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The Consequences of Low Interest Rates for the Australian Banking Sector

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This paper is an updated version of a paper that was commissioned for the RBA's 2022 annual conference on 'The Causes, Challenges and Consequences of the Low Interest Rate Environment'. Some preliminary work investigating the 'reversal rate' in Australia was conducted with Peter Rickards as part of previous research; I am very grateful for the head start this preliminary work gave me when putting this paper together. I am grateful to Luci Ellis, Rachael Fitzpatrick, Jonathan Hambur, Michelle Lewis, Matthew Read, Adam Richardson, Maxwell Sutton, John Simon, Graham White and participants at the RBA's 2022 annual conference for useful feedback and suggestions. Views expressed in this paper are those of the author and not necessarily those of the Reserve Bank of Australia. The author is responsible for any errors.

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Abstract

There is a vast international literature exploring the consequences of low interest rates for various banking sectors. In this paper, I explore how this international literature relates to the Australian banking sector, which operates differently to other jurisdictions. In the face of low rates, the profitability of Australian banks has likely been less adversely affected than what the international literature would predict, but the flip side to this is that the pass-through of monetary policy to lending rates may have been more muted. I then use a recent advance in macrofinancial modelling to explore whether pass-through in Australia could turn negative – the so called 'reversal rate' – and find that the features of the Australian banking system mean a reversal rate is highly unlikely to exist in Australia.

JEL Classification Numbers: E43, E52, G21

Keywords: banking, interest rates, monetary policy

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1. Introduction

Banks are complex. People tend to think of them as sources of credit and repositories for their savings. But banks also hold debt securities and reserves at central banks, borrow in wholesale funding markets, provision for losses on their assets, and must meet regulatory requirements. So there are many channels through which low interest rates could affect how banks operate.

In this paper, I'll examine the vast international literature that explores the consequences of low interest rates for various banking sectors. Because there are multiple channels through which these consequences might arise, and because some of these channels might operate differently in Australia, I'll structure my discussion around the various components of Australian banks' balance sheets.

Australia's major banks – accounting for more than three-quarters of bank loans in Australia – maintained a fairly stable spread between their lending rates and their costs of debt (including deposits) funding as the cash rate fell towards zero. Compression of these spreads is one of the key mechanisms highlighted in the literature that can adversely affect bank profitability at low rates, and results from competition with lenders less reliant on deposit funding and the tendency for the yield curve to flatten as rates approach zero.[1] Therefore, the lack of spread compression evidence in Australia suggests Australian banks' profitability has likely not declined as much as the international literature would predict.[2]

Low rates can still affect profitability even when spreads remain constant. Banks' net interest margins (NIMs) – the difference between their interest income and interest expenses (as a share of assets) – will fall with interest rates if spreads remain constant. This occurs because some of banks' assets are funded by equity. So as the returns on these assets fall, so does the return on this equity (all else equal). Australian banks are affected by this part of the profitability channel just as the international literature predicts.

The combination of stable spreads and a deposit lower bound would result in monetary policy pass-through becoming more muted at low interest rates. The apparent stability of spreads in Australia therefore suggests the pass-through of monetary policy to lending rates may have been more muted than what would be predicted by the literature. Previous estimates suggest that if the cash rate were to fall 25 basis points from zero per cent, the deposit lower bound would cause only 20 basis points of this to feed through to lending rates (Brassil, Major and Rickards 2022).

But 'lower than predicted' pass-through does not necessarily mean pass-through in a low-rate environment is lower overall. If the economy is in the midst of a banking crisis, monetary policy

1 Retail deposit interest rates have a lower bound around zero, due to the possibility of holding physical currency instead.

2 On the other hand, Australian banks do not benefit from the transitional profitability boost predicted by the literature. This is because most loans in Australia are variable rate, and Australian banks tend to hedge any residual interest rate risk.

pass-through temporarily becomes higher than normal.[3] To the extent that banking crises become more frequent in a low-rate world (due to increased risk-taking, for example), this suggests that pass-through will more frequently be amplified.

Outside of banking crises, however, pass-through tends to be lower at low rates. This raises a key question for central banks. Does lower pass-through mean they should move policy rates by more or less? If the central bank is solely focused on achieving its current inflation and unemployment objectives, the answer is surely more. But if the central bank has other considerations, such as financial stability, then the answer is not as clear.

There is, however, a situation in which the answer is a clear 'the central bank should do no more', and that is if the economy has reached its 'reversal rate'. The reversal rate is the point at which any further reduction in the central bank's policy rate will cause banks to increase their lending rates, such that policy rate reductions become counterproductive. Such a rate was famously theorised by Brunnermeier and Koby (2018). But with scant evidence of this rate actually being reached in any jurisdiction, and the theoretical existence of this rate being highly model dependent, there remains considerable uncertainty about both the level of the rate and its determinants (if it exists at all).

With the new banking sector addition to MARTIN (Brassil *et al* 2022) – henceforth, BA-MARTIN – it is possible to investigate whether a reversal rate can exist in Australia, and if it can, what determines its existence. BA-MARTIN is more detailed than the highly stylised model of Brunnermeier and Koby (2018), thereby enabling exploration of both the reversal rate theorised by Brunnermeier and Koby and additional channels that might lead to a reversal rate.

The Brunnermeier and Koby (2018) reversal rate does not currently exist in Australia. This is because, unlike banks in some other jurisdictions, Australian banks tend to have more liabilities that follow wholesale market interest rates than they hold as assets (e.g. debt securities and reserves).[4] Holding lending rates constant following a cash rate reduction would therefore prevent any NIM reduction and would prevent any change to credit demand; if zero pass-through is enough to prevent capital ratio deterioration, there can be no Brunnermeier and Koby reversal rate.

However, this wholesale market funding opens another potential reversal rate channel not explored by Brunnermeier and Koby (2018); the possibility that banks' creditors may deem banks' responses to further capital deteriorations as insufficient, and as a result require additional compensation to provide continued funding (i.e. a risk premium increase). If this risk premium increase offsets the cash rate reduction by a sufficient amount, lending rates would increase. While this is theoretically possible in Australia, I show that it would require an extreme and highly unlikely scenario in which banks remain below their target capital ratio for an extended period of time, they remain excluded from external equity markets for this entire period, and there is no regulatory/government policy

3 This occurs because more expansionary monetary policy lowers banks' loan losses (both by reducing the frequency of default and the loss given default), thereby improving banks' profitability and, in turn, moderating any credit supply reduction implemented by the banks. While the effect of policy on loan losses is not unique to crises, banks are assumed to reduce credit supply only when their capital falls below desired levels (Brassil *et al* 2022; Garvin *et al* 2022). This amplified pass-through is only temporary because losses return to more normal levels once the economy stabilises.

4 In general, the recent increase in reserve holdings associated with the RBA's unconventional policies has not altered this fact.

response that alleviates the problem despite the effect such a scenario would be having on the Australian economy.

In the remainder of this paper, Section 2 briefly sets the scene by explaining what is typically meant by the 'low interest rate environment'. Section 3 will explore the literature through the lens of banks' balance sheets. Given all the ways the Australian banking system differs from some of the major international systems, Section 4 will explain what the Australian banking system's features mean for the pass-through of monetary policy at low rates, and provide some quantitative estimates. Section 5 will then investigate the reversal rate in Australia. Section 6 will conclude by discussing some policy implications and avenues for future research.

2. The Low Interest Rate Environment

Before exploring the consequences of low interest rates, a brief digression to frame what is typically meant by the 'low interest rate environment'. Rather than referring to rates that are temporarily low, the low interest rate environment typically refers to a situation in which interest rates are expected to remain low for an extended period. This low-rate environment is typically discussed in reference to the 'neutral' interest rate – loosely defined as the *real* policy interest rate that will endure once all temporary (i.e. business cycle) shocks have worked their way through the economy. With a constant inflation target, if the neutral rate is low by historical standards, the nominal policy rate will also tend to be lower than has historically been the case.

A stylised fact common across advanced economies is that the neutral rate is estimated to have fallen significantly from the mid-20th century (Holston, Laubach and Williams 2017). The rate of descent may have slowed in the late 20th century, but has returned in earnest since the turn of the century (or just before). Common explanatory factors include the ageing population, productivity slowdowns, rising income inequality, increased public debt and increased risk aversion. A recent study with a model that nests most of these explanations suggests that they all have an important role to play in the United States (Platzer and Peruffo 2022). Moreover, these authors predict only a small increase in the future neutral rate from its current level to around 1 per cent, which is still 3 percentage points below the level estimated for 1950.

The neutral rate in Australia is estimated to have followed a similar profile to other advanced economies. Estimates suggest the neutral rate in Australia fell from over 3 per cent in the early 1990s to around 1 per cent around the mid-2010s (McCririck and Rees 2017). Recent updates of this work suggest the neutral rate in Australia recently fell further, to around zero per cent (Saunders 2022), before increasing back towards 1 per cent (Ellis 2022). Therefore, even though short-term interest rates are expected to continue their upward trajectory in the near term, it behoves us to learn from the recent period of low interest rates given the high probability that they will return at some point in the future.

A feature of neutral rates that is particularly important for the analysis in this paper is that, all else equal, neutral rates tend to fall when the spreads banks set between their lending rates and the policy rate increase (because it is the rates people pay that ultimately matter for economic activity). Given that increases in these spreads – caused by increases in the difference between banks' debt funding costs and the policy rate (Brassil, Cheshire and Muscatello 2018) – are suggested to explain much of the decline in Australian neutral rates following the global financial crisis (McCririck and

Rees 2017), changes in the interest rates borrowers are expected to pay in the long run may be more muted than what is suggested by the recent fall in the neutral rate. Conversely, the relatively stable neutral rate estimated for the mid-1990s to mid-2000s may have underestimated the fall in long-run expected borrowing rates as lending spreads declined significantly following deregulation of the financial sector (RBA 2014).

