Is monetary policy less effective when interest rates are persistently low?

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Abstract

This paper reviews the conceptual reasons and the empirical evidence for less effective monetary transmission at persistently low interest rates. Transmission could be less effective for two main reasons: (i) headwinds, which would typically arise in the wake of balance sheet recessions, when also interest rates are low; and (ii) inherent non-linearities, which would kick in when interest rates are persistently very low and would dampen their impact on spending. The review of the evidence suggests that headwinds during the recovery from balance-sheet recessions tend to reduce monetary policy effectiveness. At the same time, there is also evidence of inherent non-linearities. That said, disentangling the two types of effect is very hard, not least given the limited extant targeted work. In addition, there appears to be an independent role for nominal rates in the transmission process, regardless of the level of real (inflation-adjusted) rates.

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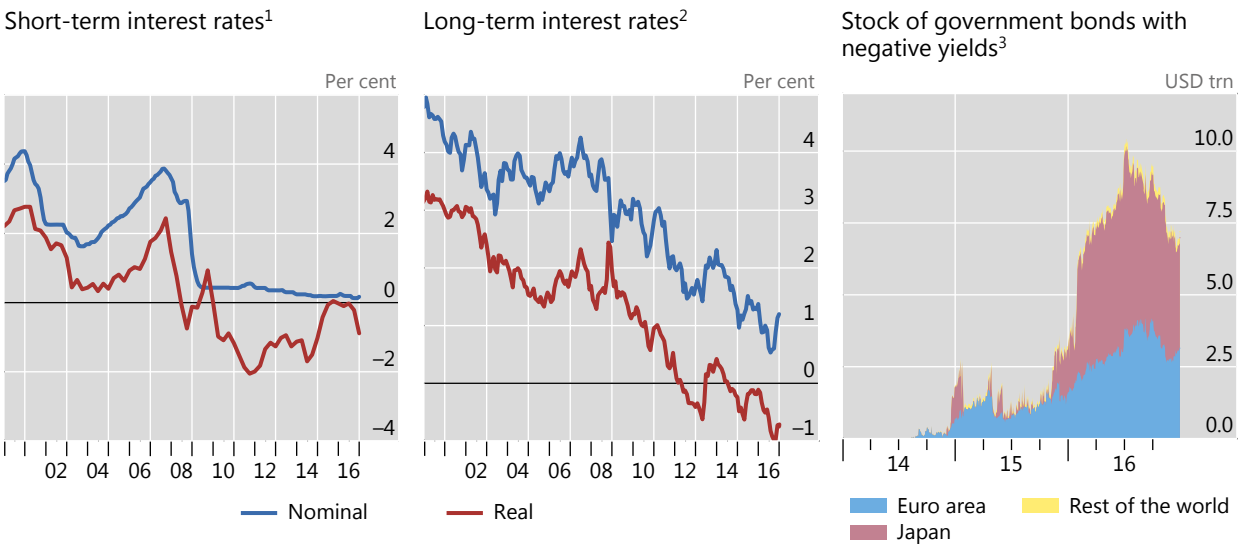
Introduction

Interest rates in the core advanced economies have been persistently low for about eight years now (Graph 1). Short-term nominal rates have on average remained near zero since early 2009 (left-hand panel) and have been even negative in the euro area and Japan, respectively since 2014 and 2016. The drop in short-term nominal rates has gone along with a fall in real (inflation-adjusted) rates to persistent negative levels. Also long-term rates have trended down, albeit more gradually, over this period: in nominal terms, they fell from between 3-4% in 2009 to below 1% in 2016, on average (Graph 1, centre panel); in real terms, they have been mostly negative since 2012. Indeed, following the adoption of negative policy rates in the euro area, Japan and some smaller advanced economies, a significant stock of global government bonds ($7 trillion or more than 20% of the total outstanding)[2] is, at the time of writing, still trading at negative yields, after reaching a peak of over $10 trillion in mid-2016**.** For all its prominence, the post-US election back up in yields has so far not fundamentally changed this picture.

Low interest rates in the core advanced economies — Graph 1



[1] Simple average of Japan, euro area, the United Kingdom and the United States. [2] Simple average of France, the United States and the United Kingdom. [3] Analysis based on the constituents of the Bank of America Merrill Lynch World Sovereign index.

Sources: Bank of America Merrill Lynch; Bloomberg; Datastream; BIS calculations; national data.

From a historical perspective, this persistently low level of short- and long-term *nominal* rates is unprecedented. Since 1870, nominal interest rates in the core advanced economies have never been so low for so long, not even in the wake of the Great Depression (Graph 2, top panels). Elsewhere, too, including in Australia, short- and long-term interest rates have fallen to new troughs, reflecting in part global

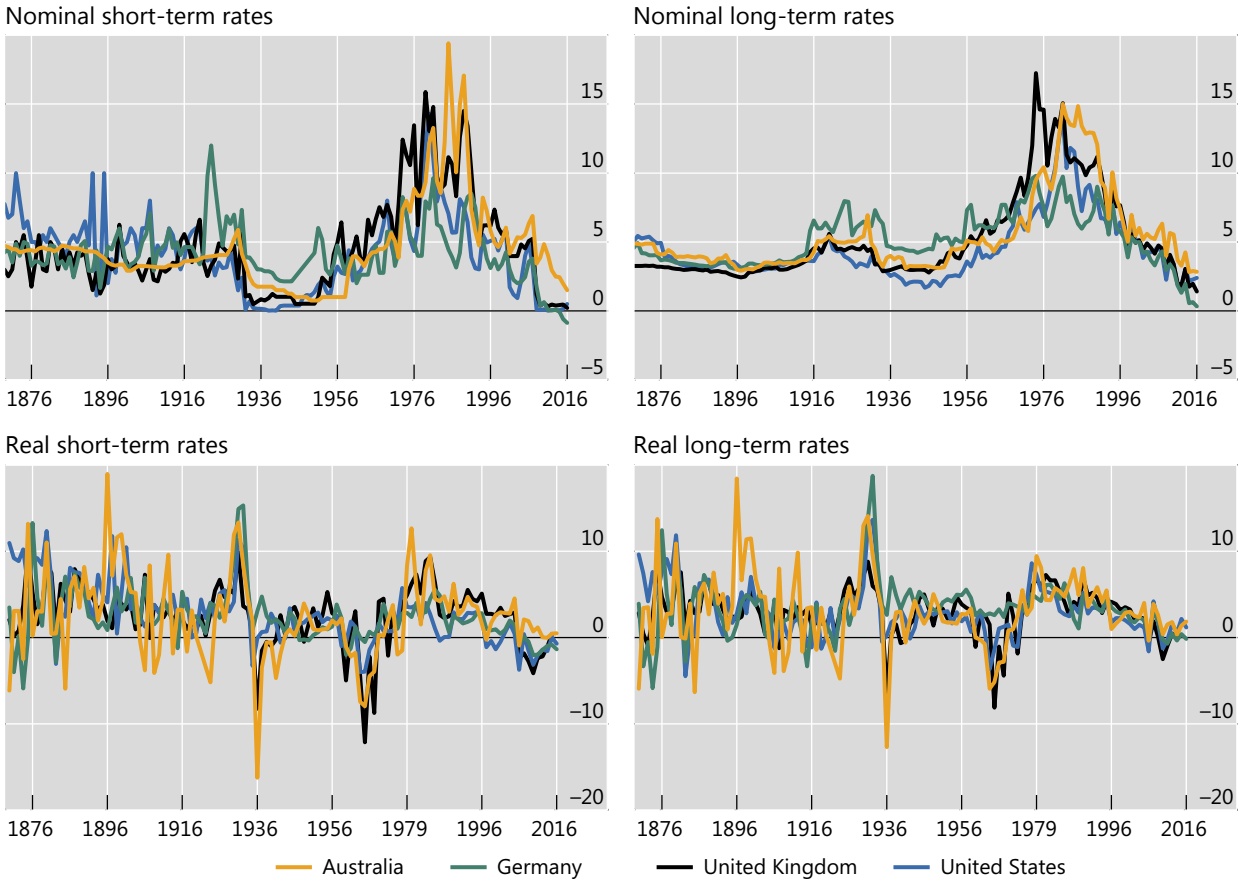
[2] The numbers refer to the sovereign bonds represented in the Merrill Lynch World Sovereign index.

interest rate spillovers especially at the long end (Obstfeld (2015), Hofmann and Takats (2015)).

The picture is not very different for interest rates measured in *real or inflation-adjusted* terms (Graph 2, bottom panels). To be sure, there have been periods in which, as a result of high inflation, real rates have been even lower, notably during the Great Inflation of the 1970s. But now rates have generally been negative for even longer than at that time.

Interest rates, 1870-2016

In per cent — Graph 2



Sources: Jordà, et al (2017); Global Financial Data; national data.

The persistently low rates in the recent past have reflected central banks' unprecedented monetary easing to cushion the fallout of the Great Financial Crisis (GFC), spur the economic recovery and push inflation back up towards objectives. However, despite such efforts, the recovery has been lacklustre. In the core economies, for instance, output has not returned to its pre-recession path, evolving along a lower, if anything flatter, trajectory, as growth has disappointed (Graph 3). At the same time, inflation has in many countries remained persistently below targets over the past three years or so (Graph 3).

Against this background, there have been questions about the effectiveness of monetary policy in boosting the economy in the low interest rate environment. This

paper assesses this issue by taking stock of the existing literature. Specifically, the focus is on whether in the proximity of what used to be called the zero lower bound of interest rates, their impact on aggregate demand diminishes. Moreover, to keep the paper's scope more manageable, we take as given the first link in the transmission mechanism, from the central bank's instruments, including the policy rate, to other rates: the extensive literature on this question has already been reviewed elsewhere (eg Borio and Zabai (2016)). And we focus exclusively on domestic transmission channels, thereby excluding the impact through the exchange rate.[3]

We review the conceptual arguments and empirical evidence. Conceptually, monetary policy transmission may be weaker when interest rates are low for at least two reasons. The first has to do with the economic context: macro-financial "headwinds" may blow more strongly when interest rates are so low. Specifically, persistently low interest rates usually prevail in the wake of balance-sheet recessions, such as the aftermath of the GFC. These recessions feature impaired borrower and lender balance sheets, resource misallocations and heightened uncertainty, all factors that would tend to mitigate the impact of monetary stimulus (eg Borio (2014a)). The second reason has to do with the possibility that, regardless of economic context, the impact of a change in interest rates on aggregate demand and output may be smaller at very low rates, ie that non-linearities are present. Examples include non-linearities through net interest margins and bank profitability possibly affecting credit supply, through consumption and saving, resource misallocations and possibly also via confidence and expectations.

