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Losing traction? The real effects of monetary policy when interest rates are low*

Rashad Ahmed, Claudio Borio, Piti Disyatat, Boris Hofmann†

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Abstract

Are there limits to how far reductions in interest rates can boost aggregate demand? In particular, as interest rates fall to very low levels, does the effectiveness of monetary policy in boosting the economy wane? We provide evidence consistent with this hypothesis. Based on a panel of 18 advanced countries starting in 1985, we find that monetary transmission to economic activity is substantially weaker when interest rates are low. The results hold even when controlling for potential confounding non-linearities associated with debt levels and the business cycle as well as for the trend decline in equilibrium interest rates. We also find evidence that the effectiveness of monetary policy wanes the longer interest rates stay low. These findings suggest that the observed flattening of the Phillips curve has gone hand in hand with a corresponding steepening of the IS curve. Monetary policy trade-offs may have become more challenging.

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Keywords: monetary policy, low interest rates, monetary transmission mechanism.

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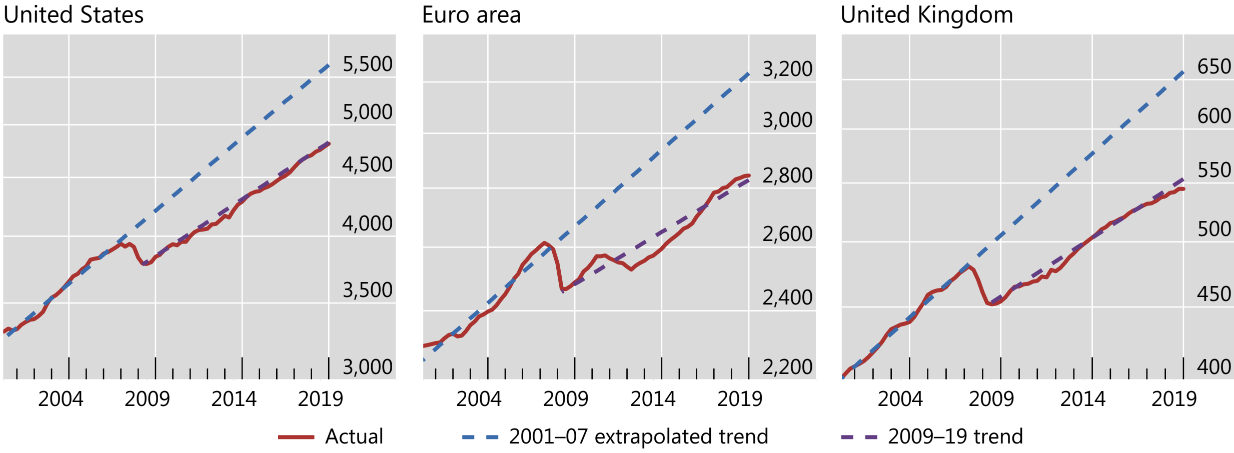
Introduction

Interest rates in many countries, particularly in the core advanced economies, have been persistently low for more than a decade now. In some jurisdictions, policy rates have even been in negative territory for several years. Yet, despite these very low rates and aggressive monetary policy easing, the strength of the economy has been, on balance, disappointing since the Great Financial Crisis (GFC). In major advanced economies, post-GFC real GDP has trailed well below its extrapolated pre-GFC trajectory, following a flatter trend (Graph 1). At the same time, inflation has tended to languish below target, at least until the post-Covid major fiscal policy expansion. Is it possible that the effectiveness of monetary policy in boosting the economy has waned?

Real GDP[1]

Quarterly data, in billions of respective currency units — Graph 1



[1] Seasonally adjusted, on a logarithmic scale.

Sources: National data; BIS calculations.

This question is not new and has prompted some possible answers. Much of the discussion of the potentially diminished traction of monetary policy has focused on the reduced policy space as a result of a fall in the equilibrium real rate of interest (eg Gust et al (2017), Hofmann et al (2021)). If equilibrium interest rates are now lower, low interest rates would provide a smaller degree of monetary accommodation. Another focal point of the debate has been a smaller impact of monetary policy on inflation due to a flattening of the Phillips curve (eg Stock and Watson (2019), Del Negro et al (2020)). If price dynamics are less responsive to economic slack, monetary policy may need to push harder to achieve inflation goals.

But it is also possible that aggregate demand itself has become less responsive to monetary policy. In other words, the IS curve may have steepened – a hypothesis laid out by Borio and Hofmann (2017). There are many potential explanations, not least headwinds linked to the need to work off the post-GFC debt overhang. A more troubling possibility, though, is that the low interest rate environment itself may be partly responsible.[1] In that case, the weakness would be a more endemic and harder

[1] See, for example, Schnabel (2020).

to overcome. The harder the central bank tries to generate monetary stimulus, the more difficult it becomes. More generally, if more aggressive easing is required to achieve inflation and output objectives, this can generate greater undesired side effects, including a further loss in policy room for manoeuvre over time.

This paper formally explores this possibility. We examine whether the responsiveness of aggregate demand to monetary policy shocks declines when interest rates are low and if it weakens over time as they stay there. In doing so, we control for confounding factors, notably the state of the business cycle, debt overhang and a possible trend decline in equilibrium interest rate levels.

There are several channels through which persistently low interest rates could diminish the traction of monetary policy on economic activity.

First, low nominal interest rates can harm bank profitability. Lower rates can sap net interest income when banks are reluctant or unable to lower deposit rates below zero, so that mark-ups shrink as interest rates fall. Moreover, the impact of low short-term rates grows if they go hand in hand with a flattening of the yield curve, eroding the returns from maturity transformation.[2] To the extent that lower bank profitability inhibits loan supply, the negative effect of lower rates on banks' net interest margins can even give rise to a "reversal interest rate", whereby accommodative monetary policy becomes contractionary (Brunnermeier and Koby (2018)).

Second, the effects of interest rates on consumption and investment could be non-linear for a variety of reasons. For consumption, the positive intertemporal substitution effects may be offset by the negative income effects of low rates, which encourage saving (Guerrón-Quintana and Kuester (2019), van den End et al (2020)). This mechanism may be especially prominent when rates are low. At the same time, persistently low rates could give rise to "satiation" effects. For example, once lumpy durables such as housing have been acquired, further rate reductions will spur less additional demand. "Satiation" may also result from certain lending contracts. For example, in the case of the United States, Berger et al (2018) note that the stock of mortgages that can be refinanced falls after successive rounds of rate cuts, so that additional cuts become less effective if previous rates have been low. A similar mechanism operates through investment expenditures. To the extent that firms' hurdle rates of return are sticky, additional reductions in funding costs will not spur investment once all profitable projects have been exhausted. This can make investment insensitive to interest rate changes (eg Lane and Rosewall (2015)).

Third, as interest rates fall towards the zero lower bound, market anticipations of further potential rate cuts are commensurately reduced. This can attenuate the signalling power of monetary accommodation and hence its impact on the economy more broadly.

Finally, persistently low rates may create disincentives to address debt overhangs, undermining efficient resource allocation and productivity. The rise of so-called "zombie firms" is one such manifestation (Acharya et al (2019, 2020) and Banerjee and Hofmann (2018, 2020)). As resources, including new lending, to more productive firms are crowded out, the expansionary impact of lower interest rates may be muted.

Most of these mechanisms also become stronger, the longer rates stay low. The extent to which low rates sap bank profitability and hence capital levels, for example, depends on how long net interest margins remain under pressure. This would force

2 A compression of the term premium is especially costly (Borio et al (2017)).

banks to tap capital markets for equity, which is quite expensive at the best of times and especially so if prospects are dim. Likewise, as debt burdens build up over time, the headwinds they generate will be greater the longer the low interest rates have contributed to debt accumulation. At a more fundamental level, Shirakawa (2021) argues that this reflects the way expansionary monetary policy inherently works: lower rates shift consumption from the future to the present, and there must be limits to this process. Moreover, the transfer also affects investment, which is profitable only if future consumption can be counted to be there.

Using quarterly data for a panel of 18 advanced economies from 1985 to 2020, we find evidence of non-linearity in the effects of monetary policy on economic activity with respect to interest rate levels. The non-linear effect survives when controlling for debt regimes and the state of the business cycle, whose importance has already been documented in the past. In fact, in a horse race, the non-linear impact of interest rates dominates those of the other two factors. These results are robust to a number of variations, including different measures of policy rates, monetary policy shocks, economic activity and interest rate thresholds. The non-linear effect also survives when controlling for a downward trend in interest rates, a proxy for the evolution of an unobservable equilibrium real rate of interest. Moreover, we find evidence that the longer rates remain low, the greater the attenuating effect becomes.

Our paper builds on a recent strand of literature that has explored the non-linear effects of monetary policy through the state-dependent local projection methods pioneered by Jordà (2005) and Ramey and Zubairy (2018). Several studies have documented that monetary policy appears to be less effective during economic downturns. Tenreyro and Thwaites (2016) do so for the United States while Jordà et al (2020) and Alpanda et al (2019) present similar results for a cross-section of advanced economies. Another key focus has been the impact of the financial cycle, and of leverage in particular. Bech et al (2014) present evidence that monetary policy appears to be less effective in downturns associated with financial crises. Alpanda and Zubairy (2019) and Aikman et al (2017) find that the impact is muted when the debt-to-GDP ratio is above trend.

A few studies have also started to look at the link between monetary policy transmission and the interest rate cycle. Borio and Gambacorta (2017) find that bank lending is less responsive when interest rates are low for long. Eichenbaum et al (2018) and Berger et al (2018) both document a weaker transmission of monetary policy in the United States after prolonged periods of low interest rates due to declines in mortgage refinancing activity. Alpanda et al (2019) study how monetary effectiveness varies between interest tightening and easing cycles in a panel of advanced economies, finding some evidence of weaker transmission during tightening phases. Closest to our approach, van den End et al (2020) investigate how the response of aggregate expenditures to monetary policy shocks in the euro area depends on the level of interest rates. They find some evidence pointing to an attenuating effect when interest rates are low. Relative to their paper, our study covers more countries, over a longer time span, and utilises different identification schemes for monetary policy shocks. Importantly, it also examines the robustness of the findings by controlling for both credit and output conditions as well as for a possible fall in the equilibrium real interest rate. In addition, it also looks at how the duration of low rates matters. We view our results as complementary to theirs.