3. The Literature through the Lens of Banks' Balance Sheets

Following Brassil *et al* (2018), a bank's balance sheet can be split into the components over which it has little control over pricing (henceforth, 'non-discretionary') and those over which it has some pricing power (henceforth, 'discretionary'). Components could be non-discretionary because the bank is a price-taker in the relevant market (e.g. wholesale debt funding markets) or because its determinants are mostly outside the control of the bank (e.g. losses on outstanding loans). Table 1 shows a stylised version of a bank's balance sheet split into non-discretionary and discretionary components. The remainder of this section will look at how low interest rates might affect each part of banks' balance sheets and will explore the domestic and international evidence.

Table 1: Stylised Balance Sheet

	Assets	Funding
Non-discretionary	Central bank deposits	Low-interest retail deposits
	Securities	Wholesale debt[(b)]
	Losses[(a)]	Wholesale deposits[(c)]
Discretionary	Loans	High-interest retail deposits
		Equity

Notes: (a) Losses subtract from the value of assets. I define 'losses' as including any provisions for expected losses.
(b) Examples include bonds, certificates of deposit, bank bills, asset-backed securities, and hybrid securities.
(c) Deposits of corporations, pension funds, and governments.

In Australia, more than 60 per cent of the major banks' funding comes from domestic deposits. And of this, just under half are owned by households (Fitzpatrick, Shaw and Suthakar 2022). The non-major banks have a slightly lower share of domestic deposit funding (around 55 per cent on average).

3.1 Non-discretionary

3.1.1 Low-interest retail deposits

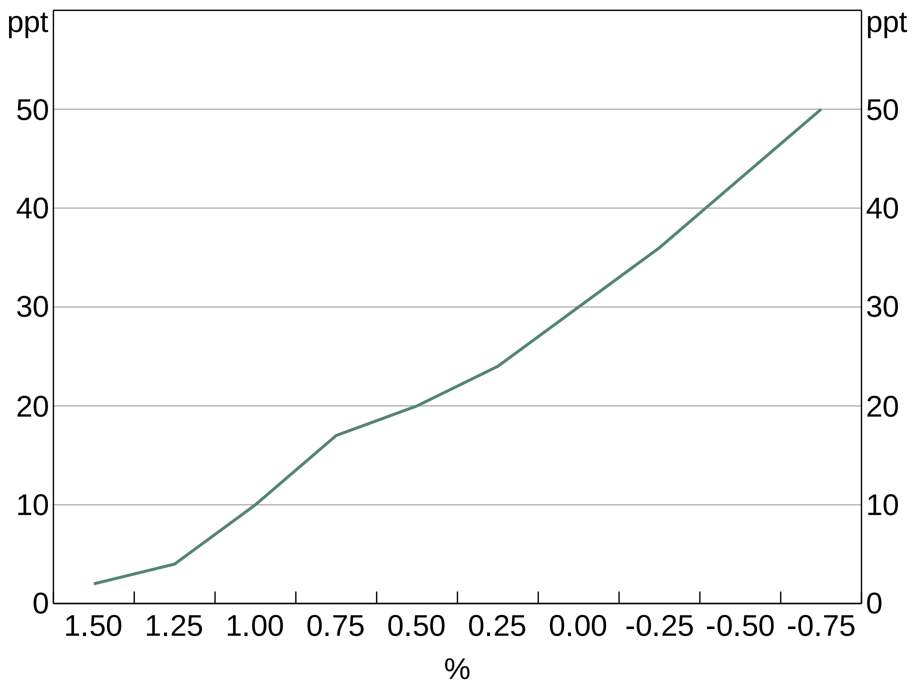
If the interest rates banks paid on the deposit accounts of households and small businesses went sufficiently negative, these savers may choose to instead hold their liquid assets in physical currency. This risk tends to prevent banks from reducing the interest rates on these accounts too far below zero; the interest rates on these accounts effectively have a lower bound.

Deposit accounts pay a range of interest rates. Some accounts always pay rates close to zero, while others typically pay some spread above the cash rate (or expected future cash rates). Therefore, as the level of interest rates falls, an increasing share of banks' deposit accounts will hit the effective lower bound (ELB). Once these rates hit the ELB, any further reductions in the cash rate will not be passed through to these accounts. As a result, when the level of interest rates is low, the spread between banks' cost of deposit funding and the cash rate can increase with further reductions in the cash rate.[5]

For Australian banks, estimates from Brassil *et al* (2022), based on data from Garner and Suthakar (2021), suggest that it is once the cash rate falls below 1.5 per cent that the share of deposits at the ELB begins to increase (Figure 1). Brassil *et al* (2022) further show that the effect this ELB has on the pass-through of monetary policy is significant; at a cash rate of zero, the ELB would cause only 20 basis points of any subsequent 25 basis point reduction to be passed through to banks' debt (including deposits) funding costs.

Figure 1: Estimated Cumulative Increase in Share of Deposits at the Lower Bound

By cash rate level



Source: Brassil, Major and Rickards (2022)

The international evidence on the existence of a retail deposit ELB is consistent with the Australian evidence. In jurisdictions with a negative policy rate, retail deposit interest rates remained close to zero (albeit negative). In Denmark, where the policy rate was –50 basis points or lower between 2015 and 2022, banks only introduced negative rates on large retail deposit balances (Kuchler, Spange and Krogstrup 2020). While in the euro area, only 5 per cent of retail deposits faced negative rates by the end of 2020 (Altavilla *et al* 2022).

In some jurisdictions, banks have increased fees to offset the cost of the ELB (CGFS 2019). To date, there is no evidence of Australian banks increasing fees to compensate for the deposit rate ELB (Sparks and Garner 2021).

5 While some of this interest rate risk can be temporarily hedged, via a 'replicating portfolio' (see Brassil *et al* (2018)), these hedges at best delay the spread expansion.

3.1.2 Wholesale debt and deposits

Wholesale debt and deposits are less likely to have an ELB near zero. This is because the values of these bank debts/deposits are typically much larger than retail deposits, making the cost for the creditor/depositor of storing an equivalent volume of physical currency, and the associated increased transaction costs, sufficiently prohibitive that physical currency is not a cost-effective substitute at small negative interest rates.

The international experience with negative interest rates is consistent with this assumption. In the euro area, 35 per cent of non-financial corporate deposits paid negative rates of interest by 2020 (Altavilla *et al* 2022), with the equivalent share in Denmark being three-quarters (Kuchler *et al* 2020). International evidence suggests complete pass-through of negative policy rates to money market rates (CGFS 2019).

The Australian experience with low (but positive) rates has been similar to the international experience. Australian banks' wholesale debt and deposit funding is typically either directly referenced to bank bill swap rates (BBSW) or hedged to these rates (Fitzpatrick *et al* 2022). And there has been full pass-through of policy rate changes to BBSW (Aziz *et al* 2022).

3.1.2.1 Unconventional policies typically used at low interest rates

While the cash rate target has remained above zero in Australia, the RBA implemented several unconventional policies designed to stimulate the economy. These unconventional policies are typically used by central banks when interest rates are low, and so should be considered a part of the central bank's toolkit at low rates.

The Term Funding Facility (TFF) provided banks with a source of funding that was significantly cheaper than issuing bonds of the same maturity (Graph 10 in Fitzpatrick *et al* (2022)). Banks therefore issued fewer bonds in favour of borrowing directly from the RBA via the TFF. In addition to the direct effect on banks' costs of funding, the lower bond issuance reduced the supply of banks' bonds, thereby lowering yields on the bonds that were issued during 2020–21 (Fitzpatrick *et al* 2022).

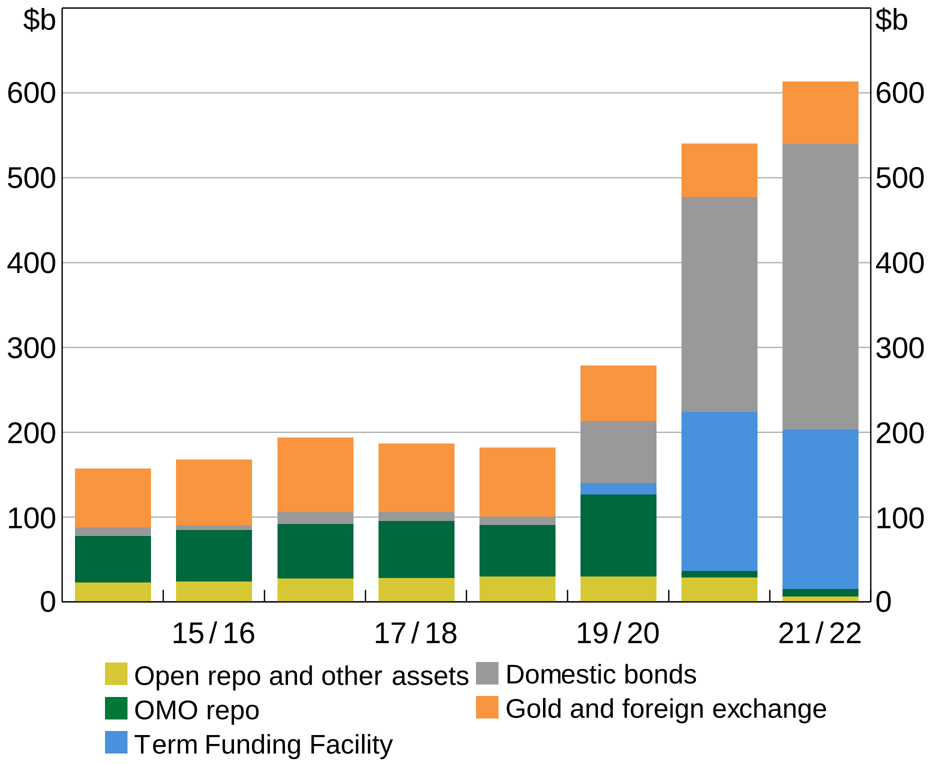
The quantitative easing measures implemented by the RBA partially operated through a 'portfolio rebalancing' channel that would further reduce the cost of bond issuance (CGFS 2019; Finlay, Titkov and Xiang 2022). Moreover, to the extent that bank debt is perceived as riskier than government debt, the purported 'search for yield' behaviour of investors at low interest rates would have further reduced banks' costs of funding (Simon 2015).