The empirical evidence addressing these questions is relatively scant. That said, what is available suggests that monetary policy transmission is indeed weaker when interest rates are persistently low. The economic context appears to matter, making it more likely that policy may push on the proverbial string as headwinds blow. More general non-linearities may also be present, at least in the case of bank profitability/bank credit supply as well as of consumption (ie a flattening of the IS curve). And there appears to be an independent role for nominal rates, regardless of the level of real (inflation-adjusted) rates.

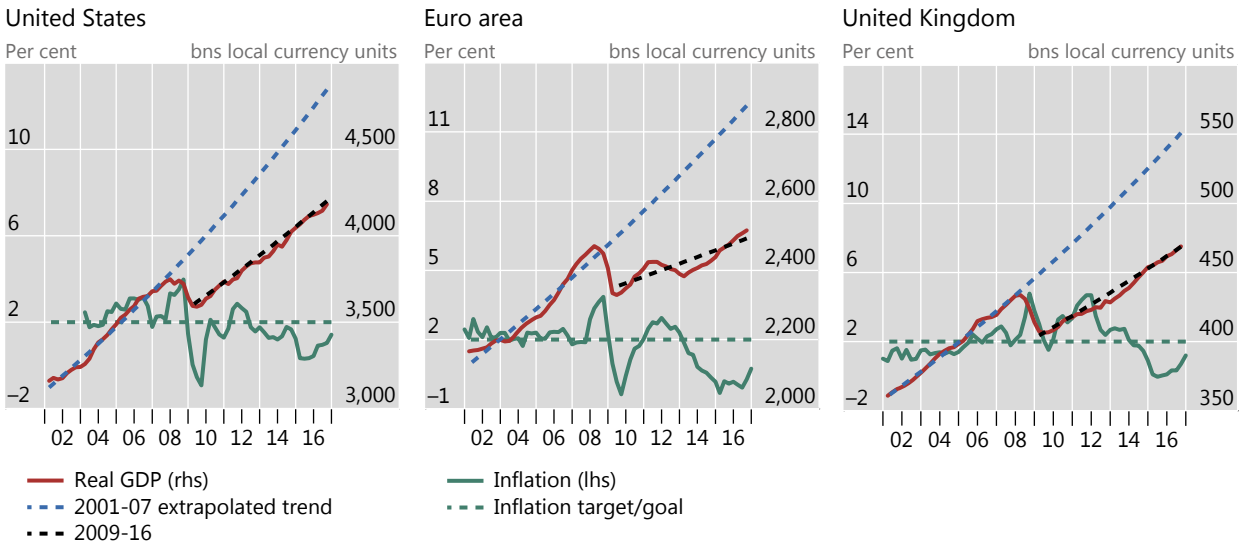
At the same time, it is important to bear in mind the caveats in any such analysis. It is very difficult to distinguish empirically between the two possible reasons for weaker transmission. And it is also hard to ensure that the observed relationships are not "spurious", ie that the weaker link between interest rates and demand or output does not result from very weak economic conditions masking the true relationship. To varying degrees, the empirical tests are designed to filter out this possibility, but the techniques are inevitably imperfect. At a minimum, though, the analysis suggests that there is ample scope to investigate this neglected question further.

The paper is organised as follows. Section 1 discusses how an environment of persistently low interest rates might affect the effectiveness of monetary transmission. Section 2 reviews the existing evidence, including recent work carried out at the BIS. In the conclusion we highlight takeaways and promising areas for further analysis.

[3] It is not obvious why the exchange rate channel should be weaker, unless the link between changes in interest rates and those in the exchange rate is itself weaker. This, of course, could be possible to the extent that at very low rates the scope for further reductions is more limited. However, the empirical evidence suggests that, if anything, the impact of monetary policy shocks on exchange rates has recently become stronger (Ferrari et al (2017)).

Output[1] and inflation post-crisis

Graph 3



[1] Seasonally adjusted, on a logarithmic scale.

Sources: National data; BIS calculations.

1. Lower monetary policy effectiveness? Potential mechanisms

There are two possible reasons why monetary policy may be less effective at persistently low rates: (i) headwinds resulting from the economic context; (ii) inherent non-linearities linked to the level of interest rates.

Headwinds

Persistently low interest rates tend to prevail in the wake of balance sheet recessions, i.e. recessions when private debt is high and a full-blown financial crisis may erupt. This was the case, for instance, during the Great Depression of the 1930s, the financial bust in Japan in the 1990s and the GFC and its aftermath more recently.

The effectiveness of monetary policy may vary across different phases of a balance sheet recession. In the initial phase, expansionary monetary policy can be highly effective by counteracting uncertainty spikes and tail risks of a financial and economic meltdown, nipping adverse feedback loops in the bud (eg Mishkin (2009). In the aftermath of the acute phase of the recession, persistent adverse demand and supply conditions may continue to weigh on the economy and may numb monetary stimulus (eg Borio (2014a,b)). These headwinds are to a large extent the legacy of the previous financial boom, typically characterised by unsustainable credit expansion, asset price increases and capital accumulation (at least in some sectors) as well as by aggressive risk-taking.

First, debt overhangs may weaken demand. In particular, the drop in output and asset prices increases debt burdens relative to income and reduces net worth.

Borrowers, who may have previously overestimated their income prospects, are likely to respond by lowering expenditures in order to cut the burdens through higher repayments and restore wealth through higher saving (Mian and Sufi (2015), Drehmann and Juselius (2015)). Giving priority to balance sheet repair over intertemporal expenditure smoothing would tend to dampen the impact of lower rates (eg Koo (2009), Di Maggio et al (2015)).[4]

Second, an impaired financial sector may curtail credit supply. Losses on loans and other assets weaken financial institutions' capitalisation and make it harder and more costly to raise capital, thereby sapping lending capacity (eg Holmstrom and Tirole (1997), Diamond and Rajan (2011)). This would tend to reduce the pass-through of stimulus.[5] To be sure, the bank lending channel literature posits that monetary transmission is stronger when banks are weakly capitalised (eg Gambacorta and Mistrulli (2004), Jimenez et al (2012)). But this relationship may be reversed in the wake of financial stress or deep recessions, when lenders are under pressure from markets or regulators to compensate the capital losses (eg Albertazzi et al (2016)).

Third, balance sheet recessions, especially if associated with full-blown crises, may tend to go hand-in-hand with low confidence and heightened uncertainty about economic prospects (Mian and Sufi (2015)). Moreover, the switch from aggressive risk-taking to pervasive risk aversion is likely to be especially marked. This uncertainty would tend to dampen expenditures and may make them less responsive to stimulus. It could boost precautionary saving (eg Skinner (1988), Deaton (1991), Dynan (1993)) and raise hurdle rates for investment (eg Bernanke (1983), Dixit (1992), Dixit and Pindyck (1994)).[6] In such a situation, firms may also prefer to use low interest rates to finance mergers and acquisitions and, even more safely, buy back shares or pay out higher dividends rather than embark on capital investments. Management incentives linked to the behaviour of share prices may strengthen this temptation. More generally, higher risk aversion may also dampen the impact of stimulus on asset prices and lending.[7]

Finally, the effectiveness of stimulus may be weakened by conditions on the supply side of the economy. Financial booms tend to go hand-in-hand with slower

[4] For example, in a stylised DSGE model Alpanda and Zubairy (2016) show that in high debt regimes household borrowing responds in a more muted way to an increase in housing collateral values engineered by monetary easing. This is because households first use rising housing equity values to reduce leverage, by letting the debt-to-equity ratio fall, before they start borrowing again.

[5] The problem could be exacerbated if the sovereign's creditworthiness came under strain: historically, fiscal crises have often come on the heels of financial crises (eg Jorda et al (2016)). This is partly because financial booms tend to flatter the fiscal accounts and financial busts drive large holes in public finances, including to deal with banking sector distress (eg Reinhart and Rogoff (2009), Borio et al (2016)).

[6] Bloom et al (2007) and Aastveit et al (2013) show theoretically that higher uncertainty not only reduces investment, but also lowers the responsiveness of investment to demand shocks, specifically to monetary impulses.

[7] The adverse initial conditions – asset prices and debt that are too high, risk-taking that has been excessive – will arguably also tend to dampen the force of the risk-taking channel of monetary policy, ie the impact on expenditures resulting from the effect of interest rates on risk perceptions and appetite (see Borio and Zhu (2012) and Adrian and Shin (2010) for a description of the channel and eg Buch et al (2014, Gambacorta (2009) and Peersman and Wagner (2015) for empirical evidence). Given these headwinds, it is possible that any higher risk-taking induced by unusually low interest rates may exhaust its impact on the financial system (financial risk-taking) and feed less into expenditures.

productivity growth, mainly as a result of a shift of resources into sectors such as construction (Borio et al (2015b)). The adverse implications for productivity growth become considerably larger if the bust ushers in a financial crisis. The mechanisms at work are poorly understood. But a possible explanation is that the boom results in the overexpansion of certain, especially interest rate sensitive, sectors, such as construction, which then need to shrink during the contraction. The reallocation of resources may, in turn, be hindered if the banking sector runs into trouble. All else equal, headwinds would blow most strongly precisely in interest rate-sensitive sectors, where excess capacity would be prevalent. In addition, ultralow interest rates could retard the welcome reallocation of resources to higher productivity sectors and firms. For instance, unless their balance sheets are quickly repaired, weakly capitalised, loss-averse banks would have an incentive to keep afloat weaker borrowers (extend and pretend) and curtail or increase the cost of credit for healthier ones – so-called "zombie lending" (see below).[8]

The strength of some of the mechanisms outlined above will depend on country-specific characteristics. Of special relevance is the structure of debt contracts and their impact on deleveraging pressures. For instance, the higher the share of the debt stock that is at variable rates and more sensitive to the short-term rate, the bigger the impact on debt servicing costs and cash flows and hence the boost to spending. Shorter maturities are helpful here, as are refinancing options, which allow borrowers to cut the net present value of their debt despite its fixed-rate long-maturity character.[9] Similarly, non-recourse loans allow over-indebted borrowers to reduce the burden, thereby reducing the need to cut their spending. For these reasons, for instance, the US mortgage market may be more sensitive to monetary stimulus than some of its European counterparts, such as Spain's.

Non-linearities linked to the level of interest rates

There are a number of possible channels through which persistently low interest rates might themselves sap the effectiveness of monetary policy. These include their impact on (i) bank profitability and hence credit supply; (ii) consumption and saving; (iii) expectations and confidence; and (iv) resource misallocation.

