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Abstract

This paper contributes to the international policy debate on the effect of macroprudential policy on housing-market dynamics. We use detailed New Zealand housing market data to evaluate the effect of loan-to-value ratio (LVR) restrictions on house prices. Our identification relies on the exemption for new builds from the LVR restrictions implemented during 2013 – 2016 by the Reserve Bank of New Zealand. We apply a difference-in-difference approach and find that, overall, the LVR policy is effective at reducing house price inflation. The house price effects of the New Zealand LVR policy were highly non-linear. The policy's impact on house prices differed by region and by the magnitude of the treatment. We find that an investor-specific LVR was more effective in Auckland than the rest of New Zealand. We also find that there are thresholds beyond which an LVR policy becomes binding. When restrictions are above this level (that is, when the policy is not binding), the effect is minimal; when the policy becomes binding, the effects of the LVR on house prices are very strong. These empirical findings will help to calibrate LVR policy in the future.

Non-technical summary

This paper contributes to the international policy debate on the effect of macroprudential policy on housing-market dynamics. We use detailed New Zealand housing market data to evaluate the effect of loan-to-value ratio (LVR) restrictions on house prices. The main challenge in identifying these effects is that housing markets are affected by a range factors over and above LVR policy. For example, New Zealand experienced a raft of policy changes and macroeconomic shocks during the periods in which LVR policy changes were implemented. Many of these shocks and policies are likely to have affected the housing market. For example, when the first LVR policy was implemented, retail interest rates were rising alongside an increasing expectation for monetary policy tightening, while the New Zealand Treasury was adjusting housing-related policies at the time of the second LVR policy. This paper uses the exemption for new builds from the LVR restrictions as a natural experiment to identify the effect of LVR policy.

We find that, over the one year window around the new home exemption, the first LVR policy (referred to as 'LVR 1') had a 3 percent moderating effect on house prices, and this moderating effect is broadly similar across both Auckland and the rest of New Zealand. Interestingly, our estimates show that LVR 2 (which tightened restrictions on Auckland properties and loosened restrictions elsewhere) did not significantly stop Auckland house prices from rising. By contrast, house prices in the rest of New Zealand (RONZ) increased by 3 percent due to the relative loosening of the LVR restriction. In LVR 3, the RBNZ further tightened the LVR restrictions on property investors nationwide. The moderating effect of LVR 3 was clearly seen in Auckland with a 2.7 percent reduction in house prices. This LVR 3 effect is both statistically and economically significant, as during the same period the average house price increased by 5.8 percent.

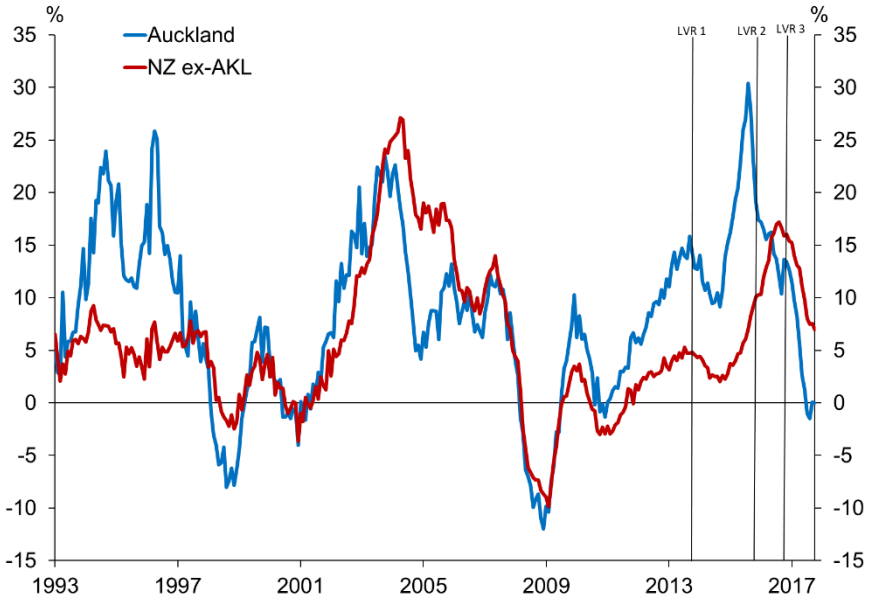
Overall, we estimate that the LVR policies reduced house price pressures by almost 50 percent. However, the effect of LVR policy is highly non-linear. When it becomes binding, LVR policy can be very effective in curbing housing prices.

