Have the LVR restrictions improved the resilience of the banking system?

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NON-TECHNICAL SUMMARY

As part of sound regulatory practice, the Reserve Bank wants to further its understanding, and the public's understanding, of how the policy has influenced financial stability. This paper contributes to this objective by developing a modelling framework that quantifies the extent that the loan-to-value ratio (LVR) policy has improved the resilience of the banking system to a severe downturn in house prices.

We find that the LVR restrictions have significantly improved the resilience of the banking system. The LVR policy has reduced the scale of mortgage defaults and credit losses that would occur in a housing downturn, due to a reduction in risky loans on bank balance sheets and the mitigation of a potential house price decline. This resilience benefit has been partly offset by a fall in capital requirements that results from lower credit risk, reducing the banks' buffer for absorbing credit losses. Nevertheless, the LVR policy is estimated to have reduced mortgage losses – as a share of the capital banks hold against their housing loans – by 12 percentage points. The policy is found to have mitigated about half of the deterioration in bank resilience from 2013 that would have occurred in the absence of the policy.

Our estimates are sensitive to judgements on key variables and inputs. The resilience benefit of the LVR policy is contingent on the level of housing market risk that would exist without the policy. This suggests a stronger case to deploy the LVR tool when the risk of a house price decline is high. We were unable to model the resilience benefit of restricting property investor lending with confidence, although a provisional estimate suggests that the benefit may be large. Therefore, the headline estimate may understate the resilience benefit of the LVR intervention. A comprehensive assessment of the policy's efficacy needs to consider the cost of the policy, which is outside the scope of this paper.

1. Introduction

A mortgage loan-to-value ratio (LVR) is a measure of the size of a borrower's loan, relative to the value of the property collateralised against the loan, often expressed as a percentage. LVR restrictions operate by requiring banks to limit their lending to borrowers with a high LVR, as defined by the policy, to below a specified proportion of their new lending (the speed limit). The Reserve Bank introduced the LVR policy in October 2013 in response to rising financial stability risks. Lu (2019) provides a detailed overview of the Reserve Bank's motivation for deploying and adjusting the LVR restrictions since 2013, including a greater focus over time on high-LVR property investor lending.

LVR restrictions are intended to reduce the scale of mortgage losses for banks in a severe house price fall, and to mitigate extremes in the credit cycle that can amplify the magnitude of an economic downturn. To help both the Reserve Bank and the public understand how the LVR policy has influenced one of its key objectives, this paper assesses the extent the policy has improved the resilience of the banking system to a severe house price correction, relative to a counterfactual scenario where the Reserve Bank has not deployed a LVR instrument. The paper also supports the Reserve Bank's review of its experience with the policy, by utilising a quantitative model to estimate its resilience benefits.

1 The speed limit is the maximum share of new mortgages loans that can be approved by a bank above the specified regulatory LVR threshold, and is generally expressed as a percentage.
resilience impact. The model incorporates the impact from all adjustments to the LVR policy to date, including the policy tightening in the earlier years and the easing in more recent years.

The remainder of the paper proceeds as follows. Section 2 outlines three transmission channels through which the LVR policy may influence bank resilience. Sections 3 to 5 explains the methodology for assessing each of the transmission channels, and provide an estimate of their impact. Section 6 presents the headline estimate for the aggregate impact on bank resilience from the LVR policy. Section 7 presents a sensitivity analysis of the model output to key assumptions and an extension to the headline result. Section 8 concludes.

2. Theory

A severe downturn in the housing market can undermine the banking system if losses on mortgage loans are sufficiently large relative to the capital (loss-absorbing capacity) of the banking system. The headline measure of bank resilience in this paper is the percentage share of banks’ housing capital requirement that would be consumed to cover mortgage defaults for a given magnitude of house price correction. LVR restrictions may influence the resilience of the system through at least three transmission channels.