Net interest margins, bank profitability and bank lending

Low *nominal* interest rates can harm bank profitability. Under quite general conditions, low *short-term* interest rates sap net interest income through the "endowment effect". Retail bank deposits are typically priced as a markdown on market rates, generally reflecting some form of oligopolistic power and transaction services. As a result, as rates decline, this markdown narrows and the benefit from this relatively cheap funding source shrinks. This is because banks are reluctant to reduce deposit rates below zero, even when the policy rate crosses that barrier. The effect is

[8] For conceptual analyses of banks' decisions to charge-off loans, or to engage in zombie lending, see eg Lepetit et al (2011) and Bruche and Llobet (2014).

[9] However, lower collateral values post-crisis, possibly in combination with tighter lending standards such as lower loan-to-value ratios, may limit the effectiveness of refinancing options.

non-linear: it becomes stronger at very low rates.[10] Intuitively, as deposit rates hit zero, any further reduction in the short-term rate would affect returns on the asset side without any impact on the cost of retail deposits.[11] The impact of low short-term rates is compounded if policy also compresses long rates and hence the *slope of the yield curve*, eroding the returns from maturity transformation (borrowing short and lending long). A compression of the term premium is especially costly.[12]

The negative effects of low interest rates on net interest income are counterbalanced by positive effects on other components of profits. Lower interest rates reduce loan loss provisions, as they reduce borrowers' debt service costs and default probabilities. They also increase non-interest income by boosting securities' valuations. Thus, the overall effect of low rates on bank profitability is unclear *a priori*. However, the net effect of *persistently* low rates would likely be negative. This is because net interest income is usually the largest single component of bank profits and because the impact of lower rates on net interest income is long-lasting while that on the other components is only temporary,[13] or at least wanes over time. This helps to explain, for instance, the very negative response of bank stocks to markets' perceptions that interest rates would stay lower for longer in January 2017 (BIS (2017)).

A negative impact of low rates on bank profitability can mitigate the effectiveness of monetary policy. It may inhibit loan supply, which depends positively on banks' capitalisation and hence on profits – retained earnings are the main source of capital accumulation. For example, based on a stylised general equilibrium model, Brunnermeier and Koby (2016) show that the negative effect of lower rates on banks' net interest margins can give rise to a "reversal interest rate" – the level of the rate at which accommodative monetary policy becomes contractionary. In their model, this level could even be positive and depends on structural features of the economy and the financial system.

Consumption and saving

Conventional consumption theory suggests that low real interest rates depress saving and boost consumption through intertemporal substitution. When the real interest rate is low, the returns from postponing consumption to the future are also low, so that current consumption should increase (substitution effect). This reasoning is the cornerstone of the standard Euler consumption equation – the consumption demand-block of modern DSGE models.[14]

[10] Borio et al (2015a) illustrate the non-linearity based on a version of the Monti-Klein model (equation A12 in the Appendix).

[11] The endowment effect was a big source of profits at high inflation rates and when competition within the banking sector and between banks and non-banks was very limited, such as in many countries in the late 1970s. It has again become quite prominent, but operating in reverse, post-crisis, as interest rates have become extraordinarily low.

[12] While the impact on the riskless curve is temporary, that which reflects a compression of the term premium is permanent. See, eg Borio et al (2015) and Dietrich and Wanzenried (2012).

[13] The capital gains on securities holdings would actually be reversed if the securities were held to maturity (and would not even show in the income statement in that case); the impact on loan provisions would be much longer lasting. At the same time, the low carrying costs of non-performing loans could delay balance sheet repair, weighing on profitability.

[14] See Woodford (2003, Chapter 4) for a discussion of how consumption depends on the expected future path of real interest rates in textbook New Keynesian models.

In more general settings, interest rates may also affect consumption through income/cash-flow and wealth effects. In particular, there is also a redistribution channel of monetary policy through its impact on incomes and/or cash flows (La Cava et al (2016)). Lower interest rates mean lower interest payments for borrowers to the extent that loans are at adjustable rates or can be refinanced. But they also mean lower interest payments for lenders. While these channels are in essence redistributive, they can give rise to first-order effects in the aggregate whenever borrowers have higher marginal propensities to consume than lenders, as typically assumed (Tobin (1982), Auclert (2016)). Clearly, the strength of the redistribution channel will also depend on the structural features of credit markets. For instance, the redistribution to borrowers will be greater if debt contracts have adjustable rates (Garriga et al (2016)).

If interest rates are persistently low, additional expected income effects may kick in. If agents become concerned that the low return on saving will persist and render their envisaged lifetime savings insufficient to ensure an adequate standard of living after retirement, they may step up saving, and reduce consumption, to compensate for the shortfall (White (2012), Hannoun (2015)). To be sure, in principle this effect should operate *regardless* of the level of interest rates. But it may become much more visible and prominent when interest rates are unusually and persistently low. For instance, concerns with the viability of pension funds or much less remunerative life insurance saving products can hammer home the need for higher saving for retirement. As a result, the effect of low rates on consumption may diminish and even reverse as rates drop to very low levels. That said, while this argument is often brought up in the public debate, we are not aware of a formalisation of this point in a theoretical model of consumption and saving.

A possible countervailing force relates to wealth effects, linked to the boost that lower interest rates give to asset prices.[15] Standard asset pricing theory suggests that changes in real interest rates should actually have a *larger* impact on asset prices when real interest rates are low.[16] As a result, the corresponding wealth effects on consumption (and possibly investment) would be *stronger* in a low rate environment. Of course, such a countervailing force would tend to be weaker during recoveries from a balance sheet recession, given heightened risk aversion and initial overvaluation.[17]

Finally, just as in the case of bank lending, nominal interest rates may matter quite independently of real rates. In addition to cash flow effects, agents may exhibit "money illusion", so that their behaviour is influenced by nominal magnitudes regardless of changes in the price level. [18] In this case, the potential non-linearities

[15] Under "wealth effects" we also include the indirect effect on the relaxation of borrowing constraints through the use of assets as collateral.

[16] This follows from the standard dividend discount model.

[17] Of course, wealth effects will tend to benefit disproportionately wealthier households, which should have a lower propensity to consume. See Domanski and Zabai (2016) for a review of the implications of wealth inequality for monetary policy in light of cross-country differences in the distribution and form of wealth.

[18] If the agent prefers the outcome with a higher nominal income but the same real income, then he/she is said to suffer from "money illusion" (Fisher (1928)). For a discussion of the concept of money illusion and the related evidence, see Borio and Zabai (2016).

linked to the various effects on consumption would apply to nominal, rather than real, rates.

Uncertainty

While monetary expansions usually appear to attenuate uncertainty and risk perceptions (Bekaert et al. (2013), Hattori et al (2016)), persistently very low rates could have adverse effects on expectations and confidence. If central banks push rates to levels that are unusually low by historical standards, agents might interpret this as signalling dark economic prospects, acting as a countervailing force against the usual stimulus.[19] The effect could also operate through pension funds and insurance companies: prominent public discussions about the risk of underfunding for defined-benefit pension schemes[20] and, possibly, about insurance companies' viability, could raise concerns about their ability to honour previous commitments to ensure post-retirement consumption.

Here, too, nominal interest rates may play a special role. Insurance companies' contracts, and their guaranteed returns, are typically set in nominal terms. The discounting of pension fund liabilities varies, but stickiness in long-term assumptions about inflation and wage growth would tend to heighten the impact of changes in nominal rates. And here, in contrast to the impact on asset prices, the effect on the value of the *liabilities* would actually increase at lower rates. [21]

Resource misallocation

Persistently low interest rates may also create disincentives to address a debt overhang and resource misallocation, fostering what has been graphically called a "zombification" of the economy. The best known channel here works through the banking sector. Low rates reduce the perceived need for banks to clean up their balance sheets. They tend to encourage banks to roll over rather than charge-off non-performing loans in a number of ways. Lower rates increase the expected recovery from non-performing loans by reducing the discount factor.[22] And they reduce the

[19] The problem of such negative confidence effects counteracting the intended expansionary effects of low rates was discussed in the context of central bank forward guidance. The economic news element of interest rate forward guidance was referred to as Delphic forward guidance (the central bank acting as an oracle) and the policy accommodation element was referred to as Odyssean forward guidance (the central bank providing information about the mast it ties itself to in order to withstand the call of the sirens). This taxonomy was originally proposed by Campbell et al (2012). Specifically calendar-based forward guidance where the guidance applies to a clearly specified time horizon, was seen as being potentially less effective due to too strong a Delphic element.

[20] The underfunding of pension funds could also erode investment, by reducing firms' profits and their cash flow. These effects would kick-in only at very low rates, and exhibit non-linearities.

[21] Theoretically, there may also be adverse effects on inflation expectations and ultimately on actual inflation, according to the so-called "Neo-Fisherian" perspective (Cochrane (2015), Bullard (2015)) which emphasises the long-term relationship between nominal interest rates and inflation. If interest rates are too low compared to the prevailing rate of inflation, the long-run relationship would normally be restored by adjustments in the interest rate to counter rising inflationary pressures. However, if such inflationary pressures cannot build up, e.g. because of high central bank credibility, the adjustment could also be brought about by a drop in inflation expectations and ultimately inflation itself.

[22] Specifically, the decisions to charge off or roll over will depend on how the expected repayments from the loan compare with the liquidation value, typically the collateral value. So, for a given collateral value, higher discounted repayments can induce more banks to decide to roll over a larger

opportunity cost of carrying non-performing loans on the balance sheet, as the returns from alternative investments, and the cost of funding the bad loans, are low. All this saps banks' intermediation capacity, as rolled over bad loans crowd out new lending for more productive borrowers. In turn, this can complicate the prudential authorities' task of identifying and resolving weak institutions, in concert with other policymakers. [23]

As in some of the other cases, nominal rates may have a prominent role to play. This is because they influence banks' funding costs and are commonly used in the discounting of non-performing loan recovery values, and also because some loan covenants become less effective when interest rates, and hence contractual repayments, are very low. In general, distinguishing viable from less viable business becomes harder.

2. The evidence

Testing the hypothesis of reduced effectiveness at persistently low rates faces a number of challenges.

To start with, assessing the effectiveness of monetary policy requires disentangling its effects from those of other factors driving the macroeconomy. The coexistence of persistently low interest rates and economic weakness is in itself no proof of policy ineffectiveness. Monetary policy may be as effective as ever, but its power may be masked by the depressed conditions. Put differently, the apparent reduced effectiveness may just be spurious if the countervailing forces are not controlled for. This, of course, is a familiar identification issue. But it may be especially hard to resolve when economic conditions are particularly depressed or unusual, as during a balance sheet recession, and when the central bank resorts to multiple instruments in addition to the policy rate, such as large-scale asset purchases, confounding the signal.

In a similar vein, and for similar reasons, even if policy is indeed less effective, it is difficult to disentangle the reasons. In particular, is it because of the headwinds that coincide with low rates or because of inherent non-linearities linked to the level of the rates? True, one might be able to shed further light on this issue by focusing on specific channels based on more granular data (eg, the banks' profit-lending nexus, or the impact on resource misallocation). Even so, this would still leave open the relevance of the detected effect at the aggregate level.