The RBA's unconventional policies were able to reduce the major banks' funding costs by a sufficient amount that the deleterious effect of the retail deposit ELB was (potentially more than) offset (Fitzpatrick *et al* 2022). Therefore, over the decade to 2021, the major banks' overall costs of debt funding fell by a similar amount to the cash rate, even though the pass-through of cash rate changes to these funding costs was more muted.

3.1.3 Central bank deposits

Central bank deposits in Australia are remunerated at a rate that moves with the cash rate target. If these central bank deposits are funded by liabilities with interest rates that also move with the cash rate, then banks' net income from holding central bank deposits does not necessarily change at low interest rates. This was the case during the pre-COVID-19 period in Australia, when deposits held at the RBA were mostly funded by short-term repurchase agreements and foreign exchange swaps (Dowling and Printant 2021) (Figure 2).

Figure 2: RBA Assets



Source: RBA

Unconventional policies implemented during COVID-19 changed how central bank deposits are funded. Central bank deposits are now mostly funded by selling government bonds to the RBA, and the TFF (Dowling and Printant 2021). In turn, these policies increased the value of banks' deposit funding (Fitzpatrick *et al* 2022). As a result, the lower pass-through of monetary policy to retail deposit rates lowers the net income from holding central bank deposits as the cash rate falls.

Several jurisdictions that have implemented negative interest rates have offset this reduced net income by implementing a 'tiered' reserves system, whereby only a subset of central bank deposits are remunerated at the negative rate (Fuhrer *et al* 2021; Hack and Nicholls 2021).

3.1.4 Securities

As with wholesale debt and deposits, the pass-through of policy rate changes to newly purchased securities is expected to be no different at low interest rates. The market value of fixed-coupon securities already held by banks will also change as interest rates change, leading to two channels through which lower interest rates could affect the banking sector.

The first is the capital gains banks would receive from these securities as interest rates fall. According to the theoretical model of Brunnermeier and Koby (2018), these capital gains provide a valuable, albeit one-off, boost to banks' profits that staves off the drastic changes in their lending behaviour that are due to net income reductions from their lending operations. Such an effect was found in an empirical analysis of euro area banks (Altavilla, Boucinha and Peydró 2018).

The second channel is interest rate risk. As the level of interest rates falls, the duration – broadly defined as the sensitivity of a bond's price to interest rate changes – of fixed-interest securities increases. The neutral rate (discussed in Section 2) is typically modelled as a random walk with constant shock variance. Assuming this is a reasonable characterisation of the behaviour of the neutral rate, then for a given asset portfolio, the combination of higher duration and constant neutral interest rate volatility means the long-run interest rate risk of the securities held by banks is higher when the level of interest rates is lower.[6] Unlike the one-off capital gains during the transition, this higher interest rate risk persists as long as the average level of rates remains low, and could require banks to hold more capital.

These channels are likely to be small in Australia, as Australian banks' holdings of fixed-income securities in their trading books amount to only 3 per cent of their assets (RBA 2022).

3.1.5 Losses

When assessing the effect of low interest rates on banks' loan losses, it is helpful to distinguish between economic downturns (that may become more frequent and/or severe in a low-rate world), and the new low-rate steady state.

3.1.5.1 Economic downturns

Holding interest rates constant, an economic downturn increases losses. Business revenues will fall, unemployment will increase and property prices will fall, all of which reduce both the ability of borrowers to repay their loans and the values of the assets these loans are secured against. Recent Australian studies exploring the quantitative relationship between macroeconomic outcomes and loan losses include Hess, Grimes and Holmes (2009), Bilston, Johnson and Read (2015), Rodgers (2015), Cummings and Durrani (2016), Brassil *et al* (2018), Bergmann (2020), Kearns, Major and Norman (2020) and Garvin *et al* (2022).

The easing of monetary policy that results from the central bank responding to the macroeconomic deterioration reduces losses (relative to a counterfactual in which interest rates were not lowered). The policy easing increases aggregate demand, thereby increasing business revenues and property prices, and reducing unemployment. In Australia, with variable-rate loans more common than fixed-rate loans, the policy easing also directly reduces borrowers' interest payments, thereby improving

6 While banks could offset this increased risk on their balance sheet by actively managing their portfolio, if this increased risk is already 'priced in', then banks would still bear some cost of the increased risk.
This long-run interest rate risk differs from higher frequency interest rate volatility (i.e. the volatility of rates around neutral). The volatility of bond prices at these higher frequencies does not appear to depend on the level of rates (Simon 2015).

their ability to repay their loans (this direct channel is not a feature of US and some European jurisdictions with high shares of long-term fixed-rate loans).

For the period 2002–17, Brassil *et al* (2018) found that a 100 basis point reduction in the cash rate reduced the major banks' annual loss provisioning rates by 7 basis points. While this may seem small, when compared with an average annual provisioning rate of just 23 basis points during this period, monetary policy is quite effective at reducing loan losses. In order to construct a more forward-looking and nonlinear response of losses to interest rate changes, Brassil *et al* (2022) use the micro-simulation model of Kearns *et al* (2020) to determine the extent to which monetary policy may be able to reduce losses in future downturns. They find that a 100 basis point reduction in the cash rate is expected to moderate any downturn-induced increase in losses by between 3 and 17 per cent (with the larger effectiveness occurring when the economic deterioration is larger).

The international literature has also found that interest rate reductions reduce banks' loan losses. Consistent with the preponderance of longer-term fixed-rate loans in the United States, Bikker and Vervliet (2017) find a 100 basis point short-term interest rate reduction is associated with a 3 basis point reduction in loss provisioning (compared with 7 basis points in Australia). Using a panel of international banks from 14 advanced economies, Brei, Borio and Gambacorta (2019) find an asymmetric effect that is largest at low interest rates (13 basis point reduction in provisioning with a 100 basis point short-rate reduction to zero per cent). Older studies by Albertazzi and Gambacorta (2009) and Bolt *et al* (2012) find similar results.

With a focus on the euro area, Altavilla *et al* (2018) stress the importance of properly controlling for the endogeneity of interest rates to both the current and expected future state of the economy.[7] In a stylised macro model designed to determine the effectiveness of monetary policy at low interest rates (including unconventional policies), an expansionary unconventional policy that reduces 10-year yields by 100 basis points reduces annual loss provisioning by a peak of 10 basis points. This is similar to the estimated effects of conventional policies discussed in previous paragraphs, suggesting that the ability of central banks to moderate loan losses does not diminish at low interest rates.

3.1.5.2 The new low-rate steady state

All of the previous studies reflect the effect monetary policy would have on losses during economic downturns (i.e. when loss provisioning would otherwise be high), which may be more frequent in a low-rate world to the extent that there would be more economic volatility in an environment where monetary policy is more frequently constrained. But banks' general level of loss provisioning could also be different in a low-rate world.

If credit risk is higher in the low-rate world, banks' interest spreads on new loans should be higher to compensate, and their general level of provisioning should also be higher. There could also be a higher risk of banks' provisioning increasing sharply given that the duration of the assets used to secure their loans will be higher (as explained in Section 3.1.4).

Given that the transition to the new low-rate world is either still continuing or had only just finished prior to the COVID-19 shock, recent studies may not yet fully capture the ongoing effect of low

7 Brassil *et al* (2018) also control for this endogeneity by incorporating RBA forecasts into their model.

interest rates on banks' loan losses. That said, in Australia just prior to the COVID-19 crisis, banks' provisioning for loan losses were no higher than prior to the global financial crisis (despite the lower level of interest rates).

If higher wealth inequality is either a cause of (Mian, Straub and Sufi 2021b), or consequence of (Dollman *et al* 2015), the lower level of interest rates, this *could* eventually lead to more of the debt in the economy being held by those who are more at risk of being unable to service this debt, thereby increasing credit risk. That said, such an outcome is not a forgone conclusion; empirical studies produce mixed results (Coibion *et al* 2014; Kumhof, Rancière and Winant 2015; Papadopoulos 2019), and face substantial endogeneity challenges (Bazillier and Hericourt 2017). Recent estimates continue to suggest that the majority of debt in Australia continues to be held by those who are most able to service this debt (RBA 2021).

It is important to remember that the low-rate world results from structural changes in the economy to which the central bank responds.[8] The economy would be in much worse shape if central banks tried (in vain) to return interest rates to their previous levels. So the potential for increased credit risk in a low-rate environment to lead to higher losses for banks should be considered second-order relative to the benefit of setting interest rates appropriately for the changed macroeconomic environment.

3.2 Discretionary

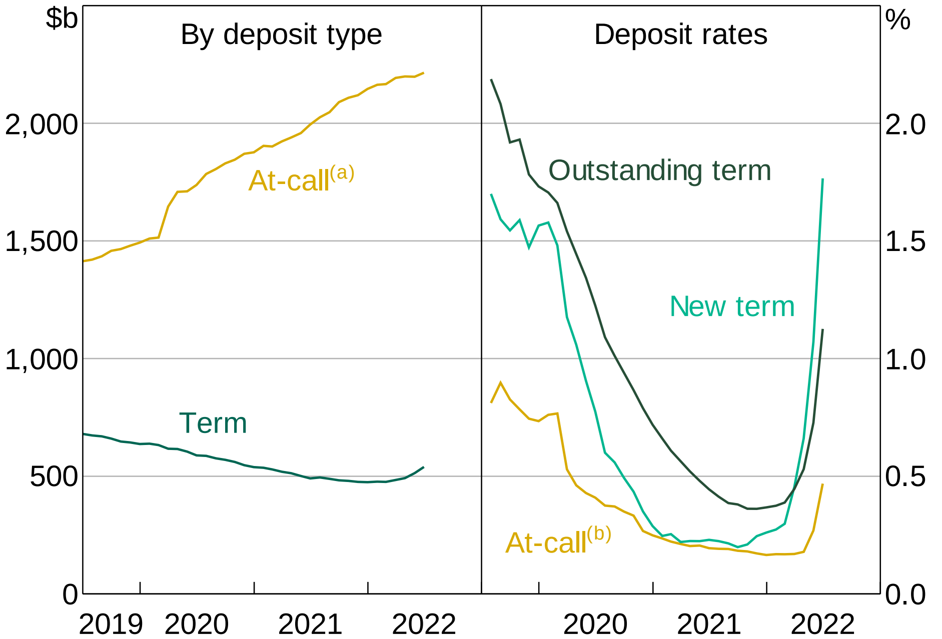
Although limited by competitive pressures and regulations, banks have some discretion over the interest rates they set for their loans, the credit quality of the loans they offer, and the interest rates they pay on high-interest deposit accounts. When combined with the interest rates on their non-discretionary assets and costs of funding, these decisions combine to form banks' net interest margins (NIMs, a key component of profitability). Because banks' discretionary loan and deposit decisions map directly to changes in profitability, I will not evaluate the various discretionary components separately. Instead, I will discuss how low levels of interest rates might affect the discretionary decisions of profit-maximising banks (including how their constraints may change).