The structure of the paper is as follows. The next two sections lay out, respectively, the data and the empirical approach. The third section presents the baseline results while the following one carries out a set of robustness checks. Section 5 explores the role of the duration of low rates and Section 6 considers high frequency monetary policy shocks as an alternative to the baseline estimation. The conclusion notes some policy considerations.

1. Data

Our (unbalanced) panel consists of 18 advanced economies covering the period from 1985Q1 to 2019Q4 – a period spanning both the Great Moderation and the post-GFC recovery.[3] Our benchmark indicator of economic activity is real GDP, but we also use the unemployment rate as a robustness check. Our indicator of monetary policy is the three-month interest rate supplemented by shadow interest rates from the Krippner (2015) database for the post-GFC period. As a robustness check, we also estimate the model using the two-year bond yield, thereby avoiding the use of estimated shadow rates. Our set of control variables include: consumer price indices (CPI), household credit-to-GDP ratios, real house prices, long-term interest rates, nominal stock prices, nominal effective exchange rates, and an equally-weighted index of commodity prices.[4] We transform all variables using natural logarithms except for the interest rates, which enter in levels. Appendix A provides details on data sources.

For the identification of the high- and low-interest rate regimes, we adopt a data-driven approach. Specifically, we determine the threshold based on a grid search, considering all possible thresholds between 0 and 5% in the estimation of our baseline non-linear regression model of monetary transmission (see next section). We choose the threshold that delivers the best empirical fit in terms of sum of squared residuals (SSR).[5] The results of the grid search are shown in Graph 2, left-hand panel. The best fit is obtained for an interest rate level of 2.25%. This roughly corresponds to the lowest 35th percentile of the interest rate distribution of the entire sample (right-hand panel). For robustness, we also explore country-specific thresholds corresponding to the lowest 35th percentile within each country distribution.

We proxy the credit cycle by the deviation of the household credit-to-GDP ratio from a long-term trend ("credit gap"). Specifically, we employ an HP filter with a smoothing parameter of 400,000. This characterisation of the credit cycle is in line with Drehmann et al (2012) and reflects its longer duration and larger amplitude than those of the business cycle, as traditionally measured (smoothing parameter equal to 1600). We classify the economy as being in a high-debt regime if the credit gap is in the top 25th percentile of its distribution, following Alpanda and Zubairy (2019).

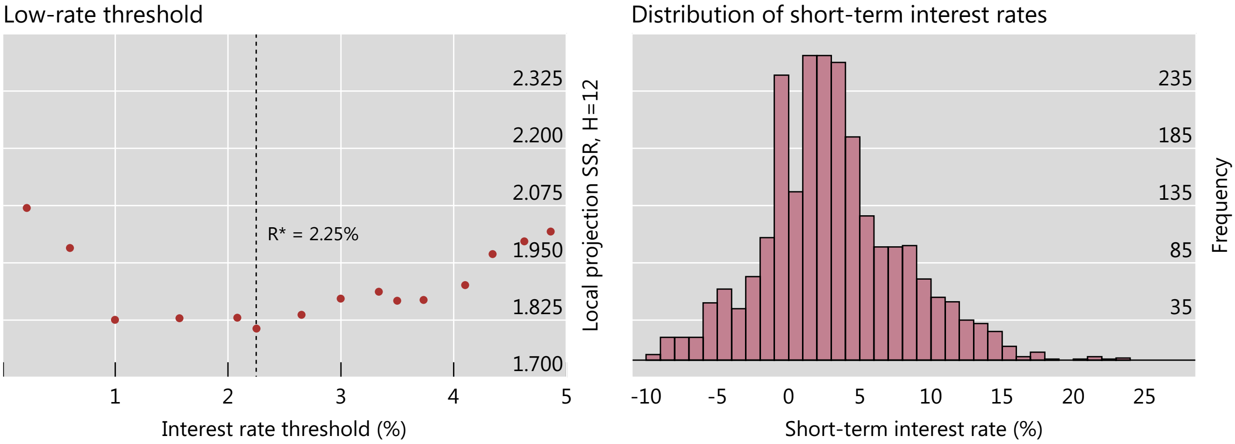
[3] Data for the credit-to-GDP ratio are available for all countries starting 1985Q1 except Denmark, Ireland, New Zealand and Switzerland.

[4] We include house prices in real terms but stock prices, exchange rates and interest rates in nominal terms as we see housing as part of the real economy while fast-moving financial variables are usually discussed in nominal terms. That said, using real stock prices and exchange rates hardly affects the results.

[5] The grid focuses on the estimation of the cumulative impact on GDP over 12 quarters, the longest estimation horizon we consider. The results are, however, unaffected when the grid is performed for shorter estimation horizons.

Low-rate threshold and interest rate distribution

Graph 2



Note: The left-hand panel shows the sum of squared residuals (SSR) from the estimation of equation (1) for h=12 quarters for different low interest rate thresholds. The broken vertical line marks the low-rate threshold minimising the SSR in the grid (2.25%). The right-hand panel shows the distribution of all interest rate observations including shadow rates.

Source: BIS calculations.

Finally, with respect to the business cycle, we characterise upturns and downturns based on the recession dates identified by the Organisation for Economic Co-operation and Development (OECD). We also cross-check the results using deviations of real GDP from a Hodrick-Prescott filtered (HP) trend.

Graphs A1–A3 in Appendix B show the resulting regime classifications. For interest rates, the low-rate regime tends to occur predominantly after 2010, though not exclusively. Japan and Switzerland, in particular, experienced sustained low-rate regimes significantly earlier, and several countries were in a low-rate regime for several years after the dot-com bubble burst in 2001. Periods leading up to and immediately following the GFC are identified as high-debt regimes in many countries, as are those in the early 1990s associated with the banking crises in the Nordic countries and Japan. In terms of output regimes, one notable feature is the apparent rise in the synchronicity of economic cycles across countries over time.

2. Empirical approach

Our focus is on the differences in the sensitivity of aggregate demand to monetary policy between high and low interest rate regimes. To this end, we infer the interest elasticity of aggregate demand from its response to monetary policy shocks in a non-linear empirical model based on the local projection method proposed by Jordà (2005). Local projections allow for a straightforward and flexible estimation of non-linear impulse response functions in a panel context. In particular, it is easy to account for multiple sources of non-linearity. This is crucial for our analysis, which aims to separate the effects attributable to the level of interest rates from those of other potential factors.

Our baseline non-linear local projection model is specified as follows:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h + \boldsymbol{I}_{i,t-1}^{A} \left[\alpha_{i,h}^{A} + \beta_h^{A} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{A} \right] + e_{i,t+h} \tag{1}$$

for h=1,..,12 where $y_{i,t+h}$ is the measure of economic activity for country i over time horizon *h*. $mp_{i,t}$ is the level of the short-term interest rate at time *t*. $\boldsymbol{X}_{i,t}^{'}$ is a vector of control variables including the current realisation and two lags of the log level of the CPI, the exchange rate, stock prices, real house prices and the commodity price index as well as the long-term nominal interest rate and the household debt-GDP ratio as well as two lags of the short-term interest rate. [6] $\alpha_{i,h}$ is a vector of country-fixed effects. We introduce non-linearity through the indicator variable $\boldsymbol{I}_{i,t-1}^{A}$, which takes a value of 0 or 1 in "alternative" states of the world, eg 0 when interest rates are high and 1 when they are low; or 0 when debt is low and 1 when it is high. The simple linear case of equation (1) obtains when removing the interaction term on the right-hand side of the equation.

As a first pass, equation (1) estimates the role of different regime variables *individually*, without conditioning on other competing regime variables. We implement the joint estimation below in order to better identify their respective roles.

From equation (1) we directly obtain an estimate of the regime-dependent dynamic effects of a change in the monetary policy stance on output from the estimated impact coefficients of the short-term interest rate. The *h*-quarter-ahead impact of monetary policy on economic activity in the normal state (eg high interest rates) is β_h, and it is $\beta_h + \beta_h^A$ in the alternative state (eg low interest rates). The sequence of response coefficients over *h* quarters traces out the impulse response function. We calculate error bands based on Driscoll and Kraay (1998) standard errors, which are robust to both cross-sectional and serial dependence.

We can interpret the impulse response functions as reflecting the dynamic effects of an exogenous change in the monetary policy stance, ie a monetary policy shock. This is because of the inclusion of the control variables $\boldsymbol{X}_{i,t}^{'}$, which capture the central bank interest rate reaction function. Equation (1) therefore implicitly imposes a standard recursive scheme for the identification of monetary policy shocks. Specifically, the setup assumes that none of the macro control variables respond contemporaneously to the policy interest rate but that the interest rate may react contemporaneously to all of these variables. This is equivalent to the standard Cholesky decomposition of residuals from a VAR where the short-term interest rate is ordered last. As in Alpanda and Zubairy (2019), we implement this identification scheme in the local projection setup by treating the contemporaneous short-term interest rate as the monetary policy shock, $mp_{i,t}$, and by including contemporaneous and lagged values of the control variables in the estimation (as reflected in the lags structure of equation (1) above). Plagborg-Møller and Wolf (2021) provide a formal derivation of the equivalence of impulse responses obtained from local projections and VARs for such recursive identification schemes.[7]

In Section 6, we cross-check our baseline results for a subset of countries by using high-frequency shocks, ie changes in market interest in a narrow time window

[6] The lag order of two was chosen based on the Schwarz-Bayes information criterion.

[7] Montiel et al (2021) further show that local projections robustly handle both stationary and non-stationary data as well as long response horizons.

around the announcement of monetary policy news. This type of analysis is constrained by the short time period and the smaller number of countries for which such high-frequency shocks are available.