In what follows we provide a selective review of the extant evidence. Two main strands of empirical literature can be distinguished: (i) studies assessing the role of headwinds in monetary transmission, but which could also capture effects coming from inherent non-linearities; (ii) studies that focus on specific channels, such as the

part of their bad loans, in particular in crisis times when the market for collateral can be depressed and illiquid. See Lepetit et al (2011) for a formal analysis.

[23] Another potential channel is of a more political economy nature: persistently and unusually low rates can make it less pressing for policymakers to address the structural root causes of protracted weak economic performance. Structural reforms in the real economy or needed fiscal consolidation are possible examples.

impact of low rates on bank profitability and through this on credit supply, non-linearities in the impact on consumption, and on resource misallocations.

Headwinds

In the wake of the GFC, a growing literature has assessed whether financial crisis-related headwinds influence the effectiveness of monetary policy. Since periods of financial stress are usually also periods of low interest rates, this literature also speaks to the question of whether transmission is different when rates are low, albeit only indirectly.

As already mentioned, one has to differentiate between different phases of a financial crisis and balance sheet recession. Monetary policy is probably more effective than usual in the acute phase of a crisis, but less effective in the recovery phase. This conjecture seems to be borne out by the empirical evidence, for both conventional monetary policy (i.e. for the policy rate) and unconventional monetary policy (i.e. monetary policy measures working through instruments other than the policy rate, in particular large-scale asset purchases).

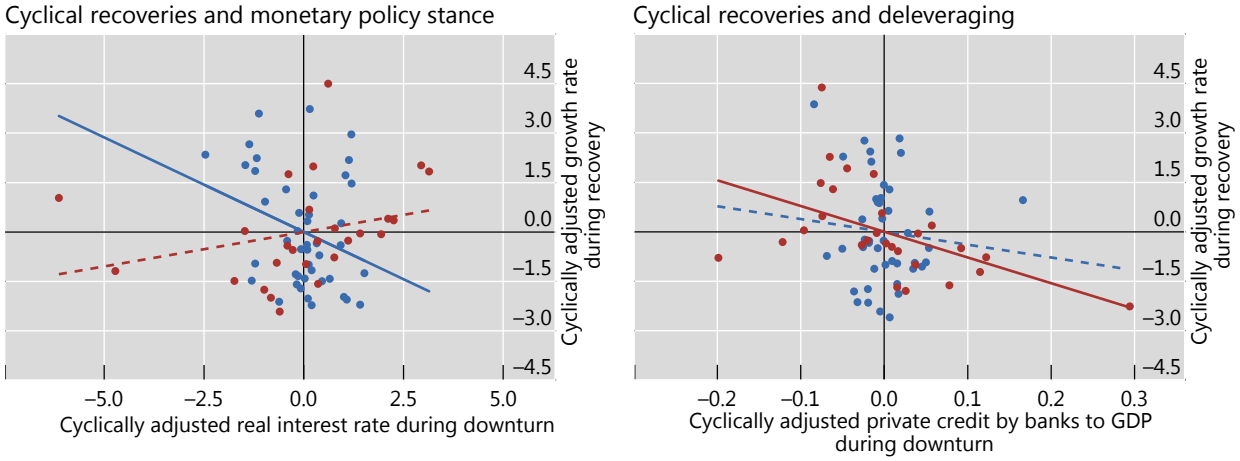
A number of recent studies have found that conventional monetary policy has stronger effects in periods of financial stress. Ciccarelli et al. (2013) suggest that the estimated effects of a monetary policy shock in the euro area increase when the GFC period (2007-2011) is added to their sample. More generally, Dahlhaus (2016) finds that the effect of a monetary policy shock in the United States is larger in periods of financial stress than otherwise. This result is confirmed by Jannssen et al (2015) for a sample of 20 advanced economies based on panel VAR analysis. They find that the impact of monetary policy in the acute phases of a financial crisis is larger than in normal phases. These results are consistent with the notion that monetary policy might be more effective in the acute phase of a financial crisis by reducing uncertainty and tail risks. That said, the mechanisms through which higher policy effectiveness during crises works remain untested.

At the same time, there is evidence that monetary policy is less effective in the recovery from a balance-sheet recession, presumably reflecting the effects of persistent headwinds and possibly low rates themselves. Jannsen et al (2015) allow for three different phases in the analysis of monetary policy effectiveness: a normal phase, a crisis phase and a crisis recovery phase. While, as noted, they find stronger transmission during crises than during normal phases, their analysis also suggests that monetary policy has essentially no macroeconomic effects during the recovery from a financial crisis. This finding is consistent with previous BIS research. Based on a sample of 24 economies, Bech et al (2014) find that across countries lower real interest rates during "normal" business cycle downturns are followed by stronger cyclical recoveries, but that there is essentially no statistically significant link between real rates and recovery strength after downturns associated with financial crises (Graph 4, left-hand panel). Instead, deleveraging seems to be the key factor determining the speed of recovery (Graph 4, right-hand panel). Overall, these results support the relevance of balance-sheet related headwinds reducing monetary policy effectiveness once the acute crisis phase is over.

Monetary policy, deleveraging and economic recoveries[1]

In per cent

Graph 4



[1] The solid (dashed) regression lines indicate that the relationship is statistically significant (insignificant). For a sample of 24 economies since the mid-1960s. Downturns are defined as periods of declining real GDP and recoveries as periods ending when real GDP exceeds the previous peak. The data cover 65 cycles, including 28 cycles with a financial crisis just before the peak. Data points for cycles are adjusted for the depth of the preceding recession and the interest rate at the cyclical peak. See Bech et al (2014) for details.

Sources: M Bech, L Gambacorta and E Kharroubi, "Monetary policy in a downturn: are financial crises special?", International Finance, vol 17, Spring 2014, pp 99–119 (also available in BIS Working Papers, no 388, at www.bis.org/publ/work388.pdf); OECD; Datastream; national data; BIS calculations.

Other studies directly test for the impact of specific types of headwinds, in particular debt overhang and heightened uncertainty.[24] Specifically, Alpanda and Zubairy (2016) find for the United States that monetary transmission is weaker in states where household debt is relatively high, reflecting in their view the attenuating effect of deleveraging motives. Bloom et al (2007) show for the United Kingdom that higher uncertainty, measured through stock return volatility, proxying financial headwinds more generally,[25] significantly reduces the responsiveness of investment to demand conditions, which in turn depend on the monetary policy stance. Similarly, Aastveit et al (2013) find that in the United States the monetary transmission to real output is weaker when uncertainty (also measured through stock volatility) is high. They interpret this result as reflecting the impact of uncertainty on investment, but

[24] There is a somewhat related literature considering asymmetries in monetary transmission depending on the direction of the monetary impulses. This literature tends to find larger effects of monetary contractions compared to expansions. Angrist et al (2013) find that U.S. policy rate hikes have larger effects on the economy than rate cuts. Similarly, Barnichon and Matthes (2016) and Tenreyro and Thwaites (2016) suggest that monetary policy shocks have larger effects in expansions than recessions. All these studies interpret their findings as reflecting the well-known string metaphor: that it is harder for monetary policy to push on a string than to pull it because of the headwinds prevailing in situation when monetary policy is loosened. And there is also a literature on the dependence of monetary transmission on the phase of the business cycle, which however has come out with conflicting findings. While some studies find stronger transmission in recessions (eg Peersman and Smets (2002) and Lo and Piger (2005)), a more recent analysis by Tenreyro and Thwaites (2016) finds the reverse.

[25] See Forbes (2016) for a comparison of different measures of financial and economic uncertainty for the United Kingdom.

acknowledge that also other mechanisms might be at work since the response of consumption drops significantly, too. This suggests that the relationship between uncertainty and monetary transmission may itself be state-dependent: while uncertainty and tail-risk perceptions might be important transmitters of monetary accommodation in crisis phases, heightened uncertainty in general seems to sap monetary policy effectiveness.

Also the literature on the effectiveness of unconventional monetary policies implemented in the wake of the GFC should give some clues about monetary policy effectiveness in environments of persistent headwinds and low interest rates. Indeed, the disappointing recovery from the GFC has raised some doubts about the effectiveness of the programmes, as discussed in BIS (2016). There is by now a large literature assessing the effectiveness of the measures on financial market prices, and a somewhat smaller one investigating the ultimate impact on the macroeconomy (see Borio and Zabai (2016) for an overview). The overall picture is that the measures have been effective in easing monetary conditions by lowering interbank rates, bond yields and credit risk spreads, and, less conclusively, that these effects have also boosted the macroeconomy.

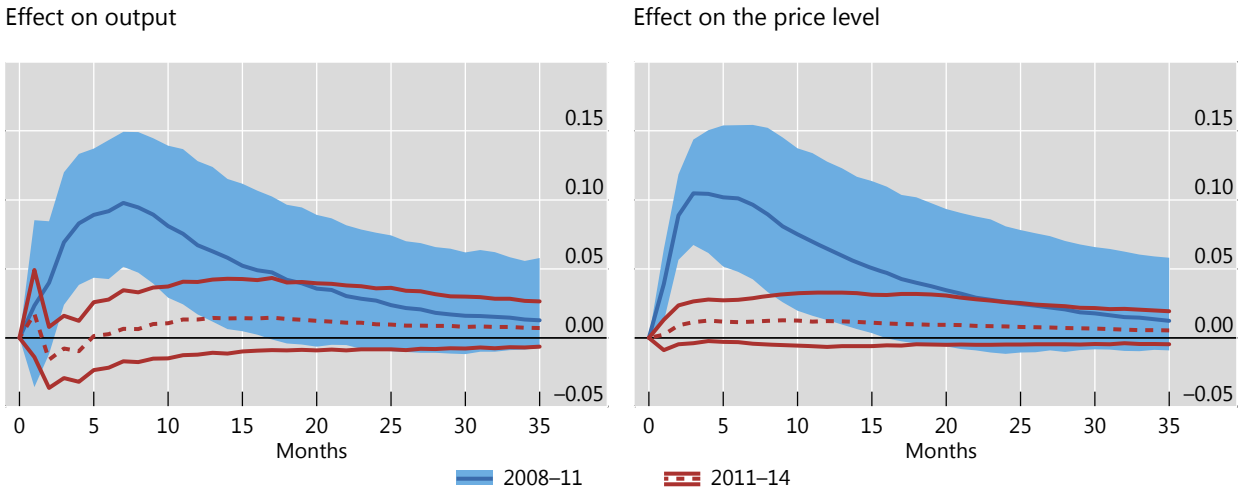
For current purposes, however, the extant studies are less informative than would be desirable. The reason is that they do not specifically test the hypothesis of reduced effectiveness at low rates, but generally tend to assume that previous relationships continue to hold -- be these concerning the link between central bank balance sheets and activity (and hence indirectly interest rates) or that between interest rates and economic activity. One obvious reason is the limited sample size. Indeed, for the time series analysis of the measures' impact on macroeconomic variables the sample period is typically rather short. That said, with now eight years of data available, assessing whether the effects have changed over time is becoming more possible, albeit the results should be taken with a pinch of salt.

