

GLOBAL ECONOMIC OUTLOOK - FEBRUARY

Monetary Department
External Economic Relations Division

2018

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Cut-off date for data

16 February 2018

CF survey date

12 February 2018

GEO publication date

23 February 2018

Notes to charts

ECB and Fed: midpoint of the range of forecasts.

The arrows in the GDP and inflation outlooks indicate the direction of revisions compared to the last GEO. If no arrow is shown, no new forecast is available. Asterisks indicate first published forecasts for given year. Historical data are taken from CF, with exception of MT and LU, for which they come from EIU.

Leading indicators are taken from Bloomberg and Datastream.

Forecasts for EURIBOR and LIBOR rates are based on implied rates from interbank market yield curve (FRA rates are used from 4M to 15M and adjusted IRS rates for longer horizons). Forecasts for German and US government bond yields (10Y Bund and 10Y Treasury) are taken from CF.

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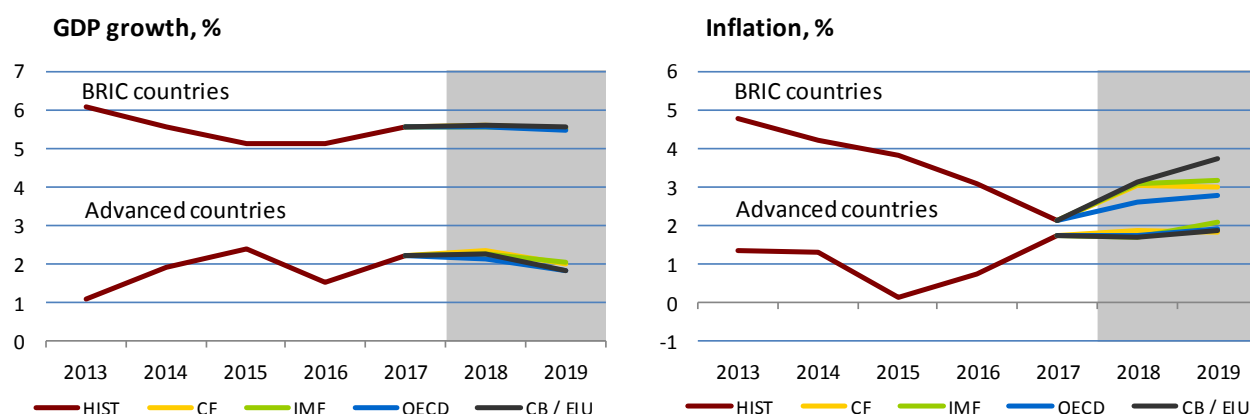
The February issue of Global Economic Outlook presents the regular monthly overview of recent and expected developments in selected territories, focusing on key economic variables: inflation, GDP growth, leading indicators, interest rates, exchange rates and commodity prices. In this issue, we focus analytically on the evolution of shadow rates in the USA in the light of the Taylor rule. Our estimates show that the derived model rate in the post-crisis period was affected primarily by the output gap and the deviation of inflation from the target. The model rate and actual shadow rates differed at the time when unconventional measures were being implemented, so there was a need for even faster monetary policy easing by the Federal Reserve than that actually indicated by shadow rates.

The current outlooks for annual economic growth in the advanced countries we monitor have risen slightly compared with January. The USA – the world's strongest economy – should thus reach a local peak this year, recording GDP growth of 2.8%. A slight slowdown is expected in 2019. Similar growth was also observed for both the euro area and its largest economy, Germany. However, they still lag behind the USA by about 0.5 pp. The outlooks for Japan and the UK continue to indicate distinctly lower economic growth, although the UK's results can be assessed as positive given the ongoing Brexit. Expected inflation levels exceed the "ideal" 2% level only in the USA and the UK, where interest rates are expected to continue to rise this year. However, the inflation outlook for the euro area remains subdued at 1.5%. The inflation outlooks for Japan are falling, with inflation expected to be only just above 1% at the end of next year.

The outlooks for annual GDP growth in the BRIC countries also indicate that the global economy will see solid growth in the near future. Both India and China are showing strong growth as usual, although the Chinese economy is still expected to gradually lose momentum to 6.3%. By contrast, the Indian economy is expected to return to 8% growth from its currently slightly weaker rates. The current inflation estimates predict inflation of just above 2% for China and around 5% for India. This does not indicate the presence of further macroeconomic risks. The economic situation of the remaining two BRIC countries, particularly Brazil, can also be viewed as positive. The Brazilian economy should approach 3% GDP growth at the end of the next year and the Russian economy will remain slightly below 2%. The good news for these countries is that they should succeed in keeping inflation close to 4%.

The outlooks for euro area interest rates remain very low, with no sign of them rising markedly at the one-year horizon. By contrast, US rates can be expected to be raised as many as three times this year – by the standard amount of 0.25 pp each time. According to CF, the US dollar will depreciate slightly against the euro, the rupee and the rouble and slightly appreciate against the yen and the renminbi at the one-year horizon. The dollar-pound rate is expected to be broadly stable. The price of Brent crude oil is expected to average about USD 62 a barrel this year and gradually fall to USD 58 a barrel on average in 2019. Prices of food commodities are rising over the outlook horizon, reflecting expected growth for all the commodities under review (wheat, corn, rice and soy). Industrial metals prices are expected to return to lower growth despite their recent visible rise.

GDP growth and inflation development and outlook in monitored countries

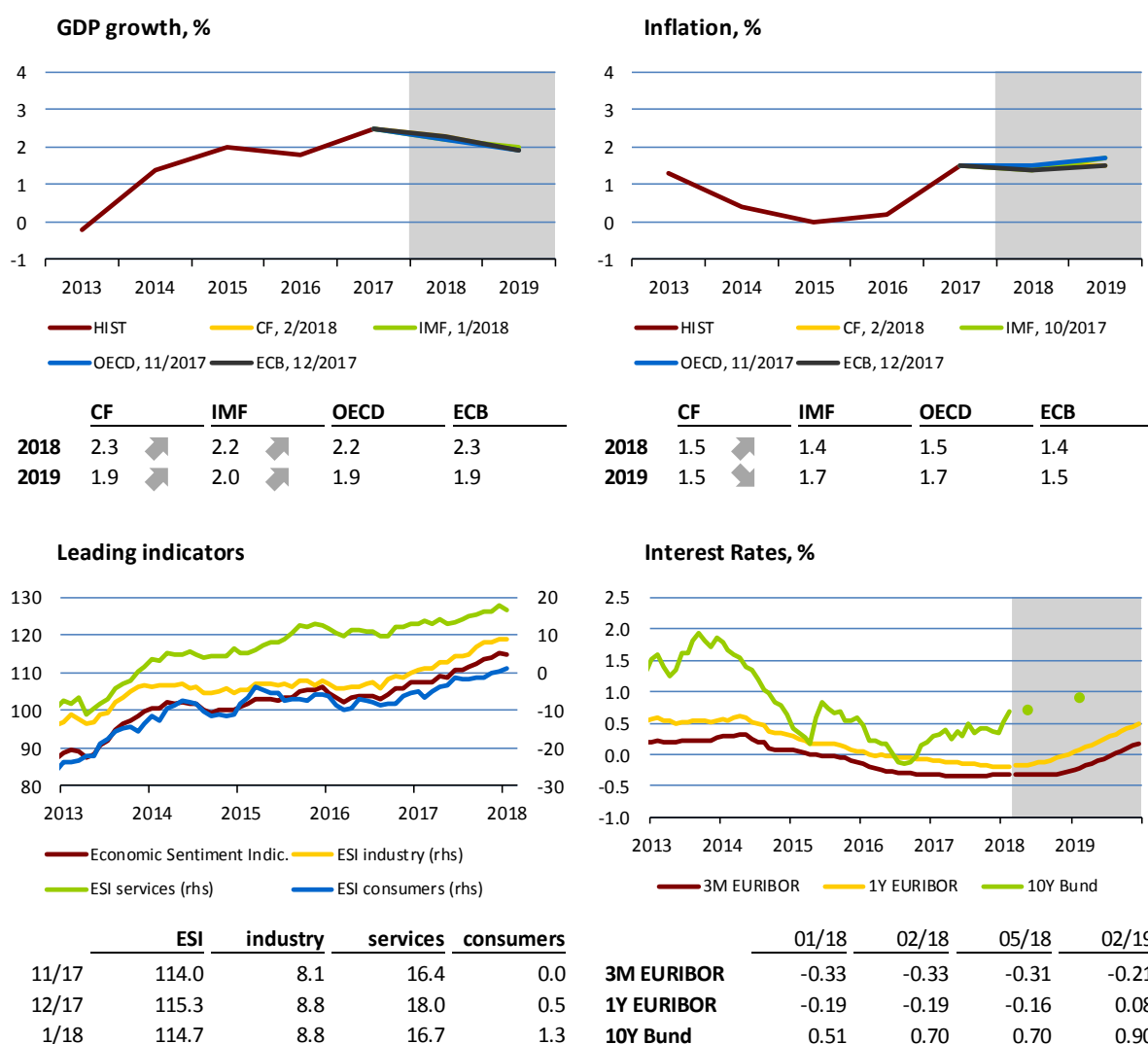


Note: The figures represent the weighted averages of historical series / outlooks in individual countries. The weights are based on nominal GDP measured in USD during 2013–2016 (source: EIU). Advanced countries: euro area, United States, United Kingdom, Japan. BRIC countries: China, India, Russia, Brazil.

II.1 Euro area

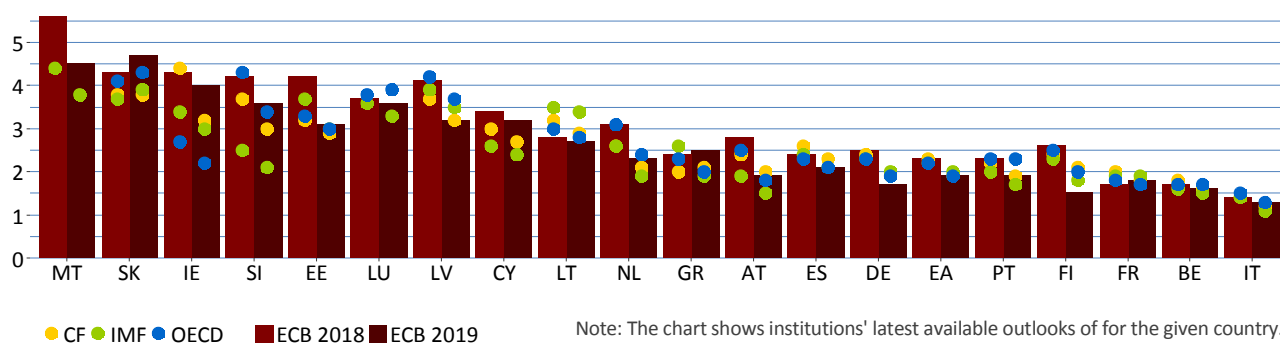
Economic growth in the euro area moderated slightly at the end of 2017, but stayed high. GDP grew by 0.6% quarter on quarter and 2.7% year on year. It continued to be driven mainly by domestic demand, supported by rising household and business confidence, an improving labour market situation and easy monetary policy. In addition, despite a stronger euro (particularly against the dollar), exports grew at a robust pace at the end of last year, rising by 7.1% in 2017 compared to the previous year. Leading indicators are favourable at the start of this year. The PMI in manufacturing, for example, is near a historical high despite having edged down slightly in January. The EC economic sentiment indicator (see the chart below) and its components also remain close to several-year highs. The monitored outlooks expect growth of around 2.2% this year, 0.3 pp lower than last year.

Headline HICP inflation in the euro area declined for the second consecutive month, to 1.3%. The drop was due mainly to a lower contribution of energy prices owing to base effects. By contrast, core inflation rose slightly to 1%. The PMI survey is signalling a rise in input prices due to diminishing economic slack, which should gradually spill over to consumer prices. At the same time, last year's low wage growth is having a downward impact on the inflation outlook. The monitored institutions thus expect average inflation to be around 1.5% this year and slightly higher next year. However, it will stay quite significantly below the ECB's target. Given the subdued inflation outlook, the ECB will continue its asset purchases until at least the end of September 2018 at a lowered monthly pace of EUR 30 billion. At its January meeting, the ECB reiterated its commitment to keep the key rates at the current levels for an extended period of time and past the horizon of the net asset purchases. The financial market outlooks for money market rates shifted upwards slightly, as did the outlook for the ten-year German government bond. This move reflects surprisingly positive data from the US labour market, which could imply faster normalisation of the Fed's monetary policy.

