanced economies



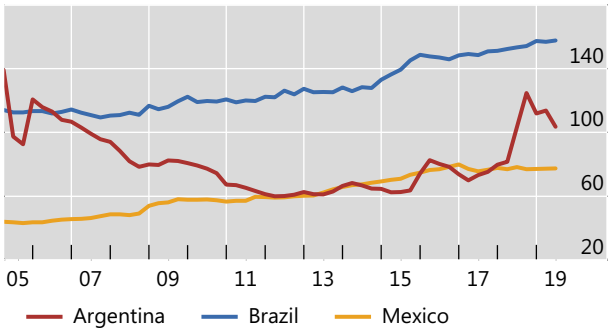
Emerging Asia



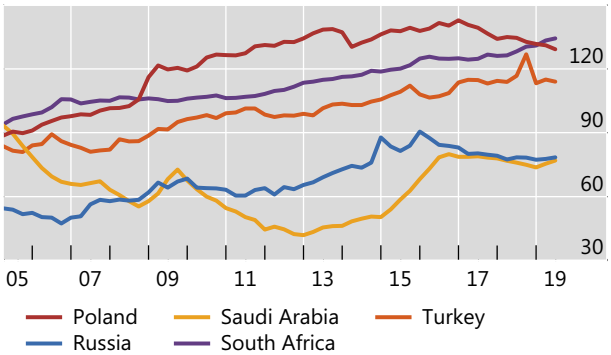
Other emerging Asia



Latin America



Other emerging market economies



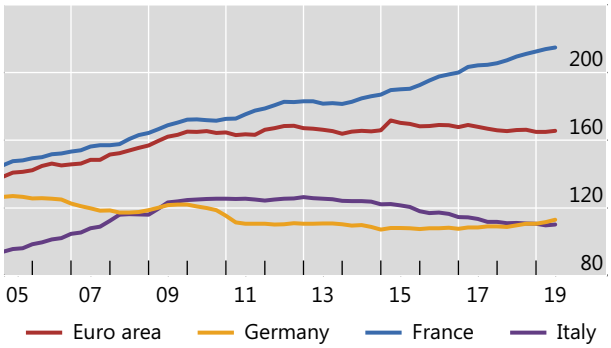
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

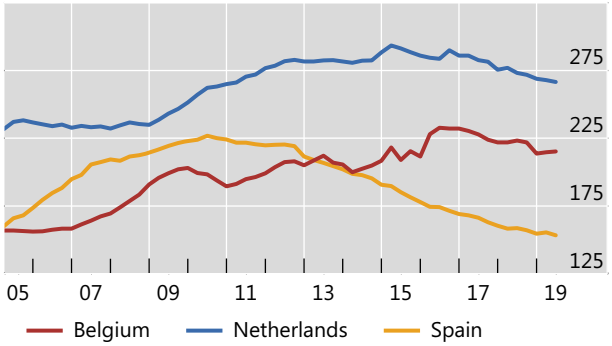
Total credit to the private non-financial sector (core debt)

As a percentage of GDP — Graph F.2

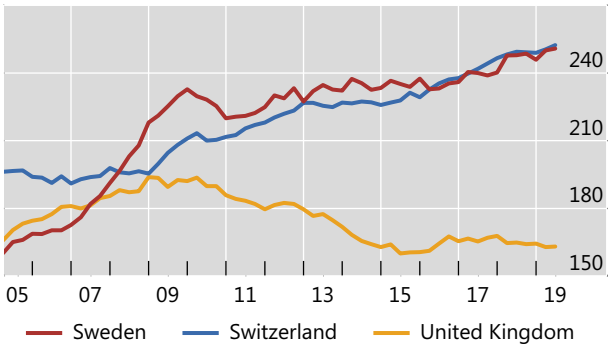
Euro area: aggregate and major countries