In this vein, a recent BIS study by Hofmann and Weber (2017) suggests that, at least for the United States, there is some indication that the effectiveness of large-scale asset purchase (QE) programmes has fallen (Graph 5).[26] The authors find that while an unanticipated increase in LSAP1 and LSAP2 purchases had a significant positive impact on real GDP and the price level, the effects of the same sized shock was not statistically significantly for MEP and LSAP3. Similar evidence is reported in Haldane et al (2016). They find that QE shocks have a significant effect when financial market stress is high, but not when it is low, with the two regimes roughly coinciding with the sample split of Hofmann and Weber (2017). Panizza and Wyplosz (2016) explore the decreasing effectiveness hypothesis for the core advanced economies that implemented large-scale asset purchases (USA, euro area, Japan and UK) also based on sub-sample analysis and come to inconclusive results. For some empirical exercises they find decreasing effectiveness, but for others not.

[26] Specifically, Hofmann and Weber (2017) follow the approach by Weale and Wieladek (2016) and assess the macroeconomic effects of a QE shock in an otherwise standard Bayesian VAR with the QE policy instrument being the cumulated size of asset purchase announcements. A QE shock is identified through a standard Cholesky scheme, ordering asset purchases announcements after GDP and the price level and before the long-term bond yields and real stock prices.

The macroeconomic impact of asset purchase shocks in the United States[1]

In per cent — Graph 5



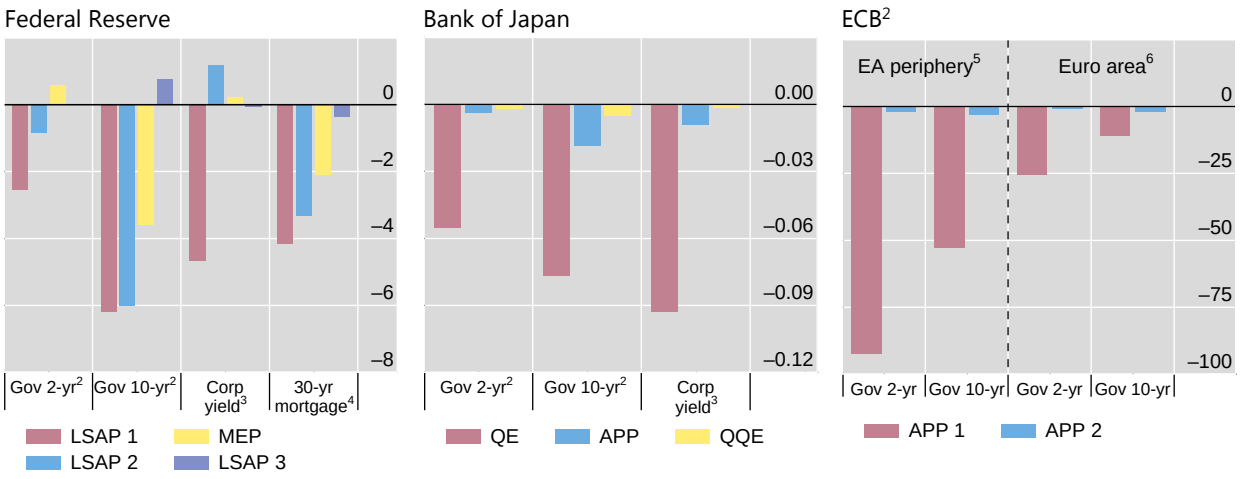
[1] From Hofmann and Weber (2017); impulse responses to the unexpected component of a $100 billion asset purchase announcement in a Bayesian VAR for the United States, consisting of log real GDP, log CPI, the size of the announced asset purchases, the 10-year Treasury yield and the log S&P 500 (the methodology closely follows that of Weale and Wieladek (2016)). Median and the 68% probability range of the impulse responses. The two subsamples considered are November 2008 to June 2011 (covering two large-scale asset purchase programmes, LSAP1 and LSAP2) and July 2011 to October 2014 (covering the maturity extension programme (MEP) and LSAP3).

Sources: B Hofmann and J Weber, "The macroeconomic effects of asset purchases revisited", BIS, mimeo, 2017.

This evidence of potentially reduced effectiveness of unconventional monetary policy may reflect various factors. One possibility is headwinds or inherent non-linearities at low rates. Another may be factors specific to large-scale asset purchases. For instance, such purchases may be most effective when financial markets are segmented and dislocated, so that the authorities' intervention can help alleviate the corresponding distortions. As the distortions vanish over time, effectiveness may diminish. Moreover, there are physiological limits to how far risk premia can be compressed, expectations guided and interest rates pushed into negative territory. Indeed, the consecutive programmes seem to have had a progressively smaller impact on financial market prices (Graph 6). The reduction in bond yields and loan rates per dollar spent in the programme has consistently fallen over time in the G3 economies. To be sure, this might simply reflect the fact that the programmes were increasingly well anticipated in markets. But the alternative possibility cannot be excluded either.

Financial market impact of asset purchase announcements

Impact per 100 billion units of local currency[1] Graph 6



APP = asset purchase programme; LSAP = large-scale asset purchases; MEP = maturity extension programme; QE = quantitative easing; QQE = Quantitative and Qualitative Monetary Easing.

[1] For each programme, the cumulative two-day change in basis points around the announcement dates, divided by the total size of each programme in local currency. For open-ended programmes, divided by the estimated size of the programme assuming an unchanged pace of purchases until December 2017. For terminated programmes, the total amount of purchases at the time of termination. [2] Government bond yields; for the ECB, weighted averages based on rolling GDP and PPP exchange rates of the economies listed in footnotes 5 and 6. [3] Merrill Lynch corporate bond yields. [4] Thirty-year fixed mortgage rate. [5] Greece, Ireland, Italy, Portugal and Spain. [6] Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

Sources: Bank of America Merrill Lynch; Bloomberg; national data; BIS calculations.

In sum, there is evidence that monetary transmission is weaker in recoveries from balance sheet recessions. The conditions identified with weaker transmission are also those that would be expected to be associated with lower interest rates. This is the case for high debt overhangs, the recovery phase after banking crises and, admittedly less specifically, high uncertainty. Thus, the detected asymmetries may at least in part also reflect reduced monetary policy effectiveness when rates are generally low.

Non-linearities linked to the level of interest rates

There is very little analysis on non-linearities in monetary transmission linked to the level of interest rates. The empirical literature is scant for both non-linearities in aggregate relationships and specific channels.

Net interest margins, bank profitability and bank lending

The positive link between interest rates and bank profitability has been long established in the academic literature (eg Samuelson (1945), Flannery (1981) and Hancock (1985)). English (2002) studies the link between interest rate risk and bank interest rate margins in 10 industrialised countries. He finds that, as the average yield on bank assets is more closely related to long-term rates than the average yield on liabilities, a steep yield curve raises interest margins. More recently, Alessandri and Nelson (2015) establish a positive long-run link between the level and slope of the yield curve and bank profitability in the United Kingdom. Genay and Podjasek (2014) also find that persistently low interest rates depress US banks' net interest margin. They also note, however, that the direct effects of low rates are small relative to the

economic benefits, including through better support for asset quality. For Germany, Busch and Memmel (2015) argue that in normal interest rate environments the long-run effect of a 100 basis points change in the interest rate on net interest margins is very small, close to 7 basis points. In the recent, low-interest rate environment, by contrast, they find that banks' interest margins for retail deposits, especially for term deposits, have declined by up to 97 basis points. The Bundesbank's Financial Stability Review of September 2015, analysing 1,500 banks, also finds that persistently low interest rates are one of the main risk factors weighting on German banks' profitability. Analysis for Japan reaches similar conclusions (Deutsche Bank (2013)).[27]

Borio et al (2015) revisit the link between bank profitability and interest rates for a sample of 108 international banks. In contrast to previous studies, they also allow for non-linearities in the relationships, as theory would suggest. They find evidence that, controlling for aggregate demand, a reduction in both short-term interest rates and in the yield curve slope depress return on assets, and that the effect increases at the margin (Graph 7). The estimated impact is significantly larger than in studies that do not allow for non-linearities.[28] Taken at face value, the results indicate that in the sample of banks covered the combined impact was, on balance, positive in the first two years post-crisis (2009–10), by an estimated cumulative 0.3 percentage points, but turned negative in the following four years (2011–14), by 0.6 percentage points, equivalent to one year of profits for the average bank in the sample.

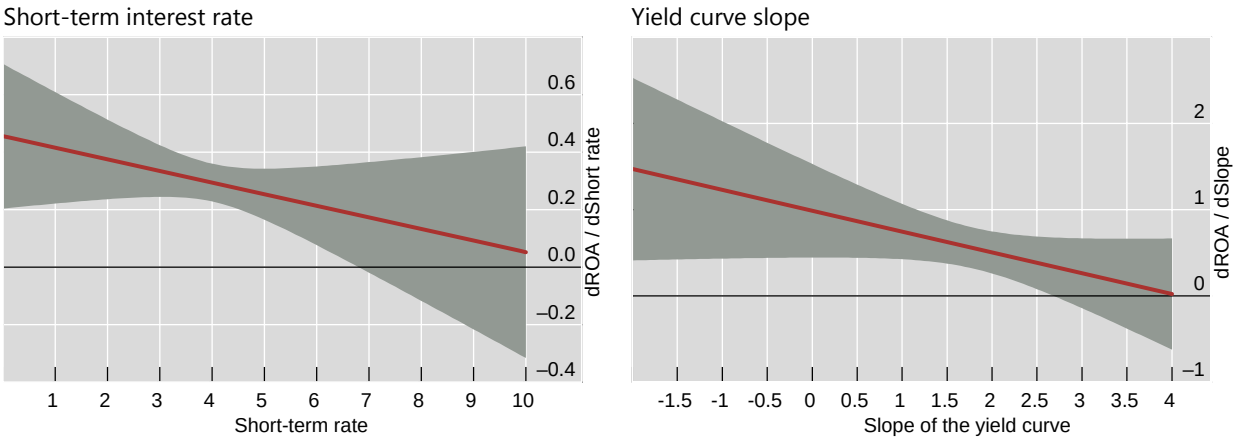
In another recent paper, Claessens et al (2015) confirm the findings of Borio et al (2015) based on a sample of 3,418 banks from 47 countries for the period 2005-2013. They classify countries for each year as being in a low- or high-rate environment based on whether the interest rate on their three-month Treasury bill rate was below or above 1.25 percent (other cut-offs were also tested and yielded similar results). After documenting that both net interest margins and return on assets are on average higher in high-rate environments, based on regression analysis they find that the negative impact of a decrease in the short-term interest rate is larger in low-rate regimes.