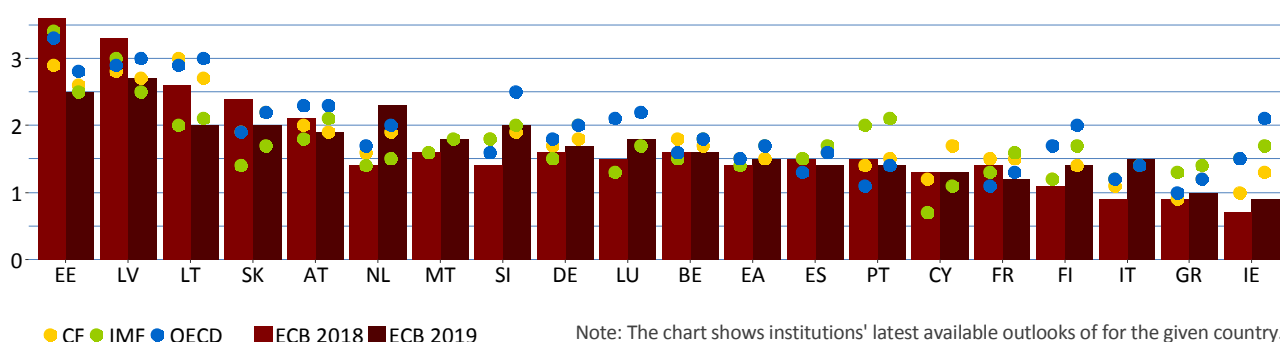


II. ECONOMIC OUTLOOK IN ADVANCED ECONOMIES

GDP growth outlooks in the euro area countries in 2018 and 2019, %

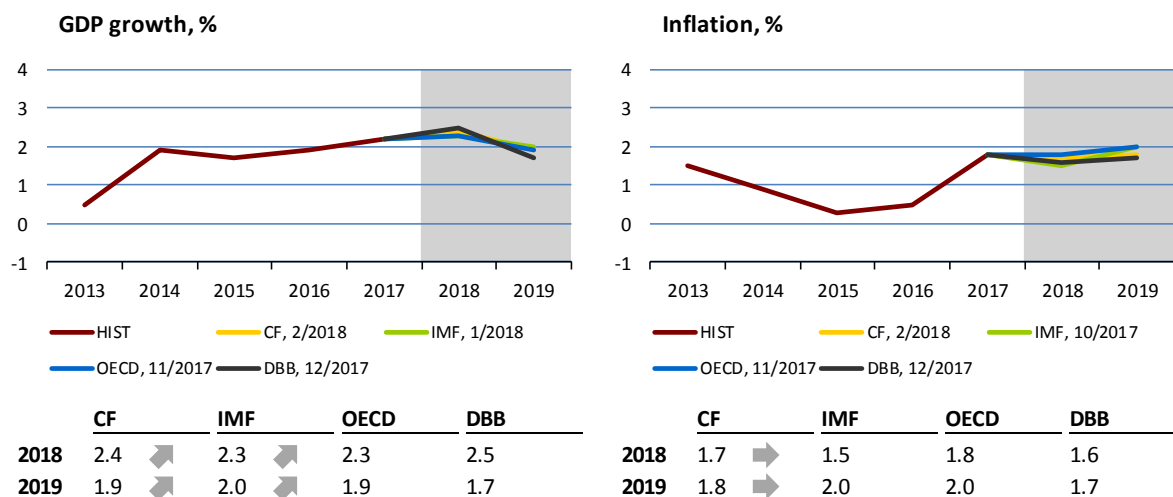


Inflation outlooks in the euro area countries in 2018 and 2019, %



II.2 Germany

According to preliminary data, the German economy grew by 2.9% year on year and 0.6% quarter on quarter in 2017 Q4. The growth was driven mainly by net exports, investment and government consumption. Industrial production remains favourable – its year-on-year growth rate increased again in December. The PMI in manufacturing fell from its December all-time high in January, but remains at its highest level in two decades. The positive economic sentiment, bolstered by a falling unemployment rate, is mirrored in rising ZEW and IFO leading indicators. The favourable economic trend was also reflected in an increase in the growth outlooks for the German economy for both monitored years (CF and the IMF). Annual consumer price inflation fell by 0.1 pp to 1.6% in January, with growth in energy prices slowing slightly and food prices rising at the same pace as in the previous month. The inflation forecasts were unchanged.

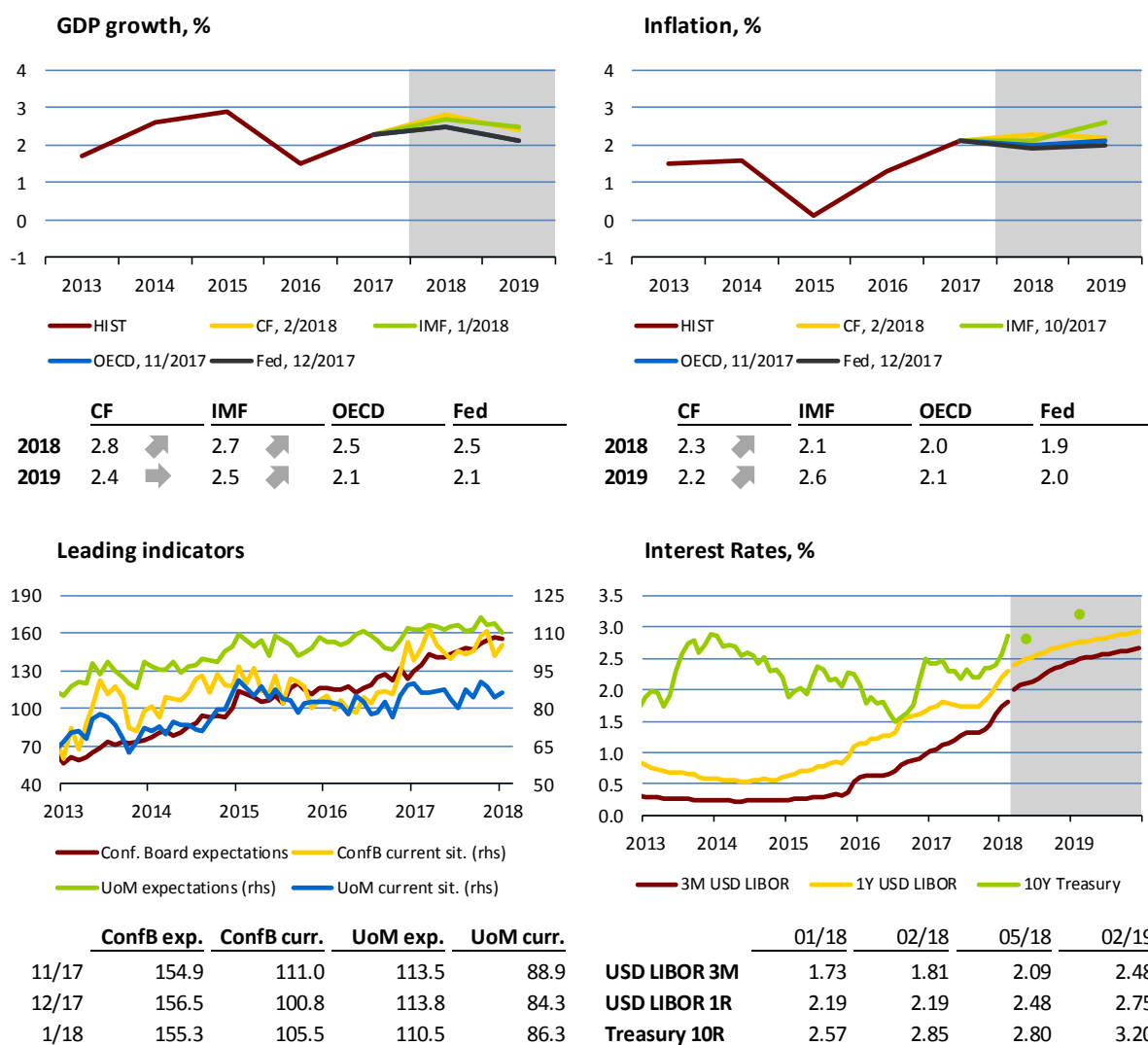


II.3 United States

US financial markets were turbulent at the start of February due to a drop in investors' risk appetite. Stock markets slumped and the VIX volatility indicator rose to its highest level since August 2015. It is not clear yet whether investors are reassessing expected developments in the US economy or whether this is just a temporary market swing. A number of indicators suggest growth in inflation pressures and hence also monetary policy tightening this year, while President Donald Trump's fiscal policy will be expansionary with a potential impact on US debt.

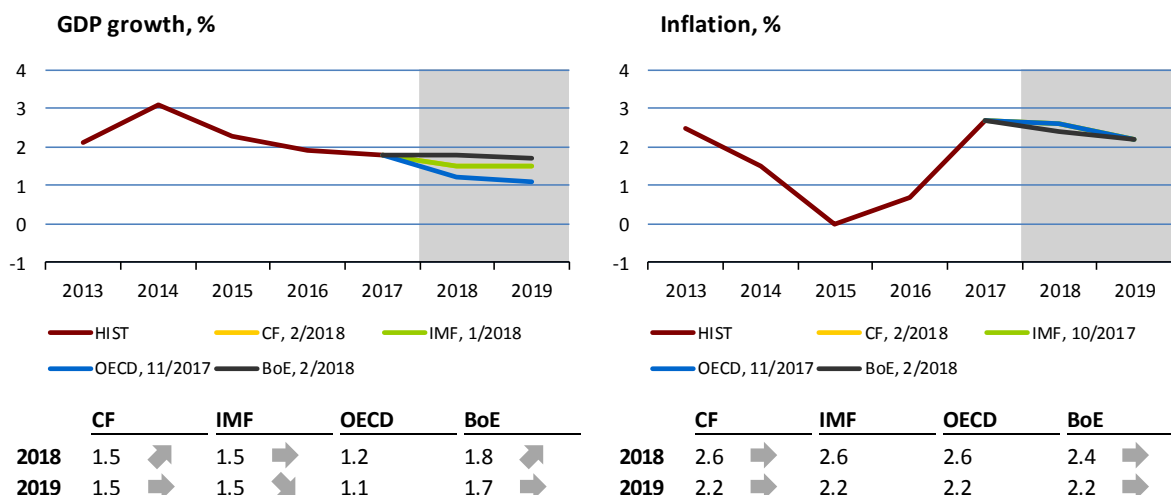
The sell-offs were triggered by the publication of the January 2018 US labour market data. Non-farm payrolls rose by 200,000, as against an expected increase of 180,000. The unemployment and participation rates remained unchanged at 4.1% and 62.7% respectively. The quits rate rose slightly, reflecting greater confidence in finding another job. Nominal wages in the USA increased at their highest year-on-year pace in eight and a half years (2.9%). Inflation also recorded substantial month-on-month growth (of 0.5%) in January, especially in the fuels, rents and health care expenditure items.

The US central bank left its monetary policy stance unchanged at the end of January. However, the Fed stated that economic activity was rising at a solid pace and inflation would go up this year. According to the first estimate, US economic growth remained robust at the end of 2017 (2.6% in quarter-on-quarter annualised terms). The strongest growth was recorded for personal consumption (3.8%) and corporate investment (6.8%). However, the pace of growth slowed slightly compared to Q3, mainly because of a significant rise in imports to the USA. The February CF revised its US inflation outlook upwards for both monitored years. CF respondents also increased their estimate for economic growth this year. The latest IMF outlook also suggests growing optimism about the US economy going forward.