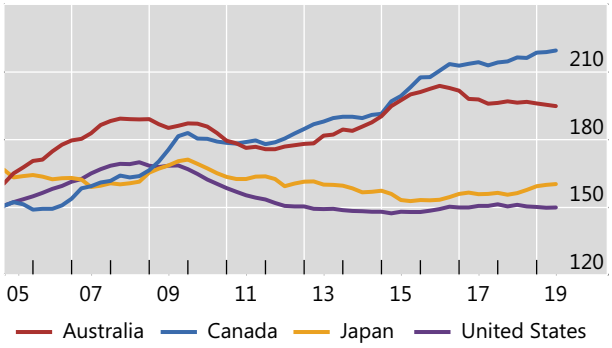
Euro area: other countries



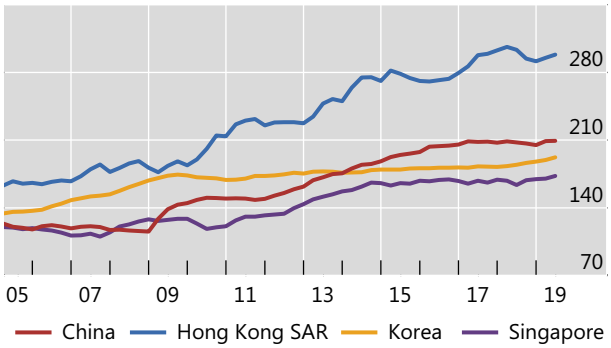
Other European countries



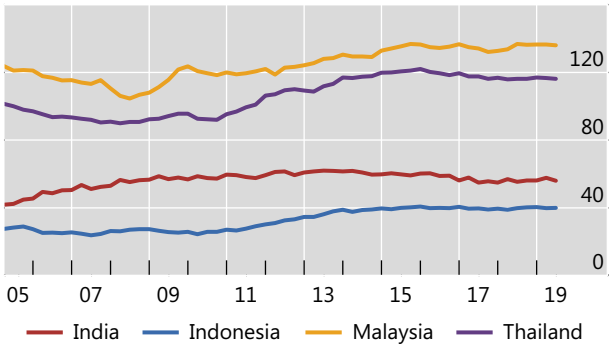
Major advanced economies



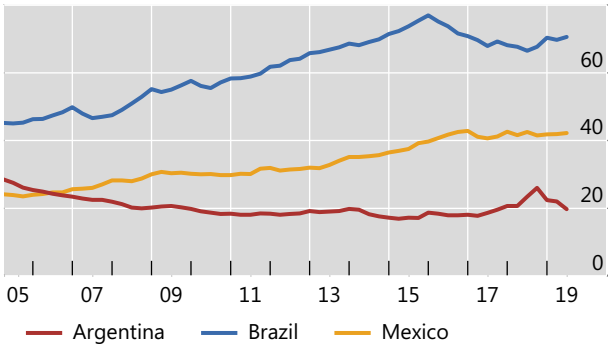
Emerging Asia



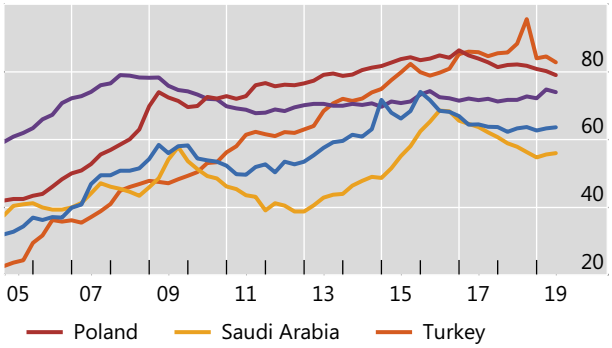
Other emerging Asia



Latin America



Other emerging market economies

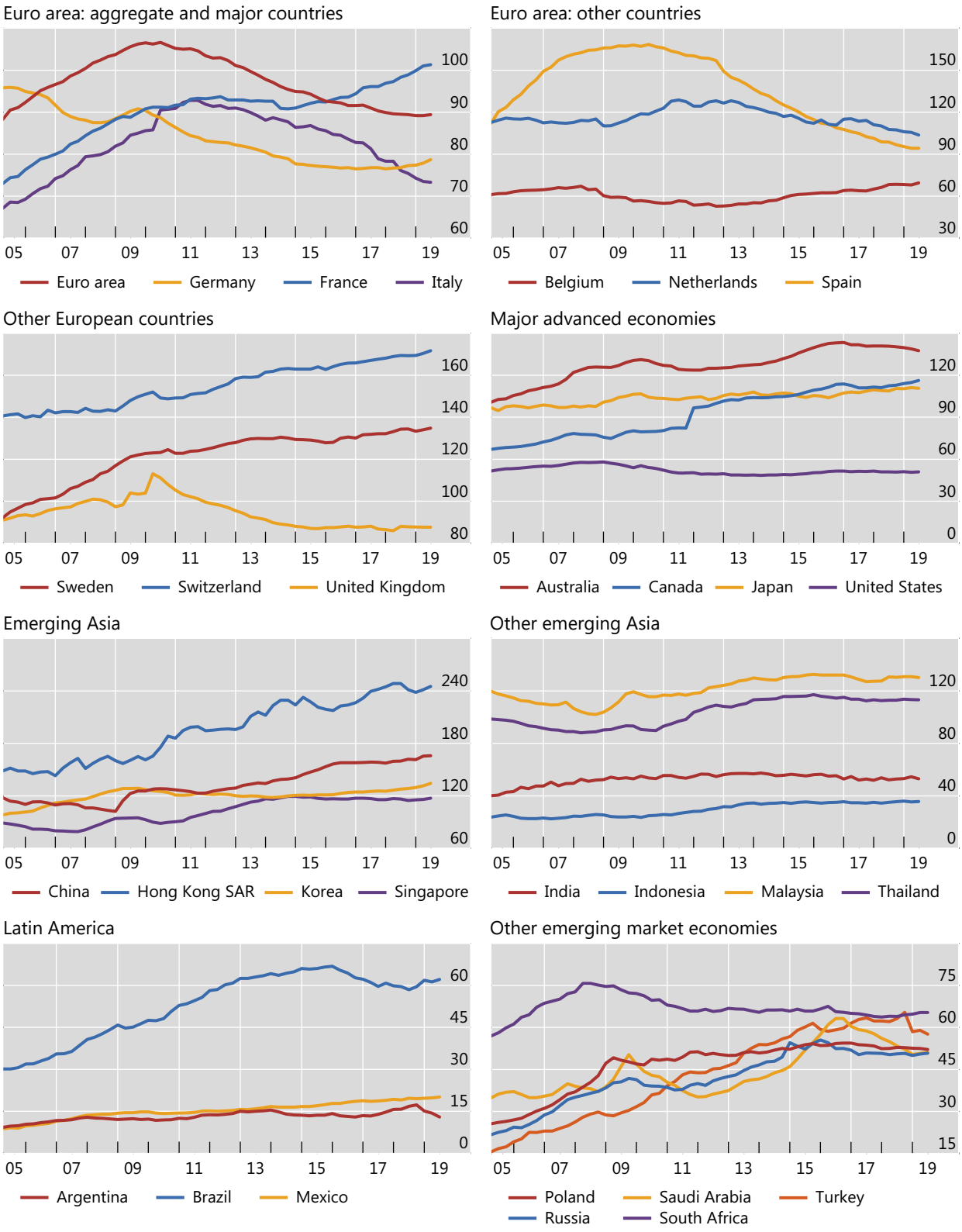


Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

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

As a percentage of GDP — Graph F.3



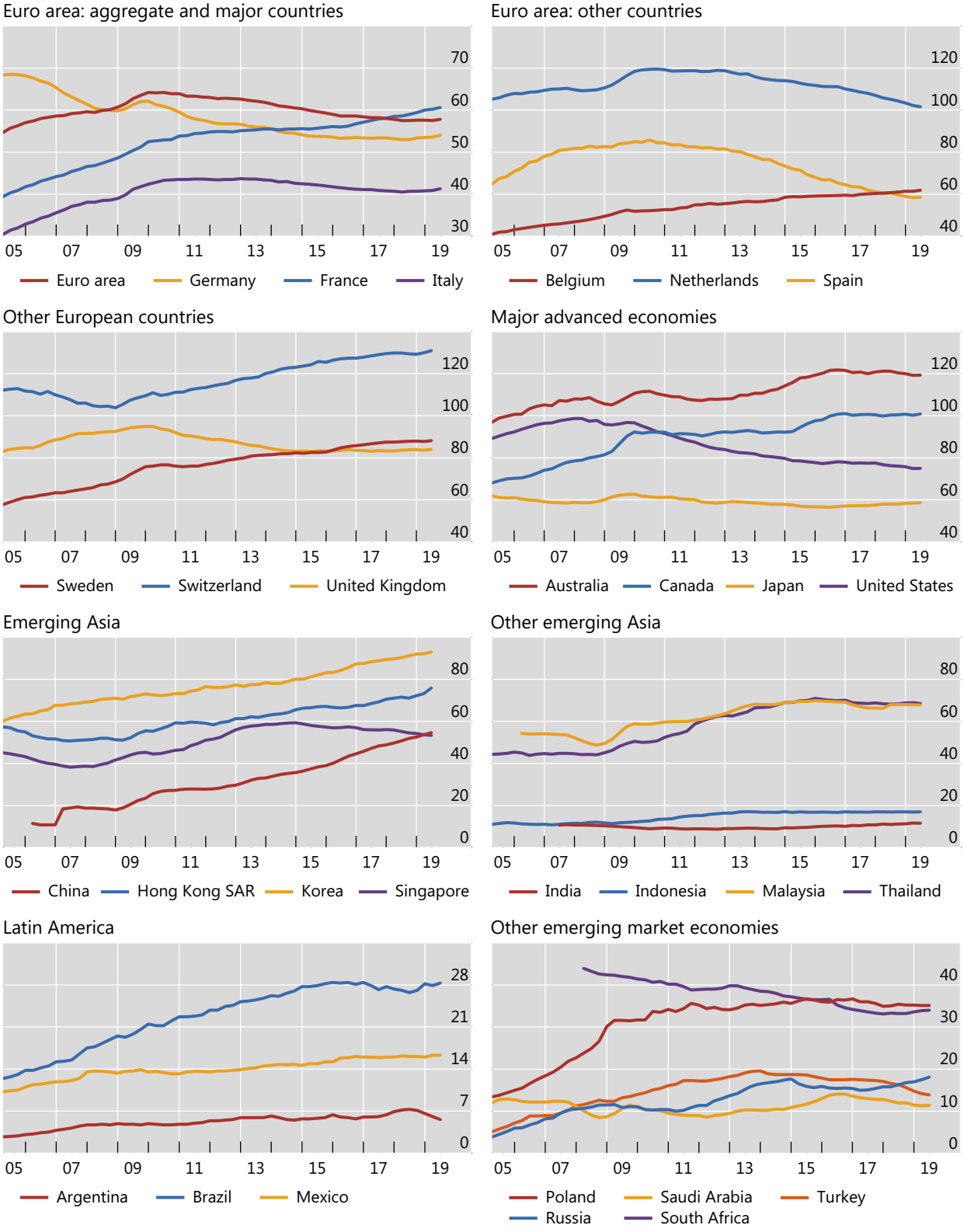
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

Total credit to households (core debt)