To disentangle the influence of each regime variable, we estimate the non-linearities *jointly*, ie including each of the three types of regime (for interest rates, debt and output) simultaneously in the regression. Specifically, we are interested in establishing how the interest rate level regime compares with the other two regime variables in accounting for non-linearities in monetary transmission. To do so, we extend equation (1) by adding a second interaction term on the right-hand side

$$\begin{aligned} y_{i,t+h} = \alpha_{i,h} + \beta_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h + \boldsymbol{I}_{i,t-1}^{A} \left[\alpha_{i,h}^{A} + \beta_h^{A} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{A} \right] \\ + \boldsymbol{I}_{i,t-1}^{B} \left[\alpha_{i,h}^{B} + \beta_h^{B} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{B} \right] + e_{i,t+h} \end{aligned} \quad (2)$$

where $\boldsymbol{I}_{i,t-1}^{A}$ is an indicator variable that takes a value of 1 when interest rates are low and zero otherwise, and $\boldsymbol{I}_{i,t-1}^{B}$similarly takes a value of 1 either in the high-debt or recession regimes and zero otherwise.

By estimating equation (2), we essentially run a horse race between two sources of non-linearity. The outcome of the horse race is reflected in the sign and statistical significance of the coefficients β_h^{A} and β_h^{B}.

Equation (2) can be further extended to capture all three regimes simultaneously by including interaction terms for all three regimes on the right-hand side. This extension runs a full horse race with all three competing regimes. The outcome is again reflected in the regime-dependent interaction coefficients for the monetary policy shock $mp_{i,t}$.

$$\begin{aligned} y_{i,t+h} = \alpha_{i,h} + \beta_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h + \boldsymbol{I}_{i,t-1}^{A} \left[\alpha_{i,h}^{A} + \beta_h^{A} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{A} \right] \\ + \boldsymbol{I}_{i,t-1}^{B} \left[\alpha_{i,h}^{B} + \beta_h^{B} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{B} \right] \\ + \boldsymbol{I}_{i,t-1}^{C} \left[\alpha_{i,h}^{C} + \beta_h^{C} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h^{C} \right] + e_{i,t+h} \end{aligned} \quad (3)$$

where $\boldsymbol{I}_{i,t-1}^{A}$ is an indicator variable that takes a value of 1 when interest rates are low and zero otherwise, $\boldsymbol{I}_{i,t-1}^{B}$ takes a value of 1 in the high-debt regime and zero otherwise, and $\boldsymbol{I}_{i,t-1}^{C}$ takes the value one in recession regimes and zero otherwise.

3. Results

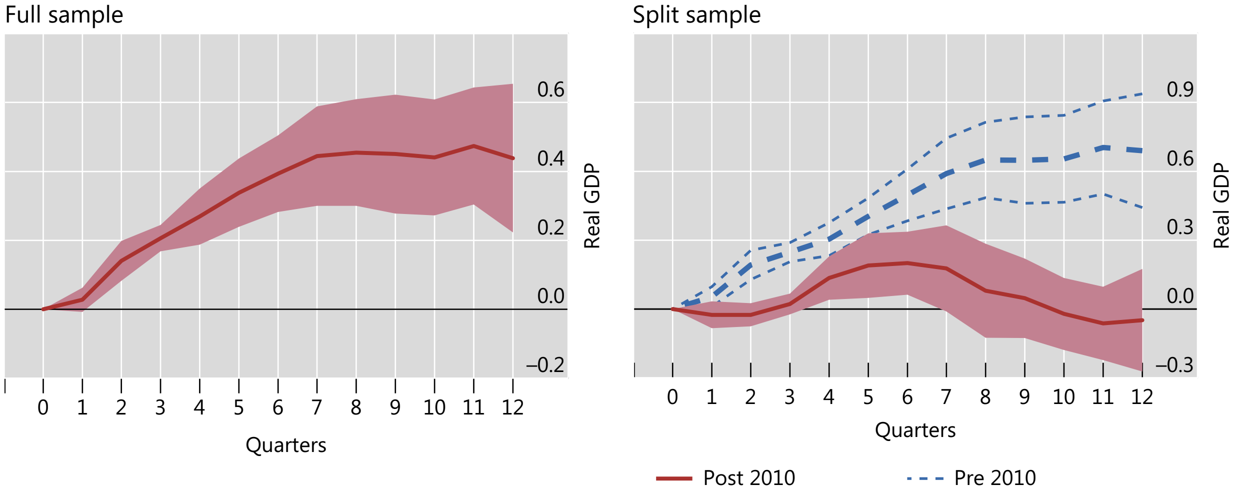
3.1 Linear case

Starting with the linear version of equation (1), where we do not differentiate between the various regimes, Graph 3 (left-hand panel) shows the response of (log) real GDP to a 100 bp monetary policy easing shock. The estimated response is in line with previous studies. The impact peaks around eight quarters after the shock (eg Alpanda et al (2019) and Aikman et al (2017)). Quantitatively, a 100 bp cut in the policy rate boosts real GDP by up to 0.5%.

The impact is not constant over time. Splitting the sample in pre- and post-GFC periods reveals that the effects of monetary policy are substantially smaller post-GFC (Graph 3, right-hand panel). Over this period, the output boost after six quarters is less than a third of that estimated for the pre-GFC period and is much less persistent.

Response to monetary stimulus: linear baseline

In per cent | Graph 3



Note: Impulse response of real GDP to a 100 bps expansionary monetary policy shock. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors. Local projections estimated from the linear model.

Source: BIS calculations.

3.2 Regime-dependent monetary transmission

What explains the reduced traction of monetary policy on output post-GFC? The period was characterised by low interest rates, a debt overhang and, in many countries, by business cycle recession phases. Did all three factors play a role?

The results of the estimation of the baseline non-linear model (equation (1)) suggest that this is indeed the case. Graph 4 shows the response of output to a 100 bp expansionary monetary policy shock conditional, respectively, on regimes related to the level of nominal interest rates (high vs low interest rates), the credit cycle (high vs low debt overhang) and the business cycle (expansion vs recession) when each of them is considered individually. We find that the response of output is weaker when interest rates are low, when debt is high, and during economic downturns. These results echo the findings of van den End et al (2020), Alpanda and Zubairy (2019), and Tenreyro and Thwaites (2016), respectively.

Two observations are worth noting. First, among the "alternative" regimes, the output response to an expansionary monetary policy shock is weakest in the case of low interest rates. Indeed, it is not significantly different from zero. Second, for each regime variable, the difference is starkest in the case of interest rates. This suggests that, as a conditioning state variable, the level of interest rates bites more than the level of debt or the stage of the economic cycle. We explore this further in the next step.

Response to monetary shocks: non-linear baseline

In per cent Graph 4

Note: Impulse response of real GDP to a 100 bps expansionary monetary policy shock. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors. Local projections estimated from equation (1).

Source: BIS calculations.

3.3 Horse races

Since high-debt, recession and low-rate regimes often overlapped over our sample period, the question is whether the low-rate regime still matters once the debt and business cycle regimes are controlled for. This subsection presents the results of the horse-race regressions assessing this question. We first consider combinations of two regimes (high debt vs low rates and recession vs low rates) based on equation (2) before running the horse race with all three regimes simultaneously.

The results of the two-regime horse races confirm the key role of the low-interest-rate regime. Table 1 presents the estimates of the interaction coefficients on the regime indicator variables (β_h^A, β_h^B). The first two columns show the results of the horse race between the low interest rates and the high-debt regime; the third and fourth columns those of the horse race between the low interest rate and economic downturns regimes. The results suggest that the low-rate regime significantly saps the strength of monetary transmission also when the debt and business cycle regimes are controlled for. The interaction coefficient for the low-rate regime is negative and significantly different from zero in both horse races, meaning that it reduces the positive effect of expansionary monetary policy on output. At the same time, Table 1 shows that also the high-debt and the recession regimes continue to have a weakening effect on monetary transmission when the low-rate regime is conditioned on. That said, in both horse races, the dampening effect of low interest rates on the strength of monetary transmission is quantitatively larger at almost all horizons.

Marginal threshold effects of expansionary monetary policy Table 1

Horizon	Conditional on interest rate and debt regime				Conditional on interest rate and output regime			
	Low rates		High debt		Low rates		Downturns	
1	-0.121*	(-0.065)	-0.083	(-0.061)	-0.087**	(-0.044)	0.015	(-0.083)
2	-0.246***	(-0.07)	-0.124	(-0.081)	-0.162***	(-0.035)	0.048	(-0.13)
3	-0.213*	(-0.11)	-0.166**	(-0.079)	-0.126	(-0.079)	0.067	(-0.135)
4	-0.17	(-0.157)	-0.16**	(-0.079)	-0.126	(-0.124)	-0.044	(-0.133)
5	-0.208	(-0.153)	-0.216*	(-0.122)	-0.197*	(-0.112)	-0.097	(-0.166)
6	-0.24	(-0.173)	-0.237*	(-0.137)	-0.261**	(-0.108)	-0.191	(-0.173)
7	-0.33*	(-0.182)	-0.25	(-0.163)	-0.367***	(-0.095)	-0.16	(-0.159)
8	-0.364	(-0.226)	-0.239	(-0.154)	-0.449***	(-0.097)	-0.213	(-0.177)
9	-0.396*	(-0.208)	-0.24*	(-0.138)	-0.516***	(-0.081)	-0.365**	(-0.181)
10	-0.395*	(-0.234)	-0.31***	(-0.12)	-0.54***	(-0.099)	-0.4**	(-0.183)
11	-0.568**	(-0.237)	-0.379***	(-0.114)	-0.72***	(-0.103)	-0.495**	(-0.213)
12	-0.485	(-0.322)	-0.425***	(-0.127)	-0.644***	(-0.148)	-0.576**	(-0.236)

Notes: Standard errors based on Driscoll and Kraay (1998) in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. Estimates of β_h^A (low rates) and β_h^B (high debt or economic downturns) from equation (2).