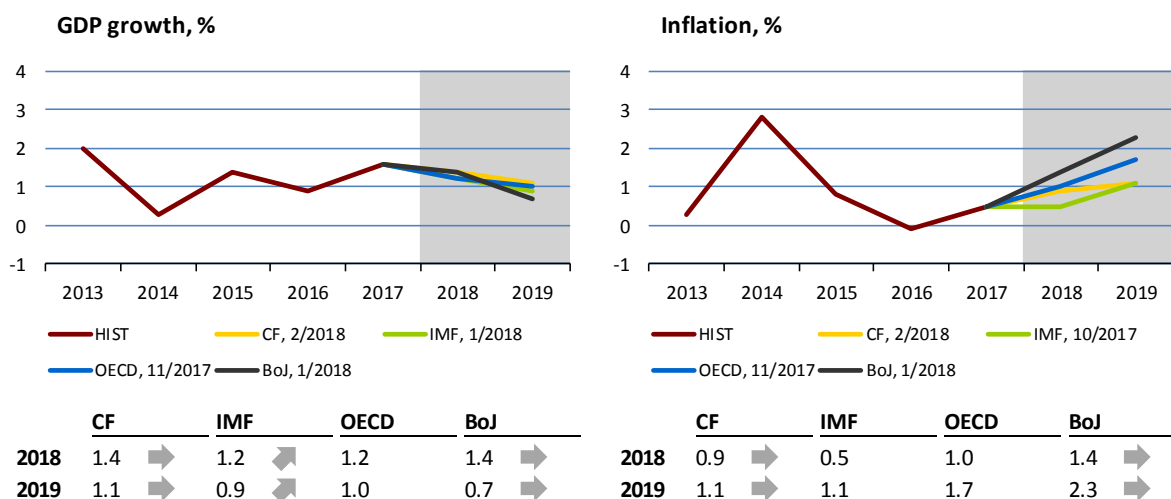
II.4 United Kingdom

The UK economy proved surprisingly resilient last year, recording growth of 1.8% in an environment of heightened uncertainty stemming from the ongoing Brexit talks. It slowed for the third consecutive year, but this time only slightly. CF and the IMF expect it to lose a little more momentum this year, but the BoE now expects growth to stay at last year's level. According to a preliminary estimate, economic growth reached 1.5% year on year and accelerated to 0.5% quarter on quarter in Q4. The main positive impulse is the global economic recovery. According to NIESR estimates, UK GDP growth is currently slightly above its potential (which fell sharply after the Brexit referendum). This is fostering inflationary pressures. Consumer prices went up by 3% in January. Real wages kept falling despite the lowest unemployment rate in 42 years. Nevertheless, the BoE expects this trend to reverse this year. The monetary policy stance remained unchanged. However, interest rates are expected to rise in May.



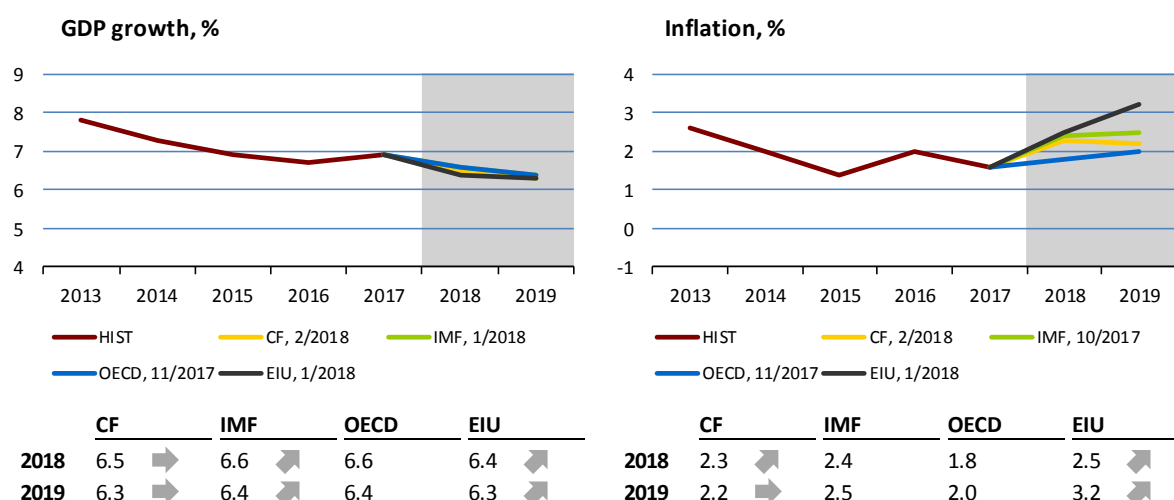
II.5 Japan

According to preliminary data, the Japanese economy grew by 0.5% in 2017 Q4 (in quarter-on-quarter annualised terms), slowing by 1.7 pp compared to the revised figure for the previous quarter. Annual retail sales growth increased in December despite a slight rise in the unemployment rate, slower wage growth and a drop in household spending. Industrial output growth accelerated in December and its pace thus remains favourable. The PMI in manufacturing went up to 54.8 points in January. According to purchasing managers, output, new orders and employment rose faster. The IMF raised its growth forecasts for both monitored years, while the other institutions left their predictions unchanged. Inflation outlooks were also unchanged. Annual inflation rose by 0.4 pp to 1% in December, mainly on the back of growth in prices of fresh food, fuels and energy. The BoJ left its monetary policy stance unchanged at its January meeting.



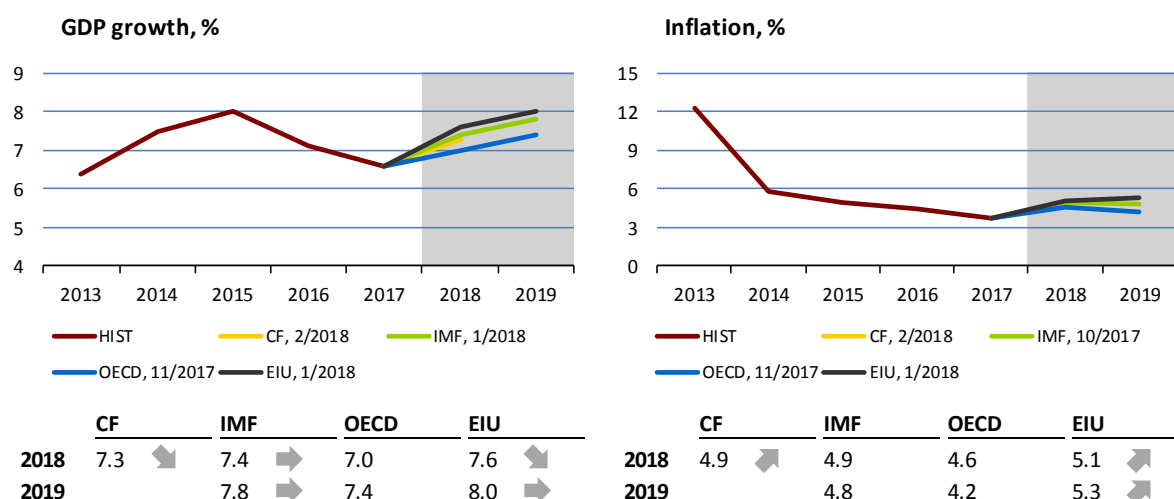
III.1 China

Economic growth in China accelerated last year for the first time in seven years, reaching 6.9% in 2017 as a whole. Annual GDP growth of 6.8% was recorded in Q4. Concerns about the effect of company shutdowns and supply shortages at the end of last year thus did not materialise. The expansion was due mainly to growth in exports, as external demand (especially for semi-conductors and other technological products) improved markedly throughout 2017. The growth was also driven by the services sector, while construction continued to fall. Inflationary pressures eased further in January in the case of both consumer prices (1.5%) and producer prices (4.3%). The central bank intends to keep monetary policy neutral this year amid sufficient liquidity. Meanwhile, it will continue to implement macroprudential measures relating to shadow banking and real estate and internet financing. CF slightly raised its inflation outlook for this year. The IMF increased its GDP growth estimates. The EIU revised both its inflation and GDP growth outlooks upwards.



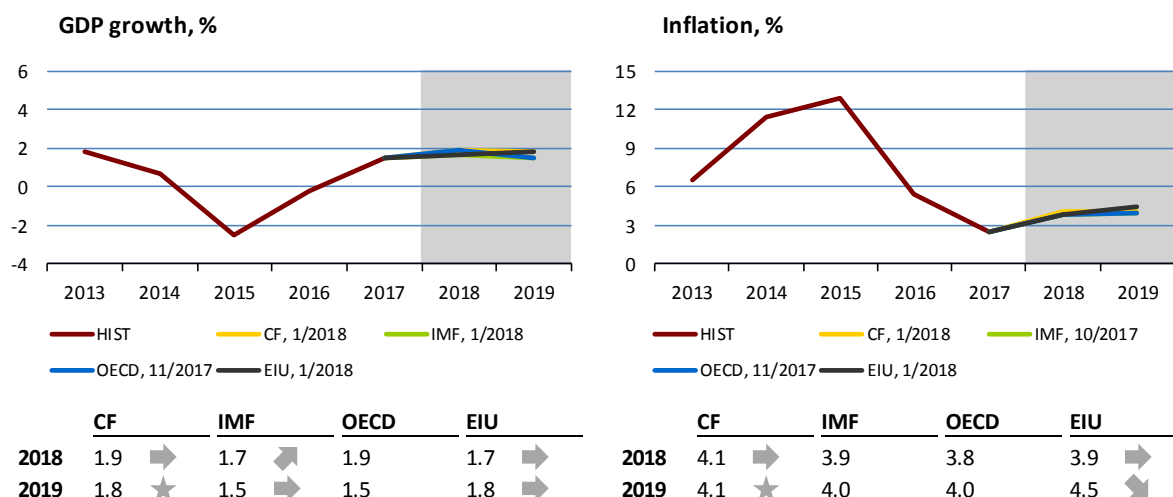
III.2 India

Annual growth in Indian industrial production slowed in December, but remains high. Manufacturing output continues to grow apace. Electricity production and mining also rose at a faster rate. The PMI in manufacturing fell to 52.4 points in January. According to purchasing managers, this was due to slower growth in output, employment and new orders. However, exports rose at their fastest pace since September 2016. CF and the EIU slightly lowered their GDP growth outlooks for fiscal year 2018/2019. Indian economic growth is expected to strengthen further in fiscal year 2019/2020. Consumer price inflation edged down to 5.1% in January. Prices of food continue to rise, albeit at a slower pace. Nevertheless, CF and the EIU raised their inflation outlooks. However, inflation should remain in the prescribed band. The RBI left its main policy rate unchanged at 6% at its February meeting.



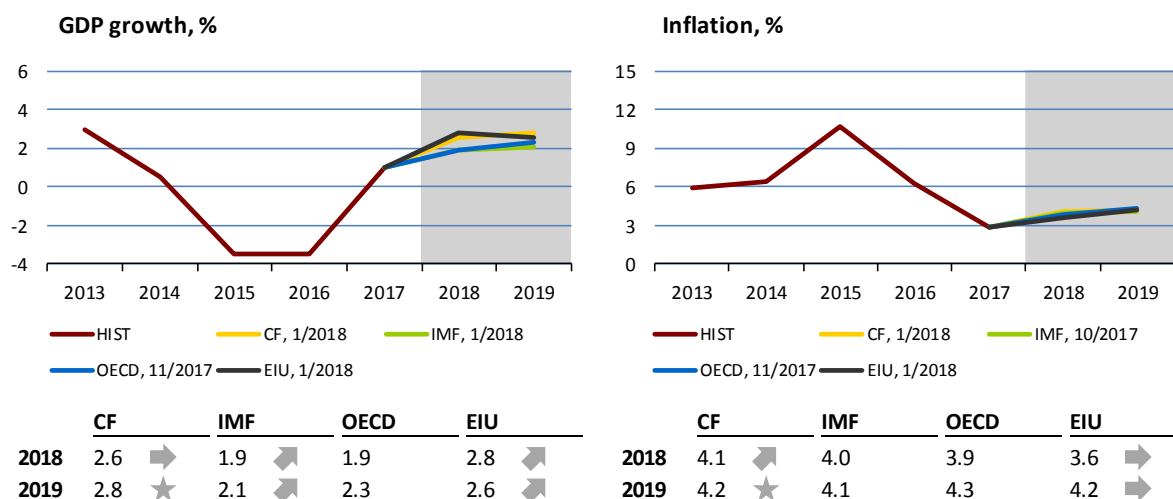
III.3 Russia

According to Rosstat's flash estimate, the overall rate of GDP growth reached 1.5% in 2017. The economic growth figure for last year will thus probably be lower than expected by any of the monitored outlooks (CF, the IMF and the EIU forecasted 1.8% and the OECD 1.9%). The GDP deflator was 5.5% in 2017. Short-term industrial indicators were surprisingly positive in January. Industrial production rose by 2.9% year on year and the PMI in manufacturing recorded 52.1 points. The Russian central bank cut its policy rate by a further 0.25 pp to 7.5% in early February. Inflation continued to slow, with consumer prices rising by just 2.2% in January. The new CF expects a slight upswing in economic activity and stronger price growth this year. Consumer prices are expected return from their current historical lows to the inflation target at the end of this year.