Low interest rates reduce the pricing discretion banks have on their deposits, due to the retail deposit ELB. This occurs both because the rates paid on existing at-call accounts progressively hit the ELB as the policy rate falls, and because depositors switch from the less liquid term deposits to at-call accounts as the interest rate differential compresses. Both of these mechanisms featured in Australia as interest rates fell (Figure 3).

For over a decade to 2021 (including during COVID-19), Australia's major banks set interest rates on their loans to maintain a relatively stable spread between the interest received on these loans and their costs of debt (including deposit) funding (Figure 4) – henceforth, the 'lending spread'. This is despite the level of interest rates falling several percentage points during this period.

8 Although some recent research suggests that monetary policy can itself move the neutral rate, at least temporarily, by intertemporally shifting demand (McKay and Wieland 2021; Mian, Straub and Sufi 2021a).

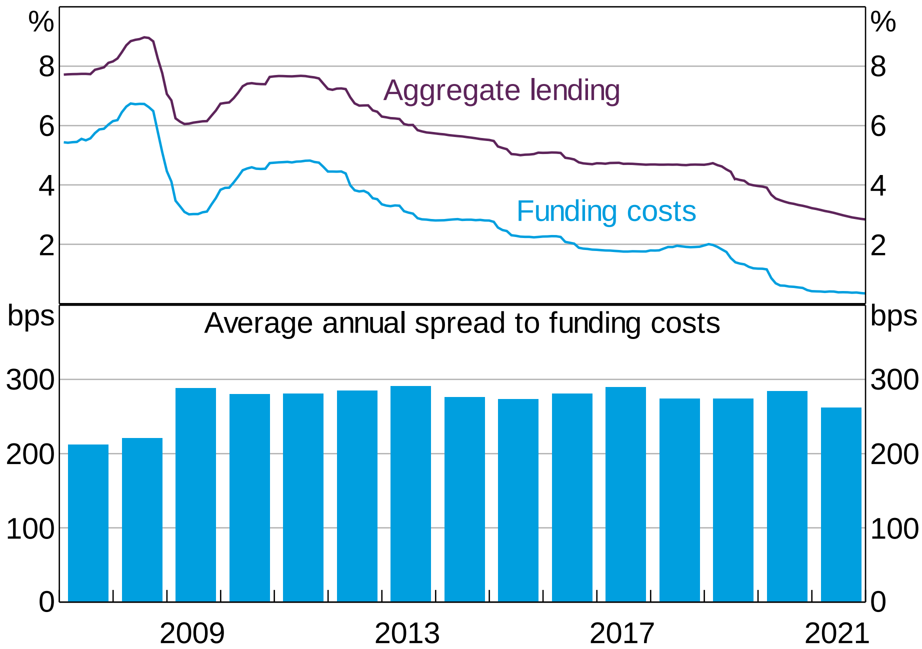
Figure 3: Banks' Deposit Funding



Notes: Data as at June 2022.
(a) Includes deposits in housing loan offset accounts and non-interest bearing deposits.
(b) Excludes deposits in housing loan offset accounts; includes non-interest bearing deposits.

Sources: APRA; RBA

Figure 4: Major Banks' Lending and Debt Funding Costs



Note: Data from the EFS collection from July 2019.

Sources: ABS; APRA; ASX; Australian Financial Markets Association; Bank liaison; Banks' websites; Bloomberg; Board of Governors of the Federal Reserve System; CANSTAR; Fitzpatrick, Shaw and Suthakar (2022); RBA; Refinitiv; Securitisation System; Tullett Prebon; Yieldbroker

Interestingly, this broadly stable lending spread does not seem to be a feature of many other jurisdictions. With the literature highlighting three main reasons:[9]

- **Competition** from institutions with lower reliance on deposit funding means the marginal lending rate is more closely tied to wholesale funding costs (rather than banks' overall cost of funding) in other jurisdictions. As a result, deposit-reliant banks' lending spreads compress as more deposit accounts hit their ELB.

- **Hedging** of interest rate risk by Australian banks – either by maturity matching or via derivatives – means changes in the slope of the yield curve do not affect their lending spreads (Brassil *et al* 2018; RBA 2022) (Figure 5).[10] In jurisdictions where hedging is less prevalent (e.g. the United States (Begenau, Piazzesi and Schneider 2015) and euro area (Hoffmann *et al* 2018)), the flattening of the yield curve that tends to occur when interest rates fall to low levels lowers banks' profits from maturity transformation (i.e. lending long and funding short).[11]

    - A likely important factor causing the divergent hedging practices between Australia and other jurisdictions is differing regulations, with APRA the only regulator requiring banks to reserve capital against interest rate risk (Waters *et al* 2020).

- **Risk-taking** by banks in response to spreads falling for other reasons could mitigate the short-term reduction in spreads, but at the risk of higher future losses. This 'search for yield' behaviour is a risk frequently highlighted in the literature. Consistent with theory, the empirical literature tends to find this behaviour in banks that offload risk via securitisation, have low capital levels, or are poorly supervised. Given that none of these features apply to Australian banks, it is not surprising that there is no evidence of Australian banks having increased the risk of their loan portfolios as interest rates fell (RBA 2021).

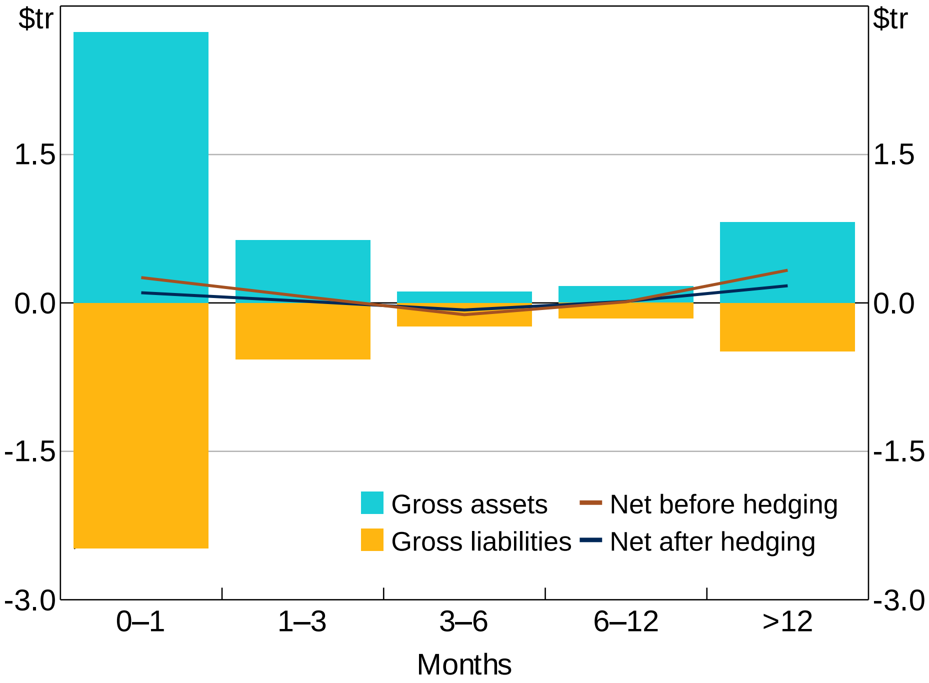
9 A small subset of the expansive international literature (including some thorough literature reviews): Albertazzi *et al* (2020); Alessandri and Nelson (2015); Altavilla *et al* (2018); Amzallag *et al* (2019); Arce *et al* (2018); Balloch, Koby and Ulate (2022); Barmeier (2022); Basten and Mariathasan (2018); Bikker and Vervliet (2017); Borio, Gambacorta and Hofmann (2017); Borio and Hofmann (2017); Brandão-Marques *et al* (2021); Brei *et al* (2019); CGFS (2018); Claessens, Coleman and Donnelly (2018); de Groot and Haas (2022); Dell'Ariccia, Laeven and Suarez (2017); Demiralp, Eisenschmidt and Vlassopoulos (2017); Eggertsson *et al* (2019); Heider, Saidi and Schepens (2019, 2021); Ioannidou, Ongena and Peydró (2015); Jiménez *et al* (2014); Junttila, Perttunen and Raatikainen (2021); Lopez, Rose and Spiegel (2020); Maddaloni and Peydró (2011); Malovaná *et al* (forthcoming); Martínez Pagés (2017); Onofri, Peersman and Smets (2021); Schelling and Towbin (2020); Stráský and Hwang (2019); Tenreyro (2021); Turk (2016) and Ulate (2021).

10 While the instruments used to hedge interest rate risk incorporate the compensation institutional investors require to hold this risk, households and small businesses are likely less able to deal with this risk, and would therefore be willing to pay more to remove this risk (so the spreads between fixed lending rates and equivalent-maturity money market rates would still retain some compensation for interest rate risk). Therefore, lending spreads on new fixed-rate loans could still fall a small amount when interest rate risk is lower even though the banks' interest rate risk is fully hedged.

11 For banks with unhedged fixed-rate assets and variable-rate liabilities, a fall in interest rates would provide a temporary boost to their interest spreads. However, this would only boost long-run profits to the extent that the rate fall was unexpected.