- **Asset quality effect**: LVR restrictions can reduce the share of new mortgage commitments with a relatively high LVR, and shift the LVR distribution of the mortgage portfolio lower. All else equal, a higher LVR makes it more probable that a house price fall will result in negative equity for the borrower. If a borrower is unable to service their mortgage, negative equity generally means that a borrower cannot sell their house to fully repay a mortgage, and consequently increases the probability of default. A higher LVR also implies greater borrower leverage, which increases the debt burden of borrowers and the probability of default. Additionally, a higher LVR boosts the size of any negative equity given a house price fall, and increases the loss given default. Therefore, a downward shift in the LVR distribution will reduce credit risks and the expected mortgage losses in the banking system given a stress event.

- **Risk weight effect**: The LVR restrictions can reduce the minimum level of capital that banks are required to use to fund their mortgage loans. A significant decline in the LVR distribution on the mortgage book of the banking system will lead to a fall in the average mortgage risk weight, which

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2 Shaar (2018) finds that the share of owner-occupiers with an elevated debt-to-income ratio has declined in the post-LVR period in New Zealand, as borrower LVRs have declined.

3 Lydon and McCarthy (2013) found a strong relationship between LVRs and mortgage defaults in Ireland between 2009 and 2011, when house prices fell more than 40 percent. Kelly (2012) also using Irish data found a strong non-linear relationship between LVRs and the probability of default. Herkenoff (2012) studying US data found that an unemployed person is much more likely to default if they have negative housing equity. The LVR policy can also constrain the overall flow of new lending, which will reduce mortgage losses in a stress event. Brunnermeier et al. (2019) studied the relationship between bank characteristics and their contribution to financial stability risks under an asset price bubble, and found that bank asset size and loan growth were among the most important determinants of systemic risk.
is intended to reflect the credit risk of mortgage assets. A fall in the mortgage risk weight will reduce the volume of risk-weighted assets for banks, which would dampen the amount of capital banks are required to hold against their housing assets. When viewed in isolation, this effect of the LVR policy is negative for banking system resilience, as it reduces the capital buffer available for banks to absorb loan losses in a stress event.

- **Indirect feedback effect:** The LVR policy can mitigate the potential magnitude of a house price correction in a stress scenario. First, the LVR policy can reduce the prevalence of distressed house sales, through reducing the likelihood of borrowers experiencing serviceability difficulty. A reduction in the share of investor lending as a result of the policy, particularly to those with high LVRs, will also limit their contribution to the number of houses available for sale in a housing downturn. Second, the LVR policy can dampen the scale of house price overvaluation leading up to the house price correction, bringing prices more in line with economic fundamentals. This helps to make house prices more durable to changing economic drivers of the housing market. All else equal, a smaller scale of a house price correction helps to maintain the value of the housing collateral, and therefore will reduce mortgage losses.

Our modelling framework will quantify each of these transmission channels. Following that, we will combine all three effects to estimate an aggregate impact of the LVR policy on system resilience.

3. **Asset quality effect**

The first step in the modelling framework is to estimate the asset quality effect of the LVR restrictions. The estimation methodology essentially answers two questions:

1. How did the LVR restrictions policy affect the LVR distribution of the mortgage portfolio?
2. How did any changes in the LVR distribution of the mortgage portfolio affect the sensitivity of housing defaults and credit losses to a house price downturn?

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4 Within the capital framework, the risk weight of a loan is a function of the probability that the loan defaults (PD), the expected loss on that loan if a default occurs in a severe downturn (LGD), and whether default of that loan is likely to be correlated with defaults of other loans in that portfolio (correlation).
To answer the first question, we model the LVR distribution in a counterfactual scenario where the Reserve Bank had not implemented the LVR restrictions, and compare the output to the current LVR distribution. To do this, we use the Reserve Bank’s LVR Lending Positions Survey, which tracks the stock and flows of mortgage lending split by LVR buckets. Each LVR bucket contains all mortgage values within a specified LVR range of 5 percentage points (figure 1).