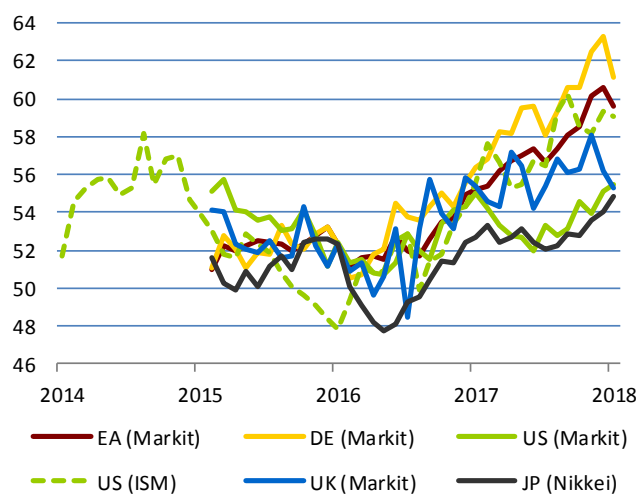
III.4 Brazil

Short-term indicators from the end of last year suggest quite a favourable trend in the Brazilian economy. Industrial production rose by 4.3% year on year in December and growth in manufacturing output went up to 5.7%. Unemployment simultaneously fell below 12%. The PMI in services rose sharply in January, reaching the threshold between expansion and contraction for the first time since September 2017. The composite PMI is just above this 50-point level. As inflation remains below the target and the Brazilian economy is showing signs of a recovery, the central bank sees accommodative monetary policy as desirable for the time being. It thus lowered its policy rate to 6.75% in early February in line with expectations. The latest monitored outlooks foresee a marked upswing in economic activity this year. GDP growth should accelerate from around 1% last year (estimate) to 1.9%–2.8% this year. Annual consumer price inflation is expected to be in the range of 3.6%–4.1% as of December 2018.

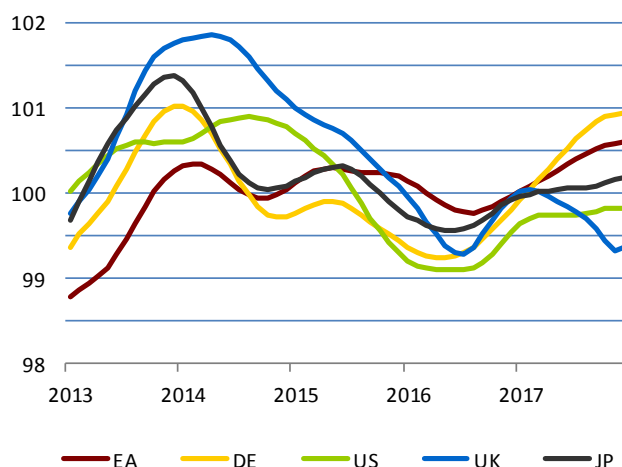


IV.1 Advanced economies

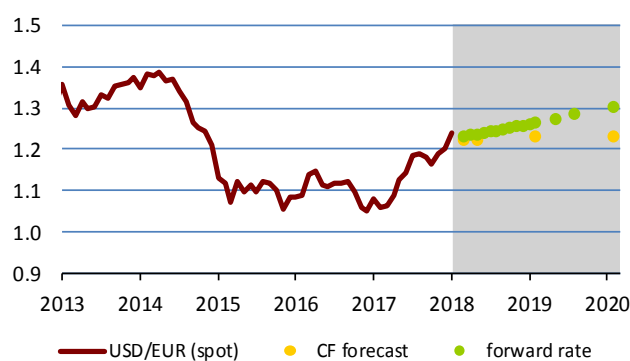
PMI in manufacturing



OECD Composite Leading Indicator

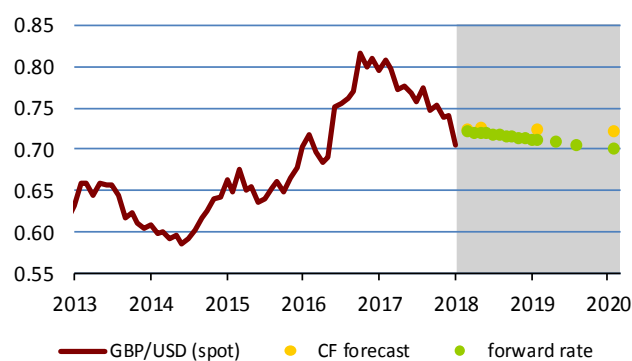


The US dollar (USD/EUR)



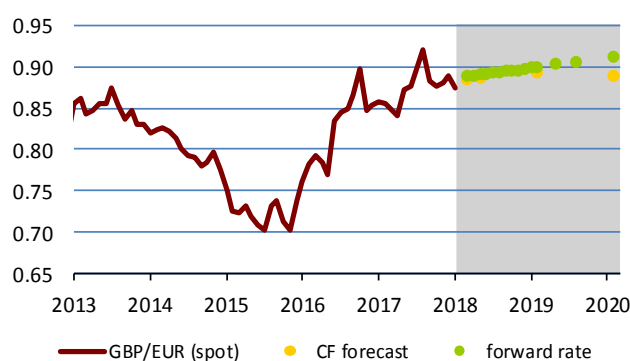
	12/2/18	03/18	05/18	02/19	02/20
spot rate	1.228				
CF forecast		1.222	1.224	1.232	1.233
forward rate		1.231	1.237	1.265	1.302

The British pound (GBP/USD)



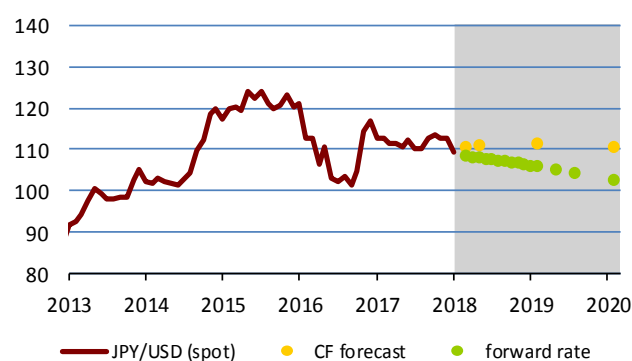
	12/2/18	03/18	05/18	02/19	02/20
spot rate	0.724				
CF forecast		0.724	0.725	0.724	0.721
forward rate		0.722	0.720	0.711	0.701

The British pound (GBP/EUR)



	12/2/18	03/18	05/18	02/19	02/20
spot rate	0.889				
CF forecast		0.884	0.888	0.892	0.889
forward rate		0.889	0.890	0.900	0.912

The Japanese yen (JPY/USD)

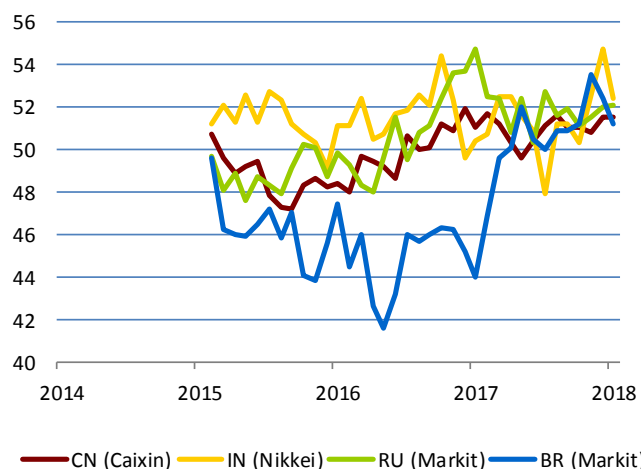


	12/2/18	03/18	05/18	02/19	02/20
spot rate	108.5				
CF forecast		110.5	111.0	111.4	110.6
forward rate		108.5	108.0	105.8	102.6

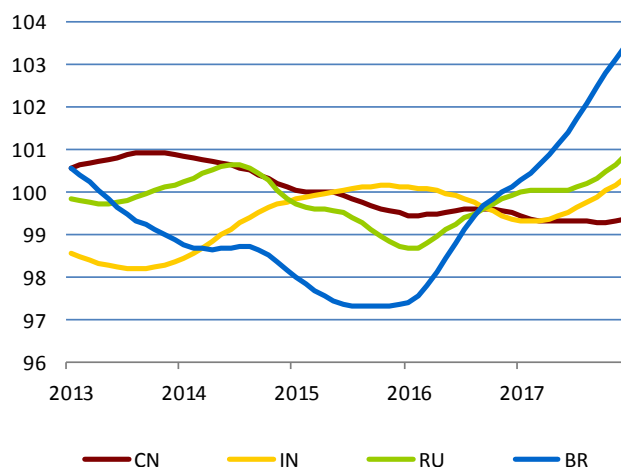
Note: Exchange rates as of last day of month. Forward rate does not represent outlook; it is based on covered interest parity, i.e. currency of country with higher interest rate is depreciating. Forward rate represents current (as of cut-off date) possibility of hedging future exchange rate.

IV.2 BRIC countries

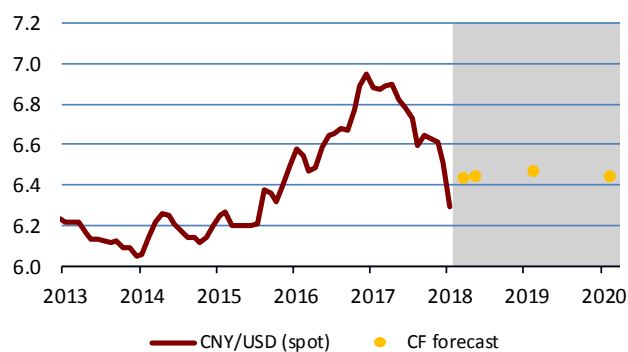
PMI in manufacturing



OECD Composite Leading Indicator

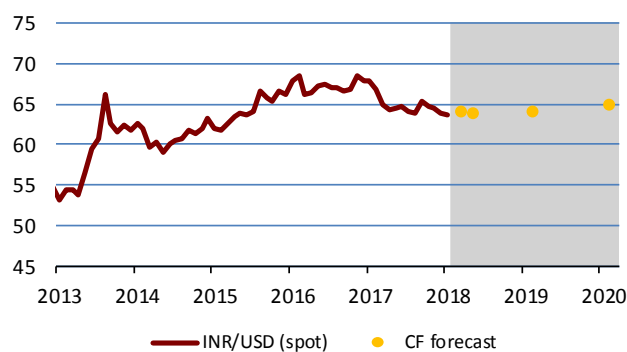


The Chinese renminbi (CNY/USD)



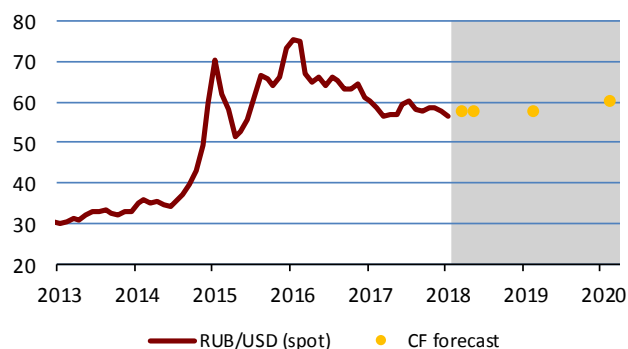
	12/2/18	03/18	05/18	02/19	02/20
spot rate	6.329				
CF forecast		6.435	6.446	6.465	6.441

The Indian rupie (INR/USD)



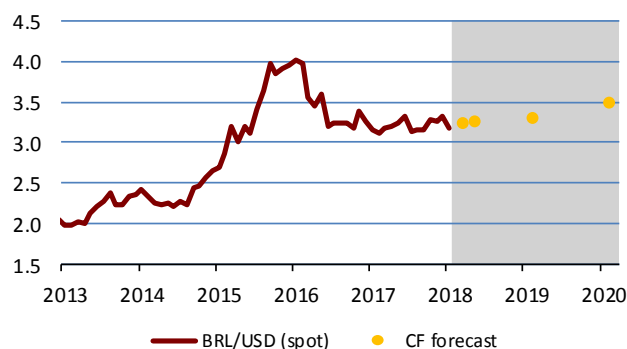
	12/2/18	03/18	05/18	02/19	02/20
spot rate	64.32				
CF forecast		64.04	63.94	64.03	64.98