1. Introduction

Reinhart and Rogoff (2009) and Claessens *et al*, (2012) find that recessions are more severe when they are accompanied by financial crises. This comovement between financial crises and recessions is problematic for policy-makers because the experience of the global financial crisis highlighted that prototypical monetary policy focused on price stability did not ensure financial stability. To foster financial stability, policy-makers developed a new set of policies – known as macroprudential policies – as a complement to monetary policy.

Broadly speaking, macroprudential policy has two main objectives: i) enhancing the resilience of the financial system by increasing buffers within financial institutions; and ii) limiting the build-up of financial imbalances by moderating asset price and credit cycles. In this paper, we focus on the second objective of macroprudential policy and evaluate the effectiveness of loan-to-value ratio (LVR) restrictions in moderating house price inflation.[2]

Figure 1: House Price Inflation in Auckland and the rest of New Zealand



Source: REINZ, RBNZ.

As shown in figure 1, in response to financial stability risks associated with rapidly rising house prices, the Reserve Bank of New Zealand (RBNZ) implemented three rounds of restrictions on high-LVR lending between 2013 and 2016. The first round of LVR policy was imposed

[2] Restrictions on household borrowers have been recently adopted in several advanced economies in addition to New Zealand, such as Ireland, Korea, the UK, and several other European countries (see e.g. Hartmann, 2015).

nationwide in October 2013, with the goal of helping to "slow the rate of housing-related credit growth and house price inflation, thereby reducing the risk of a substantial downward correction in house prices that would damage the financial sector and the broader economy" (Wheeler, 2013). This policy had a notable effect on house price inflation in both Auckland and the rest of New Zealand for around six months. Subsequent rounds of LVR policy changes were implemented in November 2015 and October 2016. These policies were designed with a similar objective in mind, but varied across purchaser classes and regions to target areas and groups viewed as being of particular risk to financial stability.[3]

We contribute to the international policy debate on the effectiveness of macroprudential policy. We quantify the effect of LVR policy as implemented in New Zealand between 2013 and 2016, in moderating house prices. The main challenge in identifying these effects is that housing markets are affected by a range factors over and above LVR policy. For example, New Zealand experienced a raft of policy changes and macroeconomic shocks during the periods in which LVR policy changes were implemented. Many of these shocks and policies are likely to have affected the housing market. For example, when the first LVR policy was implemented, retail interest rates were rising alongside an increasing expectation for monetary policy tightening, while the New Zealand Treasury was adjusting housing-related policies at the time of the second LVR policy.[4]

Given the potential effects of these other policies and events on the housing market, it is challenging to disentangle the effect of LVR policy. To cope with this identification problem, in this paper, we use a detailed micro-dataset of housing market transactions in New Zealand and apply a difference-in-difference (DiD) methodology to identify the effects of the LVR policies on house prices. In particular, purchases of new dwellings were exempt from the Reserve Bank of New Zealand's LVR policies (but not from other macroeconomic shocks or policy changes). This allows us to use 'new builds' as the control group relative to existing homes, with the latter representing the 'treatment' group affected by changes in the LVR policies. [5]

Applying this approach to identify the effect of LVR policy, we find that, over the one year window around the new home exemption, the first LVR policy (referred to as 'LVR 1') is

[3] For a more detailed discussion of LVR policy in New Zealand, see Section 2.

[4] See Table A1 in the appendix for details of policy and events around LVR policy times.

[5] For more detailed information on the new house exemption, please refer to: https://www.rbnz.govt.nz/-/media/ReserveBank/Files/Financial%20stability/LVR/Construction-exemption-categories-from-LVR-restrictions-QandAs.pdf?la=en

estimated to have had a 3 percent moderating effect on house prices, and this moderating effect is broadly similar across both Auckland and the rest of New Zealand. Interestingly, our estimates show that LVR 2 (which tightened restrictions on Auckland properties and loosened restrictions elsewhere) did not significantly stop Auckland house prices from rising. By contrast, house prices in the rest of New Zealand (RONZ) increased by 3 percent due to the relative loosening of the LVR restriction. In LVR 3, the RBNZ further tightened the LVR restrictions on property investors nationwide. The moderating effect of LVR 3 was clearly seen in Auckland with a 2.7 percent reduction in house prices. This LVR 3 effect is both statistically and economically significant, as during the same period the average house price increased by 5.8 percent. In total, we estimate that the LVR policies reduced house price pressures by almost 50 percent. Based on these findings, we argue that the effect of LVR policy is highly non-linear. When it becomes binding, LVR policy can be very effective in curbing housing prices.