The value of mortgage stock in any LVR bucket at time $t$ can be expressed as

$$Stock_t = Stock_{t-1} - Repayments_t - Transitions_t + Drawdowns_t$$

Repayments captures both full and partial repayment of principal, and drawdowns captures the flow of new mortgage lending. Transitions captures the effect of loan LVRs changing over time, either due to loan amortisation or changes in property values being recognised. A limitation of the underlying data is that it only records the net transition of loans into and out of each LVR bucket. For simplicity and
tractability, we assume that all transitioning loans shift down by one LVR bucket from its original LVR bucket to estimate the full transition matrix.

From September 2014 onward, the LVR Lending Position Survey provides data on each of these categories of flows (Figure 2). Prior to that date we have information on new mortgage commitments (conceptually similar to drawdowns). To model the counterfactual scenario, we require an estimate of the LVR distribution when LVR restrictions were first introduced in October 2013. To accomplish this, we start with the LVR distribution for September quarter 2014, the first period the LVR Lending Position Survey is available. We then backcast the mortgage portfolio back to the September quarter 2013, using the new mortgage commitments to approximate the drawdowns between the two dates.\(^5\)

The next step is to forecast how the LVR distribution would have evolved from this baseline in the absence of the LVR restrictions. To do this, we assume:

- 35 percent of drawdowns would be at LVRs of above 80 percent - similar to the share in early 2013.\(^6\)
- That the level of mortgage drawdowns would be a little higher in the counterfactual scenario to reflect Reserve Bank estimates that the LVR restrictions policy have restrained housing credit growth by 5 percentage points cumulatively.\(^7\)
- That repayment rates and transition between LVR buckets have not been affected by LVR restrictions, so averages over 2013-2018 can be used to construct the counterfactual case.

Based on the above methodology, the LVR distribution of mortgage portfolios would have edged slightly higher in the counterfactual scenario after September 2013, in contrast to the actual LVR data that showed a large fall in the LVR distribution (figure 3). The share of the mortgage stock with a LVR of above 80 percent would have increased from 20.7 percent in September 2013, to a share of 24.3 percent by December 2018 in the counterfactual scenario, in contrast to the decline observed in the actual data to 6.8 percent in December 2018 (figure 4).

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\(^5\) To test the robustness of our estimate for the pre-policy LVR distribution of mortgages, we compared them against a limited pre-LVR dataset with less granularity in its LVR buckets (compared to the lending positions survey) and covering only part of the banking sector. The share of mortgages with a LVR of above 80 percent from our estimate broadly matches the dataset, which corroborates our approach.

\(^6\) The LVR distribution of drawdowns above the high-LVR threshold are assumed to match the pre-policy pattern in the counterfactual scenario, and the distribution of drawdowns below the high-LVR threshold are assumed to be unaffected by the policy and matches their actual distribution.

\(^7\) The 2013 introduction of the policy, as well as the 2016 tightening of the investor restrictions, were followed by slowing growth in household debts. Price (2014) estimated that the introduction of the LVRs in 2013 had lowered housing credit growth by 1 percentage point. An internal study found that the third LVR tightening reduced housing credit growth by 3 percentage points, using the framework outlined by the Bank of International Settlements in Gambacorta and Murcia (2018).
As explained in section 2, a fall in borrower LVRs will lower the probability of default (PD) and the loss given default (LGD). Therefore, an estimate of the impact of the LVR policy on mortgage losses requires information on the PD and LGD associated with different LVRs in a stress scenario. Estimates of PD and LGD for New Zealand mortgages are uncertain, reflecting the absence of a severe housing downturn in recent decades to study. We draw on two resources:

- Loss estimates from a 2017 stress test of the four largest banks. The stress test scenario involves a rise in the unemployment rate from 4.9 percent to 11.0 percent, a peak-to-trough fall in real GDP of 3.6 percent, and a decline in nominal house prices of 35 percent.
- The Reserve Bank’s structural stress testing model (the TUI model) provides an estimate of PD and LGD for a given LVR, and for any house price, unemployment and interest rate scenarios. In TUI, default rates depend on the serviceability of the borrower, while loss given default
depends on LVR. We run the TUI model using similar assumptions to the 2017 stress test.\(^8\)