As a percentage of GDP

Graph F.4



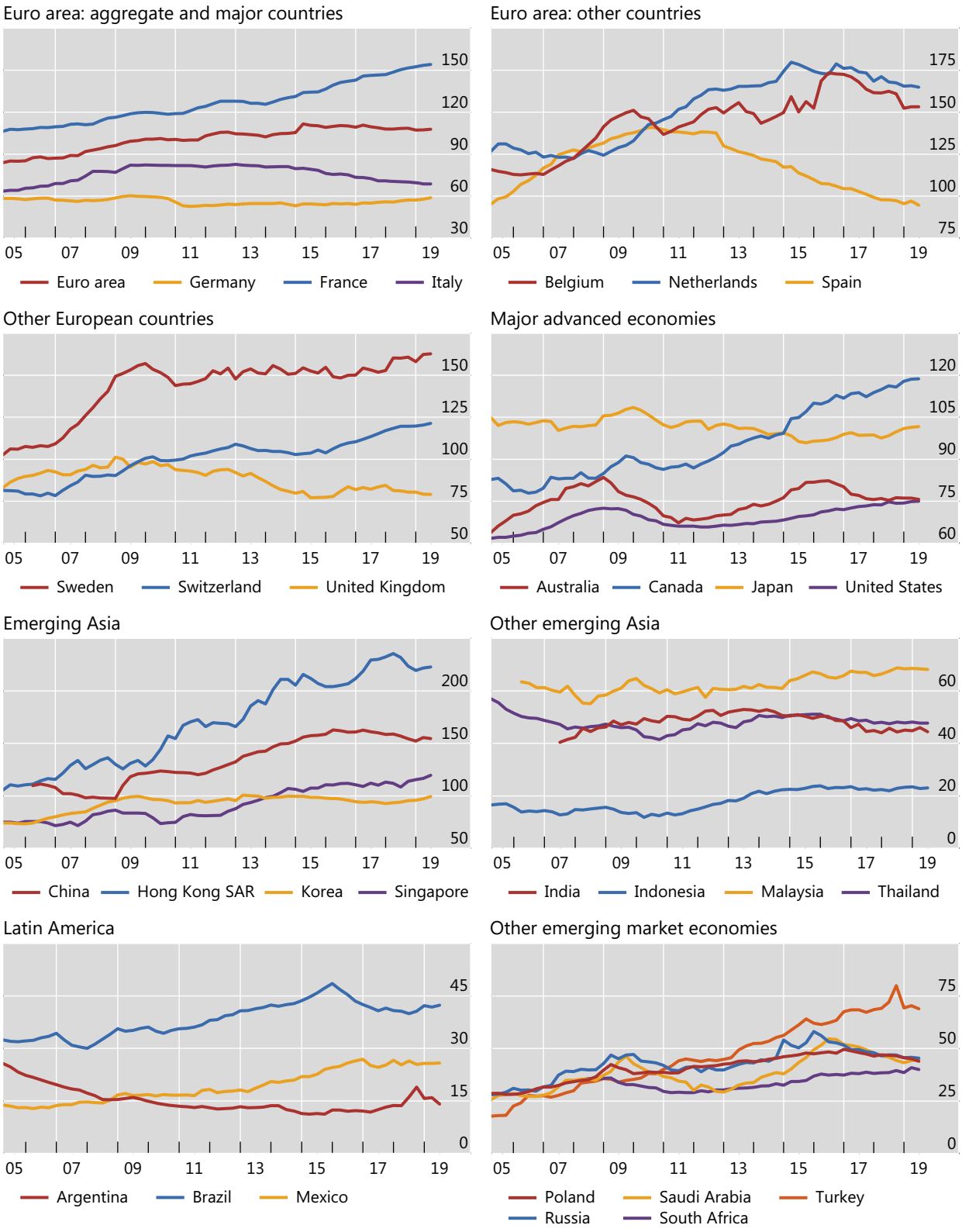
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

Source: BIS total credit statistics.

Total credit to non-financial corporations (core debt)

As a percentage of GDP

Graph F.5



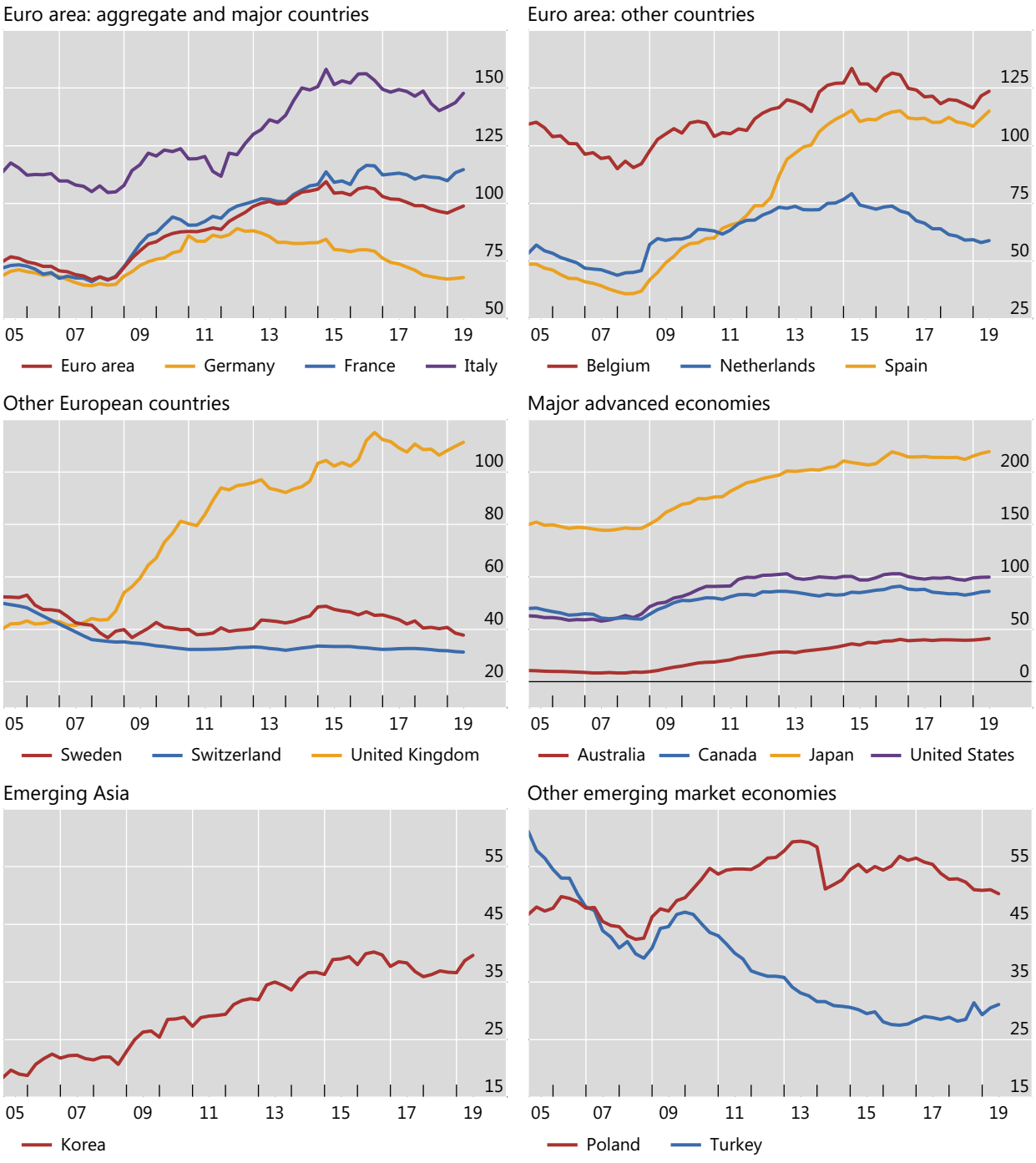
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