[27] Using capital market prices, rather than financial statements, English et al (2012) also find negative effects of low interest rates on bank profitability. In their analysis they find that while equity prices of US banks fall following unanticipated increases in interest rates or a steepening of the yield curve, a large maturity gap weakens this effect. Thus, because of their maturity transformation function, banks gain from a higher interest rate or a steeper yield curve.

[28] Specifically, an increase in the short-term rate from 0% to 1% raises the ROA by 0.4 percentage points over one year, but by only 0.15 percentage points if the rate increases from 6% to 7% (Graph 7, left-hand panel). By contrast, Alessandri and Nelson (2015) find that the (linear) impact is around 0.2 percentage points, and in Genay and Podjasek (2014) 0.1 percentage points. Of course, other aspects of the studies could account for the results. Similar differences apply to the impact of changes in the slope (eg a 1.2 decline in ROA for increases in the slope form -2 to -1 percentages points compared with 0.1–0.7 percentage points in linear specifications). Here, however, comparisons are even harder, given the different slope measures used in the literature.

Effect of the short-term interest rate and the slope of the yield curve on bank profitability

Graph 7



Note: The horizontal axis shows respectively possible values for the level of the short-term interest rate (three month interbank rate) and the slope of the yield curve (the difference between the 10-year government bond and the three-month interbank rate, in percentage points). The vertical axis shows the derivative of bank profitability (return on assets) respectively with respect to the short-term rate and the slope. The shaded area indicates 95% confidence bands.

Source: Authors' calculations.

These findings suggest that, over time, bank capital is negatively affected by lower rates and that the impact is larger when rates are low. This could then also inhibit credit expansion if the supply of credit is capital-constrained, especially given that banks are generally reluctant to raise capital externally. The results reported in Gambacorta and Shin (2016) suggest that higher bank capital is indeed associated with greater lending, and that the mechanism involved in this channel is the lower funding costs associated with better capitalised banks.[29]

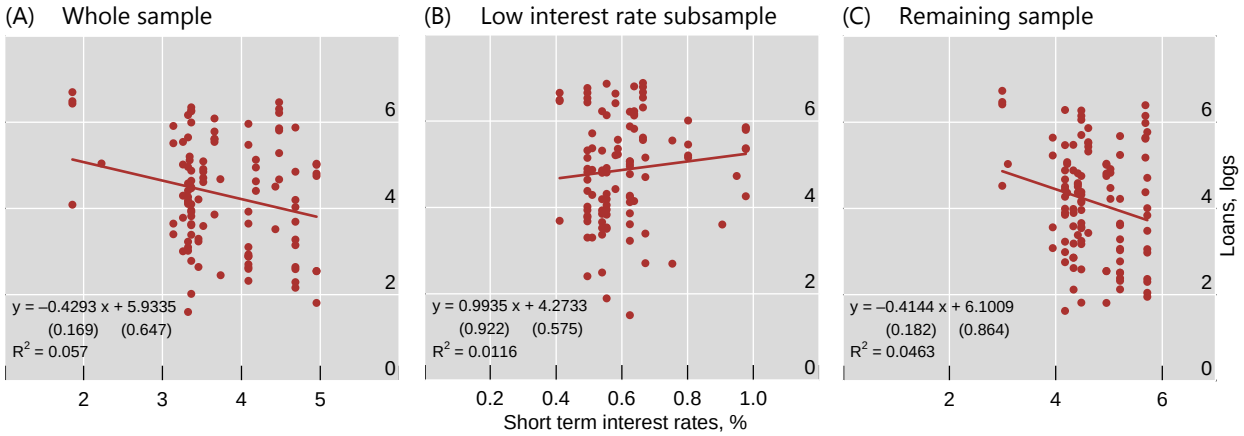
Borio and Gambacorta (2017) directly address the question of the impact of low interest rates on banks' extension of loans. They find evidence that lending becomes less responsive to reductions in short-term rates when interest rates are already low. Graph 8 conveys this point in a simple way based on raw data. The chart plots the average log level of lending to the non-financial sector of the 108 internationally active banks against the average short-term interest rate that each bank has faced in the jurisdictions in which it operates. The usual negative link between lower rates and bank loans (left-hand and right-hand panels) is not apparent at very low rates (middle panel) – in fact, the relationship switches sign. Borio and Gambacorta (2017) find that the pattern suggested by Graph 8 also holds after controlling for business and financial cycle conditions and different bank-specific characteristics, such as liquidity, capitalisation, funding costs, risk and income diversification. Importantly, it also holds

[29] A positive association between bank capitalisation and bank credit supply had already been found in previous studies, eg by Albertazzi and Marchetti (2010), who show that credit contraction in Italy in the wake of the GFC was driven by weak bank capitalisation. Michelangeli and Sette (2016) use a novel dataset constructed from randomised applications to online mortgage brokers to show that better capitalised banks lend more. Also the results reported in EBA (2015) suggest that better capitalised banks are in a better position to expand lending.

when financial crises are controlled for. And it operates through the impact of lower rates on net interest margin. A simple back-of-the-envelope calculation suggests that the reduction of net interest income caused by the low interest rate environment could explain one third of lending dynamics in the period 2010-2014. [30] To be sure, any such result should not be taken at face value. And fully controlling for the various influences, including weakness in loan demand, is not straightforward. But the results do suggest that the effect could be material and worth exploring further.

Overall, therefore, there is evidence that persistent low levels of interest rates compress net interest margins and bank profitability, and that such a negative effect on bank profitability may in turn inhibit lending. How relevant this effect is for aggregate macroeconomic outcomes remains on open question.

Semi-elasticity of bank lending to the short-term interest rate[1] Graph 8



[1] Scatter plots of the average level of lending (in logs) against the level of the short-term interest rate for a group of 108 international banks; the interest rate is the average for the currencies in which each bank obtains funding. The dots thus refer to semi-elasticities. The left-hand panel covers the whole sample (1995–2014); the centre panel only periods in which the average interest was very low (last quartile of the distribution, below 1.25 percentage points); and the right-hand panel the rest of the sample. Standard errors are shown in brackets.

Sources: BankScope; authors' calculations.

Consumption and saving

A screening of the literature reveals that work on possible non-linear interest rate effects on consumption and saving when interest rate are very low is very limited.

Recently, ING reported the results from an IPSOS survey that seeks to shed some light on this question. The survey asked 13,000 consumers from Europe, the United States and Australia how their saving behaviour has changed in response to low interest rates and, going forward, how they might react to negative interest rates (ING (2016), see also Cliffe (2016) for a summary)). According to this survey, 31% of

[30] Borio and Gambacorta (2017) suggest that the result may reflect the impact of lower rates on the profitability of the lending business. If capital is perceived as scarce, banks would have an incentive to allocate it towards the activities that are more profitable at the margin. And lower interest rates could have a larger effect on the profitability of this activity relative to, say, mergers and acquisitions or trading. Any such impact would be even larger at the margin if the banks operated under some minimum profit constraint (eg, so as to remain attractive to investors while seeking to maximise some managerial objective).

respondents had changed their behaviour, including possibly only their portfolio decisions. Of those that did, some 38% said they had decreased saving but as much as 17% said that they had in fact *increased* theirs, with the rest mainly changing asset allocation only. This indicates the possibility of adverse effects at very low rates, although it is silent about how behaviour would have changed at higher rates.

Recent BIS research explores possible non-linearities in the consumption-interest rate nexus further through formal panel-econometric analysis. Specifically, Hofmann and Kohlscheen (2017) estimate reduced-form regressions linking real consumption growth to the level of the interest rate.[31] The analysis is based on annual data for a panel of 31 countries over the period 1995-2015. Non-linearities are modelled through piece-wise regressions, allowing the interest rate semi-elasticity to vary across different interest rate level thresholds.[32]

The results yield two main insights. First, interestingly, real consumption growth seems to be linked to the level of *nominal* rates rather than *real* rates, pointing to the empirical relevance of money illusion or specific transmission channels working through or proxied by the nominal interest rate.[33] Second, there is evidence that interest rate elasticity of consumption growth increases with the level of the interest rate (Graph 9, left-hand panel). The elasticity rises from -0.3 for the full set of observations to above -1.2 when only observations with a nominal rate above 5% are included. The non-linearity also carries over to aggregate output growth, albeit in this case it is weaker and is not statistically significant owing to large confidence bands, suggesting that the non-linearity mainly works through consumption (Graph 9, right-hand panel).

These findings could be interpreted as indicating a flattening of the IS curve at low rates. However, the non-linearities detected at such an aggregate level cannot shed light on the underlying mechanisms. They might reflect specific non-linearities in the effect of interest rates on consumption when interest rates are low arising through the channels discussed before. Yet, just like the studies testing the role of headwinds may pick up effects coming through low rates, the detected lower interest rate elasticity at low levels of interest rates may likewise partly reflect the effects of headwinds, as the two mechanisms cannot be clearly disentangled in empirical analysis of aggregate relationships.

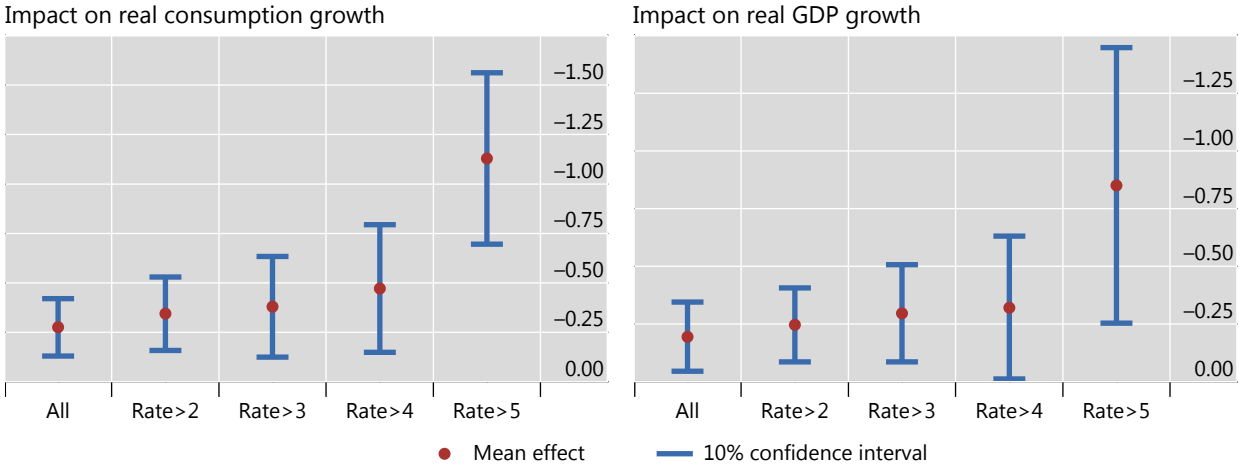
[31] There is a voluminous empirical literature on the Euler equation for consumption, testing the intertemporal elasticity of substitution in consumption. Establishing a link between consumption and real interest rates has turned out to be difficult and to require modifications to the baseline model of intertemporal consumption optimisation, such as allowing for consumption habits, hand-to-mouth consumers and wealth effects. See Ascari et al (2016) for a review and an empirical assessment of the various extensions of the baseline consumption Euler equation for the United States.