This paper is related to the rapidly expanding literature on the effectiveness of macroprudential policy. Wong et al (2011) present cross-country evidence from Korea, Hong Kong SAR, Singapore, and Malaysia that shows that low LVRs can reduce delinquencies in response to economic downturns and property price busts. Lim et al (2011) also consider several different measures of macroprudential policy, using data covering 49 countries from 2000 to 2010. They find that in more than half of the countries in their sample, credit growth and house price inflation decline after the implementation of an LVR rule. Kuttner and Shim (2016) use a panel of 57 countries to evaluate the effectiveness of a wide range of macroprudential, housing, and tax policies on imbalances in the housing market. They find that maximum debt-service-to-income ratios and increases in housing-related taxes have significant negative effects on housing credit and house price growth. Tightening LVR restrictions has a statistically significant effect on house prices, but loosening LVR restrictions does not have a statistically significant impact. In our study, we find evidence of strong effects for both LVR tightening and loosening, depending on whether the loan-to-value ratio is binding or not in the economy.

Cerutti et al (2015) use a more recent survey on the use of macroprudential policies in 119 countries. Their analysis covers 12 different measures, some of which are targeted towards households, namely debt-to-income (DTI) and LVR rules. When looking at advanced and emerging countries separately, the authors find that in the advanced countries there is a weak negative association between some of the borrower-based measures and household credit growth

but no association between the measures and house prices.[6] In general, cross-country studies mostly show that the implementation of credit restrictions on mortgage loans is associated with slower credit and house price growth. While this approach permits broad conclusions to be drawn regarding macroprudential policy, it is difficult to interpret the results without further details on the measures implemented and housing market conditions. In contrast, our country-specific study provides a precise identification strategy that exploits country-specific policy details that cannot be taken into consideration in large cross-country studies. In particular, we use specific features of the policy changes that allow us to use a DiD methodology to more precisely estimate the impact of the policy changes.

In this sense, this paper is also related to recent literature using micro data and the difference-in-difference approach to evaluate the effectiveness of macroprudential policies. Jiménez et al (2012) study the effects of the dynamic provisioning scheme implemented in Spain on credit growth using credit register data. Aregger, Brown, and Rossi (2013) examine the impact of transaction taxes and capital gains taxes on house price growth in Switzerland. Barroso, Ganzalez, and Nazar Van Doornik (2017) estimate the impact of reserve requirements on credit supply and Godoy de Araujo, Barroso, and Gonzalez (2017) study the effect of LVR restrictions on credit supply. Both studies use a large loan-level dataset from Brazil. Similarly, Aguirre and Repetto (2017) assess the impact of capital- and currency-based macroprudential policy measures on credit growth at the bank-firm level, using credit registry data from Argentina.

The most closely related study to ours is Igan and Kang (2011), who investigate the effects of changing DTI and LVR limits on housing market activities and house prices in Korea. Similar to our study, they use micro data to address the endogeneity issue in teasing out the effect of LVR changes from those associated with other policies and macroeconomic effects. In particular, they use household-level data to compare control and treatment household groups with similar characteristics and interpret the average difference as the effect of macroprudential policy. They find that both DTI and LVR limits are associated with a decline in house price inflation and housing market activity.

The remainder of the paper is organised as follows. Section 2 discusses the LVR policy implemented in New Zealand and provides some information on the considerations that motivated its implementation and subsequent changes. Section 3 presents a discussion of our

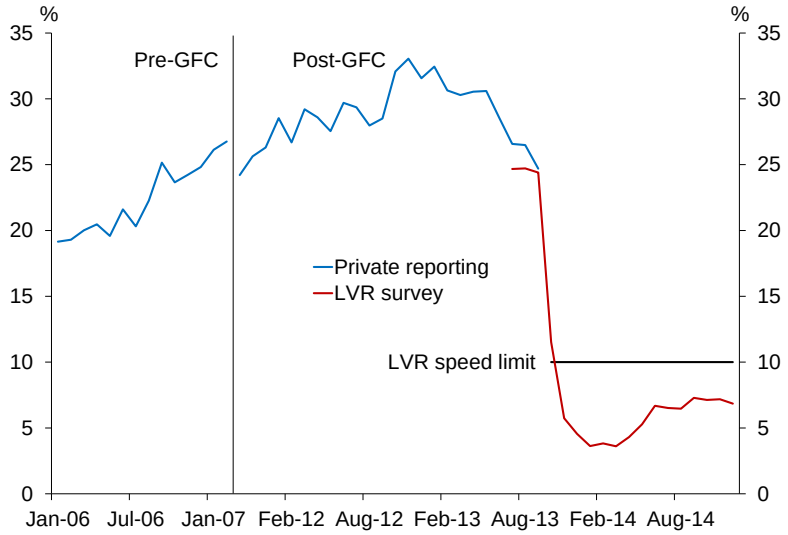
[6] Similar studies in this vein include Hilbers et al. (2005), Borio and Shim (2007), Crowe at el. (2013) and Vandenbusshe et al. (2015), among others.