We use the information on PDs and LGDs to estimate the mortgage loss rate of the banking system in a stress scenario, under the current LVR distribution, the counterfactual LVR distribution, and the initial LVR distribution prior to the LVR policy respectively. The stress test assumptions and the TUI model output do not produce the same default and loss rate, mainly given differences in methodology (figures 5 and 6). The estimated mortgage losses are higher under the PD and LGD specified in the 2017 stress test than those from the TUI model (figure 6).

However, the stress test assumptions and the TUI model produce similar results in terms of the proportional reduction in expected mortgage losses as a result of the LVR policy. Both estimates suggest that LVR restrictions have reduced mortgage loss rate in a given housing market downturn by 25 to 28 percent relative to the counterfactual scenario (figure 6).\(^9\)

Figure 5: Stressed default rate

![Figure 5: Stressed default rate](image)

Figure 6: Stressed mortgage loss rate

![Figure 6: Stressed mortgage loss rate](image)


\(^9\) These results are stronger than previous estimates of the policy impact on loss rates. Prior to introducing the first LVR restrictions, Bloor and MacDonald (2013) estimated that loss rates would be around 10 to 15 percent lower if a downturn occurred two years after the introduction.
4. Risk weight effect

A comprehensive view of the resilience impact needs to consider how the fall in borrower LVRs has affected the housing capital requirement of banks. Mortgage loan assets with a higher LVR will, all else equal, attract a higher risk weight. The four largest banks use the internal ratings-based approach to estimate risk weights, so the exact relationship between LVR and risk weights varies somewhat between the major banks. Figure 7 below illustrates the relationship between LVR and risk weights between the two credit risk approaches.10

Figure 7: Relationship between mortgage risk weights and LVR

Clearly, the decline in the LVR distribution will have reduced the average mortgage risk weight. We quantify this effect by comparing the mortgage risk weight in the counterfactual scenario with the actual risk weights. The counterfactual average risk weight is derived by applying the risk weight curve shown in figure 7 to the LVR distribution in the counterfactual scenario. We find that the average mortgage risk weight in the counterfactual scenario would have increased slightly since 2013, in contrast to the decline that was actually observed (figure 8). The comparison suggests that the LVR policy has reduced the average mortgage risk weight by around 26 percent.

10 For illustration, the figure assumes a constant PD of 0.8% for loans assessed using the IRB approach, which is the typical default rate for a mortgage held by a major bank. Depending on a bank’s IRB model, PD may depend on the LVR as well, which would tend to increase the slope of the relationship under the IRB approach.
A reduction in the average mortgage risk weight flows mechanically to a reduction in the capital banks are required to hold against a given volume of housing assets. The modelled results show that the LVR restrictions have reduced the minimum capital for each dollar of housing asset on the mortgage book by 26 percent. This negative impact on bank resilience of the risk weight effect has largely offset the positive asset quality effect, although not completely. The outcome shows that the differential in credit risks arising from borrower LVRs implied by our model is broadly consistent with the differential in credit risks incorporated in banks’ capital models.

The calibration of housing risk weights with respect to borrower LVRs (as well as investment property loans) was subject to two reviews between 2013 and 2015. As a consequence, the Reserve Bank increased capital requirements for high-LVR mortgage loans and investor mortgages over this period. The average mortgage risk weight has only declined by 6 percent since 2013, a significantly smaller magnitude than implied by the differential between the current risk weight and the counterfactual risk weight. However, this reduction in the fall in risk weights is clearly not the result of the LVR policy, and is not accounted for in our analysis.

5. Indirect feedback effect

The final transmission channel is the indirect feedback effect, which encapsulates the benefit to banking system resilience from the policy’s mitigation of the potential magnitude of a house price fall.