The Russian rouble (RUB/USD)



	12/2/18	03/18	05/18	02/19	02/20
spot rate	58.02				
CF forecast		57.7	57.6	57.51	60.17

The Brazilian real (BRL/USD)

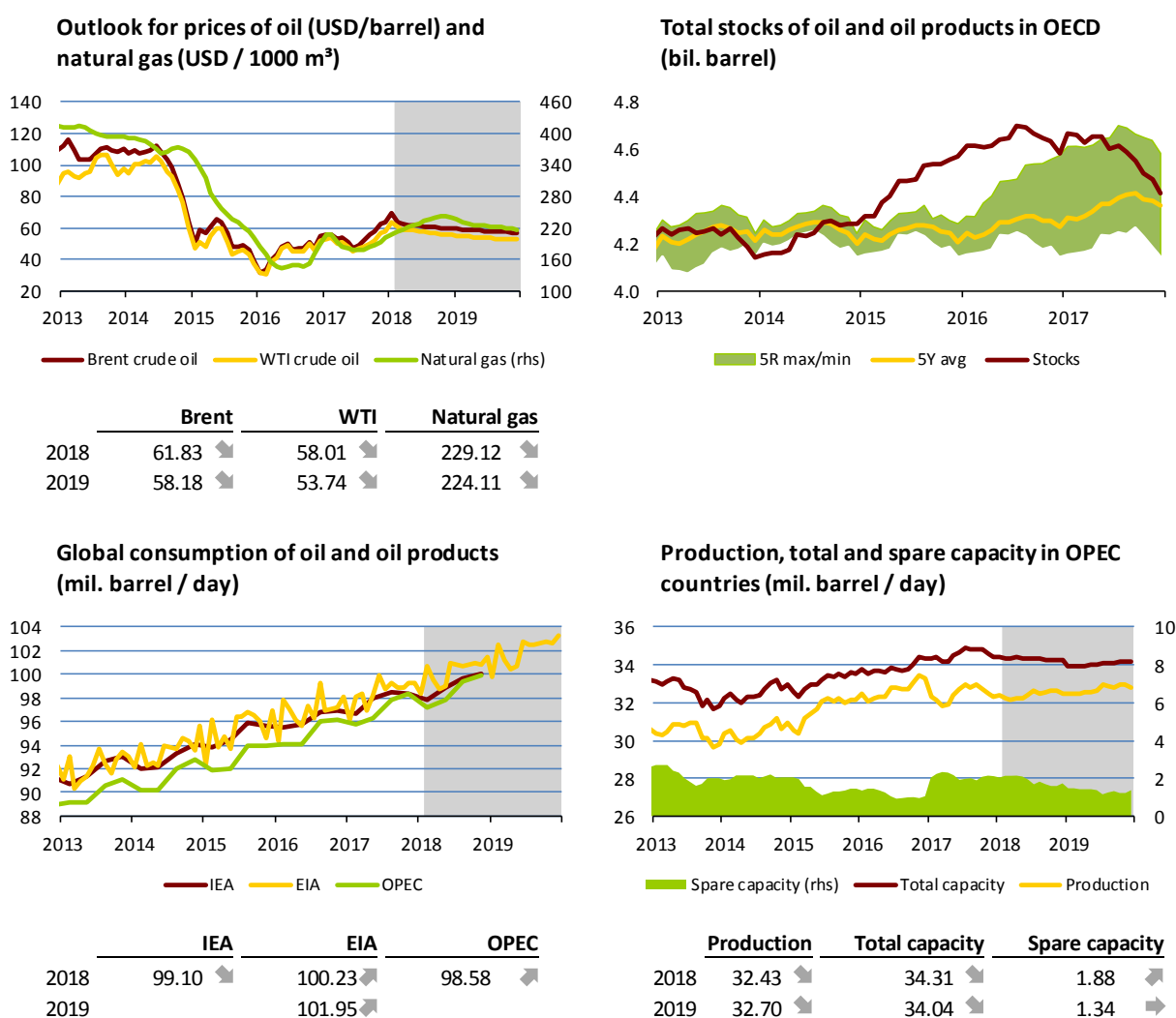


	12/2/18	03/18	05/18	02/19	02/20
spot rate	3.296				
CF forecast		3.239	3.264	3.304	3.488

Note: Exchange rates as of last day of month.

V.1 Oil and natural gas

Fundamental factors continue to keep oil prices relatively high. Observance of the deal struck by OPEC and other countries to limit output led to a sharp fall in global oil stocks, especially in 2017 Q4. Commercial stocks in the USA fell for ten weeks in a row (and most news reports overlooked a simultaneous decline in local strategic stocks). At the same time, sound global economic growth is continuing to foster high demand for oil. Increased geopolitical tensions, sharply falling production in Venezuela and the recent closures of key pipelines are also playing a role. However, oil prices were probably affected most of all by the exchange rate of the dollar, especially at the start of this year. The Brent crude oil price broke through the level of USD 70/bbl in early January and then fluctuated with no visible trend for the rest of the month, while the WTI price continued to rise. Speculative funds raised their net long positions in oil futures to record highs and the ratio of long to short positions grew to levels which in the past have usually come before sharp price corrections. A correction occurred in early February, when oil prices returned to their mid-December levels (following the stock market slump) in response to appreciation of the dollar. However, growth in US oil stocks and in particular a strong increase in output and drilling activity in the USA also played their parts. The EIA revised expected output growth in the USA strongly upwards for both this year and the next. After last year's drop, it expects global oil stocks to return to moderate growth (of 0.2 million barrels a day) this year and the next. According to the market curve, the average Brent crude oil price will be USD 61.8/bbl this year and USD 58.2/bbl next year (the EIA expects USD 64/bbl for this year).



Source: Bloomberg, IEA, EIA, OPEC, CNB calculation

Note: Oil price at ICE, price of Russian natural gas at German border – IMF data, smoothed by the HP filter. Future oil prices (grey area) are derived from futures and future gas prices are derived from oil prices using model. Total oil stocks (commercial and strategic) in OECD countries – IEA estimate. Production and extraction capacity of OPEC – EIA estimate.

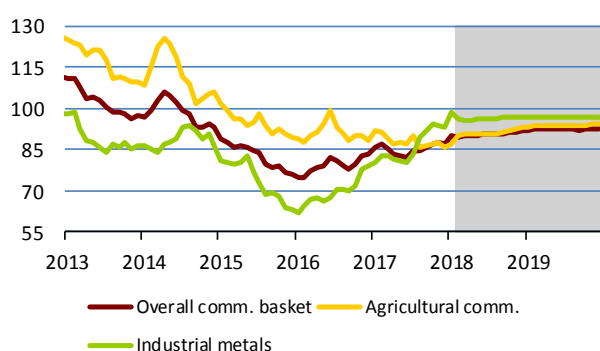
V.2 Other commodities

After a modest fall in December, the aggregate non-energy commodity price index rose in January and stagnated at a three-year high in the first half of February. The January rise in the aggregate index was due mainly to a strong increase in the industrial metals price sub-index. The latter, however, saw a slightly correction of its previous growth in February and its outlook is only moderately rising. By contrast, growth in the food commodity price sub-index accelerated in February and its forecast is also rising.

Prices of most basic metals continued to go up in January (or remained high after having risen in December – copper and aluminium) on the back of a weakening dollar and a continued favourable outlook for manufacturing. The January JPMorgan manufacturing PMI declined only slightly from its seven-year high of 54.5 and the Chinese PMI stayed at 51.5. However, the February stock market fall and appreciation of the dollar were reflected in a slight drop in metal prices. Nevertheless, it was smaller than that recorded for energy commodities. The price of iron ore grew by 5.7% month on month in January as Chinese steelworks stocked up in advance of the lifting of winter steel production limits. Coal prices fell sharply at the end of January. Cotton and rubber prices also reversed their previous growth in the second half of January.

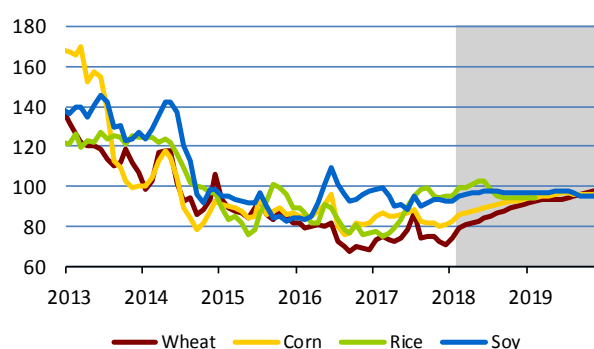
Grain prices recorded only modest growth in January. Compared to the previous month, the USDA slightly lowered its outlooks for final stocks of most commodities after the 2017/2018 harvest. However, stocks remain well above the previous year's levels. Meat prices also increased due to expected lower production. By contrast, the price of sugar went down.

Non-energy commodities price indices



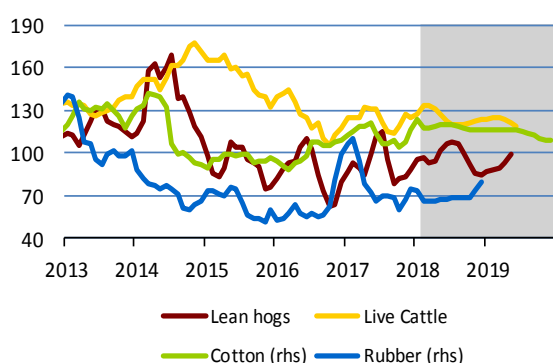
	Overall	Agricultural	Industrial
2018	90.6 ↗	90.9 ↗	96.5 ↘
2019	92.4 ↗	93.9 ↗	97.0 ↘

Food commodities



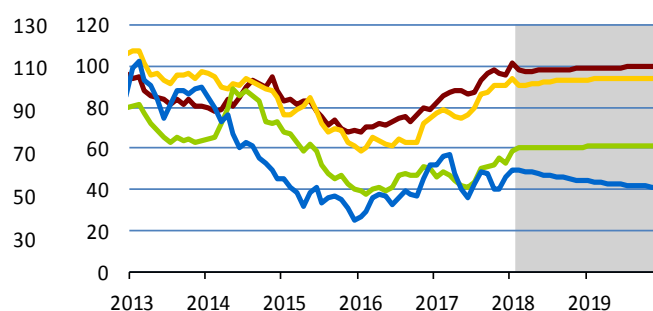
	Wheat	Corn	Rice	Soy
2018	84.4 ↗	89.3 ↗	97.6 ↗	96.5 ↗
2019	94.8 ↗	95.8 ↗	94.3 ↗	96.6 ↗

Meat, non-food agricultural commodities



	Lean hogs	Live Cattle	Cotton	Rubber
2018	97.0 ↘	125.4 ↗	82.4 ↗	49.7 ↘
2019	91.4 ↘	123.0 ↗	79.4 ↗	

Basic metals and iron ore



	Aluminium	Copper	Nickel	Iron ore
2018	98.4 ↘	92.4 ↘	60.2 ↗	47.0 ↘
2019	99.3 ↘	93.5 ↘	61.1 ↗	42.5 ↘

Source: Bloomberg, CNB calculations.

Note: Structure of non-energy commodity price indices corresponds to composition of The Economist commodity indices. Prices of individual commodities are expressed as indices 2010 = 100.

The evolution of shadow rates in the light of the Taylor rule¹

Monetary policy rules make it possible to create simple policy rate prescriptions and are also accepted as practical tools for analysing the central bank's stance. They contain simple links between a small number of economic variables in relation to the policy rate level. The best known is the Taylor rule (1993), under which the policy rate follows the deviation of inflation from the target and the output gap. However, the applicability of monetary policy rules is limited when the (zero) lower bound is reached and when asset purchase or liquidity supply programmes are launched to further ease monetary conditions. One possible solution is to use shadow rates, as they can be negative and reflect the degree to which monetary policy has been eased using unconventional tools. Our estimates suggest that the sensitivity of shadow rates to macroeconomic variables (as defined by the Taylor rule) is comparable to the sensitivity of interest rates in the pre-crisis period. The derived model rate in the post-crisis period was affected primarily by the output gap and the deviation of inflation from the target. However, a difference is apparent between the model rate and actual shadow rates at the time when unconventional measures were being implemented, so there was a need for even faster monetary policy easing than indicated by shadow rates. The difference can be explained if we include the credit-to-GDP gap in the model. This implies that monetary policy is sensitive to risks to financial stability.