We next use the estimates of the two-regime horse race to illustrate the role of the low-rate regime conditional on each of the other two regimes (debt and business cycle). In order to do so, we calculate regime-dependent impulse responses. More specifically, for any two regime variables, equation (2) partitions the sample into four combinations. In the case of interest rates and debt, for example, the impact of a monetary policy shock is given by

β_h for the high interest rate/low-debt regime

$\beta_h + \beta_h^A$ for the low interest rate/low-debt regime

$\beta_h + \beta_h^B$ for the high interest rate/high-debt regime

$\beta_h + \beta_h^A + \beta_h^B$ for the low interest rate/high-debt regime

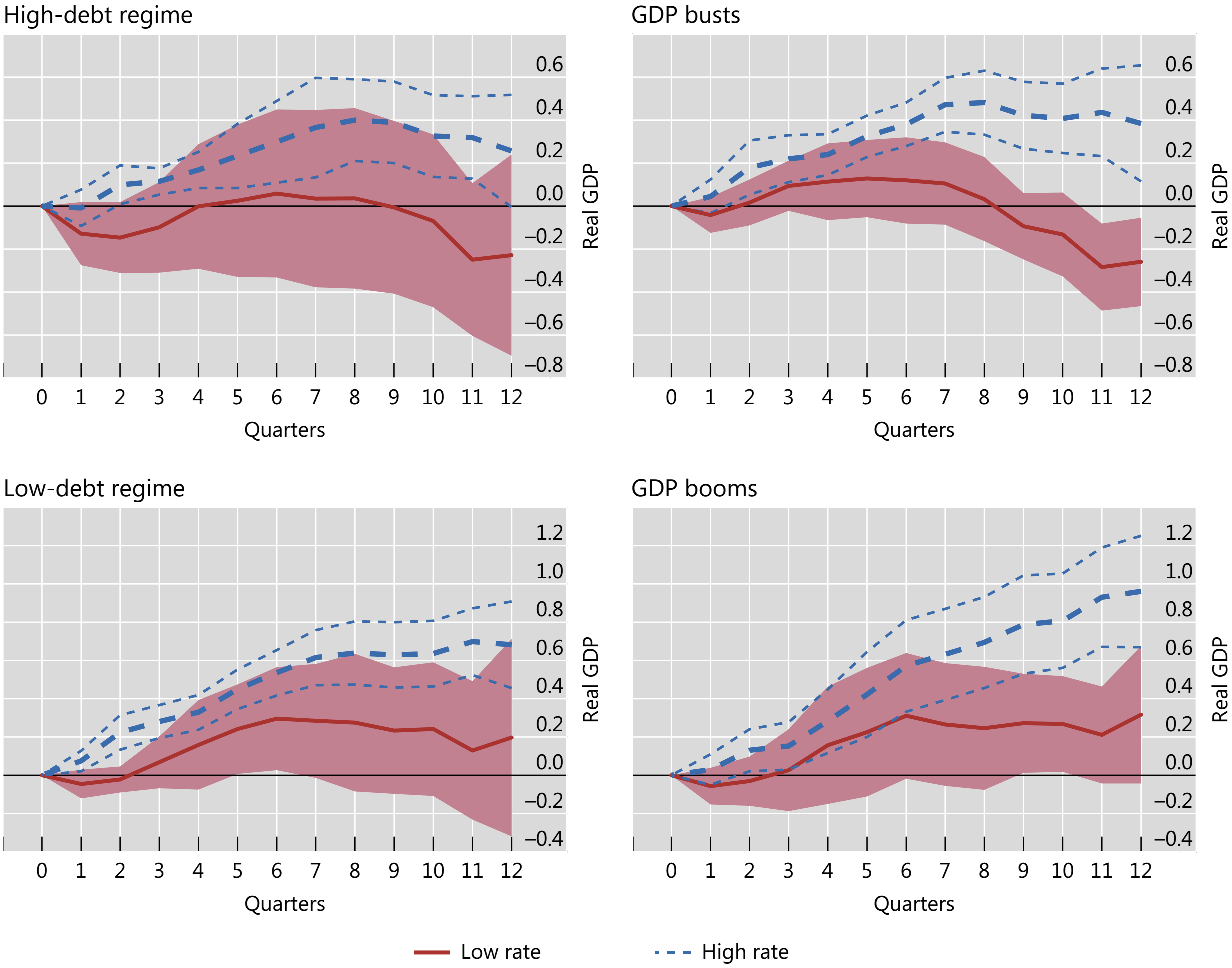
These combinations capture the role of the interest rate regime conditional on the debt regime. Analogous combinations apply to interest rates and the business cycle regimes.

Graph 5 shows the impulse responses from these two-regime regressions. The charts illustrate that the weaker impact of monetary policy when interest rates are low holds regardless of the debt regime (left-hand column) or of the state of the business cycle (right-hand column). At the same time, it is still the case that the impact is smaller when debt is high or during recessions, regardless of the interest rate regime.

The weaker impact of monetary policy continues to hold when the interaction effects of all the regimes are considered simultaneously (Table 2). The low-rate interaction coefficient remains negative and statistically significant at almost all horizons. In addition, the dampening effects of high debt and business cycle downturns both continue to be present, but they are statistically significant only at longer horizons.

Interest rate non-linearity conditional on debt and output regimes

In per cent — Graph 5



Note: Impulse response of real GDP to a 100 bps expansionary monetary policy shock. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors. Local projections estimated from equation (2).

Source: BIS calculations.

We now go one step further and use the estimates of the three-regime horse race to illustrate the role of the low-rate regime conditional jointly on the debt and business cycle regimes. For the three-regime case, we have in total eight possible regime combinations.[8] For the sake of brevity, we illustrate the transmission of monetary policy under the low- and high-rate regimes in "bad" and "good" states of the world. Specifically, we consider transmission under high/low interest rates in the high-debt and recession regime as well as in the low-debt and no recession regime. From equation (3), the impact of a monetary policy shock is given by

β_h for the high interest rate/low-debt/boom regime

$\beta_h + \beta_h^A$ for the low interest rate/low-debt/boom regime

$\beta_h + \beta_h^B + \beta_h^C$ for the high interest rate/high-debt/recession regime

$\beta_h + \beta_h^A + \beta_h^B + \beta_h^C$ for the low interest rate/high-debt/recession regime

[8] The possible combinations are high debt/recession, high debt/no recession, low debt/recession, low debt/no recession, respectively, for both the low-rate and the high-rate regimes.

Graph 6 shows the impulse responses from these joint regime-dependent regressions. The charts illustrate that the weaker impact of monetary policy when interest rates are low holds both in the high-debt/recession regime (left-hand column) and in the low debt/boom regime (right-hand column). In addition, the results indicate that the impact of monetary policy is smaller when there is a "debt overhang", in the sense that debt is high and the economy is in recession. This is the true regardless of the interest rate regime.

Marginal threshold effects of expansionary monetary policy — Table 2

Conditional on debt and output regimes

Horizon	Low rates		High debt		Downturns	
1	-0.09*	(0.051)	-0.078	(0.050)	0.029	(0.088)
2	-0.185***	(0.043)	-0.103	(0.072)	0.048	(0.139)
3	-0.142*	(0.081)	-0.134*	(0.073)	0.084	(0.125)
4	-0.15	(0.123)	-0.124	(0.084)	-0.033	(0.118)
5	-0.211*	(0.110)	-0.2*	(0.120)	-0.078	(0.142)
6	-0.258**	(0.122)	-0.224*	(0.134)	-0.158	(0.126)
7	-0.338***	(0.122)	-0.25	(0.179)	-0.132	(0.119)
8	-0.398***	(0.154)	-0.243	(0.179)	-0.176	(0.138)
9	-0.456***	(0.127)	-0.234	(0.164)	-0.324**	(0.128)
10	-0.463***	(0.158)	-0.31**	(0.155)	-0.347***	(0.128)
11	-0.671***	(0.154)	-0.383**	(0.153)	-0.468***	(0.161)
12	-0.597***	(0.227)	-0.423***	(0.156)	-0.547***	(0.186)

Notes: Standard errors based on Driscoll and Kraay (1998) in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. Estimates of β_h^A (low rates) and β_h^B (high debt) and β_h^C (downturns) from equation (3).

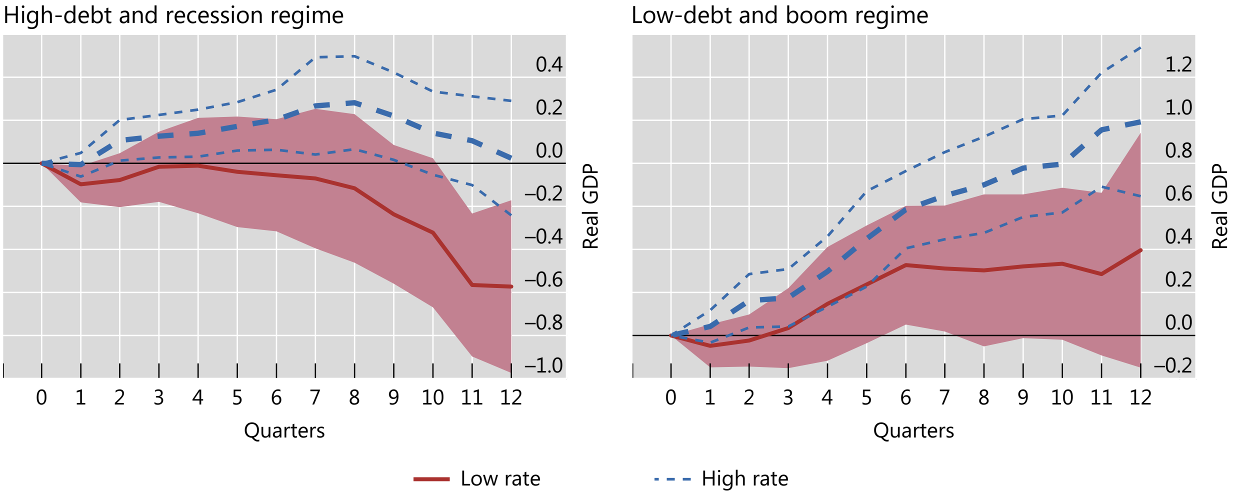
Taken together, these findings suggest that over and above any influence coming from debt levels and the business cycle, the level of interest rates matters for the strength of monetary transmission in and of itself. That is, the IS curve steepens as interest rates fall independently of any headwinds coming from high debt or economic contraction. One implication is that interest rate normalisation is important for retaining policy effectiveness over the cycle.[9]

In this context, a related but different question is whether the estimates of a weaker impact on activity is symmetrical, ie whether it holds irrespective of whether monetary policy is eased or tightened. There may be grounds for believing that, once interest rates have been low for quite some time, a tightening may have a larger impact than an easing. There is, in principle, no upper bound to higher rates. And if rates stay low for a long time, they can contribute to conditions that may make the economy more sensitive to higher rates, such as higher debt or possibly stretched asset valuations. Such asymmetry would complicate the normalisation process, in turn possibly entrenching low interest rates (Borio and Disyatat (2014)). Unfortunately, however, given data limitations, we are unable to assess this hypothesis formally.