To estimate the indirect feedback effect, we need to first assess the risk of a house price correction currently, before considering how the LVR policy has influenced the level of housing market risk. The extent to which house prices exceed their fundamentals, such as household incomes and rents, can increase the risk of a future house price decline. There are several ways to assess this risk. A simple technique is to use the gap between the house price to household income ratio and its historical average as a benchmark. In the period from October
2013 to December 2018, the nationwide house price to income ratios have increased from 5.3 to 6.6. If we assume that the house price to income ratio falls 10 percent below the 1997-2013 average in a stress scenario – returning the ratio back to its mid-2003 level of around 4 – house prices would now have to fall by around 40 percent, more than the 25 percent in the second half of 2013.

A more sophisticated method for assessing the current risk of a house price correction is a discounted user cost model. This model estimates a household’s valuation for a house in terms of the returns from holding it (in actual or implicit rents) and expected capital gains, relative to the cost of holding (mortgage interest and other housing costs). The appendix explains the model in detail. Given plausible assumptions for the parameters of the model, we can estimate the expected capital gains that is required to justify house prices at any given point in time.\textsuperscript{11} The model suggests implied capital gains expectations of 2 percent are required to justify house prices, higher than 1.5 percent in 2013 (table 1).

Table 1: House price fundamentals and expected capital gains, 2007 to 2018

<table>
<thead>
<tr>
<th>Date</th>
<th>Rental yields</th>
<th>Estimated long-term mortgage rate</th>
<th>Estimated capital gains expectation</th>
<th>Nominal median house price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 2003</td>
<td>7.0 percent</td>
<td>6.9 percent</td>
<td>0.9 percent</td>
<td>186,000</td>
</tr>
<tr>
<td>Jun 2007</td>
<td>4.8 percent</td>
<td>7.0 percent</td>
<td>2.5 percent</td>
<td>327,000</td>
</tr>
<tr>
<td>Jun 2013</td>
<td>5.4 percent</td>
<td>6.7 percent</td>
<td>1.5 percent</td>
<td>350,000</td>
</tr>
<tr>
<td>Dec 2018</td>
<td>4.1 percent</td>
<td>6.3 percent</td>
<td>2.0 percent</td>
<td>545,000</td>
</tr>
</tbody>
</table>

This set-up allows us to assess what might happen to house prices if any of the fundamental drivers changed under a stress scenario. We calibrate two plausible stress scenarios. Housing market stress in scenario A is driven by a 22 percent decline in rents (underpinned by a large fall in household incomes in the background). Scenario B is characterised by an increase of 1.5 percentage points in the long-term mortgage rate perceived by market participants. Scenario B captures the peak of a large housing boom, when increasing pressures on home buyers become the catalyst to a house price correction. \textit{Both} scenarios assume that capital gains expectations revert to 1 percent under stress.

\textsuperscript{11} We substitute in actuals for rental yields and tax rates, and representative estimates of the average mortgage rate that can be expected over a thirty year mortgage. We calculate the expected rate of capital gains as a residual that is needed to bring the valuation implied by the model to be the same as the median house price.
The model suggests that house prices will become overvalued by 42 percent under both scenarios (figure 9), which may trigger a house price decline. The same scenarios in 2013 would have generated a decline of roughly 30 percent. The larger fall under current market conditions reflects that the starting point for capital gains expectations is higher, and that the current low level of long-term mortgage rates amplifies the impact of changes in fundamentals on the degree of overvaluation. The estimated sensitivity of the housing market to a stress scenario is similar to prior to the Global Financial Crisis.

Figure 9: Potential house price decline under stress scenarios

Having formed a view on housing market risk under current conditions, we are in a position to discuss how the LVR policy has influenced the risk. The macroprudential literature suggests a number of ways the LVR restrictions may reduce housing demand and house price overvaluation. First, a larger down payment acts as a barrier to entry, and restricts some buyers from entering the market (Jacome and Mitra 2015). Second, the announcement of LVR tightening may send a message to the market, and dampens the expectations of investors and banks alike on future house price growth, and consequently put a temporary brake on the feedback loop between house price growth and the access to credit (Basten and Koch 2015; Landvoigt 2017).