Monetary policy rules in the USA²

Monetary policy rules contain simple links between a small number of economic variables (such as the output gap and inflation) in relation to the policy rate level. They provide a simple guide for conducting monetary policy analyses and preparing policy rate prescriptions, although they must be interpreted with caution and in a broader context. They also have undeniable advantages, as they satisfy, among other things, the requirement that monetary policy should respond in a predictable way to changes in economic conditions. The construction of the rules also reflects the fact that monetary policy should be easy when inflation (or even employment) is below the required level and tight when the opposite holds.

Many definitions of monetary policy rules can be found in the literature, starting with the most famous – the Taylor rule.³ Our overview of the rules used at the Fed (see Table 1)⁴ contains the unemployment rate (or the deviation from the long-run unemployment rate) as the main variable, since the US central bank's mandate covers the labour market. However, the rules are usually written in relation to the output gap, which is tightly linked to unemployment. To calculate the first three rules, we need an estimate of the neutral interest rate r^{LR} , i.e. the rate consistent with sustaining maximum employment and stable inflation in the long run. The next two rules show how the monetary policy stance should change depending on the current situation. However, they introduce more volatility into the decision-making. The construction of the Adjusted Taylor rule was motivated by the fact that rates cannot be negative, so easing is insufficient at times when the original Taylor rule prescribes negative rates.

The simple construction of the rules makes monetary policy easier to interpret, but their practical use poses several problems.

The first is that the rules focus only on a limited set of variables, the movement of which is used to derive conclusions about economic developments. The unemployment rate is just one of the labour market indicators; employment growth and the participation rate, for example, are also closely monitored. At the same time, economies have very complex structures,

Table 1 – Monetary policy rules used at the Fed

Taylor (1993) rule	$R_t^{T93} = r_t^{LR} + \pi_t + 0.5(\pi_t - \pi^{LR}) + (u_t^{LR} - u_t)$
Balanced-approach rule	$R_t^{BA} = r_t^{LR} + \pi_t + 0.5(\pi_t - \pi^{LR}) + 2(u_t^{LR} - u_t)$
Adjusted Taylor rule	$R_t^{T93\ adj} = \text{maximum}\{R_t^{T93} - Z_t\}$
Change rule	$R_t^{FD} = R_{t-1} + 1.2(\pi_t - \pi^{LR}) + 2(u_t^{LR} - u_t)$
First-difference rule	$R_t^{FD} = R_{t-1} + 0.5(\pi_t - \pi^{LR}) + (u_t^{LR} - u_t) - (u_{t-4}^{LR} - u_{t-4})$

Source: Fed (2017):

Note: R_t is the federal funds rate (FFR), r_t^{LR} is the neutral rate, π_t is inflation, u_t is the unemployment rate at time t and Z is the cumulative sum of past deviations from the Taylor rule. The upper index LR denotes a long-run value.

¹ Author: Soňa Benecká. The views expressed in this article are those of the author and do not necessarily reflect the official position of the Czech National Bank.

² The Taylor rule is also used as a tool for modelling the loss and reaction functions of central banks. This, however, is not the objective of this article.

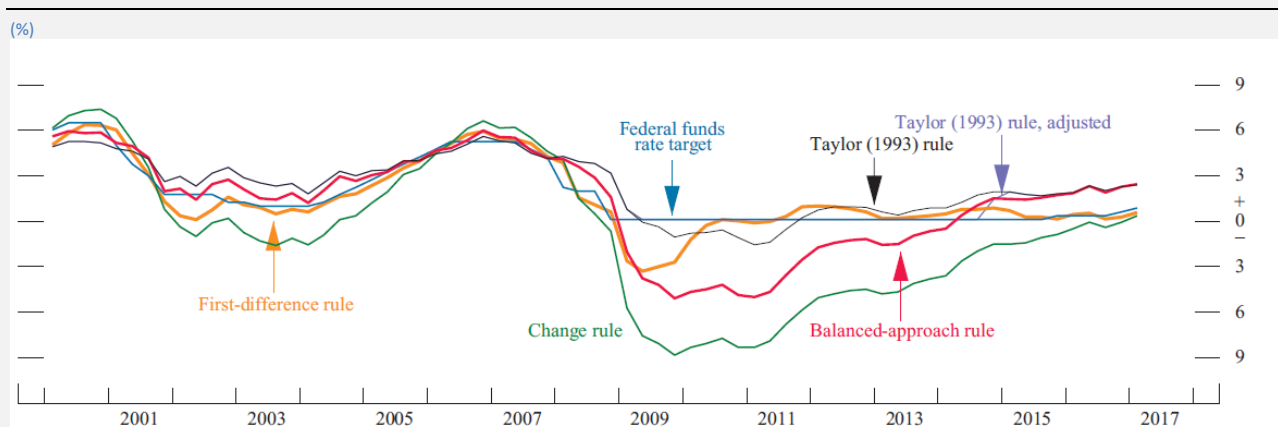
³ When President Donald Trump was considering the nominations for FOMC Chairman in autumn 2017, one of the candidates was the author of the first rule – John Taylor, a professor of economics at Stanford University. His possible nomination sparked a huge media debate, as Taylor has always argued for transparent, rule-based monetary policy.

⁴ References to each of the rules can be found in John B. Taylor and John C. Williams (2011), "Simple and Robust Rules for Monetary Policy," in Benjamin M. Friedman and Michael Woodford, ed., *Handbook of Monetary Economics*, vol. 3B (Amsterdam: North-Holland), pp. 829–859.

which the rules, by construction, cannot capture. Likewise, they do not capture other risks in the economy, such as those linked with financial instability. The rules also differ in their sensitivity to the individual components; hence they provide different views on the trade-off between inflation and unemployment. Moreover, some indicators, such as inflation, have many possible measures, which may not always move in the same way. Besides consumer prices (CPI), an index derived from personal consumption expenditures (PCE) is widely used in the USA. The PCE takes into account housing and healthcare costs differently. The long-run neutral interest rate and the long-run unemployment rate are also difficult to estimate.

That said, monetary policy rules have had their place in the Fed's toolkit since 1995 and are still drawn up for the FOMC. The federal funds rate (FFR) derived from the rules, including an outlook for several years ahead, can be found in the regular report prepared by the Fed's analysts for FOMC meetings (known as the Tealbook). The rates include both the current data and estimates of long-run indicators that were available to the analysts at the time. This is not easy to reproduce in retrospect. As Chart 1 shows, the prescribed FFR rates usually agree in terms of direction (up/down), but differ in level depending on the rule applied. The rules indicated negative rate levels in the post-crisis period, but to different extents. The prescriptions also differ as regards monetary policy normalisation. Except under the change rule, the prescribed rates return to positive levels earlier than actually implemented by the FOMC (December 2016).

Chart 1 – Historical federal funds rate prescriptions using monetary policy rules



Source: Fed (2017)

Monetary policy rules are also considered an important tool for understanding monetary policy. The Taylor Rule Utility, published by the Atlanta Fed on its website, is one example of this.⁵ Using this utility, users can arbitrarily change the Taylor rule definition and simulate rate prescriptions. In terms of construction, it is the closest to the change rule. The general notation of the variables is as follows:

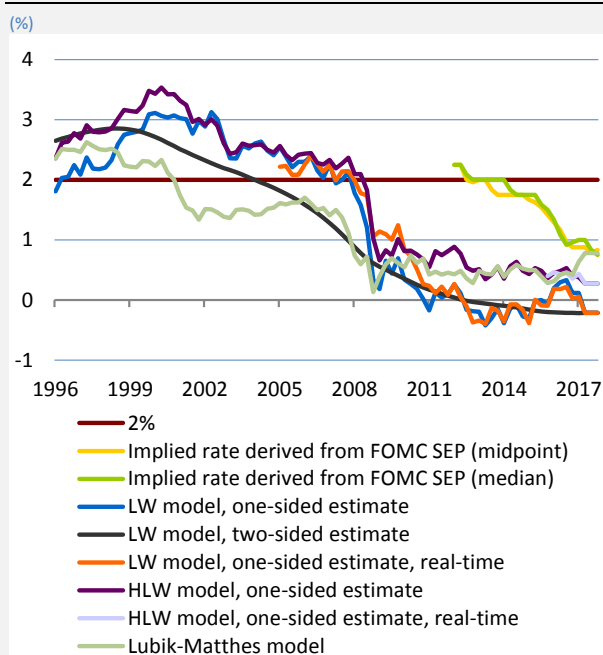
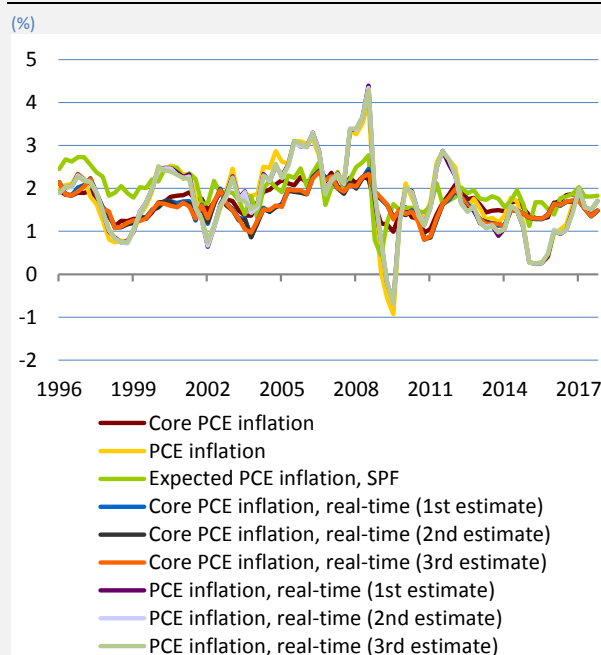
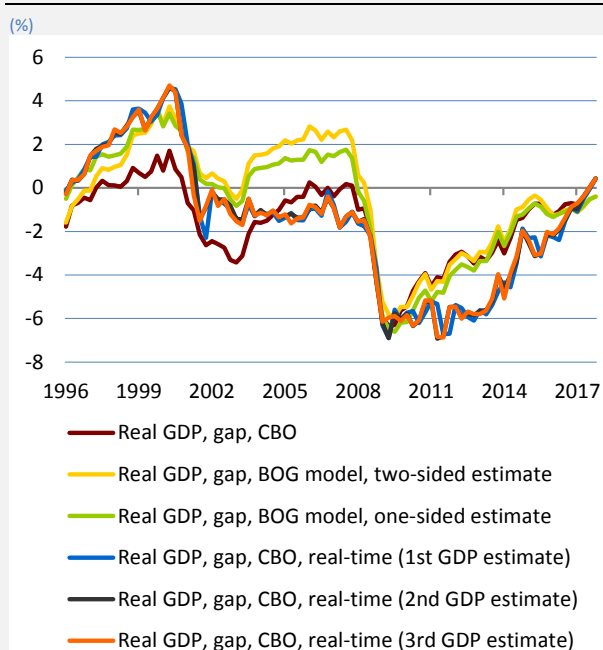
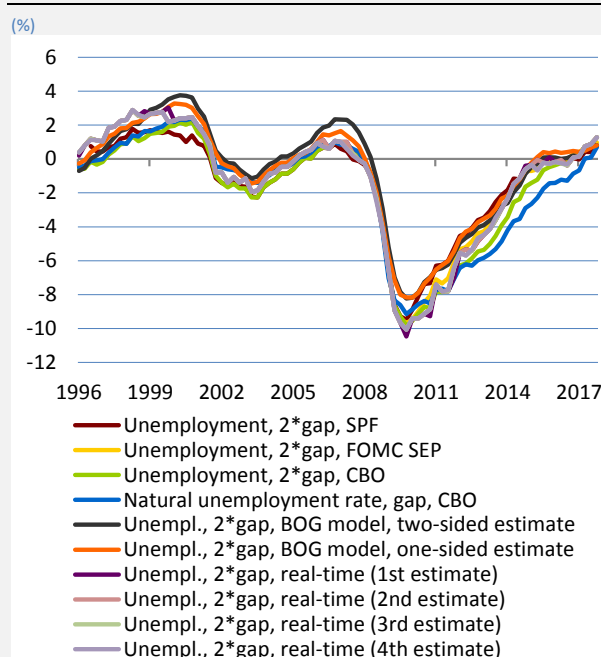
$$FFR_t = \rho FFR_{t-1} + (1 - \rho)[(r_t^* + \pi_t^*) + 1.5 * (\pi_t - \pi_t^*) + \beta gap_t] \quad (1)$$

where FFR is the federal funds rate, r_t^* is the natural real interest rate (2%, derived from the Laubach-Williams, Holston-Laubach-Williams, Lubik-Matthes or FOMC models – nine measures in all), π_t^* is the inflation target (2%, the longer-run FOMC projection for PCE inflation), π is inflation (headline, core, expected – nine measures in total), gap is the resource gap (GDP, unemployment rate – 18 measures in all), ρ is the interest-rate smoothing parameter (0–0.99, usually 0–0.85) and β is the weight on the resource gap (0–5, usually 0.5–1.0).