[32] The controls included in the regressions comprise country- and time fixed effects as well as real GDP growth, real house and stock prices increases, the level of per capita income, the credit-to-GDP ratio and the dependency ratio.

[33] One important transmission channel for the nominal rate is the debt service ratio, defined as the ratio of interest obligations to income which is directly influenced by the nominal interest rate. Recent studies have found a significant negative link between the debt-service ratio and consumption growth (Kharroubi and Kohlscheen (2017)), which would also be picked up by the nominal interest rate elasticity of consumption growth. Another reason could be that the short-term nominal rate proxies for the ex-ante long-term real interest rate, as suggested by Fuhrer and Moore (1995).

Interest rate semi-elasticity of consumption and GDP growth[1]

In percentage points — Graph 9



[1] Estimated semi-interest rate elasticities from reduced-form empirical Euler equations linking real consumption and real GDP growth to the level of the nominal short-term interest rate. The analysis is based on annual data for a panel of 31 countries over the period 1995-2015. Non-linearities are modelled through piece-wise regressions, allowing the interest rate semi-elasticity to vary across different interest rate level thresholds.

Source: Hofmann and Kohlscheen (2017), mimeo, Bank for International Settlements.

Resource misallocation

The empirical literature on possible resource misallocation at very low interest rates typically finds evidence of these mechanisms at work. Caballero et al (2008) find that after the asset price crash of the late 1980s/early 1990s, Japanese banks kept credit flowing to otherwise insolvent borrowers (i.e. zombies) through forbearance lending and that the market congestion created by the zombies reduced the profits for healthy firms, depressing investment, employment growth and productivity. A recent study by the OECD suggests that such zombification is a more general phenomenon since the mid-2000s. Specifically, Adalet McGowan et al (2017) show that "zombie" firms, ie. old firms that have persistent problems meeting their interest payments, are stifling labour productivity performance, because they are themselves less productive and because they constrain the growth of more productive firms. This paper suggests that the rise of the zombies has probably been a key factor behind weak investment and low productivity growth in the OECD countries over this period, and that forbearance lending has probably been a channel through which zombie firms contribute to the productivity slowdown.

There is, however, only scant *specific* econometric evidence on the role that very low interest rates play in this context. The bank-level regressions reported by Lepetit et al (2011) indicate that banks' loan charge-offs significantly increase with the level of short-term interest rates, consistent with the prediction of their theoretical analysis. Similarly, Borio et al (2015a) find that the interest rate sensitivity of loan loss provisions increases at low rates, which could reflect evergreening. But in both cases the link between interest rates and loan charge-offs could also reflect other mechanisms, notably the impact of monetary conditions on default probabilities through aggregate demand.

Closely related evidence on possible misallocations comes from a recent paper by Acharya et al (2016), who study the effects of the ECB's Outright Monetary Transactions (OMT) announcement. The paper finds that banks that benefited from the announcement (through the revaluation of their sovereign bond holdings) increased their overall loan supply, but that this supply was mostly targeted towards low-quality firms with pre-existing lending relationships with these banks. There was, however, no positive impact on real economic activity, such as on employment or investment, as these firms mainly used the newly acquired funds to build up cash reserves. The paper further documents that creditworthy firms in industries with a prevalence of zombie firms suffered significantly from the credit misallocation, which slowed down the economic recovery.

Conclusion

This review suggests that both conceptually and empirically there is support for the notion that monetary transmission is less effective when interest rates are persistently low. Lower effectiveness can arise for two main reasons: (i) headwinds that typically blow in the wake of balance sheet recessions, when also interest rates are low (eg debt overhangs, an impaired banking system, high uncertainty, resource misallocations); and (ii) inherent non-linearities linked to the level of interest rates (eg impact of low rates on banks' profits and credit supply, on consumption and saving, including through possible adverse confidence effects, and on resource misallocations). The review of the existing empirical literature suggests that the headwinds during the recovery from balance-sheet recessions can significantly reduce monetary policy effectiveness. There is also evidence that lower rates have a diminishing impact on consumption and on the supply of credit. Importantly, these results point to an independent role for *nominal* rates, regardless of the level of real (inflation-adjusted) rates.

Our review revealed that the relevant theoretical and empirical literature is much scanter than one would have hoped, in particular given that periods of persistently low interest rates have become more frequent and longer-lasting. While there are appealing conceptual arguments suggesting that monetary transmission may be impaired when rates are low, many of these have not been formalised through rigorous theoretical modelling. And the extant empirical work is limited, both geographically and in scope. For instance, most studies assessing changes in transmission in low rate environments focus on the United States. Similarly, there is hardly any work assessing specific mechanisms. The field is wide open and deserves further exploration, not least given the first-order policy implications.[34]

[34] This paper will not explore the policy implications of the analysis. But a possible one is that policymakers should pay closer attention than hitherto to the financial cycle, ie boom-bust cycles in credit and asset markets that then usher in balance sheet recessions and persistent low interest rates. See Borio (2014a,b) for a more detailed exposition of this view and the review papers prepared for this conference on the link between low interest rates and financial instability (Laeven (2017)) and on the leaning-against-the-wind debate (Dell'Arricia (2017)).

References

Aastveit, K, G Natvik and S Sola (2013): "Economic uncertainty and the effectiveness of monetary policy," *Norges Bank Working Papers*, no 2013/17.

Acharya, V., T. Eisert, C. Eufinger and C. Hirsch (2016): "Whatever it takes: The real effects of unconventional monetary policy", *mimeo*, New Yok University.

Adalet McGowan, M, D Andrews and V Millot (2017): "The walking dead? Zombie firms and productivity performance in OECD countries", *OECD Economics Department Working Papers*, no 1372.

Albertazzi, U and D Marchetti (2010): "Credit supply, flight to quality and evergreening: an analysis of bank-firm relationships after Lehman", Bank of Italy, *Temi di discussione*, no 756.

Albertazzi, U, A Nobili and F Signoretti (2016): "The bank lending channel of conventional and unconventional monetary policy", Bank of Italy, *Temi di discussione,* no 1094.

Alessandri, P and B Nelson (2015): "Simple banking: profitability and the yield curve", *Journal of Money Credit and Banking*, vol 47, no 1, pp 143–75.

Alpanda, S and S Zubeiry (2016): "Household debt overhang and transmission of monetary Policy", *mimeo,* Texas A&M University.

Amato, J and T Laubach (2004): "Implications of habit formation for optimal monetary policy", *Journal of Monetary Economics*, vol 51, no 2, pp 305-325.

Angrist, J, O Jórda and G Kuersteiner (2013): "Semiparametric estimates of monetary policy effects: String theory revisited", *NBER Working Papers*, no 19355.

Ascari, G, L Magnusson and S Mavroeidis (2016): "Empirical evidence on the Euler equation for consumption and output in the US", *mimeo*, University of Oxford.

Auclert A (2016): "Monetary policy and the redistribution channel", *mimeo*, Stanford University.

Barnichon, R and C Matthes (2016): "Gaussian mixture approximations of impulse responses and the non-linear effects of monetary shocks", *mimeo*, Federal Reserve Bank of San Francisco.

Bech, M, L Gambacorta and E Kharroubi (2014): "Monetary policy in a downturn: are financial crises special?", *International Finance*, vol 17, no 1, pp 99–119.

Bekaert, Geert, Marie Hoerova, and Marco Lo Duca. 2013. "Risk, uncertainty and monetary policy", *Journal of Monetary Economics*, vol 60, no 7, pp 771–88.

Bernanke, B (1983): "Irreversibility, uncertainty, and cyclical adjustment", *Quarterly Journal of Economics*, vol 98, no 1, pp 85–106.

Bank for International Settlements (BIS) (2016): *86th Annual Report*, Basel.

Bank for International Settlements (BIS) (2017): Overview, *BIS Quarterly Review*, March 2017.

Bloom, N, S Bond, and J van Reenen (2007): "Uncertainty and investment dynamics", *Review of Economic Studies,* vol 74, no 2, pp 391–415.

Borio, C (2014a): "The financial cycle and macroeconomics: what have we learnt?", *Journal of Banking & Finance*, vol 45, August, pp 182–98. Also available as *BIS Working Papers*, no 395.

Borio, C (2014b): "Monetary policy and financial stability: what role in prevention and recovery*?", Capitalism and Society*, vol 9, no 2, article 1, pp 1–27. Also available as *BIS Working Papers*, no 440.

Borio, C and L Gambacorta (2017): "Monetary policy and bank lending in a low interest rate environment: diminishing effectiveness?", *BIS Working Paper*s, no 612.

Borio, C, L Gambacorta and B Hofmann (2015a): "The influence of monetary policy on bank profitability", forthcoming in *International Finance* (also available as *BIS Working Papers,* no 514).

Borio, C, E Kharroubi, C Upper and F Zampolli (2015b): "Labour reallocation and productivity dynamics: financial causes, real consequences", *BIS Working Papers*, no 534, December.

Borio, C, M Lombardi and F Zampolli (2016), "Fiscal sustainability and the financial cycle", *BIS Working Papers*, no 552.

Borio, C and A Zabai (2016): "Unconventional monetary policies: a re-appraisal", *BIS Working Papers,* no 570.

Bruche, M and G Llobet (2014): Preventing Zombie Lending, *Review of Financial Studies*, vol 27, no 3, pp 923-956.

Brunnermeier, M and Y Koby (2016): "The "reversal interest rate": An effective lower bound on monetary policy", *mimeo*, Princeton University.

Buch, C, S Eickmeier and E Prieto (2014): "In search for yield? Survey-based evidence on bank risk taking," *Journal of Economic Dynamics and Control*, Elsevier, vol 43(C), pp 12-30.