The Reserve Bank has estimated the empirical effect of the LVR policy on house prices in New Zealand. Price (2014) used counterfactual modelling to estimate that the introduction of the LVR policy in 2013 had reduced house price inflation by 3 percentage points. Yao et al (2018) studied the impact on house prices using a micro data approach, and found that the first and third rounds of the LVR policy reduced house price growth by 2 to 3 percent each. All told, the LVR policy may have cumulatively lowered house prices by 5 percent relative to the counterfactual scenario.
The LVR policy can also mitigate the extent of distressed house sales in a stress scenario.\textsuperscript{13} We previously showed that the LVR policy may have reduced stressed mortgage default rates from 12 percent to 10 percent (Figure 5), which limits the potential for distressed sales to amplify a house price correction. Although our model is not able to distinguish owner-occupier and investor loans, the introduction of the nationwide investor LVR policy in October 2016 was followed by a large decline in the share of lending flows to investors, which is likely to reduce the scale of a downturn. In general, the greater the presence of investors, the more salient is the risk of fire-sales given a severe fall in house prices, owing to both defaults (as rental incomes deteriorate) and a trader-like incentive to exit the housing market as the cycle turns.

The scale of a potential house price decline in a stress scenario may be around 40 percent currently. In the counterfactual scenario, house prices may fall as much as 45 percent, owing to a higher starting level of house prices and a greater distressed sales in a downturn (Table 2). This suggests that a conservative estimate of the impact of the LVR policy on the scale of a potential house price decline is 5 percentage points. That said, the housing market is currently at greater risk of a severe correction than before the LVR policy was introduced, owing to strong growth in house prices (Table 2).

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Scenarios & Drivers of a potential fall & Assumed magnitude of fall \\
 & Stressed default rate & Overvaluation & \\
\hline
Current & 10 percent & 42 percent & 40 percent \\
Counterfactual & 12 percent & 45 percent & 45 percent \\
Pre-LVR & 12 percent & 30 percent & 30 percent \\
\hline
\end{tabular}
\caption{Potential magnitude of a severe house price decline}
\end{table}

6. Aggregate LVR policy impact on bank resilience

We estimate an aggregate impact on the resilience of the banking system from the asset quality effect, the risk weight effect and the indirect feedback effect. This is completed through the following steps:

1. We use information from the 2017 stress test to calibrate PDs, and the TUI model to calibrate LGDs,\textsuperscript{14} for the different magnitudes of house price declines we have estimated for the current conditions, pre-LVR conditions and the counterfactual scenario.

2. These estimated PDs and LGDs are applied to the LVR distribution under each scenario, to produce a mortgage loss rate for each.

\textsuperscript{13} Related to this, work by Mian and Sufi among others has shown that aggregate leverage was a significant driver of house price declines at the city level. See Thornley (2016), “Financial stability risks from housing market cycles”, for a summary of this literature.

\textsuperscript{14} We use the LGDs in the TUI model because they are sensitive to the scale of a house price fall, while the PDs in the stress test were our preferred estimate of the PD as they draw on more recent data and utilise a range of modelling approaches.
3. Mortgage risk weights (and bank housing capital) are estimated for each scenario. The steps taken so far allow the calculation of losses as a share of housing capital in each scenario.

4. We compare mortgage losses as a share of housing capital between current and the counterfactual scenarios.

The estimated measure of bank resilience suggests that banks are more vulnerable to a housing market correction now than in 2013, with losses rising from 71 percent to 84 percent of housing capital. This deterioration since 2013 is because of the increased magnitude of a potential house price correction. However, had we not imposed LVR restrictions, we estimate that mortgage losses would be 96 percent of housing capital (figure 10). The LVR policy increased bank resilience chiefly through limiting the potential decline in house prices, while the resilience benefit of the asset quality effect is largely offset by the risk weight effect that reduced bank capital minimums.