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



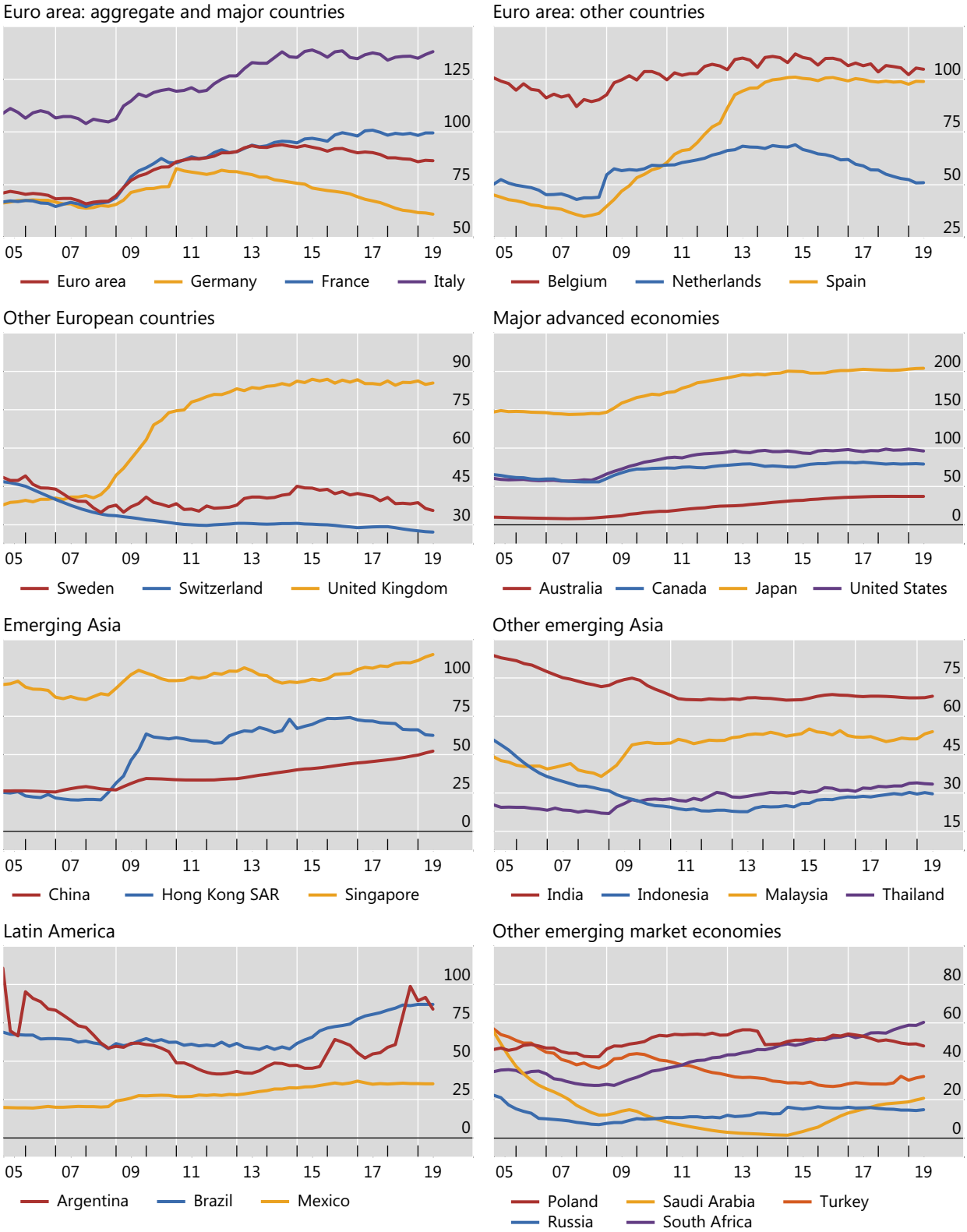
Further information on the BIS credit statistics is available at www.bis.org/statistics/totcredit.htm.

[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



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

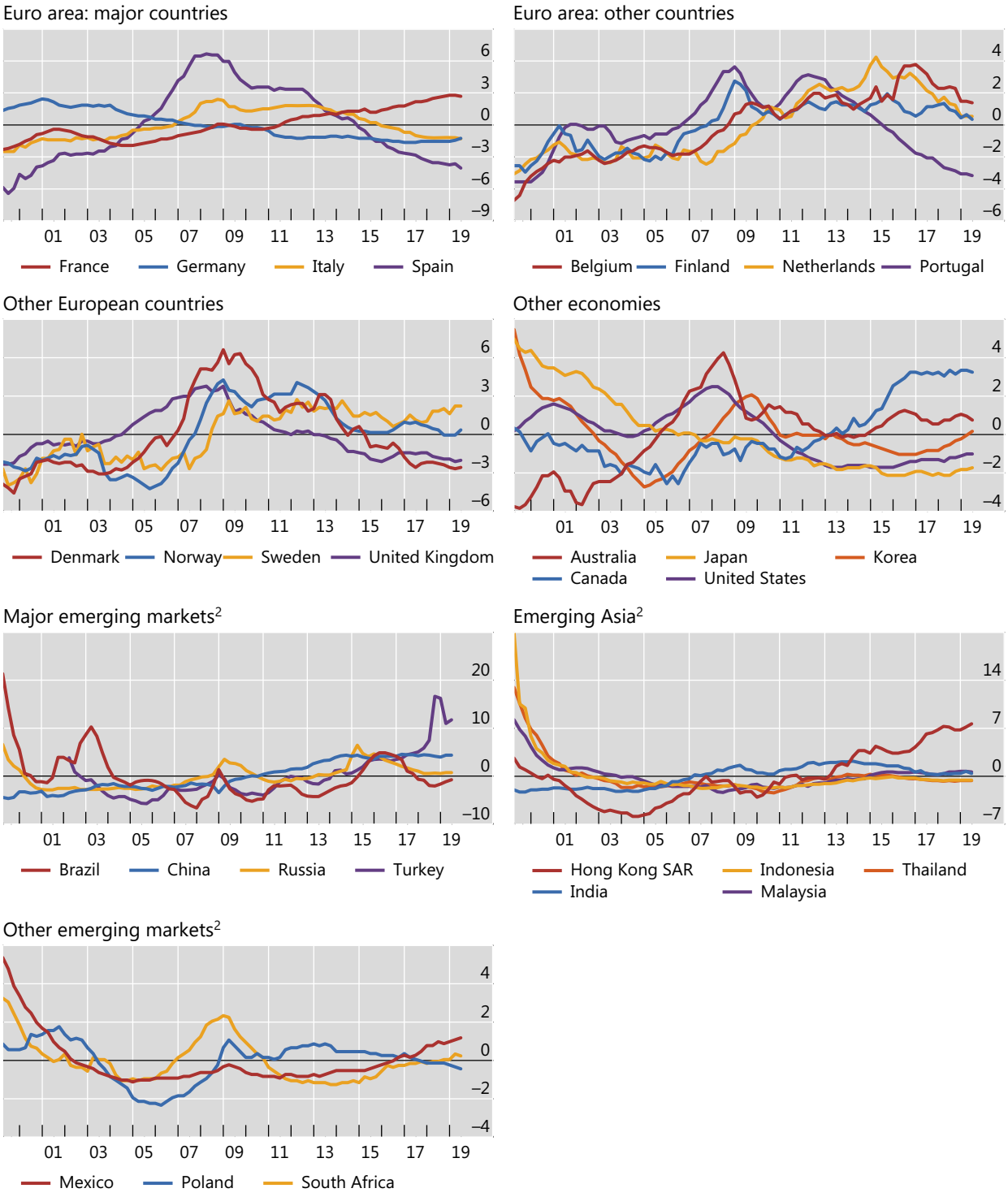
[1] Consolidated data for the general government sector; central government for Argentina, Indonesia, Malaysia, Mexico, Saudi Arabia and Thailand.