[9] Rungcharoenkitkul et al (2019) analyse the possibility that certain policy reaction functions can result in a trend decline in interest rates over successive economic cycles, resulting in a loss of policy space.

Interest rate non-linearity jointly conditional on debt and output regimes

In per cent Graph 6



Note: Impulse response of real GDP to a 100 bps expansionary monetary policy shock. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors. Local projections estimated from equation (3).

Source: BIS calculations.

4. Robustness

The above results survive a number of robustness checks. These include allowing for a fall in trend interest rates over time, using the two-year bond yield as monetary policy instrument, using different measures of economic activity and using different specification of the interest rate threshold.

4.1 Robustness checks

Fall in equilibrium real interest rates

Several studies have provided evidence suggesting that the equilibrium real rate of interest has fallen significantly over the past couple of decades (eg Christensen and Rudebusch (2019), Holston et al (2017)). Such a fall would reduce policy space and may explain at least in part the reduced traction of monetary policy in low-rate environments documented in the previous section. In order to check the robustness of our results with respect to this alternative explanation, we re-estimate the non-linear models including an estimate of the equilibrium real interest rate as an additional control variable. We estimate country-specific equilibrium real interest rates by extracting the trend component from the Hodrick-Prescott-filtered (smoothing parameter of 1,600) real interest rate, computed as the short-term rate minus trailing four-quarter inflation.[10]

[10] The results are hardly affected when we take instead the US natural rate estimate of Holston-Laubach-Williams (Holston et al (2017)) to proxy for global trends in equilibrium real rates.

Two-year bond yields as monetary policy instrument

The binding zero lower bound over the past decade makes it harder to identify the effects of monetary policy. The use of shadow rates is a common approach to overcome this problem, but it potentially raises other issues, as the shadow rates are estimates obtained from a separate empirical model. To test robustness to this caveat, we replicate the analysis using the two-year bond yield as the monetary policy instrument. Post-GFC, the two-year yield has in many countries also been very low but has generally not been constrained by the ZLB. Its shifts reflect changes in the path of the policy rate over the corresponding horizon, thereby capturing the signalling effect of monetary policy (Nakamura and Steinsson (2018)).

Alternative thresholds for the low-rate regime

As regards the interest rate threshold, we explore robustness with respect to country-specific thresholds. We use the lowest 35th percentile as a cut-off for each country. The resulting mean interest rate threshold across countries is 2.42%, with a standard deviation of 1.22%.

Alternative measure of economic activity

To test robustness to alternative measures of the outcome variable, economic activity, we redo the analysis replacing output with the unemployment rate.

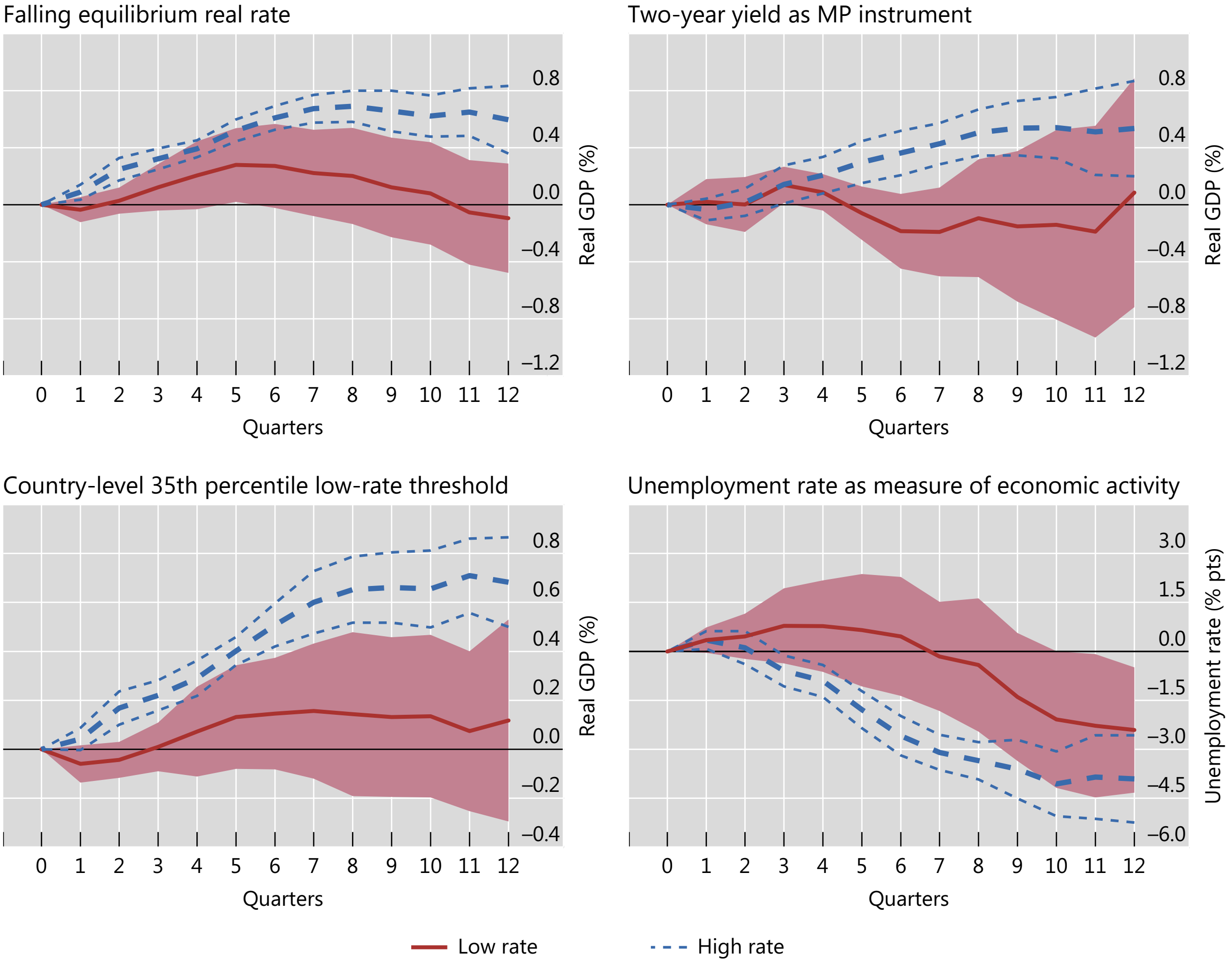
4.2 Robustness results

For the sake of brevity, we focus the robustness checks on the results for the high vs low interest regime in the single-regime regressions (equation (1)) as well as for the interaction coefficient for the low-rate regime from the full three-regime horse race regressions (equation (3)).

The results suggest that our findings are robust with respect to all the four checks above. Graph 7 shows that in all four cases there is a significantly weaker effect of monetary loosening in the low-rate regime, while Graph 8 shows that the reduction in monetary policy traction in the low-rate regime remains present in the three-regime horse race regressions.

Robustness checks for high- vs low-rate regime

Graph 7

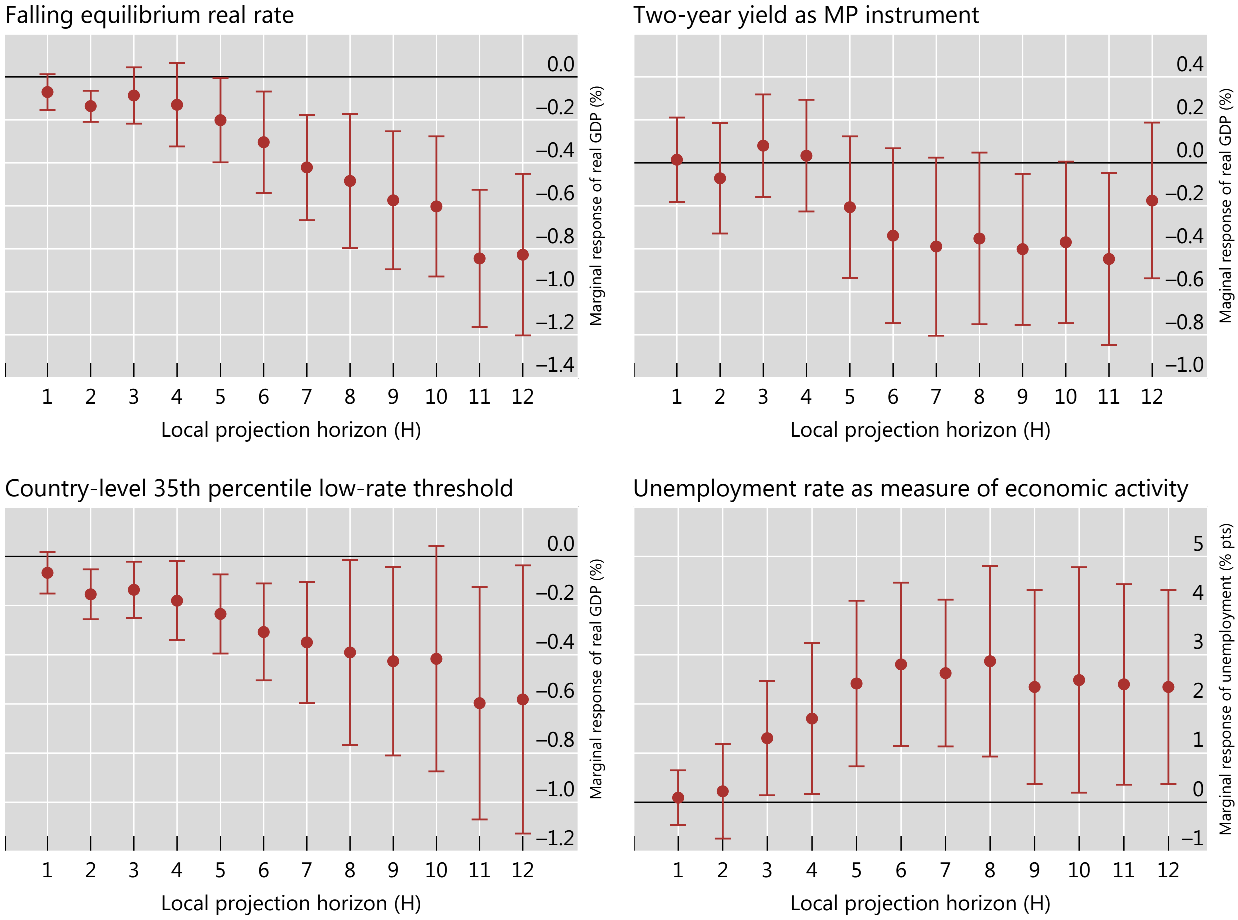


Note: Impulse responses to a 100 bps expansionary monetary policy shock from equation (1) for alternative model specifications. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors.