Figure 10: Mortgage loan losses as a share of housing capital requirement

The LVR restrictions has reduced mortgage losses as a share of housing capital in a downturn by around 12 percentage points. To phrase this differently, the LVR restrictions have offset around 50 percent of the deterioration in banking system resilience that would have occurred after 2013 if the LVR policy was not used. This estimate is probably the most reliable measure of the effectiveness of the LVR policy in improving banking system resilience the Reserve Bank has produced to date.

So what lessons can we draw from this analysis for the effectiveness of LVR restrictions? The risk weight effect (owing to the interaction between the LVR policy and the capital regime) tends to offset most of the asset quality effect of LVR restrictions. That is, while credit losses are likely to be lower for any given downturn, bank capital buffers will tend to decline by a similar margin. It is worth considering whether future LVR policy moves should be paired with adjustments to capital requirements to mitigate this offset.

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15 This counterfactual assumes that we still would have made adjustments to the capital regime.
7. Sensitivity analysis on the estimated LVR policy impact

The policy’s mitigation of a potential house price fall is uncertain

Our headline estimate presumes that house prices would fall by 5 percentage points less as a result of the policy. However, this estimate is uncertain. If we instead assume that house prices would fall by 10 percentage points less as a result of the LVR policy, the resilience benefit would increase to 23 percentage points of housing capital, almost double the headline estimate. In contrast, if the severity of a house price fall is not affected by the policy, the resilience benefit would fall to only 3 percentage points of housing capital.

The resilience benefit of policy is contingent on baseline housing risks

Intuitively, if the potential magnitude of a house price decline is relatively high in the counterfactual scenario, the resilience benefit associated with the LVR policy should be high. To derive this result in the model, we need to assume:

- For an increase in the scale of a house price correction, both the PD and LGD of borrowers with a higher LVR will increase by more than those with a lower LVR.

This seems realistic, because more indebted borrowers should be more vulnerable to the house price fall and the underlying economic stress than less indebted borrowers. The headline estimate in section 6 does not incorporate this, owing to limitations in the main stress test assumptions and the TUI model. To quantify the relationship between PD and the size of house price declines, we draw on the sensitivity analysis by banks during the 2017 exercise, which suggested that default rates would increase by 20 percent if house prices fell by an additional 10 percentage points. We impose the above conditions and re-estimate the resilience benefit for a range of house price declines (figure 11). This stylised estimate shows that the resilience benefit of the LVR policy is greater if the baseline level of housing market risk, which would have prevailed without the LVR policy, is greater. This suggests that there is a stronger case for deploying the LVR instrument when the risk of a house price fall is high, and for easing the LVR restrictions, and for considering alternative tools, when housing risks are low.
Between 2015 and 2016, the LVR restrictions were calibrated to become more restrictive on property investors than owner occupiers. International evidence suggests that investor loans are more prone to default when house prices fall sharply, than owner occupier loans for a given LVR ratio. Investors with multiple leveraged properties have a strategic incentive to default in a severe house price fall, because they are more likely than owner occupiers to experience heavy negative equity relative to their expected future incomes. Investor incomes are also more correlated with house price cycles, owing to the cycle’s impact on rents and rental vacancy. Through this channel, the tightening of the LVR policy in 2015 and 2016 may have reduced the scale of mortgage losses in a stress event, by reducing the share of high-risk investor lending. We refer to this as the borrower composition effect.

There are hurdles to formally quantify the borrower composition effect, owing to a lack of data.

- We are unable to take a firm view on how the overall size of the investor loan book would change in the counterfactual scenario. This depends crucially on amortisation rates of investor loans at each LVR. We do not have data on amortisation rates for different borrower types, but investor loans are likely to amortise slower than owner occupier loans, owing to tax-based incentives for investors to maintain higher leverage.
- We do not have reliable estimates of the PD and LGD of investor mortgages in a potential house price downturn, which are likely to be higher than for the overall mortgage book.