data and the methodology employed. Section 4 shows our main empirical results and robustness checks. Finally, we conclude in Section 5.

2. Loan-to-value ratio restrictions in New Zealand

In October 2013, the RBNZ implemented restrictions on high-LVR lending to limit the risk to financial stability posed by rapid growth in house prices and household debt. Banks were required to restrict new residential mortgage lending at LVRs of over 80 percent to no more than 10 percent (the "speed limit") of the dollar value of their new housing lending flows.[7] This led to an immediate fall in the share of high-LVR loans to around 5 percent of new commitments (figure 2), and a decline in the rate of house price growth (see figure 1). The introduction of the LVR improved bank balance sheet resilience to a potential housing market downturn, with the share of outstanding loans at high LVRs declining post-implementation (figure 3).

Figure 2: Share of new housing lending at an LVR exceeding 80, by value



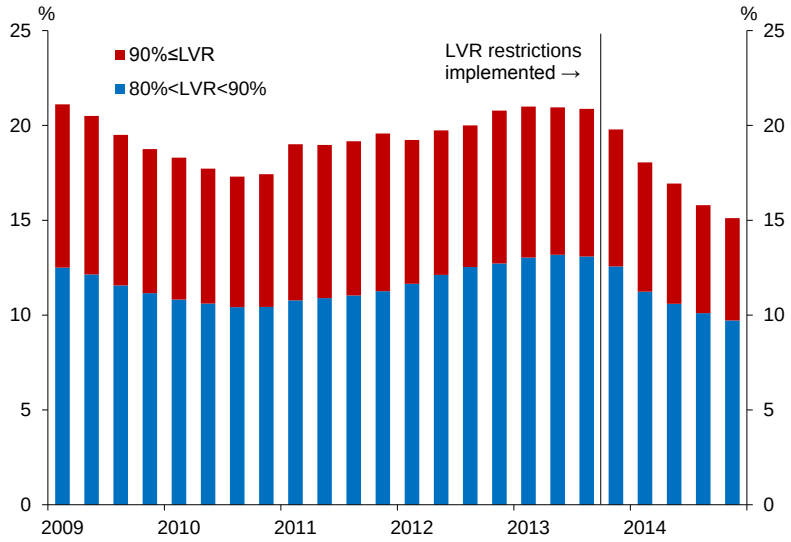
Source: RBNZ.

While the initial LVR restrictions eased house price pressures and moderated housing-related financial stability risks through 2014, a resurgence of house price inflation in Auckland from October 2014 led to a re-emergence of financial stability risks. In response, the RBNZ revised the LVR policy in November 2015, resulting in a tightening of restrictions for Auckland

[7] These restrictions entailed several exemptions to minimise any associated effect on housing supply. One such example is the construction exemption, which we make use of in this paper. For more information on the details of the exemptions, see: https://rbnz.govt.nz/-/media/ReserveBank/Files/Financial%20stability/LVR/lvr-restrictions-guide-for-borrowers.pdf?la=en.

investors and a loosening of restrictions for investors and owner-occupiers outside of Auckland (see table 1 for details).[8]

Figure 3: Share of outstanding housing loans at an LVR exceeding 80, by value



Source: RBNZ.