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



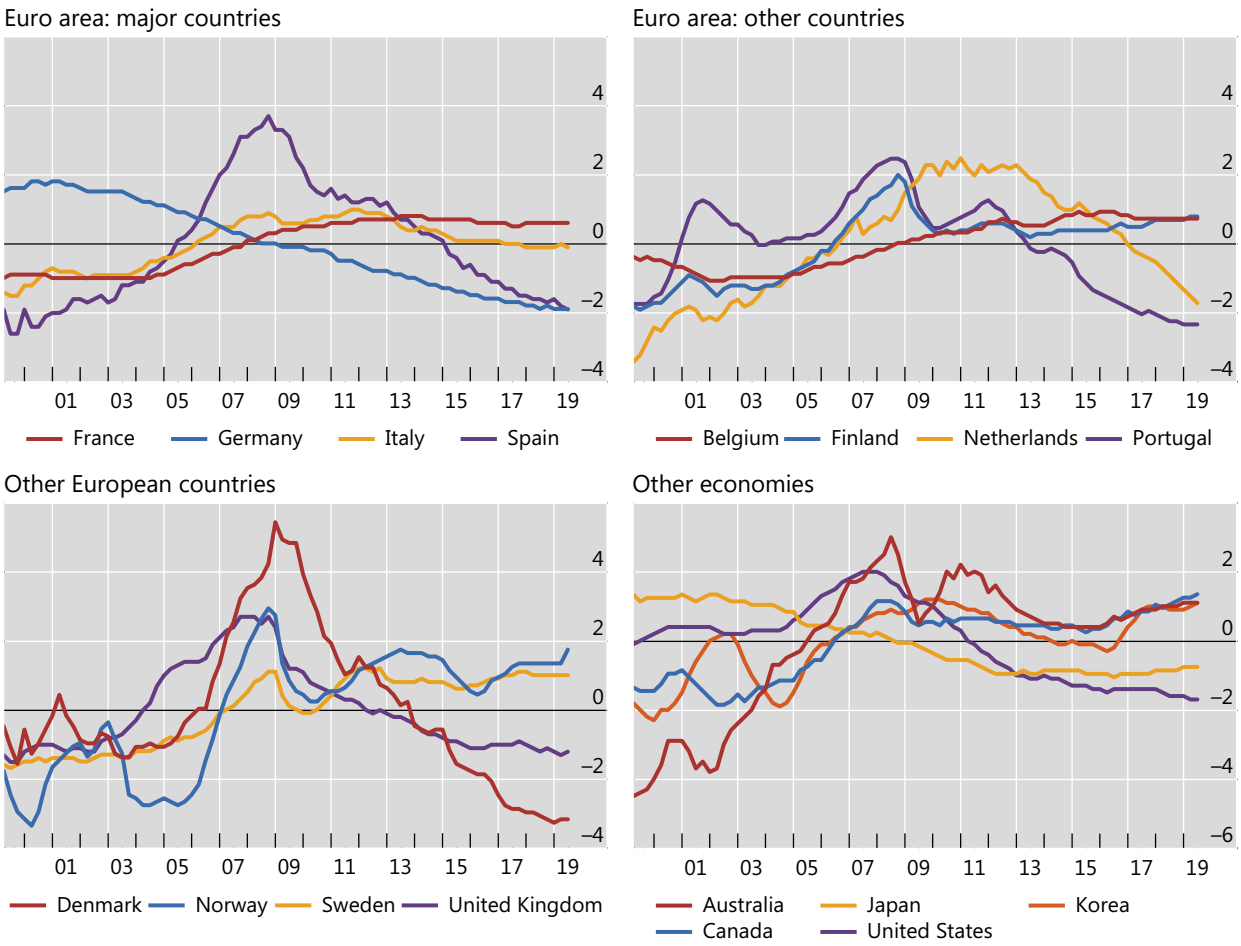
Further information on the BIS debt service ratio statistics is available at www.bis.org/statistics/dsr.htm.

[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



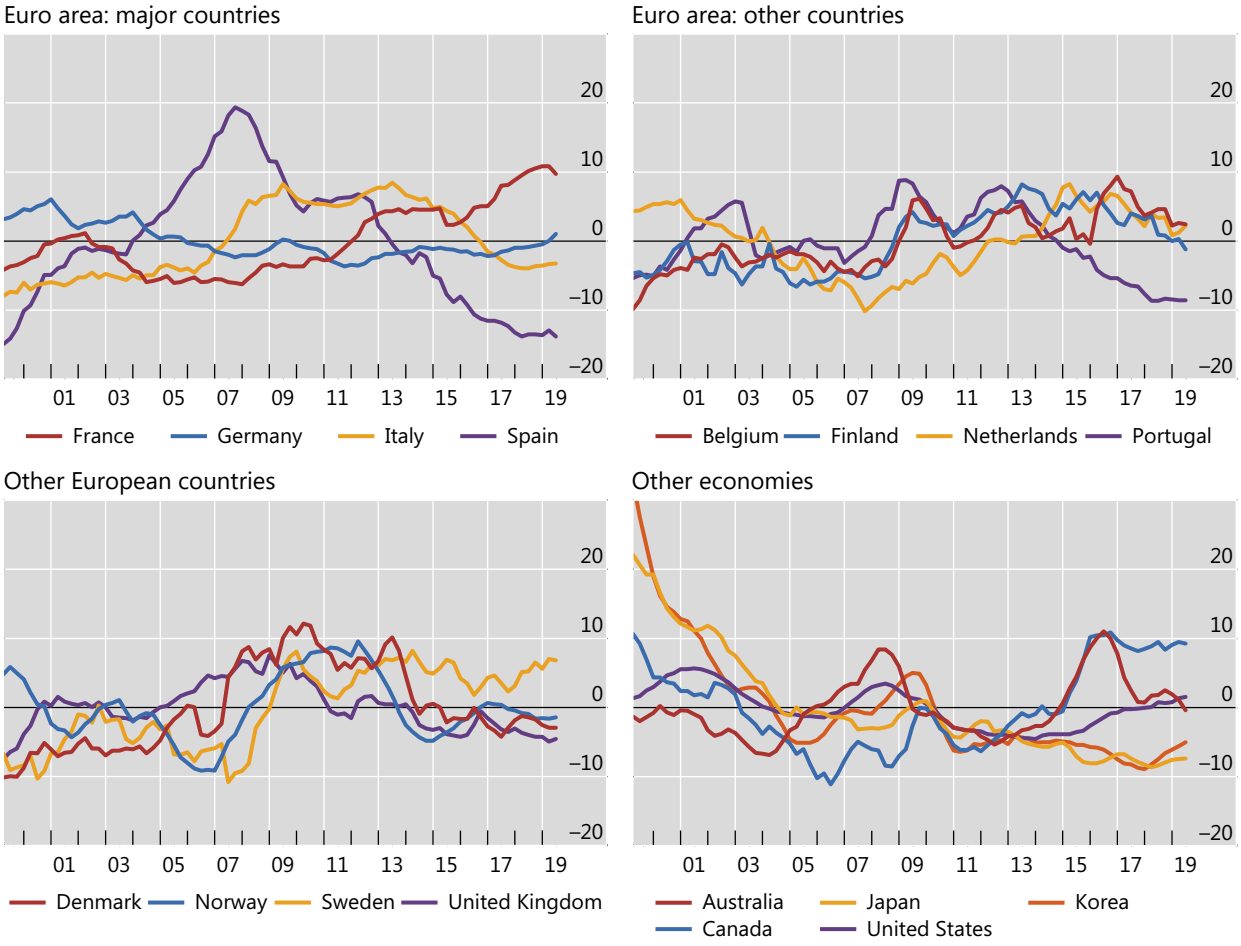
Further information on the BIS debt service ratio statistics is available at www.bis.org/statistics/dsr.htm.

[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.

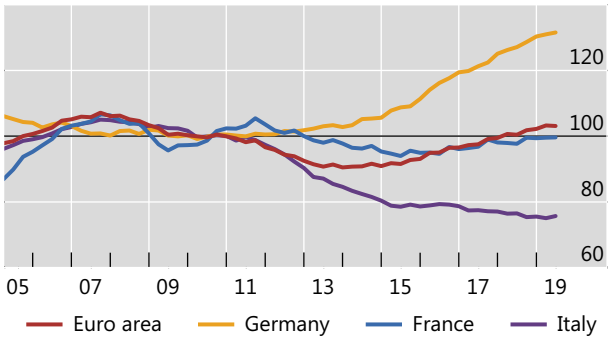
Source: BIS debt service ratios statistics.