Figure 5: Repricing Maturity of Assets and Liabilities

Banks operating in Australia, December 2021



Sources: APRA; RBA (2022)

This spread compression in other jurisdictions is touted in the literature as the primary cause of lower bank profitability at low interest rates (especially in the long run, once the positive effects on losses and asset repricing fade). The broadly stable spread in Australia therefore suggests that perhaps we should be less concerned about the profitability of Australian banks at low interest rates.

Even if banks' lending spreads remain constant, their NIMs still fall as the level of interest rates fall. This mechanically results from banks having more assets than liabilities, and can be shown by rewriting the NIM identity:

$$\text{NIM} \equiv \frac{i_A A - i_L L}{A} = (i_A - i_L) + i_L\left(\frac{E}{A}\right) \tag{1}$$

In Equation (1), i_A and i_L are the average interest rates on banks' interest-bearing assets and liabilities. A, L and E are the values of banks' assets, liabilities and equity. When the NIM identity is rewritten as the lending spread plus banks' cost of debt funding multiplied by their equity ratio, it is clear that a constant spread means NIMs will fall as the level of interest rates (i_L) falls.

Interestingly, while the ELB on retail deposits is expected to reduce profitability as rates fall in some jurisdictions (see above discussion), the deposit ELB reduces the pass-through of policy rate changes to i_L. Therefore, with constant spreads, the ELB should actually help Australian banks maintain profitability at low interest rates (all else equal).

3.2.1 *A potential caveat*

A potential caveat to this conclusion is the observed compression in lending spreads during 2021 (Figure 4). The literature does highlight that banks' profitability is likely to be more adversely affected after an extended period of low interest rates. So even if Australian banks' were able to maintain their lending spreads while interest rates were falling, this spread compression in 2021 could be the beginning of the delayed effect predicted by the literature.

However, the delayed effect in the literature is caused by fixed-rate loans being progressively rolled over to lower rates as the yield curve flattens. Given Australian banks' interest rate risk is very well hedged, this is unlikely to be the cause of the recent spread compression in Australia. Moreover, previous analysis has attributed much of this spread compression to increased competition for fixed-rate loans resulting from cheap term funding facilitated by the RBA's suite of unconventional policies, rather than as a result of low interest rates.[12] All that said, given the lack of definitive evidence that the recent spread compression was not caused by low rates, this compression warrants further investigation and monitoring.

3.2.2 *A potential confounding factor*

Banks use both debt and equity to fund their loans. So it is possible that the stability of the major banks' lending spreads ($i_A - i_L$) could reflect a spread compression via the usual competition channel cited in the literature being offset by an increase in the relative cost of equity or an increase in the equity share of assets. To see this more explicitly, the way banks price their loans in period t can be expressed as a time-varying mark-up (μ_t) over their cost of funding the loan:

$$i_{A,t} = \mu_t + \frac{i_{L,t}L_t + i_{E,t}E_t}{A_t}$$

Using this general pricing equation, it is possible to determine the relationship between mark-ups and equity funding required for lending spreads to remain constant between periods $t-1$ and t:

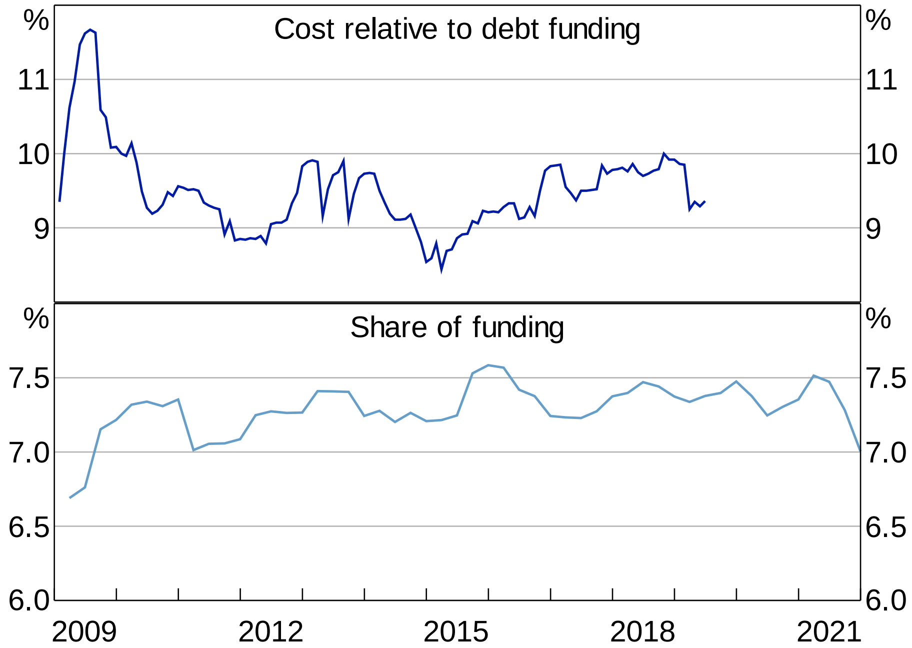
$$\Delta\mu_t = -\left(i_{E,t} - i_{L,t}\right)\Delta\left(\frac{E_t}{A_t}\right) - \left[\Delta\left(i_{E,t} - i_{L,t}\right)\right]\frac{E_{t-1}}{A_{t-1}}$$

In this framework, an increase in competition at low interest rates would reduce the mark-ups the major banks are able to charge ($\Delta\mu_t < 0$). If lending spreads remain constant despite this increase in competition, then it must be the case that this fall in mark-ups was offset by either an increase in the relative cost of equity ($\Delta\left(i_{E,t} - i_{L,t}\right) > 0$) or increase in the equity share of funding ($\Delta \frac{E_t}{A_t} > 0$).

12 These policies included the Term Funding Facility (TFF), yield target and bond purchase program. For example, because the cost of accessing the TFF was the same for all banks, the TFF lowered the term funding costs of the non-major banks by more than the majors' term funding costs (Black, Jackman and Schwartz 2021). Moreover, because the major banks issued fewer bonds while drawing on the TFF, it also indirectly reduced the costs of the non-major banks' and non-bank lenders' other funding sources. The TFF therefore likely contributed to greater competition for fixed-rate loans, with this increased competition being a primary driver of the 2021 spread compression (Fitzpatrick *et al* 2022).

While there is no single widely accepted method of measuring the cost of equity, recent research by Cheung and Printant (2019) computes a simple average of three commonly used pricing models. Using their data, the relative cost of equity in 2019 was around the same level that is was in 2010, and significantly lower than during 2009 (Figure 6). Therefore, the relative cost of equity is not a confounding factor.

Figure 6: Major Banks' Equity Funding



Sources: ABS; APRA; Bloomberg; Cheung and Printant (2019); RBA; Refinitiv

Cheung and Printant (2019) also show how the major banks' common equity Tier 1 capital ratio has increased since 2009, in response to regulatory changes – first in response to the Basel III reforms, then further changes designed to make Australia's bank capital framework 'unquestionably strong' (RBA 2016). So this could be a potential confounding factor. However, in the calculation of capital ratios assets are risk weighted in the denominator, whereas for determining overall funding costs it is the unweighted equity ratio that needs to be analysed. The major banks' unweighted equity ratio has been fairly stable since 2009, and has fallen recently (Figure 6, bottom panel).

In short, neither the cost nor funding share of equity appear to be confounding factors that could hide the competition effect cited in the literature.

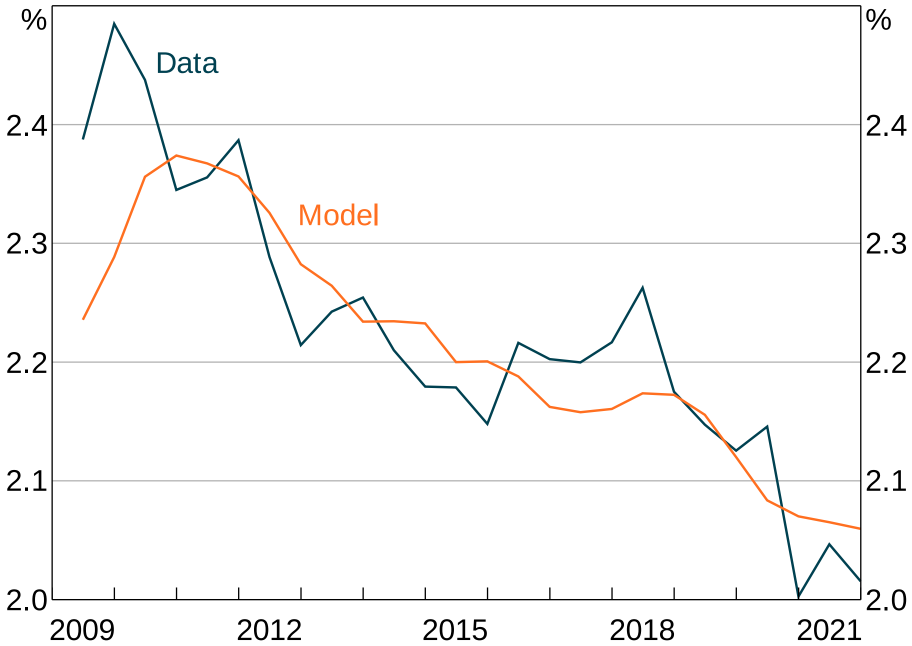
3.2.3 A robustness check

Figure 4 is constructed using detailed information on the pricing of the major banks' various loans and sources of debt funding, and detailed information on the compositions of these banks' balance sheets. But it does not directly use information on banks' reported NIMs. Equation (1) provides a way to use banks' reported NIMs as a robustness check; if lending spreads have been broadly constant since 2009, the major banks' NIMs should be highly correlated with movements in $i_L\left(\frac{E}{A}\right)$.