Bullard, J (2015): "Permazero", speech given at the Cato Institute–33rd Annual Monetary Conference on " Rethinking Monetary Policy", Washington, D.C., Nov. 12, 2015.

Busch, R and C Memmel (2015): "Banks' net interest margin and the level of interest rates," *Deutsche Bundesbank Research Centre Discussion Papers*, no 16.

Caballero, R, T Hoshi and A Kashyap (2008): "Zombie lending and depressed restructuring in Japan", *American Economic Review*, vol 98, pp 1943–77.

Campbell, J, C Evans, J Fisher and A Justiniano (2012): "Macroeconomic effects of Federal Reserve forward guidance", *Brookings Papers on Economic Activity*, Spring, Issue 1, pp 1–80.

Campbell, J and G. N. Mankiw (1989): "Consumption, income, and interest rates: Reinterpreting the time series evidence," in O Blanchard and S Fisher (eds): *NBER Macroeconomics Annual*, pp 185-216, MIT Press, Cambridge, MA.

Ciccarelli, M, A Maddaloni, and J-L Peydró (2013): "Heterogeneous transmission mechanism: monetary policy and financial fragility in the Eurozone", *Economic Policy,* vol 28, no 75, pp 459–512.

Claessens S, N Coleman and M Donnelly (2016): "Low-for-long" interest rates and net interest margins of banks in advanced foreign economies", *IFDP Notes*, April.

Cliffe, M (2016): "Negative rates, negative reactions", Vox blogpost, 26 February 2016.

Cochrane, J (2015): "Do higher interest rates raise or lower inflation?", *mimeo*, University of Chicago Booth School of Business.

Dahlhaus, T (2016): "Conventional monetary policy transmission during financial crises: An empirical analysis", forthcoming, *Journal of Applied Econometrics*.

Deaton, A (1991): "Saving and liquidity constraints," *Econometrica*, vol 59, pp 1221-48.

Dell'Arricia, G (2017): "An overview of the leaning against the wind debate", paper presented at the Reserve Bank of Australia conference "Monetary Policy and Financial Stability in a World of Low Interest Rates", 16-17 March 2017, Sidney.

Di Maggio, M, A Kermani and R Ramcharan (2015): "Monetary policy pass-through: Household consumption and voluntary deleveraging," *Society for Economic Dynamics 2015 Meeting Papers,* no 256.

Diamond, D and R Rajan (2011): "Fear of fire sales, illiquidity seeking, and credit freezes", *Quarterly Journal of Economics*, vol 126, pp 557-591.

Dietrich, A and G Wanzenried (2011): "Determinants of bank profitability before and during the crisis: evidence from Switzerland", *Journal of International Financial Markets, Institutions and Money*, vol 21, issue 3, pp 307–27.

Dixit, A (1992): "Investment and hysteresis", *Journal of Economic Perspectives*, vol 6, no 1, pp 107-132.

Dixit, A and R Pindyck (1994): "Investment under uncertainty", Princeton University Press.

Domanski, D and A Zabai (2016): "Wealth inequality and monetary policy", *BIS Quarterly Review*, March 2016.

Drehmann, M and M Juselius (2015): "Leverage dynamics and the real burden of debt", *BIS Working Papers*, no 501.

Dynan, K (1993): "How prudent are consumers?," *Journal of Political Economy,* vol 101, pp 1104-13.

English, W (2002): "Interest rate risk and bank net interest margins", *BIS Quarterly Review*, December, pp 67-82.

English, W, S van den Heuvel and E Zakrajsek (2012): "Interest rate risk and bank equity valuations", *Finance and Economics Discussion Series*, 2012–26, Board of Governors of the Federal Reserve System.

European Banking Authority (EBA) (2015): "2015 EU-wide transparency exercise - Aggregate report".

Ferrari, M, J Kearns and A Schrimpf (2017): Monetary shocks at high-frequency and their changing FX transmission around the globe, forthcoming, *BIS Working Papers*.

Fisher, I (1928): *The money illusion*, Longmans: Toronto.

Flannery, M (1981): "Market interest rates and commercial bank profitability: An empirical investigation", *Journal of Finance,* vol 36, pp 1085-102.

Forbes, K (2016): "Uncertainty about uncertainty", speech at J.P. Morgan Cazenove "Best of British" Conference, London, 23 November 2016.

Fuhrer, J and G Moore (1995): "Monetary policy trade-offs and the correlation between nominal interest rates and real output", *American Economic Review*, vol 85, pp 219–39.

Gambacorta, L (2009): "Monetary policy and the risk-taking channel," *BIS Quarterly Review*, December, pp 43-53.

Gambacorta L and P Mistrulli (2004): "Does bank capital affect lending behaviour?", *Journal of Financial Intermediation*, vol 13, pp 436-57.

Gambacorta, L and H S Shin (2016): "Why bank capital matters for monetary policy", *BIS Working Papers*, no 558.

Garriga, C, F Kydland and R Sustek (2016): "Nominal rigidities in debt and product markets", *NBER Working Papers*, no 22613.

Genay, H and R Podjasek (2014): "What is the impact of a low interest rate environment on bank profitability?", *Chicago FED Letter*, no 324, July.

Haldane, A, M Roberts-Sklar, T Wieladek and C Young (2016): "QE: the story so far", *Bank of England Staff Working Papers*, no 624.

Hancock, D (1985): "Bank profitability, interest rates, and monetary policy", *Journal of Money, Credit and Banking*, vol 17, pp 189-202.

Hannoun, H (2015): "Ultra-low or negative interest rates: what they mean for financial stability and growth", remarks at the Eurofi High-Level Seminar, Riga.

Hattori, M, A Schrimpf and V Sushko (2016): "The response of tail risk perceptions to unconventional monetary policy", *American Economic Journal: Macroeconomics*, vol 8, no 2, pp 111-36 (also published as *BIS Working Papers*, no 425).

Hofmann, B and E Kohlscheen (2017): "Consumption and interest rates: A cross-country analysis", *mimeo*, Bank for International Settlements.

Hofmann, B and E Takats (2015): "International monetary spillovers", *BIS Quarterly Review*, September 2015.

Hofmann, B and J Weber (2017): "The macroeconomic effects of asset purchases revisited", *mimeo*, Bank for International Settlements.

Holmstrom, B and J Tirole (1997): "Financial intermediation, loanable funds, and the real sector", *Quarterly Journal of Economics*, vol 112, pp 663-691.

Iacoviello, M and S Neri (2010): "Housing market spillovers: Evidence from an estimated DSGE model," *American Economic Journal: Macroeconomics*, vol 2, pp 125-163.

ING (2016): "Negative rates, negative reactions", ING Economic and Financial Analysis.

Jannsen, N, G Potjagailo and M Wolters (2015): "Monetary policy during financial crises: Is the transmission mechanism impaired?", *Kiel Working Papers*, no 2005, Kiel Institute for the World Economy (IfW).

Jimenez, G, S Ongena, J-L Peydro and J Saurina (2012): "Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications," *American Economic Review*, vol 102, no 5, pp 2301-26.

Jordà, O, M Schularick and A Taylor (2016): "Sovereigns versus banks: Credit, crises, and consequences", *Journal of the European Economic Association*, vol 14, no 1, pp 45-79.

Jordà, O, M Schularick, and A Taylor (2017): "Macrofinancial history and the new business cycle facts", in M Eichenbaum and J Parker (eds): *NBER Macroeconomics Annual 2016*, vol 31, University of Chicago Press.

Kharroubi, E and E Kohlscheen (2017): "Consumption-led expansions", *BIS Quarterly Review*, March 2017.

Koo, R (2009): *The holy grail of macroeconomics - Lessons from Japan's Great Recession*, John Wiley & Sons (Asia).

La Cava, G, H Hughson and G Kaplan (2016): "The household cash flow channel of monetary policy", *Reserve Bank of Australia Research Discussion Papers*, no 2016-12.

Laeven, L (2017): "An examination of whether low interest rate environments are linked with financial instability", paper presented at the Reserve Bank of Australia conference "Monetary Policy and Financial Stability in a World of Low Interest Rates", 16-17 March 2017, Sidney.

Lepetit, L, F Strobel and D Dickinson (2011): "Does uncertainty matter for loan charge-offs", *Journal of International Financial Markets, Institutions and Money*, vol 22, pp 264-277.

Lo, M and J Piger (2005): "Is the response of output to monetary policy asymmetric? Evidence from a regime-switching coefficients model", *Journal of Money, Credit and Banking*, vol 37, no 5, pp 865–886.

Mian, A and A Sufi (2015): *House of debt*, University of Chicago Press.

Michelangeli, V and E Sette (2016): "How does bank capital affect the supply of mortgages? Evidence from a randomised experiment", *BIS Working Papers*, no 557.

Mishkin, F (2009): "Is monetary policy effective during financial crises?", *American Economic Review*, vol 99, no 2, pp 573-77.

Obstfeld, M (2015): "Trilemmas and trade-offs: living with financial globalisation", *BIS Working Papers*, no 480.

Panizza, U and C Wyplosz (2016): "The folk theorem of decreasing effectiveness of monetary policy: What do the data say?", paper prepared for the 17th J. Polak Annual Research Conference (IMF).

Peersman, G and F Smets (2002): "Are the effects of monetary policy in the euro area greater in recessions than in booms?", in L. Mahadeva and P. Sinclair (eds): *Monetary Transmission in Diverse Economies*, Chapter 2, pp 28–48. Cambridge University Press.

Peersman, G and W Wagner (2015): "Shocks to bank lending, risk-taking, securitization, and their role for U.S. business cycle fluctuations," *CEPR Discussion Papers*, no 10547.

Reinhart, C and K Rogoff (2009): *This time is different: Eight centuries of financial folly*, Princeton University Press.

Samuelson, P (1945): "The effect of interest rate increases on the banking system." *American Economic Review*, vol 35, pp 16-27.

Skinner, J (1988): "Risky income, life cycle consumption, and precautionary savings," *Journal of Monetary Economics*, vol 22, pp 237-255.

Tenreyro, S and G Thwaites (2016): "Pushing on a string: US monetary policy is less powerful in recessions", *American Economic Journal: Macroeconomics*, vol 8, no 4, pp 43-74.

Tobin, J (1982): "Asset accumulation and economic activity: Reflections on contemporary macroeconomic theory", University of Chicago Press.

Weale, M and T Wieladek (2016): "What are the macroeconomic effects of asset purchases?", *Journal of Monetary Economics*, vol 79, pp 81-93.

White, W (2012): "Ultra easy monetary policy and the law of unintended consequences", *Globalization and Monetary Policy Institute Working Papers*, no 126, Federal Reserve Bank of Dallas

Woodford, M (2003): *Interest and prices: Foundations of a theory of monetary policy*, Princeton University Press: Princeton.