H Property price statistics

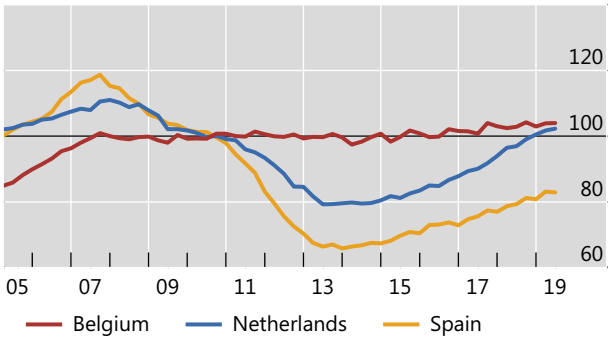
Real residential property prices

CPI-deflated, 2010 = 100 Graph H.1

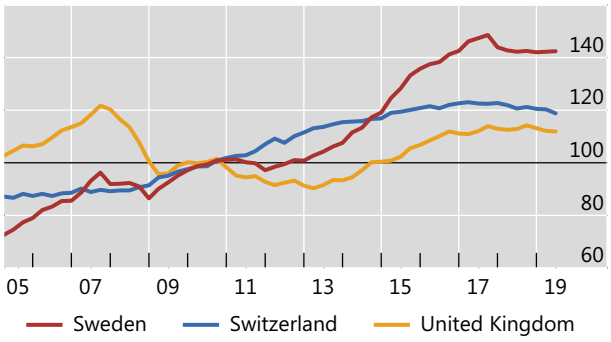
Euro area: aggregate and major countries



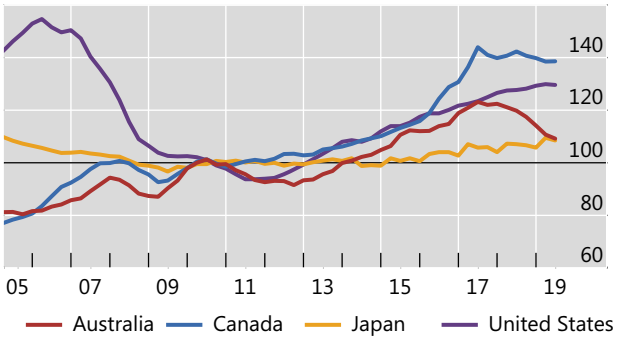
Euro area: other countries



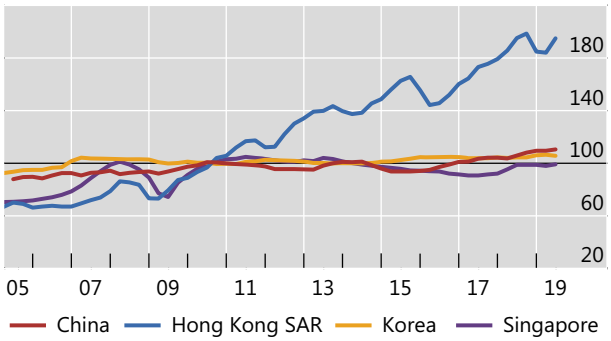
Other European countries



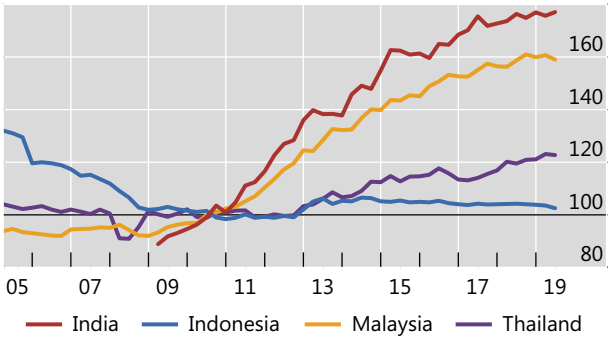
Major advanced economies



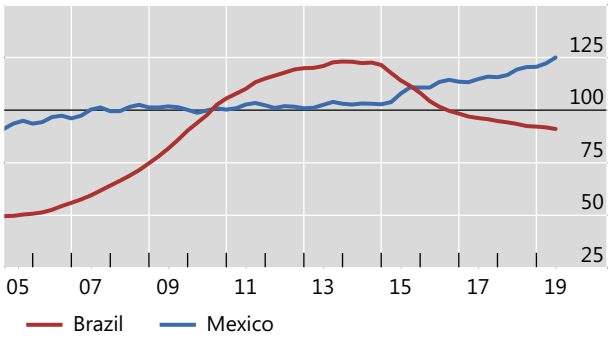
Emerging Asia



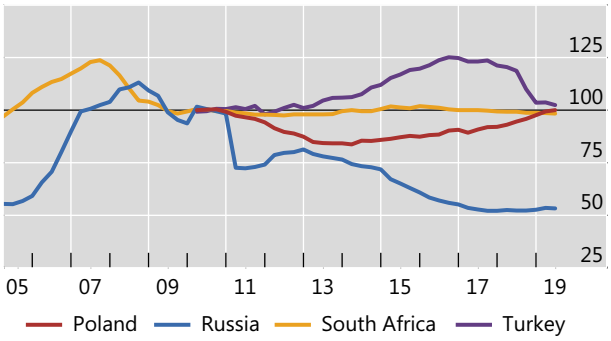
Other emerging Asia



Latin America



Other emerging market economies



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

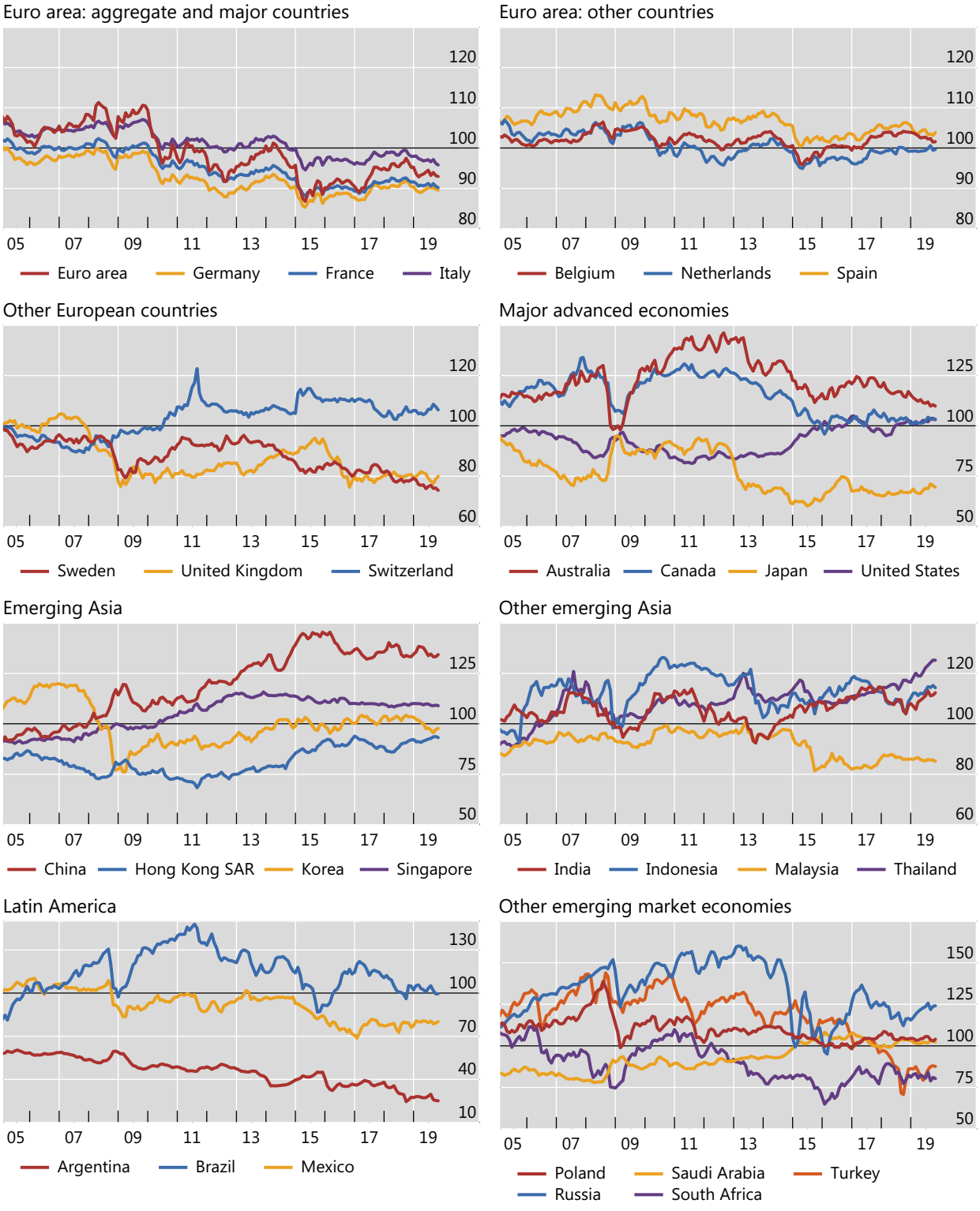
Source: BIS property prices statistics.