Figure 7 plots the major banks' reported NIMs against a model that includes a constant and $i_L\left(\frac{E}{A}\right)$ as the sole regressor (with regressor coefficient restricted to one, consistent with Equation (1)). With an *R*-squared of 82 per cent, the overwhelming majority of the movements in the major banks' NIMs since 2010 can be explained by movements in $i_L\left(\frac{E}{A}\right)$, confirming the 'broadly stable lending spread' result in Figure 4.[13,14]

Figure 7: Major Banks' Net Interest Margin

Domestic, half-yearly



Sources: ABS; APRA; ASX; Australian Financial Markets Association; Author's calculations; Banks' financial reports; Bank liaison; Banks' websites; Bloomberg; Board of Governors of the Federal Reserve System; CANSTAR; RBA; Refinitiv; Securitisation System; Tullett Prebon; Yieldbroker

4. The Pass-through of Monetary Policy at Low Interest Rates

From the discussion in Section 3, it is clear that the Australian banking system operates differently to the banking systems typically discussed in the international literature. Unlike systems in which lending spreads are expected to expand as policy rates fall and then compress as these rates settle their new low-rate steady states, lending spreads in Australia remained broadly stable as the cash rate fell. As a result, there are three main channels through which low interest rates affect the Australian banking sector: deposit ELB, losses, and NIMs.

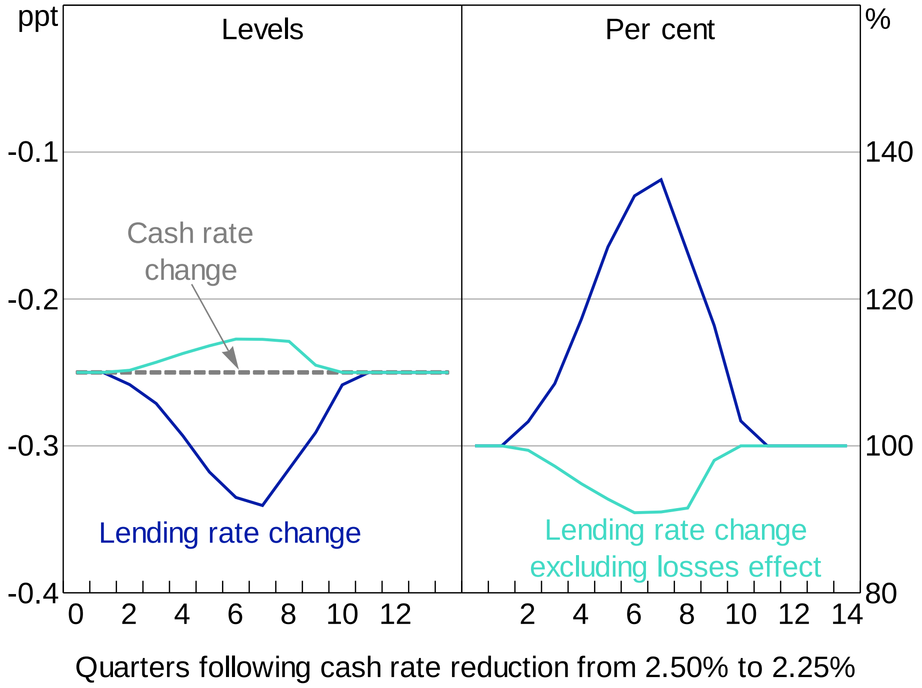
13 Because I am imposing a coefficient of one (rather than estimating the value) and the regression residuals are stationary, the spurious regression risk associated with potentially non-stationary variables is low. In any case, estimating the model in first-differences finds the constant to be insignificantly different from zero, consistent with a stable lending spread.

14 Interestingly, this strong positive relationship does not appear to be evident in New Zealand, despite similar banking systems (Richardson 2022).

Brassil *et al* (2022) incorporate all three of these channels into BA-MARTIN, and are therefore able to capture the effect each of these channels has on the pass-through of monetary policy to lending rates when the level of the policy rate is low.

During large downturns, the losses channel makes expansionary monetary policy more effective than usual (Figure 8). This occurs because the expansionary policy has its usual effect via lowering banks' funding costs and an additional effect of increasing credit supply. To explain, expansionary policy lowers losses by ensuring unemployment and interest rates are lower than otherwise, and asset prices are higher than otherwise. By lowering losses, the cash rate reduction reduces banks' capital deteriorations, thereby mitigating the extent to which these banks reduce credit supply in response. A smaller reduction in credit supply means a smaller increase in lending spreads; hence, the pass-through of policy is greater than 100 per cent.

Figure 8: Cash Rate Pass-through to Banks' Lending Rates



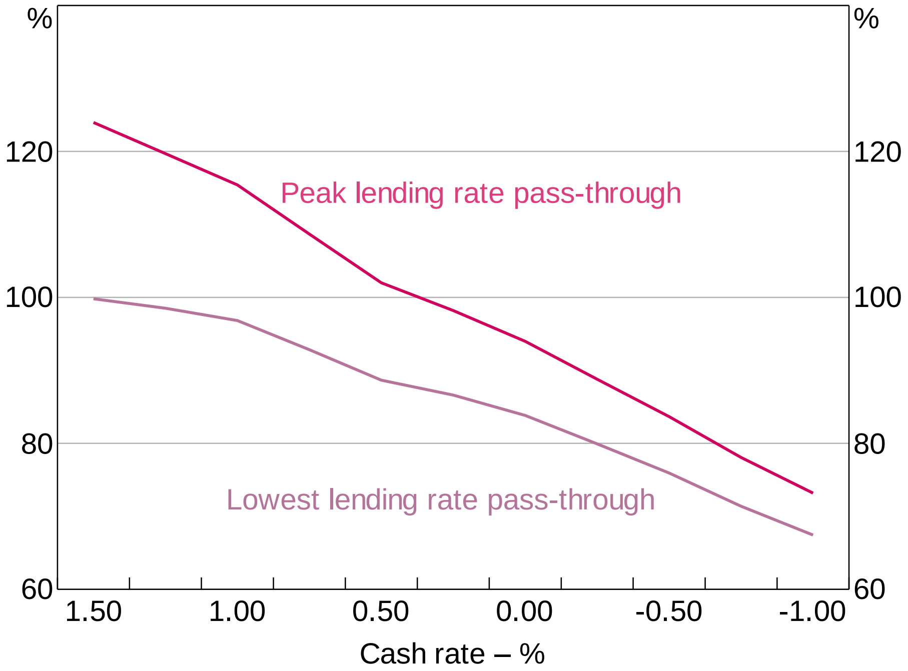
Source: Brassil, Major and Rickards (2022)

But losses do not remain higher forever. Once banks have provisioned for the extra losses they expect from the downturn, monetary policy effectiveness is no longer amplified. Instead, monetary policy becomes less effective than normal. When losses are sufficiently high to reduce banks' capital, the deleterious effect policy rate reductions have on banks' NIMs and credit growth will amplify any increase in lending spreads – a fall in NIMs reduces banks' abilities to raise capital via retained earnings, while the increase in credit growth inflates the denominator of banks' capital adequacy ratios (see Brassil *et al* (2022) for a detailed explanation) – thereby partially offsetting the reduction in funding costs. Of course, if banks have also replenished their capital levels by the time losses normalise, policy pass-through need not fall below 100 per cent (as shown in the Figure 8 example).

The losses, NIM and credit growth channels are not specific to low interest rate environments; they are active at any level of interest rates as long as the downturn is sufficiently large. The deposit ELB, however, is only operational at low levels of the cash rate. Figure 9 shows how the deposit ELB affects the pass-through of policy as the level of the cash rate falls. This figure shows the peak pass-through (when the losses channel is at its peak) and the lowest level of pass-through (once the losses channel subsides); these curves converge due to the nonlinear effect of interest rate changes on loan losses.

Figure 9: Cash Rate Pass-through

By cash rate level



Source: Brassil, Major and Rickards (2022)

In short, the losses channel is an especially powerful, albeit short-lived, amplifier of monetary policy during severe downturns. But at low levels of interest rates, the losses channel is unlikely to be sufficiently powerful to fully offset the deposit ELB. Therefore, at low interest rates, we should expect less than full pass-through of monetary policy.

That said, even during the large hypothetical downturns explored by Brassil *et al* (2022), policy pass-through remained above 80 per cent for positive and small-negative levels of the cash rate. So cash rate reductions remain an effective policy tool during large downturns and at low interest rates. The question then is: are there scenarios that weren't explored by Brassil *et al* (2022) in which cash rate reductions are no longer an effective tool of monetary policy? This question is explored in the next section.

5. Investigating the 'Reversal Rate' in Australia

The 'reversal rate' is the point at which any further reduction in the central bank's policy rate will cause banks to *increase* their lending rates, such that policy rate reductions become counterproductive. In simple theoretical models (Brunnermeier and Koby 2018), the reversal rate results from banks being subject to an occasionally binding equity constraint (essentially a minimum capital ratio).[15] If this constraint binds (i.e. they cannot avoid it by raising external equity), reductions in the policy rate tighten the constraint by reducing banks' net interest income. The only margin of adjustment available to the banks in this scenario is their credit supply, so they respond to this constraint tightening by reducing credit supply (i.e. increasing lending rates and reducing lending volumes). At some point, this credit supply reduction more than offsets the effect on funding costs, such that lending rates increase in response to the policy rate reduction.

Subsequent research has shown that the existence of a reversal rate is not assured, and even in theory is highly model dependent. Repullo (2020) shows that even in Brunnermeier and Koby (2018)'s model, the reversal rate only exists for banks that are net investors in debt securities; this is particularly relevant for Australian banks, who have historically been net borrowers in debt markets. Repullo then proposes an alternative model in which banks retain access to external equity markets, and shows that the reversal rate never exists in this model.

As far as I am aware, there is little empirical evidence of a reversal rate having been reached in any jurisdiction:

- There is no evidence of a reversal rate being reached in Denmark, despite policy rates being negative between 2012 and mid-2022, and reaching –0.75 per cent (Kuchler *et al* 2020).

- Arce *et al* (2018) look specifically at the effect of an extended period of low rates in Spain and find that while some banks reduce their credit supply, there is no evidence of an aggregate reduction in credit supply (let alone a reversal rate).

- While Eggertsson *et al* (2019) find some evidence of the reversal rate having been reached in Sweden, their evidence is not statistically significant.