Federal funds rate prescriptions differ depending on the measures chosen for the variables. Charts 2–5 show that there is great uncertainty regarding the estimates of the output gap, the natural real interest rate and inflation. The opposite is true of unemployment, where the differences between the measures are relatively small. The prescribed rates from the Taylor Rule Utility (like those in Chart 1) indicate that there was a need to ease monetary policy fundamentally after the zero lower bound (ZLB) was reached at the start of 2009.

In response to the financial crisis, the Fed did indeed implement unconventional tools after the room for standard monetary policy had been exhausted. In the first phase, the Fed intervened to supply the necessary liquidity to the financial sector. In the following phases, it focused on cutting long-term interest rates as another monetary policy instrument to revive the stock and mortgage markets and boost corporate investment. However, it is not easy to identify the degree to which monetary conditions were eased via these unconventional tools. One possible approach is to use shadow rates.

⁵ <https://www.frbatlanta.org/cqer/research/taylor-rule.aspx?panel=1>

Chart 2 – Natural real interest rate – r^* Chart 3 – Inflation – π Chart 4 – Gap (1st part, real GDP) – gap Chart 5 – Gap (2nd part, unemployment) – gap 

Shadow rates from the perspective of the Taylor rule⁶

The term **shadow rates** refers to the hypothetical path that monetary policy rates would follow if they were not subject to the ZLB and the same easing of monetary conditions would be achieved using

⁶ We discussed shadow rates in the USA in various contexts in the October 2015 and March 2017 issues of *Global Economic Outlook* and the February 2017 issue of *Central Bank Monitoring*.

these rates as using the unconventional tools actually applied. One example is Krippner (2014), who derives shadow rates from the yield curve (shadow short rates, SSRs). Unlike the federal funds rate, shadow rates have been significantly negative in the post-crisis period (see Chart 6). If, therefore, we proxy the monetary policy stance using shadow rates, the Taylor rule can be applied to break down the effects in different periods. At the same time, it would be possible to test to what extent the Taylor rule can be applied when unconventional measures are being implemented.

In the first step, we need to estimate the parameters of the Taylor rule using shadow rates and compare them with the prescribed levels. Significantly different sensitivity of shadow rates to macroeconomic variables would make the comparison more difficult. For simplicity and comparability, in the next part we will use an approach based on the Taylor Rule Utility modified into the following form:

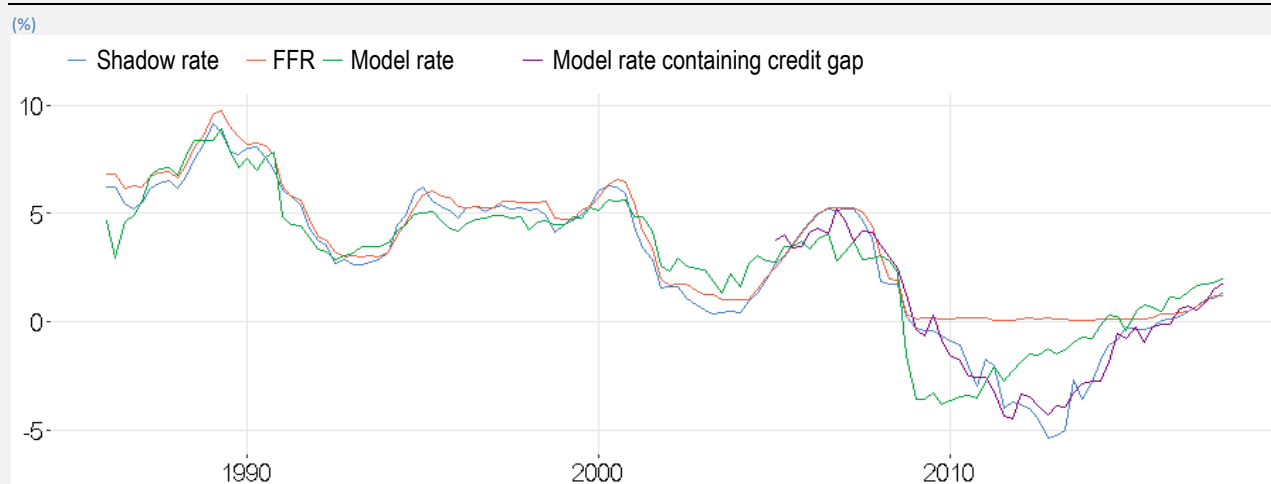
$$\frac{shadow_t - \rho shadow_{t-1}}{1-\rho} = (r_t^* + \pi_t^*) + 1.5 * (\pi_t - \pi_t^*) + \beta gap_t \quad (2)$$

where the smoothed series of shadow rates (*shadow*) with $\rho = 0.5^7$ depends on the natural real interest rate, the inflation target, the deviation of current inflation from the inflation target and the output gap. For simplicity, only the Fed's official target (2%) is given for the inflation target. The number of measures for the individual variables of the Taylor Rule Utility had to be limited due to the length of the time series (e.g. the implied rate from the FOMC SEP⁸), but there were still 765 potential linear models. The adjusted R^2 was chosen as the criterion for selecting the best. The resulting best model has the following form:

$$\frac{shadow_t - \rho shadow_{t-1}}{1-\rho} = 0.81 * (r_t^* + \pi_t^*) + 0.98 * 1.5 * (\pi_t - \pi_t^*) + 0.55 * gap_t \quad (3)$$

where all the coefficients are statistically significant.⁹ The best model uses the series from the Laubach-Williams model for r_t^* , expected PCE inflation (SPF) for inflation and 2*unemployment gap (CBO) for the resource gap. The estimated parameters do not deviate substantially from the prescribed levels, which were empirically estimated using data from the pre-crisis period. The level is slightly lower for the natural interest rate and higher for the output gap. The use of shadow rates as an alternative method for capturing the monetary policy stance seems to be justified. The resulting model rate is shown in Chart 6.

Chart 6 – The shadow rate, the federal funds rate (FFR) and the model rate



Source: Datastream, Krippner (2017), CNB calculations

Note: Shadow rates and the FFR are smoothed; the model rate is derived from the model in equation (3); the model rate containing the credit gap is supplemented by the credit-to-GDP gap

The shadow rate deviated substantially from the model rate at times when the US central bank was monitoring risks in the financial sector in addition to macroeconomic developments. The model rate deviated only moderately from the shadow rate in the pre-crisis period. By contrast, it indicated a need for a faster monetary policy easing when unconventional measures were being implemented. The deviation widened in the pre-crisis period when the Fed was responding to growth in banking sector risks. The prescriptions for the exit from unconventional measures and the tightening of monetary conditions also differ. The model rate turns positive in late 2014/early 2015.

⁷ A change in the smoothing parameter does not imply any significant change in the model's behaviour. For example, with substantially lower smoothing (0.2), the adjusted R^2 is 0.899 and the coefficients change by a maximum of 0.02. Conversely, greater smoothing (0.85) substantially reduces the fit of the model (0.65).

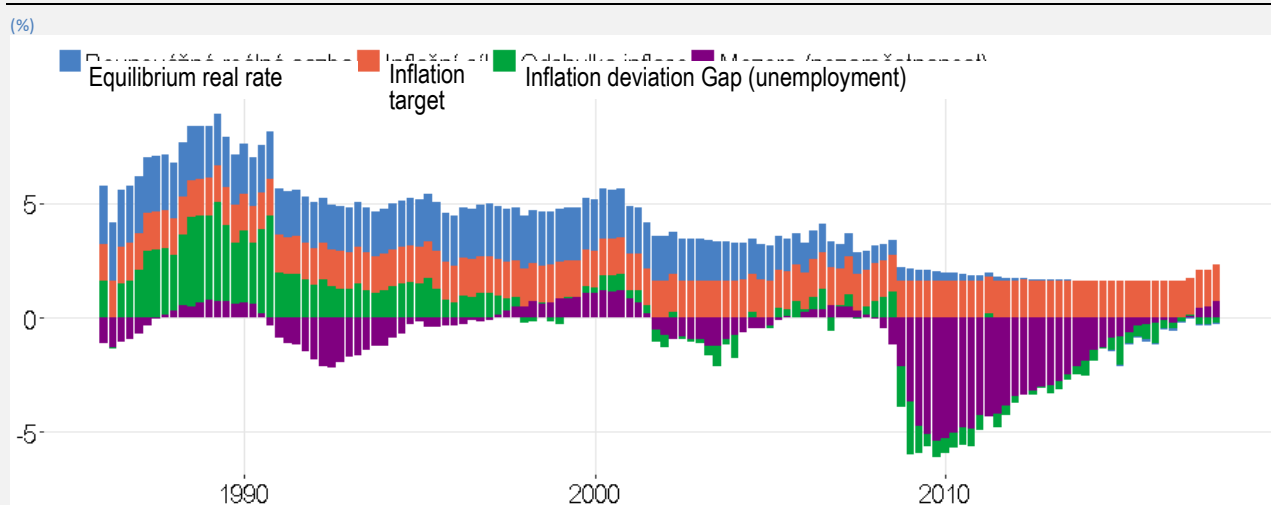
⁸ FOMC SEP stands for the Summary of Economic Projections drawn up for the Federal Open Market Committee.

⁹ The adjusted R^2 is 0.892. Given the simplicity of the model and the linearity requirement, no further tests were performed.

To illustrate the effect of financial stability-related risks, the model was extended to include the effect of the credit-to-GDP gap (see Chart 6).¹⁰ The best model was found on the shorter time series for the real natural interest rate (the LW model), but it models shadow rates very well. It seems that the central bank took financial variables into account when easing monetary policy in the post-crisis period.

The Taylor rule approach also makes it possible to break down the components' effects on the rate prescribed by the model (see Chart 7). As equation (3) shows, we can distinguish four components – the real natural rate, the inflation target, the deviation of inflation from the target and the resource gap. The effect of the inflation target is by definition positive and constant, whereas the effect of real rates disappeared in the post-crisis period. By contrast, the significance of the unemployment gap, which until then had been relatively small, increased at that time. The contribution of the deviation of inflation from the target was positive until 2000 but is distinctly negative after 2009. The effect of the unemployment gap has been positive in the last three quarters, contributing to a prescription of monetary policy tightening at the end of the period under review.

Chart 7 – Contributions of components to the rate prescribed by the model



Source: Krippner (2017), Datastream, CNB calculations

Conclusion

The measures implemented by the Federal Reserve after the zero lower bound was reached complicate simple rule-based analysis of the monetary policy stance. As this article showed, one possible solution is to use shadow rates, as their evolution reflects the effect of unconventional tools. Our estimates confirm the relevance of this approach. Moreover, they point to an effect of financial stability-related risks, especially after 2009. The decomposition of the Taylor rule makes it possible to evaluate the effects of various factors (the output gap and inflation) and the consistency of interest rate movements in the USA with macroeconomic developments. The analysis could also be applied to the FOMC's projections or analysts' outlooks.

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¹⁰ The estimate of the credit-to-GDP gap, defined as the gap between the credit-to-GDP ratio and its trend, is taken from the BIS database: https://www.bis.org/statistics/c_gaps.htm.