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.

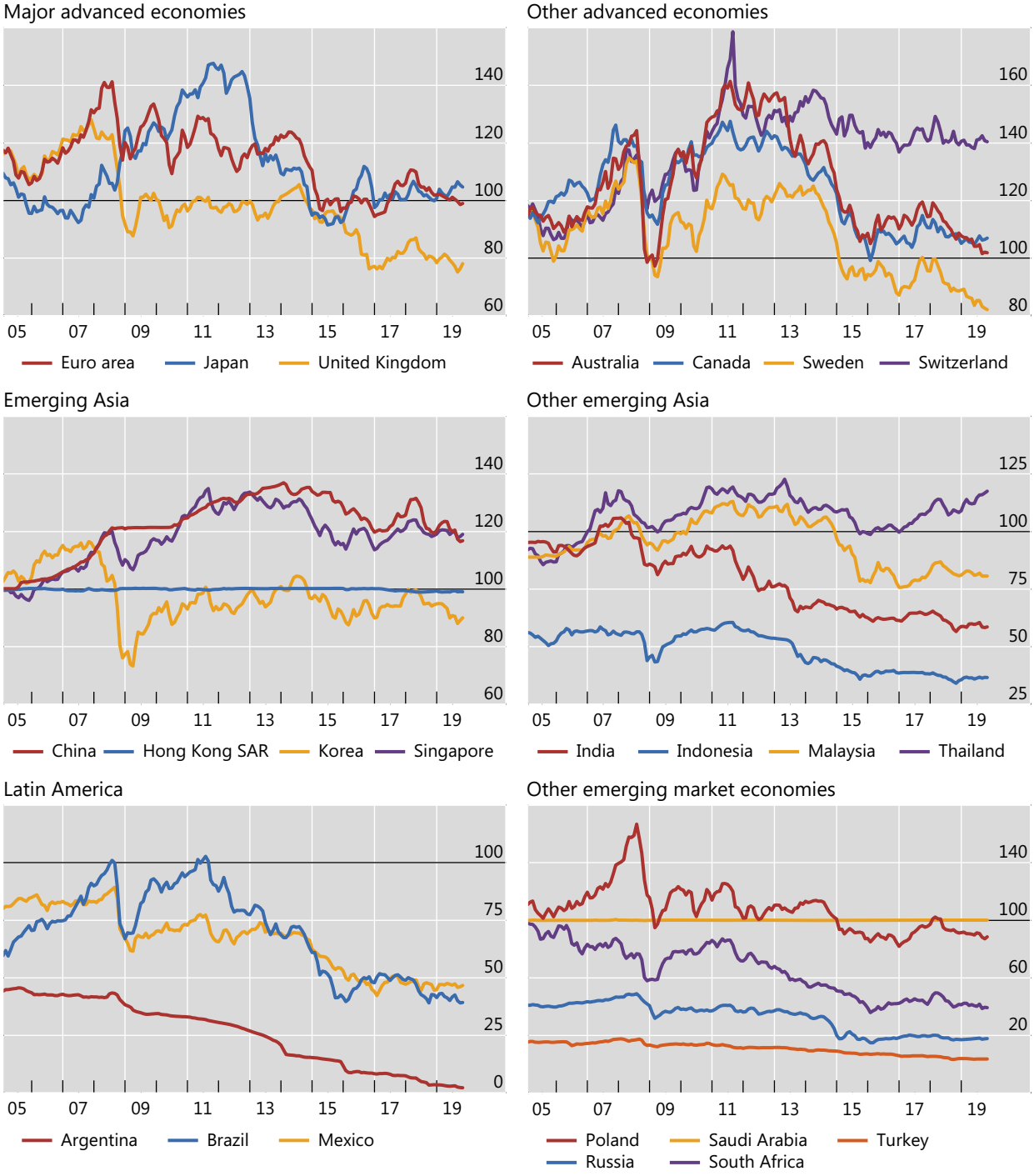
[1] An increase indicates a real-term appreciation of the local currency against a broad basket of currencies.

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.

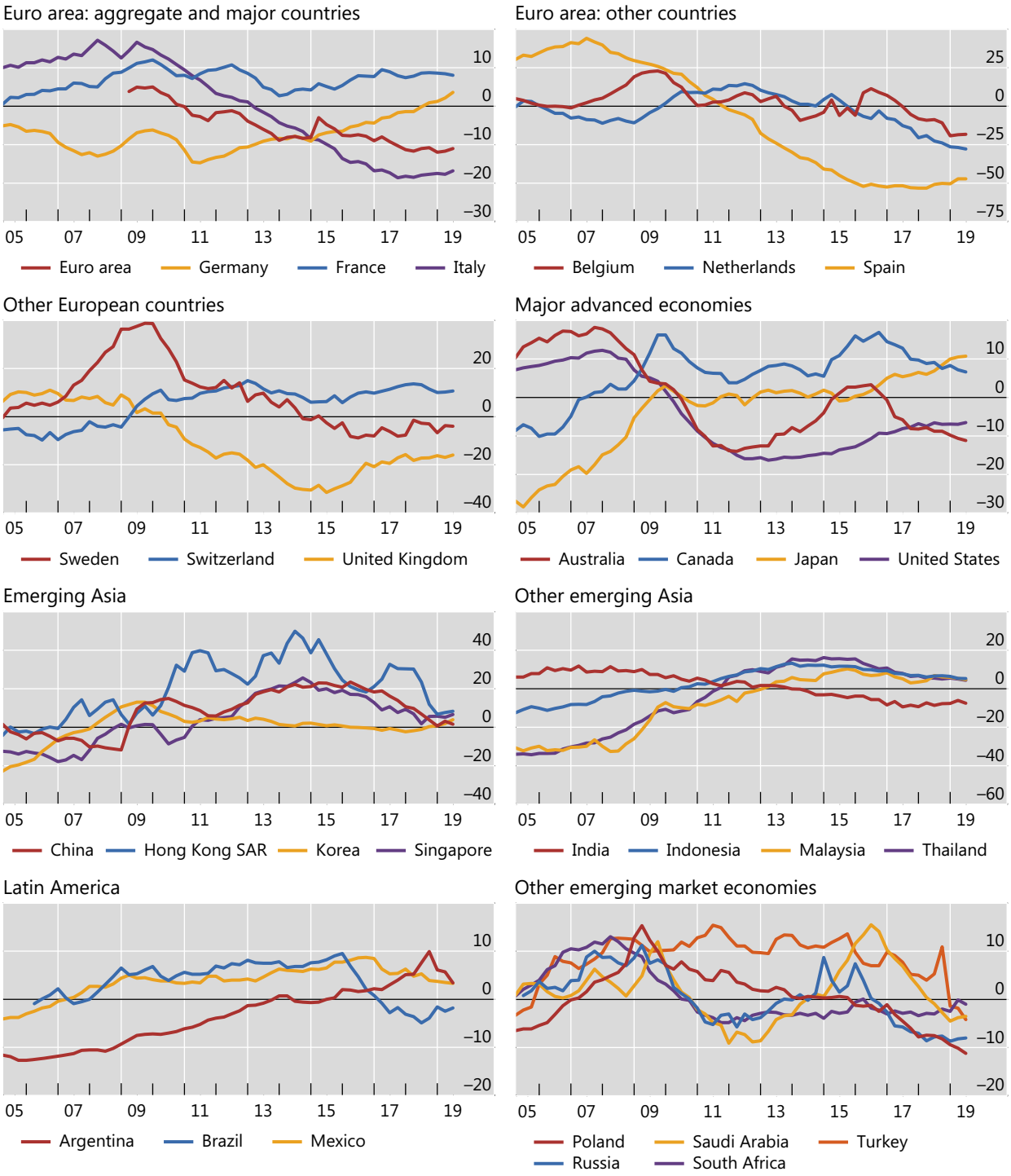
[1] An increase indicates an appreciation of the local currency against the US dollar.