- Bech and Malkhozov (2016) suggest that Swiss mortgage rates increased in response to policy rate reductions into negative territory. However, their analysis does not control for any potentially confounding factors. Conversely, the more thorough analysis of Baeriswyl *et al* (2021) provides mixed results, and suggests that, if anything, it is only temporarily negative policy rates that lead to a reversal rate, whereas a low-for-long scenario retains positive (albeit muted) pass-through (this is the opposite of the theoretical reversal rate predictions).

- Central banks that have implemented negative rates state that negative rates have 'contributed to the achievement of their policy goals' (CGFS 2019), suggesting that they do not perceive the reversal rate as having been reached.

- Darracq Pariès *et al* (2020) construct a New Keynesian DSGE model that can produce a reversal rate under some calibrations. A reversal rate exists in their model when calibrated to the euro area, but it is at a lower level than any policy rate set by the ECB. So its existence remains theoretical.

Moving beyond the theoretical models and international evidence, BA-MARTIN provides an environment well suited to investigating whether a reversal rate exists in Australia, and if so, its

15 Darracq Pariès, Kok and Rottner (2020), Heider and Leonello (2021) and Koenig and Schliephake (2022) also construct theoretical models that produce a reversal rate under some calibrations.

determinants. During banking crises, the banks in BA-MARTIN lose access to external equity markets. As a result, any capital shortfall can only be replenished by either retained earnings or reducing assets. Without a change in credit supply, cash rate reductions both reduce banks' NIMs and increase loan demand, thereby making it harder for banks to replenish capital. So BA-MARTIN has the same fundamental mechanism as in Brunnermeier and Koby (2018)'s model.

But having the same mechanism does not mean a reversal rate necessarily exists, as BA-MARTIN is a more detailed modelling framework than either the Brunnermeier and Koby (2018) or Repullo (2020) models. In the remainder of this section, I will investigate whether a reversal rate exists in Australia.

5.1 A reversal rate does not exist in the baseline BA-MARTIN model

From Brassil *et al* (2022), period t lending rates in the Australian economy ($r_{M,t}$) can be expressed as the sum of banks' cost of debt (including deposit) funding ($r_{D,t}$), a spread that is unrelated to domestic economic conditions ($s_{M,t}$), and an endogenous response to a deterioration in their capital (z_t^*):[16]

$$r_{M,t} = r_{D,t} + s_{M,t} + z_t^*$$

Given that I am exploring the *existence* of the reversal rate, I want to explore scenarios in which pass-through is as low as possible. So in the remainder of Section 5, and in Appendix A, I assume that banks' provisioning for losses has already returned to normal (so the amplifying channel of pass-through described in Section 4 is not operational) but that they still have a capital shortfall when the cash rate is reduced further. This leaves four channels that permit pass-through to be lower than normal, thereby potentially culminating in a reversal rate:

1. Deposit ELB – while this lower bound mutes the pass-through of monetary policy at low rates, it cannot, by itself, make the pass-through of monetary policy negative.

2. NIM compression – from Equation (1), reductions in banks' costs of funding reduce their NIMs, which slows the speed at which banks replenish their capital via retained earnings (holding lending spreads and all else equal).

3. Credit growth – increased credit growth increases the denominator of banks' capital ratios. Therefore, the accelerated credit growth that comes with interest rate reductions would slow the speed at which banks return to their capital ratio targets (holding lending spreads and all else equal).

4. Credit risk – if channels 2 and 3 slow the speed of capital ratio increases, the risk for banks' creditors would remain elevated for longer. This would increase banks' costs of debt funding.

16 In BA-MARTIN, debt funding costs and banks' endogenous responses have the same effect on all lending rates.

In reality, all else is obviously not equal, and banks may respond by increasing z_t^*. The question is, can the banks' endogenous z_t^* responses more than offset the reductions in $r_{D,t}$ that come from cash rate reductions at low interest rates?

In the BA-MARTIN model, which is designed to reflect the Australian banking system, the answer is no. This is because in BA-MARTIN, as in reality, most of Australian banks' assets are loans (over which they have pricing discretion), while they have a significant share of liabilities that follow hedged wholesale market pricing. This means that, rather than keeping lending *spreads* constant (as they do in normal times, Section 3.2), if banks instead kept their lending *rates* constant then their NIMs would increase as their funding costs fell.[17] So zero pass-through is enough to more than offset the NIM compression channel discussed above.

Moreover, with zero pass-through there would be no *direct* change in credit demand.[18] So zero pass-through is also enough to offset the credit growth channel discussed above.

With the structure of Australian banks' balance sheets meaning zero pass-through is sufficient to offset both the NIM compression and credit growth channels, there can be no Brunnermeier and Koby (2018) reversal rate – this result is consistent with Repullo (2020)'s critique that the reversal rate requires banks to be net investors in debt securities. I confirm this intuition in Appendix A, by showing mathematically that even a very conservative pass-through lower bound in the baseline version of BA-MARTIN is above zero, and that even if the parameters in the model changed from the baseline calibration, zero pass-through would always be sufficient.[19]

5.1.2 A 'credit risk' reversal rate is theoretically possible but highly unlikely, and does not occur in the baseline calibration

The 'credit risk' channel is a potential reversal rate channel not covered by the Brunnermeier and Koby (2018) framework, and it works in quite a different way. While the Brunnermeier and Koby channel is all about banks endogenously responding to a binding constraint, the credit risk channel arises if banks are *not* sufficiently responsive to any deterioration in their capital ratio. With the credit risk channel, it would be a sufficiently strong response from banks' creditors that could lead to a reversal rate.

In Appendix A, I show that Australian banks are estimated to be sufficiently responsive, and the response of creditors to be sufficiently small, that this credit risk channel does not lead to a reversal rate. I also show how banks becoming less responsive to capital ratio shortfalls would increase the likelihood of the credit risk channel leading to a reversal rate. But that a credit risk reversal rate would still require an extreme and highly unlikely scenario in which banks remain below their target

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17 From Equation (1), if lending rates were held constant then $\frac{d\text{NIM}}{di_L} = \frac{-L}{A} < 0$.

18 The effect of the cash rate reduction on the parts of the economy that are not intermediated by the banking sector (e.g. the exchange rate channel) would still lead to a small *indirect* increase in credit demand.

19 BA-MARTIN is an aggregate model that does not account for heterogeneity among the banks. That said, even if some small banks are net investors in debt securities, competition from the majority of banks that aren't net investors would mean these smaller banks could achieve their desired reduction in credit growth with smaller lending rate increases than if all banks were net investors in debt securities. This means the amount of 'reversal' experienced by these smaller banks would be muted, and therefore any spillover to the majority would also be muted. Still, further research incorporating bank heterogeneity should be conducted.

capital ratio for an extended period of time, they remain excluded from external equity markets for this entire period, and there is no regulatory/government policy response that alleviates the problem despite the effect such a scenario would be having on the Australian economy.

All that said, my analysis is based on the current structure/behaviour of the Australian banking system. Were this to change, a reversal rate could emerge. An example highlighted by Brunnermeier and Koby (2018) is that quantitative easing (QE) may increase both the share of non-discretionary assets held by banks and the share of low-interest deposits, both of which increase the likelihood of a reversal rate. QE enacted by the RBA has caused some shift in this direction (RBA 2020). However, large Australian banks' holdings of securities and central bank reserves generally remain smaller than their funding that follows wholesale market pricing.

6. Conclusions, Policy Implications and Future Research

In the face of low rates, the profitability of Australian banks has likely been less adversely affected than what the international literature would predict. The flip side to this is that the pass-through of cash rate changes to lending rates may have been more muted than what the literature would predict.

That said, the pass-through of Australian monetary policy has remained high. And pass-through would likely remain at similar levels were the cash rate reduced to the small negative interest rates implemented in some other jurisdictions. Moreover, a reversal rate is highly unlikely to exist in Australia.

As noted in Section 5, even if Australia faced an extreme scenario in which banks remained below their target capital ratio for an extended period of time and they remained excluded from external equity markets for this entire period, government/regulatory policies could be used to alleviate the problem and prevent a reversal rate from emerging. For example, in jurisdictions that have a positive countercyclical capital buffer (CCyB), this tool could be used by the regulator to temporarily reduce the capital ratio buffer they require banks to hold. This allows banks to reduce the speed at which they increase their capital ratios following a crisis, thereby permitting smaller reductions in credit supply and stronger pass-through of monetary policy. Future research could use BA-MARTIN to explore how different CCyB calibrations could change how the Australian banking sector, and therefore the economy, weather large downturns. Given that BA-MARTIN is a large macro model, this research could also be used to assess the potential complementarities or trade-offs between the RBA's inflation and full employment objectives and its financial stability objective.

Even without a reversal rate, the question remains as to whether central banks should lower policy rates by more or less as the pass-through to lending rates falls. The answer depends on the central bank's objectives, the costs of policy rate reductions (e.g. the increased risk of crises (Schularick and Taylor 2012)), and how it weights the trade-offs.

The international literature makes clear that maintaining adequate prudential supervision is key to ensuring banks do not 'search for yield' as interest rates fall, thereby reducing the extent to which low rates make large downturns more likely. And preventative macroprudential policies, such as floor rates for assessing loan serviceability, can also mitigate any increased risk that may emerge at low rates. Even without these prudential policies, there is some evidence from recent research that suggests interest rates have too small an effect on the probability of a crisis for this benefit to be worth the higher unemployment that would result from not 'doing more' as pass-through falls (see Saunders and Tulip (2019) and references therein).

It would also be beneficial to research the overall welfare implications of the Australian banking system's structure relative to the structure in other jurisdictions. The apparent ability of Australia's major banks to maintain their lending spreads as rates have fallen has ensured these banks remained profitable and resilient to further shocks, thereby improving financial stability. But this has likely come at the cost of lower pass-through to lending rates.