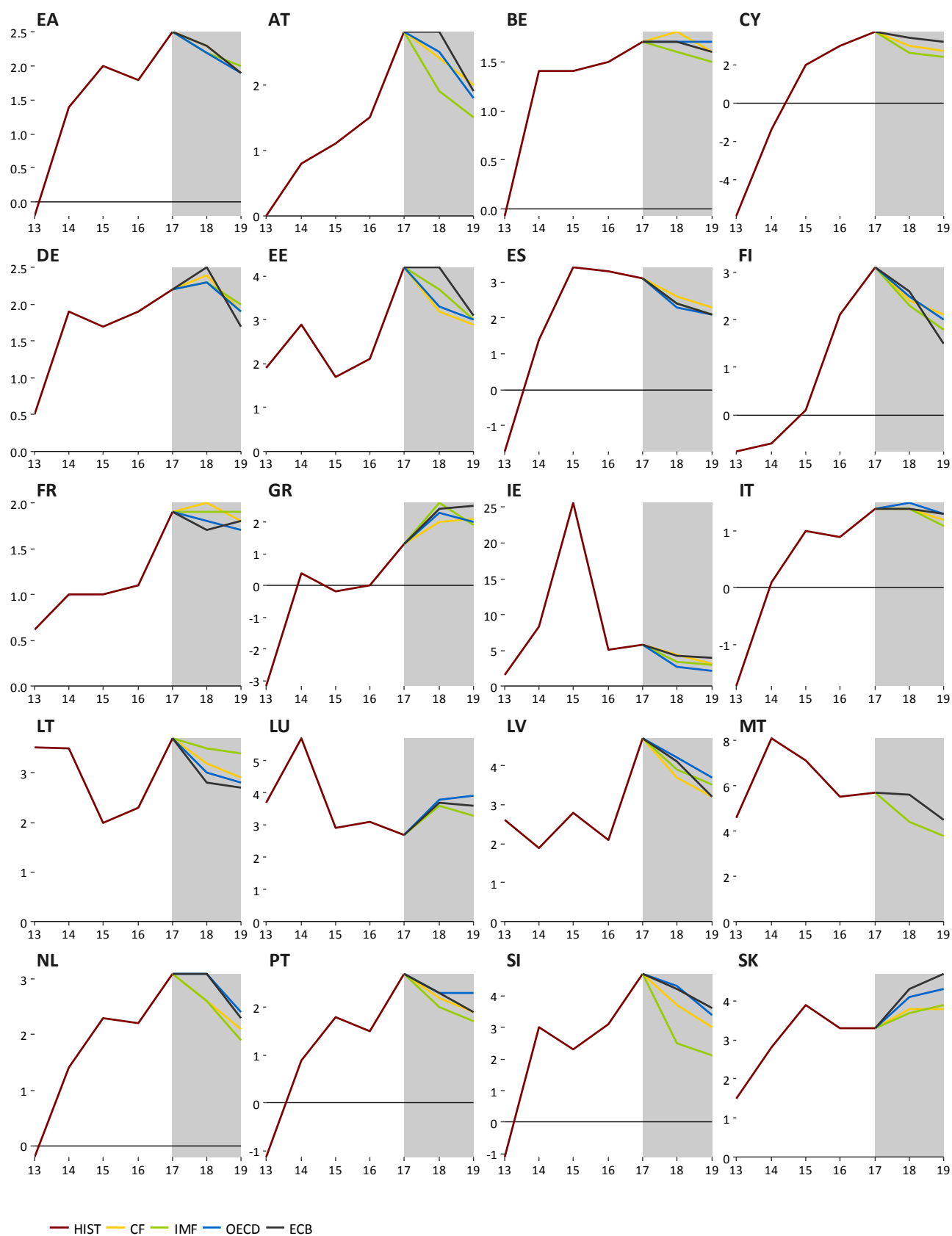
A1. Change in GDP predictions for 2018

	CF		IMF		OECD		CB / EIU	
EA	+0.1	2018/2	+0.3	2018/1	+0.3	2017/11	+0.5	2017/12
		2018/1		2017/10		2017/9		2017/9
DE	+0.1	2018/2	+0.5	2018/1	+0.2	2017/11	+0.8	2017/12
		2018/1		2017/10		2017/9		2017/6
US	+0.1	2018/2	+0.4	2018/1	+0.1	2017/11	+0.4	2017/12
		2018/1		2017/10		2017/9		2017/9
UK	+0.1	2018/2	0	2018/1	+0.2	2017/11	+0.2	2018/2
		2018/1		2017/10		2017/9		2017/11
JP	0	2018/2	+0.5	2018/1	0	2017/11	0	2018/1
		2018/1		2017/10		2017/9		2017/11
CN	0	2018/2	+0.1	2018/1	0	2017/11	+0.6	2018/1
		2018/1		2017/10		2017/9		2017/11
IN	-0.1	2018/2	0	2018/1	-0.2	2017/11	-0.1	2018/1
		2018/1		2017/10		2017/9		2017/12
RU	0	2018/1	+0.1	2018/1	-0.2	2017/11	0	2018/1
		2017/12		2017/10		2017/9		2017/11
BR	0	2018/1	+0.4	2018/1	+0.3	2017/11	+0.5	2018/1
		2017/12		2017/10		2017/9		2017/11

A2. Change in inflation predictions for 2018

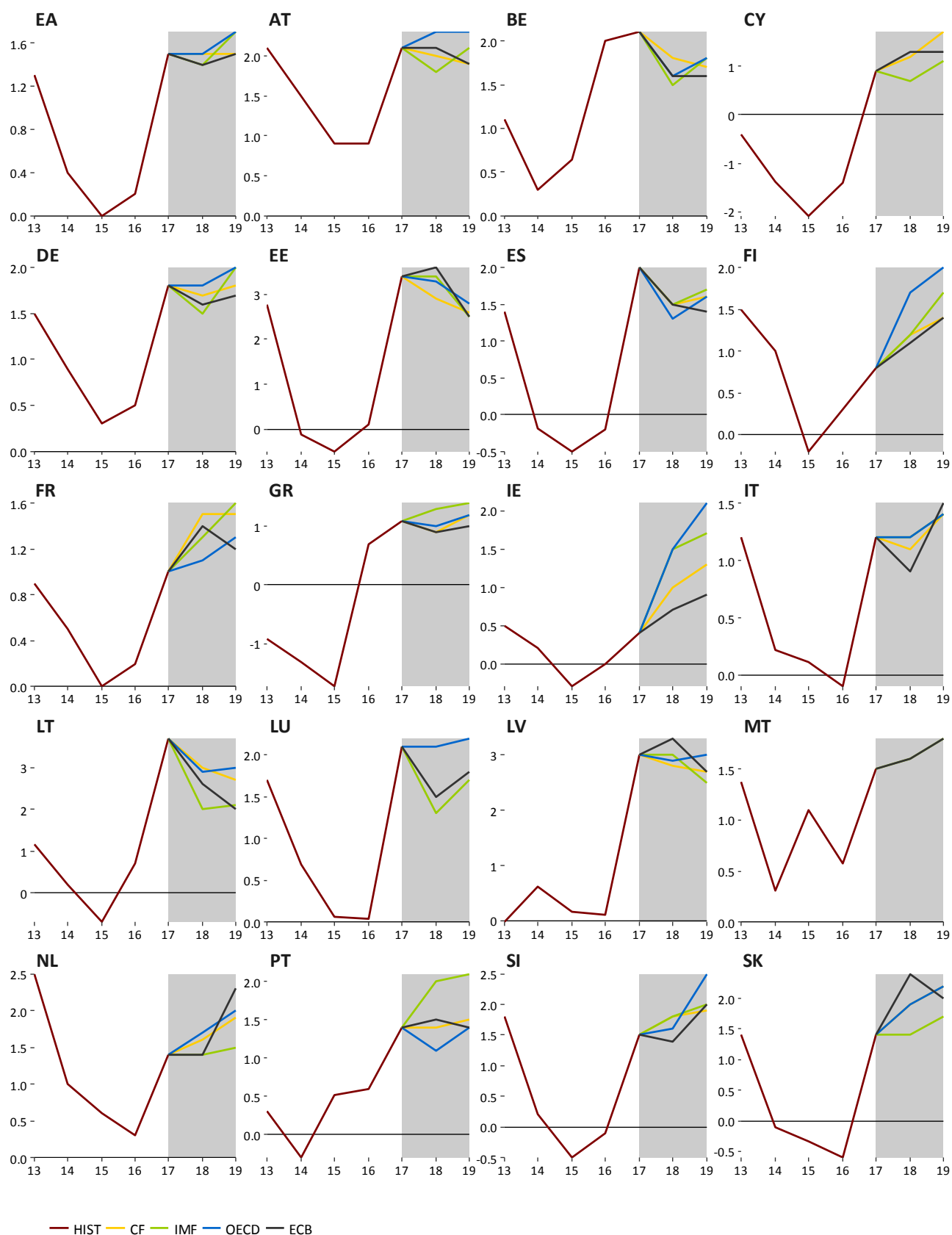
	CF		IMF		OECD		CB / EIU	
EA	+0.1	2018/2	-0.1	2017/10	+0.1	2017/11	+0.2	2017/12
		2018/1		2017/4		2017/6		2017/9
DE	0	2018/2	-0.2	2017/10	+0.2	2017/11	+0.2	2017/12
		2018/1		2017/4		2017/6		2017/6
US	+0.2	2018/2	-0.3	2017/10	-0.2	2017/11	0	2017/12
		2018/1		2017/4		2017/6		2017/9
UK	0	2018/2	0	2017/10	-0.1	2017/11	0	2018/2
		2018/1		2017/4		2017/6		2017/11
JP	0	2018/2	-0.1	2017/10	0	2017/11	0	2018/1
		2018/1		2017/4		2017/6		2017/11
CN	+0.1	2018/2	+0.1	2017/10	-0.2	2017/11	+0.5	2018/1
		2018/1		2017/4		2017/6		2017/11
IN	+0.2	2018/2	-0.2	2017/10	0	2017/11	+0.7	2018/1
		2018/1		2017/4		2017/6		2017/12
RU	0	2018/1	-0.3	2017/10	-0.2	2017/11	0	2018/1
		2017/12		2017/4		2017/6		2017/11
BR	+0.1	2018/1	-0.3	2017/10	-0.6	2017/11	0	2018/1
		2017/12		2017/4		2017/6		2017/11

A3. GDP growth in the euro area countries



Note: The chart shows institutions' latest available outlooks of for the given country (in %).

A4. Inflation in the euro area countries



Note: The chart shows institutions' latest available outlooks of for the given country (in %).

A5. List of abbreviations

AT	Austria	IE	Ireland
bbl	barrel	IEA	International Energy Agency
BE	Belgium	IFO	Leibniz Institute for Economic Research at the University of Munich
BoE	Bank of England (the UK central bank)	IMF	International Monetary Fund
BoJ	Bank of Japan (the central bank of Japan)	IN	India
bp	basis point (one hundredth of a percentage point)	INR	Indian rupee
BR	Brazil	IRS	Interest Rate swap
BRIC	countries of Brazil, Russia, India and China	ISM	Institute for Supply Management
BRL	Brazilian real	IT	Italy
CB	central bank	JP	Japan
CBR	Central Bank of Russia	JPY	Japanese yen
CF	Consensus Forecasts	LIBOR	London Interbank Offered Rate
CN	China	LME	London Metal Exchange
CNB	Czech National Bank	LT	Lithuania
CNY	Chinese renminbi	LU	Luxembourg
ConfB	Conference Board Consumer Confidence Index	LV	Latvia
CXN	Caixin	MKT	Markit
CY	Cyprus	MT	Malta
DBB	Deutsche Bundesbank (the central bank of Germany)	NIESR	National Institute of Economic and Social Research (UK)
DE	Germany	NKI	Nikkei
EA	euro area	NL	Netherlands
ECB	European Central Bank	OECD	Organisation for Economic Co-operation and Development
EE	Estonia	OECD-CLI	OECD Composite Leading Indicator
EIA	Energy Information Administration	PMI	Purchasing Managers' Index
EIU	Economist Intelligence Unit	pp	percentage point
ES	Spain	PT	Portugal
ESI	Economic Sentiment Indicator of the European Commission	QE	quantitative easing
EU	European Union	RBI	Reserve Bank of India (central bank)
EUR	euro	RU	Russia
EURIBOR	Euro Interbank Offered Rate	RUB	Russian rouble
Fed	Federal Reserve System (the US central bank)	SI	Slovenia
FI	Finland	SK	Slovakia
FOMC	Federal Open Market Committee	UK	United Kingdom
FR	France	UoM	University of Michigan Consumer Sentiment Index - present situation
FRA	forward rate agreement	US	United States
FY	fiscal year	USD	US dollar
GBP	pound sterling	USDA	United States Department of Agriculture
GDP	gross domestic product	WEO	World Economic Outlook
GR	Greece	WTI	West Texas Intermediate (crude oil used as a benchmark in oil pricing)
ICE	Intercontinental Exchange	ZEW	Centre for European Economic Research