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.

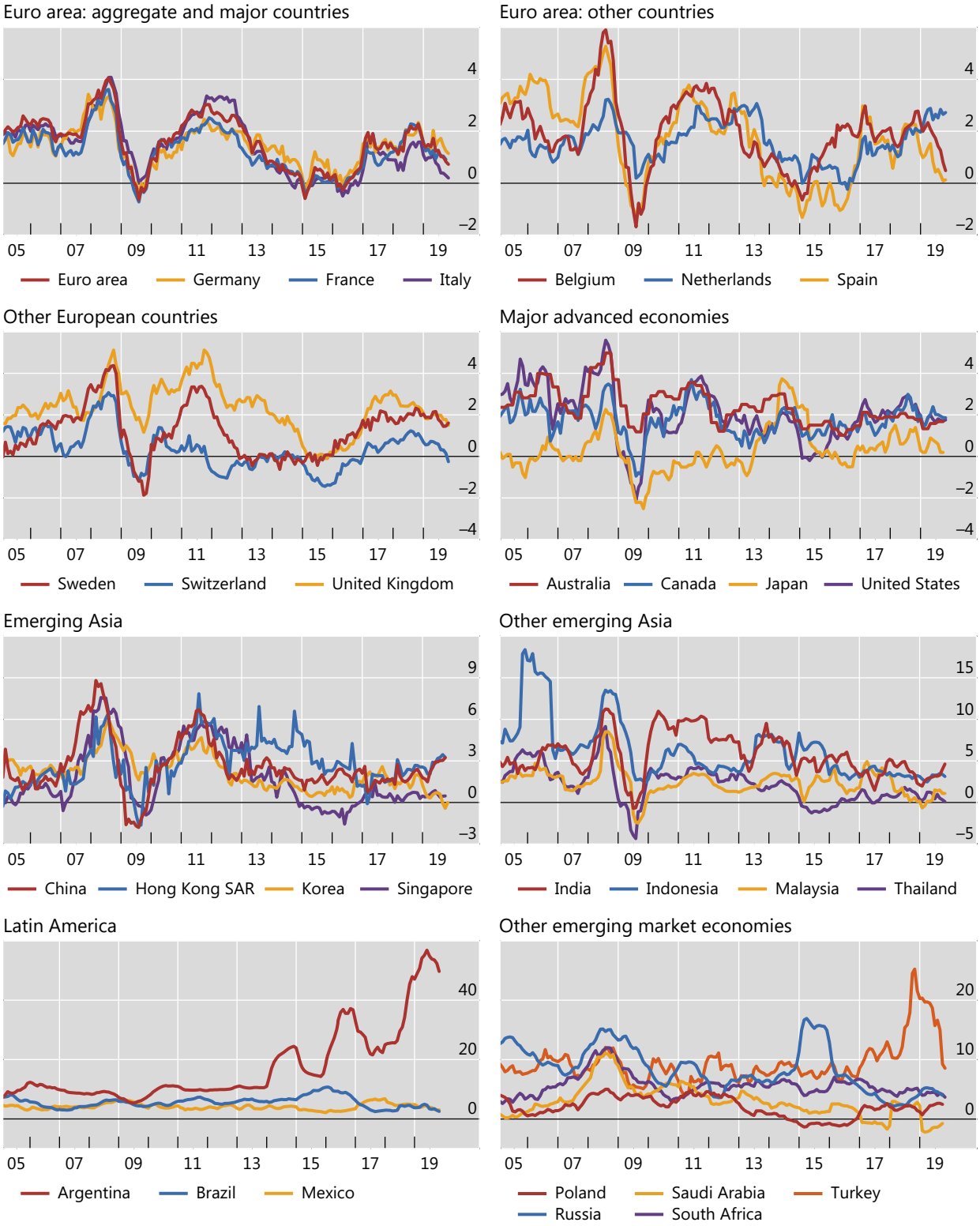
Source: BIS credit-to-GDP gaps statistics.

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.

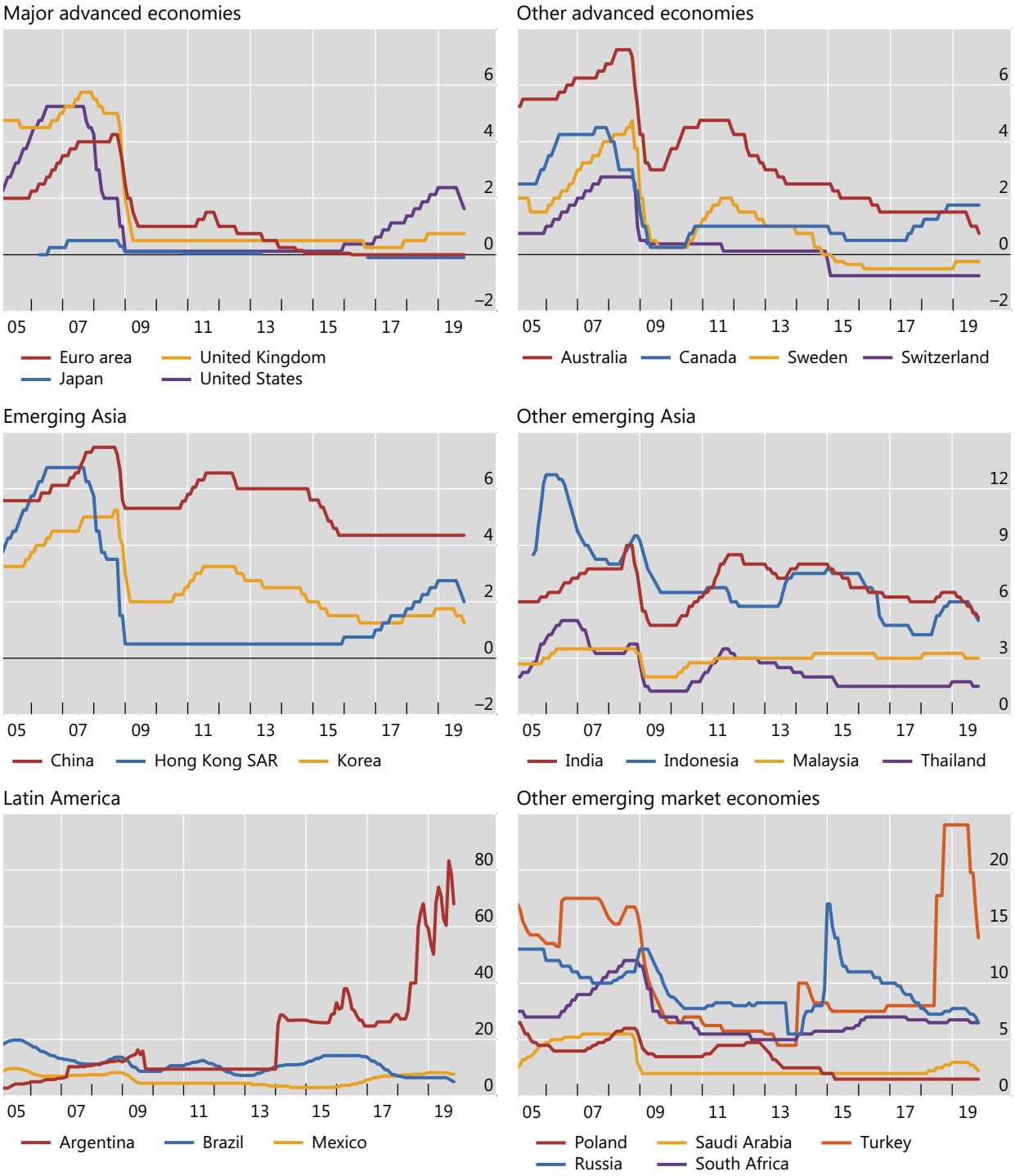
Source: BIS consumer price statistics.

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.