Source: BIS calculations.

Robustness checks for the three-regime horse race

Coefficient on Low rates x Interest rate Graph 8



Note: Low-rate regime interaction coefficients with confidence bands (for h=1,...,12) from equation (3) for alternative model specifications. Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors.

Source: BIS calculations.

5. Low for long

Is there evidence that the impact of low interest rates on expenditures diminishes as interest rates remain low for long?

To assess this question, we construct a low-for-long variable, which captures the length of time (quarters) that a country remains in a low interest rate regime, in the spirit of Claessens et al (2018). This indicator is constructed as the natural log of 1 plus the number of quarters in the low-rate regime. The log transformation implies that, while the attenuation effect operates and increases at all horizons, it increases less strongly as the duration of low rates rises.[11] We then replace the indicator variable $\boldsymbol{I}^{A}_{i,t-1}$ in equation (1) with this low-for-long count variable $LFL=ln(1+l)$ where l denotes

[11] We also tried a simple linear-count specification of the low-for-long variable, which turned out to be insignificant for most of the horizons. This suggests that the data are more consistent with the log-count specification.

the number of quarters that rates have been in the low-rate regime (ie below the low-rate threshold of 2.25%).

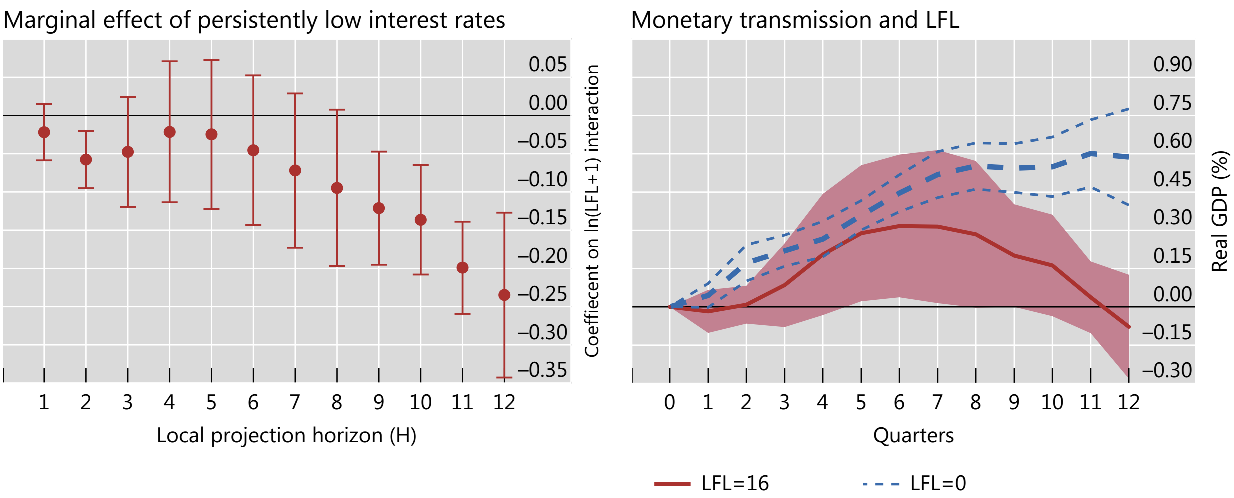
The estimating equation takes the following form:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}_h + \boldsymbol{LFL}_{i,t-1}\left[\alpha_{i,h}^{A} + \beta_h^{A} mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}_h^{A}\right] + e_{i,t+h} \quad (4)$$

The response of output to a monetary policy shock in the high interest rate regime is now given by β_h as before, and the marginal effect in the low-rate regime by $\beta_h^A * LFL$.

The estimation results suggest that low-for-long (LFL) indeed saps the strength of monetary transmission at all horizons, and significantly so especially at longer ones. This can be seen from the left-hand panel of Graph 9, which plots the marginal effect of LFL (β_h^A) on the impact of a 100 bp expansionary monetary policy shock for each projection horizon, along with the associated 90% confidence band. The impact of LFL on the strength of monetary policy transmission is illustrated on the right-hand panel. The panel shows the dynamic effect of a 100 bp monetary easing shock when the interest rate is not low (LFL=0) and when it has low for 16 quarters (LFL=16), calculated as $\beta_h + \beta_h^A * \ln(1 + l)$ where $l = 0,\ 16$. The results suggest that the effect of an expansionary 100 bp interest rate cut on real GDP is weakened by about 0.6 percentage points down to essentially 0 when rates have been low for 16 quarters. This is quantitatively very similar to the findings of the differences between transmission in high and low interest rate regimes from our regime-based analysis in the previous two sections, see Graph 4, left-hand panel. Put differently, the marginal impact of the duration of LFL is similar to that of low rates.

Low for long Graph 9



Notes: The left-hand panel shows the interaction coefficient between the expansionary monetary policy shock and the low-for-long count variable. The right-hand panel shows the impulse response of real GDP to a 100 bps expansionary monetary policy shock when the interest rate is low for zero quarters (LFL=0) and for 16 quarters (LFL=16) as implied by the estimation of equation (4). Error bands are respectively 90% confidence intervals based on Driscoll-Kraay (1998) standard errors.

Source: BIS calculations.

In order to assess whether the LFL effects are robust to conditioning on the debt and the business cycle regime, we estimate the following equation. This is the same as equation (3) except that the interest rate regime indicator is replaced with LFL count variable:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}_h + \boldsymbol{LFL}_{i,t-1}\left[\alpha^A_{i,h} + \beta^A_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}^A_h\right] + \boldsymbol{I}^B_{i,t-1}\left[\alpha^B_{i,h} + \beta^B_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}^B_h\right] + \boldsymbol{I}^C_{i,t-1}\left[\alpha^C_{i,h} + \beta^C_h mp_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}'_{i,t-l}\boldsymbol{B}^C_h\right] + e_{i,t+h} \quad (5)$$

As before, $\boldsymbol{I}^B_{i,t-1}$ equals 1 in the high-debt regime and zero otherwise, while $\boldsymbol{I}^C_{i,t-1}$ equals 1 in recession regimes and zero otherwise.

Estimation of equation (5) suggests that the effect of LFL on monetary policy transmission is unaffected when controlling for debt and business cycle regimes. The estimated interaction effects of LFL turn out to be very similar to those shown in Graph 9, left-hand panel. We do not reproduce these estimates for the sake of brevity. Instead, we illustrate the role of LFL across debt and business cycle regimes. To this end, as before, we reproduce Graph 6 based on the estimation of equation (4), considering again only two cases – that of a downturn with a debt overhang (high debt/recession) and of a benign upswing (low debt/boom). Specifically, we calculate the regime dependent transmission of monetary policy as follows:

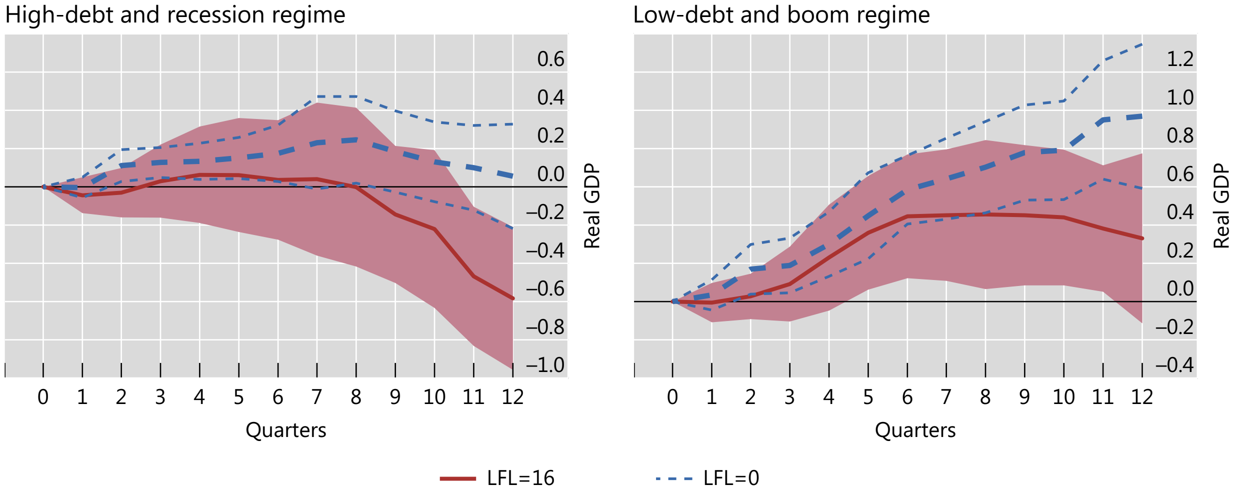
$\beta_h + \beta^A_h * LFL$ for the low debt/boom regime

$\beta_h + \beta^A_h * LFL + \beta^B_h + \beta^C_h$ for the high debt/recession regime

The results reported in Graph 10 are very similar to those reported in Graph 6, when the non-linearity was linked to a high/low interest rate regime. They suggest that LFL saps monetary policy transmission irrespective of the prevailing debt and

Low-for-long conditional on debt and output regimes

In per cent Graph 10



Notes: Impulse response of real GDP to a 100 bps expansionary monetary policy shock for LFL=0 and LFL=16 quarters as implied by the estimation of equation (5). Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors.