That said, the high share of variable-rate loans in Australia means that even muted pass-through feeds through to the interest rates households pay much faster than in jurisdictions with long-term fixed-rate loans, thereby enhancing the effectiveness of policy via the cash flow channel (La Cava, Hughson and Kaplan 2016). But this also means that Australian households bear more interest rate risk than in other jurisdictions. Over time, many of these households respond to this risk by building up substantial buffers of excess repayments, so financial stability need not be lower as a result of households bearing this risk. But new borrowers and those unable to build buffers remain vulnerable to this risk.

Appendix A: Pass-through Lower Bound in BA-MARTIN

A.1 The immediate effect

By substituting Brassil *et al* (2022)'s Equations (8), (11) and (12) into their Equation (14), the immediate effect of a change in the cash rate ($r_{C,t}$) on lending rates is:

$$\frac{dr_{M,t}}{dr_{C,t}} = \frac{dr_{D,t}}{dr_{C,t}} + \underbrace{\left[\frac{-400\lambda w_t}{\tau - 400 w_t e_t \beta_{M,t}}\right]}_{\text{Endogenous response to capital ratio}} \times \left[\underbrace{\frac{\tau w_{t-1} e_t}{400 w_t}}_{\text{Effect of NIM on capital ratio}} + \underbrace{-e_t \beta_{M,t}}_{\text{Effect of credit growth on capital ratio}}\right] \times \frac{dr_{D,t}}{dr_{C,t}}$$

The reversal rate exists if $\frac{dr_{M,t}}{dr_{C,t}} < 0$. Given that $\frac{dr_{D,t}}{dr_{C,t}} > 0$, simplification of the equation above shows that an immediate reversal rate occurs *iff*:

$$\frac{\lambda e_t \left(\tau w_{t-1} - 400 w_t \beta_{M,t}\right)}{\tau - 400 w_t e_t \beta_{M,t}} > 1$$

With credit demand contemporaneously responding negatively to interest rates ($\beta_{M,t} < 0$, as discussed in Brassil *et al* (2022)), even if the behavioural response parameter λ takes its highest possible value of 1, the above condition would require $w_{t-1} e_t > 1$, which can never hold as w_{t-1} is the lagged aggregate risk weight ($w_{t-1} < 1$) and e_t is the equity share of assets ($e_t < 1$). Therefore, in the baseline version of BA-MARTIN, cash rate cuts will always have an initial expansionary effect via the banking sector.

A.2 The low-for-long effect

While there is no immediate reversal rate, holding rates low for an extended period will amplify the credit demand response. There is also an additional amplifying mechanism when rates are held low for an extended period. The nonlinearity of the banking sector in BA-MARTIN means the amount banks want to increase their capital ratios in each period depends on the amount of capital they have at the beginning of the period. This means that smaller capital ratio increases in previous periods (resulting from a cash rate reduction) will affect pass-through in those periods, and in all future periods in which capital ratios remain below their target.

To see if these additional low-for-long mechanisms can lead to a reversal rate, I continuously substitute the expressions for past capital shortfalls into Brassil *et al* (2022)'s Equation (14). This provides an expression for the effect an extended period of lower cash rates ($r_{C,s\to t}$) has on current lending rates ($r_{M,t}$):[20]

20 $r_{C,s\to t} = x$ denotes the cash rate being held constant at x between periods s and t.

$$\frac{dr_{M,t}}{dr_{C,s\to t}} \approx \underbrace{\frac{dr_{D,t}}{dr_{C,t}}}_{\text{A}} + \underbrace{\left(\frac{-400\lambda\overline{w}}{\tau - 400\overline{we}\beta_M}\right)\frac{dy_t}{dr_{C,s\to t}}}_{\text{B}} + \left[\underbrace{-\psi}_{\text{C}} + \underbrace{\frac{-400\lambda\overline{w}(1-\lambda)}{\tau - 400\overline{we}\beta_M}}_{\text{D}}\right]\underbrace{\sum_{j=0}^{t-1-s}(1-\lambda)^j\frac{dy_{t-1-j}}{dr_{C,s\to t}}}_{\text{E}} \quad \text{(A1)}$$

where

$$\frac{dy_{t-j}}{dr_{C,s\to t}} \approx \underbrace{\left(\frac{\tau\overline{e}}{400}\right)\frac{dr_{D,t-j}}{dr_{C,s\to t}}}_{\substack{\text{Effect of NIM}\\ \text{on capital ratio}}} + \underbrace{-\overline{e}\frac{d\Delta a_{t+1-j}}{dr_{C,s\to t}}}_{\substack{\text{Effct of}\\ \text{credit growth}\\ \text{on capital ratio}}}$$

Explaining the components of Equation (A1):

A. The effect of the current lower cash rate on current debt funding costs.

B. The endogenous response to the effect of the persistently lower cash rate on the current capital ratio.

C. The effect persistently lower capital ratios have on debt funding costs by increasing bank default risk.

D. The endogenous response to persistently lower capital ratios.

E. The effect persistently lower cash rates have had on past capital ratios.

Equation (A1) is an approximation of the true response because in places where the risk weights and equity shares act as coefficients, I have replaced their contemporaneous values with their steady-state values. The magnitude of the effects would be little different without this approximation, but the expression would be far more complex and less intuitive.

Equation (A1) does not solve to a simple inequality as with the 'immediate effect' above. Instead, by replacing each NIM and credit growth effect by the largest possible values these effects take over the extended period, I can construct a lower bound for pass-through:

$$\frac{dr_{M,t}}{dr_{C,s\to t}} > \frac{dr_{D,t}}{dr_{C,t}} - \left\{\frac{400\overline{w}}{\tau - 400\overline{we}\beta_M}\left[1-(1-\lambda)^{t-s+1}\right] + \frac{\psi}{\lambda}\left[1-(1-\lambda)^{t-s}\right]\right\}\Theta_t \quad \text{(A2)}$$

where

$$\Theta_t = \left(\frac{\tau\overline{e}}{400}\right)\frac{dr_{D,t}}{dr_{C,t}} + \max\left\{-\overline{e}\frac{d\Delta a_{t+1-j}}{dr_{C,s\to t}} \forall t \geq s\right\}$$

With the baseline calibration of BA-MARTIN, Equation (A2) is bounded by:

$$\frac{dr_{M,t}}{dr_{C,s\to t}} > \frac{dr_{D,t}}{dr_{C,t}} - \left[1-0.85^{t-s+1}\right]\left[0.0525\times\frac{dr_{D,t}}{dr_{C,t}} + 30\max\left\{-\frac{d\Delta a_{t+1-j}}{dr_{C,s\to t}}\,\forall t\geq s\right\}\right]$$

Following a 100 basis point cash rate reduction, the maximum increase in quarterly credit growth is less than 1 percentage point, even after holding the cash rate at this lower level for a decade. Substituting in this maximum credit growth response, the lower bound simplifies to the following:

$$\frac{dr_{M,t}}{dr_{C,s\to t}} > 0.94\times\frac{dr_{D,t}}{dr_{C,t}} - 0.3$$

Even at the lowest debt funding cost pass-through that results from the retail deposit ELB, this lower bound remains above zero. Therefore, even with an incredibly conservative methodology – that would also require banks to be below their target capital ratio and be excluded from external equity markets for an extended period – the lending rate pass-through lower bound with the baseline BA-MARTIN calibration remains above zero in a low-for-long scenario.

A.3 Zero pass-through is sufficient to prevent capital ratio deterioration following a cash rate cut

From Equation (9) in Brassil *et al* (2022), changes in banks' capital ratios can be decomposed into changes in their equity, credit growth and changes to their risk weights. Once provisioning for losses has returned to normal, risk weights do not respond to changes in the cash rate. And with credit demand only directly responding to cash rate changes via the resulting change in lending rates, zero pass-through would also mute the effect of cash rate changes on credit growth. Therefore, in the stressed state, it is only through changes in banks' return on assets that cash rate changes would affect banks' capital ratios when pass-through is zero.

From Equation (8) in Brassil *et al* (2022), cash rate reductions *increase* banks' return on assets when pass-through is zero:

$$\frac{dROA_t}{dr_{C,t}} = \frac{-\tau}{400}\left(1-w_{t-1}e_t\right)\frac{dr_{D,t}}{dr_{C,t}} < 0$$

This means that if banks were happy with the speed at which they were replenishing their capital ratios before the cash rate reduction, they would be no worse off after the cash rate reduction if pass-through was zero. Therefore, zero pass-through is always more than sufficient to maintain banks' desired speed of capital ratio replenishment, which means a Brunnermeier and Koby (2018) reversal rate cannot exist.

This can also be shown by considering how banks would need to change their desired speed of adjustment (the λ parameter in BA-MARTIN) if lending rates remaining constant following the cash rate reduction was the optimal response:

$$\frac{d\lambda}{dr_{C,t}} \approx -\left[\frac{\left(\tau-400\overline{we}\beta_M\right)+\lambda\tau\left(1-\overline{we}\right)}{400\overline{w}z_t}\right]\frac{dr_{D,t}}{dr_{C,t}} < 0$$

This inequality shows that if the cash rate is reduced, it is optimal for banks to keep their lending rates constant only if they desire an increased speed of adjustment. The implication being that if banks keep their desired speed of adjustment constant (as is assumed in BA-MARTIN because this is considered a behavioural parameter), then zero pass-through would be excessively responsive to the cash rate change.

A.4 The credit risk channel with less responsive banks

If banks became sufficiently unresponsive to capital shortfalls (i.e. $\lambda \rightarrow 0$), Equation (A1) would simplify to the following:

$$\frac{dr_{M,t}}{dr_{C,s\rightarrow t}} \approx \frac{dr_{D,t}}{dr_{C,t}} - \psi \sum_{j=0}^{t-1-s} \frac{dy_{t-1-j}}{dr_{C,s\rightarrow t}}$$

With $\frac{dy_{t-j}}{dr_{C,s\rightarrow t}} \geq 0$, the longer the cash rate is held lower, the more likely this sum will become sufficiently large to generate a reversal rate. However, the longer it takes for this sum to become large, the more likely it is that banks' capital ratios will have returned to target, they will have regained access to equity markets, or some policy response is implemented to alleviate the problem. Therefore, this equation is not proof that a reversal rate would exist in a low-for-long scenario even with sufficiently unresponsive banks.

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