If assumptions are made on the above parameters, it is possible to incorporate the borrower composition effect. We estimate the resilience impact from the LVR

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16 Studies on the post-GFC experiences in Ireland (Kelly and O’Malley, 2014; Central Bank of Ireland, 2014) and the UK (McCann, 2014; HM Treasury, 2015) show that the mortgage loss rates on investor lending are significantly higher than that on owner occupier lending.
policy under the assumptions that investor mortgages amortise at 70 percent of the rate of the overall mortgage book, and investors default 50 percent more often than owner occupiers in a house price downturn. Based on these assumptions, the LVR distribution of investor lending are projected to be significantly higher in the counterfactual scenario than currently (figure 12), similar to its pre-LVR distribution. This suggests that the LVR restrictions have shifted the LVR distribution of the investor stock lower. The estimated resilience benefit of the LVR policy increases from 12 percentage points to 20 percentage points of housing capital. However, as noted previously, we lack the data to estimate the true borrower composition effect with a reasonable degree of confidence.

Figure 12: High-LVR share of investor mortgage lending

8. Conclusion

This paper presents a modelling framework that quantifies the impact of the LVR policy on one of its key objectives: improving the resilience of the banking system to a severe downturn in house prices. We find that the LVR restrictions policy has significantly enhanced the resilience of the banking system. The LVR policy is estimated to have reduced mortgage losses as a share of housing capital by 12 percentage points, offsetting around half of the deterioration in bank resilience from late 2013 that would have occurred in the absence of the policy. The resilience benefit of the policy arises chiefly from its mitigation of the severity of a potential house price fall. The improvement in the quality of mortgage assets from a fall in their LVRs also contributes to bank resilience by reducing mortgage losses in a potential downturn, but this benefit is largely offset by the fall in bank capital requirement as credit risk declines.

Our headline estimate of the resilience benefit is sensitive to several uncertainties. First, the resilience benefit is contingent on the baseline level of housing market risk that would prevail without the policy. All else equal, this suggest a stronger case for using a LVR instrument if the risk to the banking system associated with a

17 We have data on the LVR distribution of the investor mortgage stock based on unpublished bank private reporting dating back to 2017. For 2013, we only have data on the LVR distribution of the investor mortgage stock for a single major bank.
house price decline is high. Second, the resilience benefit depends on the extent the LVR policy has mitigated a potential house price fall, and a larger effect than we have incorporated is plausible. Lastly, we are relatively uncertain on the extent the reduction in risky investor lending has influenced resilience, owing to data limitations. A provisional assessment based on plausible assumptions suggests that the resilience benefit from restricting investor lending may be large, and the actual resilience benefit of the LVR policy may be greater than our headline estimate.
REFERENCES


**Appendix: Discounted cash-flow model functional form**

The discounted cash-flow model incorporates a range of factors determining the net yield of the house as an asset into its prediction of a buyer's valuation for housing. The model takes the form:

\[
V = \frac{A(1-t)}{(i + f)(1 - t) - g},
\]

where a buyer’s valuation for property V is a function of annual rental incomes A, mortgage interest rates i, other housing costs f (e.g. property rates, body corporate fees, maintenance, and property management fees), expected capital gains g and tax rates t. For investors, t is the current tax rate, as they pay tax on rental income and can obtain tax losses on expenses. For owner occupiers, t is zero as they do not pay tax on the implicit rents they pay to themselves, or to put differently, the benefits from living in the property. Hargreaves (2008) provides a comprehensive primer on the theory underpinning the model.

To find out the expectations of capital gains that would justify current house prices for a given investor, we set V equal to the prevailing house price. We substitute the actual values for the parameters i, f, A and t for investors, and then solve for the value of the unknown g. The process for solving the expected capital gains for owner occupiers is the same, except that t is zero and f can be different (cost of maintaining a rental property may be higher).