Source: BIS calculations.

business cycle regime. Again, the strength of transmission is particularly weak when debt is high, the economy is weak and rates have been low for long.

6. High-frequency monetary policy shocks

As an additional robustness check, we also consider an alternative identification scheme based on high-frequency financial market reactions to monetary policy announcements. Following Ferrari et al (2017), we take interest rate changes in a narrow window (30 minutes) around monetary policy announcements. These include both scheduled monetary policy events, such as the release of information on the outcomes of policy meetings, and non-scheduled events (eg key speeches or press releases). Given data availability, we focus on the three-month instrument for seven countries starting in 1999. The countries covered by this analysis are Australia, Canada, the euro area, Japan, Switzerland, the United Kingdom and the United States.

To investigate the sensitivity of our results to the identification of monetary policy shocks, we compare the baseline results of the linear and the non-linear model to those based on the high-frequency shocks. The left-hand panel of Graph 11 shows the linear response of output to an accommodative monetary policy shock (1 standard deviation or roughly 10 bp), which is in line with that of our baseline in terms of the overall dynamic profile. #

For the non-linear estimation, the sample period is too short to pursue the regime-based approach of the previous section. Given the shorter sample, we gauged the non-linearity by adding an interaction term capturing the interest rate level one quarter before the monetary policy shock. That is, we assess how the effects of monetary shocks depend on the prevailing level of interest rates.

The non-linear estimating equation is given by:

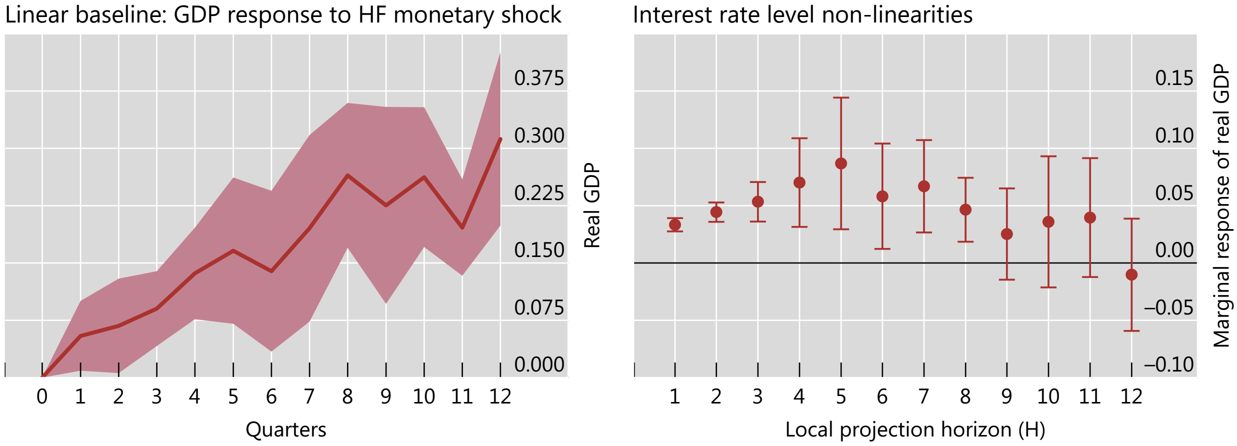
$$y_{i,t+h} = \alpha_{i,h} + \beta_h HF_{i,t} + \sum_{l=0}^{n} \boldsymbol{X}_{i,t-l}^{'} \boldsymbol{B}_h + \beta_h^A HF_{i,t} mp_{i,t-1} + e_{i,t+h} \tag{6}$$

where HF denotes the high-frequency monetary policy shock (with a positive realisation representing an expansionary shock as before) while all other variables are defined as before. The coefficient β_h^A captures the non-linearity: it would be significantly positive if lower rates ($mp_{i,t-1}$) sap the positive output effects of an expansionary monetary policy shock. #

The results reported in Graph 11, right-hand panel, suggest that the interaction coefficient between the monetary policy shock and the level of the short-term interest rate is indeed significantly positive. Thus, also when using high-frequency shocks, the reduced traction of monetary policy when interest rates are lower is apparent. This result should be taken with the caveat that the analysis is based on much fewer observations.

Robustness: High-frequency identified monetary policy shocks

In per cent | Graph 11



Note: The left-hand panel shows the impulse response of real GDP to an expansionary high-frequency monetary policy shock from the linear model. The right-hand panel shows the interaction coefficient between the expansionary high-frequency monetary policy shock and the level of the short-term interest rate estimated from equation (6). Error bands are 90% confidence intervals based on Driscoll-Kraay (1998) standard errors.

Source: BIS calculations.

Conclusions

It is well known that persistently low interest rates can raise important challenges for central banks. These are primarily intertemporal in nature. Necessary as they may be to support aggregate demand and boost inflation in the near term, persistently low rates could lead to greater risk to long-term macroeconomic resilience and stability. By sapping interest margins, profits and hence banks' ability to build up capital, they may weaken financial intermediation and credit supply (eg Borio et al (2017), Brunnermeier and Koby (2018)). By fostering the build-up of debt and thereby increasing debt service burdens over time, they may generate downside risks and financial vulnerabilities in the longer term (eg Borio (2014), Hofmann and Peersman (2017)). By fostering resource misallocations, they can hamper efficiency (eg Acharya et al (2019), Banerjee and Hofmann (2018)). And to the extent that they weaken the economy's ability to withstand higher rates, such as through higher debt burdens and greater market sensitivity to policy tightening, they make normalisation harder, reinforcing the persistence of low interest rates (Borio and Disyatat (2014), Rungcharoenkitkul et al (2019)).#

This paper raises a further complication. The sensitivity of aggregate demand to monetary stimulus may weaken when interest rates are low and stay low. Diminishing returns would mean that a more forceful response is needed to generate a given impact. If so, the policy trade-offs can change materially once rates are low. In particular, the relative importance of the side effects noted above rises, since policy needs to push harder to attain short-term goals.

Taken together with the observed flattening of the Phillips curve, this suggests that a degree of flexibility may be desirable in central banks' pursuit of their inflation targets. A lengthening of the horizon over which inflation is to be brought back to target, for example, would allow greater consideration of the medium-term impact that policy may have. At the same time, the findings highlight the importance of policy normalisation not only in rebuilding buffers, but also in restoring the effectiveness of those buffers.

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Appendix A: Data sources

Our panel consists of 18 developed countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States. For most countries, the quarterly data cover the period 1985Q1 to 2019Q4. The following four countries have credit-to-GDP data starting later: Denmark beginning in 1994 Q4, Ireland starting 2002 Q1, the Netherlands starting 1990 Q4, New Zealand starting 1990 Q4, Switzerland starting 1999 Q4.

Real output, CPI, household credit-to-GDP, house prices, short- and long-term interest rates, stock prices, effective exchange rates, and unemployment rates are taken from various public sources (FRED, OECD, BIS). Short-term rates refer to the three-month Treasury bill rate, or estimated shadow rates from Krippner (2015) when policy rates are at the zero-lower bound. Long-term yields refer to the 10-year government bond yield. The two-year government bond yields used in one of the robustness checks are backdated with the change in three-month rates if the series starts later than 1985Q1.

Commodity prices are based on the Refinitiv Equal Weight Commodity Index originally created in 1957. It consists of equal-weighted front month continuously balanced commodity futures contracts. The 17 underlying index components are: cocoa, coffee, copper, corn, cotton, crude oil, gold, heating oil, live cattle, live hogs, natural gas, orange juice, platinum, silver, soybeans, sugar and wheat. The index is taken from Datastream.

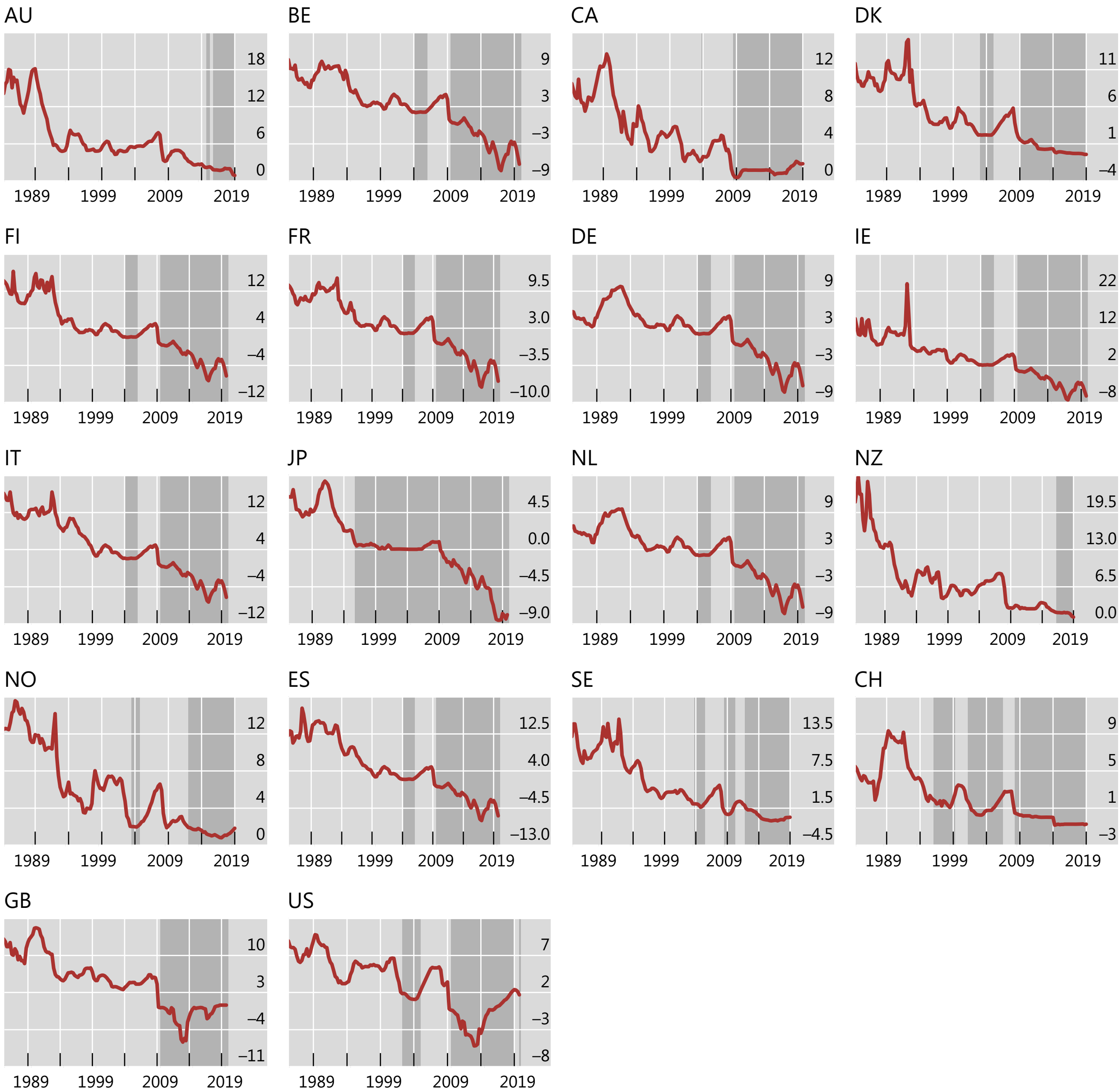
Boom-bust regimes are identified based on the OECD composite leading indicators and reference turning points for business cycles. We define economic busts as periods between business cycle peaks and their subsequent trough.

High-frequency monetary policy shocks are based on intraday government bond futures price changes around monetary policy announcements, specifically 30-minute windows. Monetary policy announcement dates are taken from Ferrari et al (2017).

Appendix B: Interest rate, output and debt regimes

Interest rate regimes

Percent Graph A1

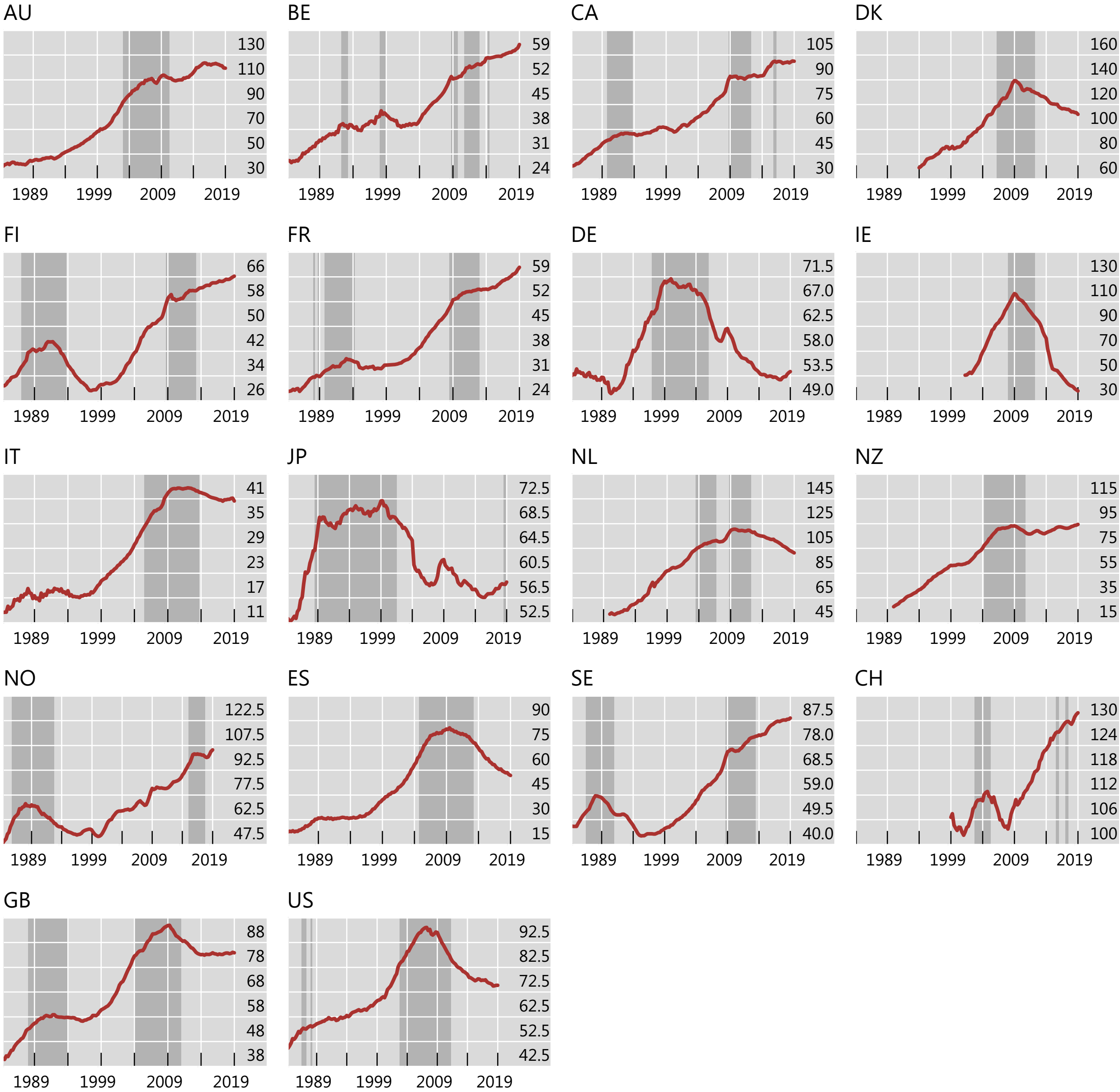


Note: The shaded area denotes low interest rate regimes.

Source: BIS calculations.

Debt regimes

Percentage of GDP Graph A2

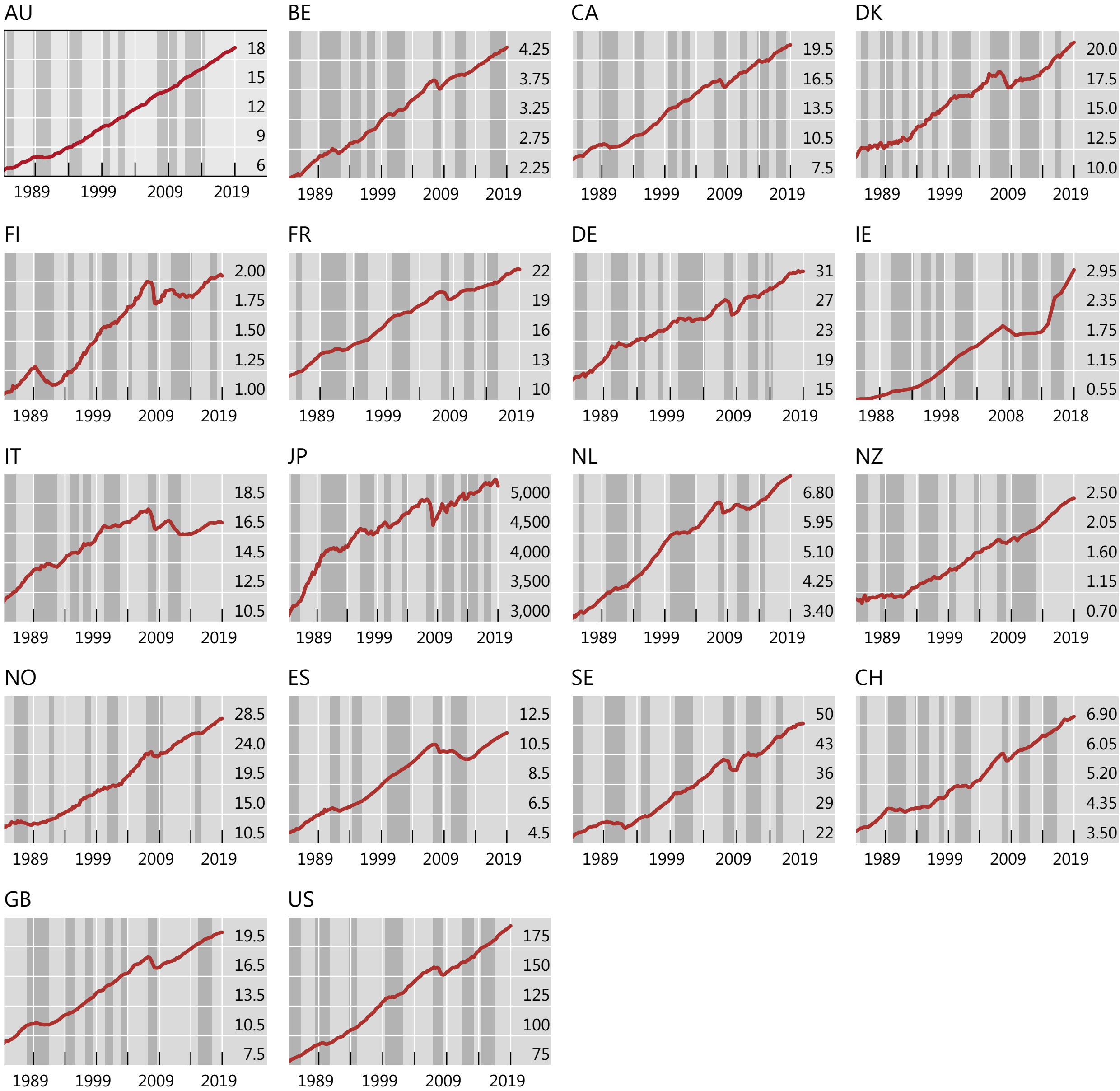


Note: The shaded area denotes high debt regimes.

Source: BIS calculations.

Output regimes

In hundred billion national currency units | Graph A3



Note: The shaded area denotes periods of economic downturns.

Source: BIS calculations.

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