This policy was motivated both by the Auckland-specific nature of the risks, and international evidence that investor loans posed greater risks to financial stability. [9] Following announcement of the policy, the share of nationwide investor lending at an LVR exceeding 70 percent fell from around half to just under one-third of investor lending (figure 4).[10]

Table 1: Summary of LVR policy settings

	LVR 1	LVR 2	LVR 3
Auckland investors	80% (10%)	70% (5%)	60% (5%)
Auckland owner-occupiers	80% (10%)	80% (10%)	80% (10%)
Rest of NZ investors	80% (10%)	80% (15%)	60% (5%)
Rest of NZ owner-occupiers	80% (10%)	80% (15%)	80% (10%)

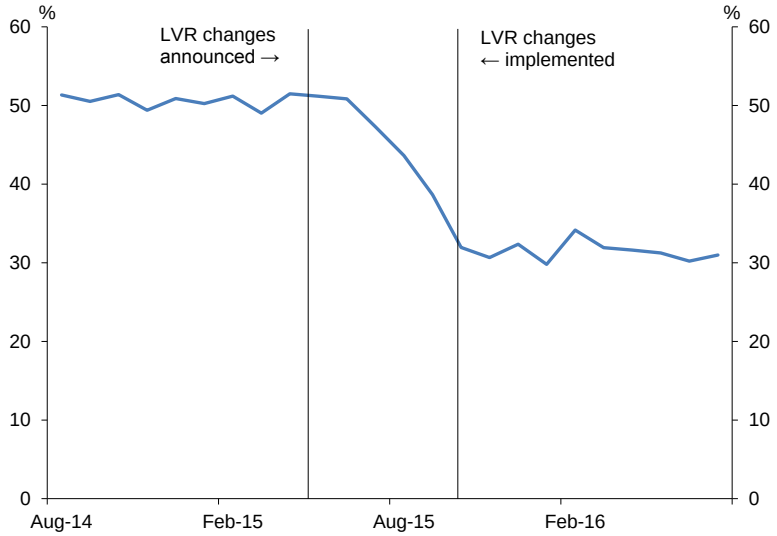
Note: Numbers prior to parentheses refer to the LVR thresholds; numbers in parentheses refer to the maximum share of new lending that can exceed the LVR threshold. For regulatory purposes, all groups with identical restrictions were grouped together in the calculation of high-LVR shares. For example, under LVR 3, the "60% (5%)" limit applied to the combined lending to all investors nationwide, rather than separate limits by regions.

[8] 'Property investment loans' were defined as those not secured against a property that the borrower lives in or uses as a holiday house.

[9] See, for example, Kelly, R and T O'Malley (2014) and Gerardi K, *at el.* (2017).

[10] As region-specific commitments data were not available prior to the implementation of the second round of LVR policy, we are unable to examine the change in the share of Auckland investor lending at an LVR exceeding 70 percent.

Figure 4: Share of nationwide investor commitments at an LVR exceeding 70, by value



Source: RBNZ.

Although house price inflation slowed significantly in Auckland following the first and second LVR changes, house price inflation in the rest of New Zealand increased sharply (see figure 1). With house prices becoming increasingly stretched relative to incomes and rents, the Reserve Bank deemed it necessary to mitigate the associated financial stability risks by expanding and tightening the investor LVR restrictions, and modifying the speed limit for owner-occupiers (see table 1). This entailed a 5 percent speed limit on nationwide investor lending at an LVR exceeding 60 percent, and a 10 percent speed limit on nationwide owner-occupier lending at an LVR exceeding 80 percent. These measures were introduced in October 2016.

Following these policy changes, there was a relatively broad-based fall in house price inflation across New Zealand. One year after policy implementation, as of October 2017, annual house price inflation in Auckland and the rest of New Zealand stood at 0 percent and 6.9 percent respectively, down sharply from their respective peaks.[11] However, as this occurred alongside other macroeconomic and housing-policy changes, not all of the slowing effects can be attributed to the LVR policies. The remainder of this paper seeks to estimate the extent to which the slowing in house price inflation can be attributed to each of the LVR policy changes.

[11] For further reading on the New Zealand experience with LVR restrictions, refer to the Reserve Bank's semi-annual *Financial Stability Reports* and the 'Loan-to-value ratio restrictions' page on the Reserve Bank's website, available at: https://rbnz.govt.nz/financial-stability/loan-to-valuation-ratio-restrictions.

3. Methodology and data

In this section, we conduct a micro-econometric analysis, based on the difference-in-differences methodology. DiD is a micro-econometric technique popularised in the early 1990s (see, for example, Card and Krueger, 1994). DiD takes advantage of a differential treatment across groups in order to identify an economic impact through a pseudo-experiment. In most cases of DiD there are two clearly identifiable groups in the population, of which only one receives the treatment. Though there may be differences in the measurement variable between the two groups prior to the treatment being imposed, DiD methodology allows researchers to look through this by comparing the difference between the groups *before* the treatment to the difference between the groups *after* the treatment. In such a way, the methodology allows us to split out the post-treatment difference into two components: the pre-treatment difference between the two groups (which is assumed to be constant, even after treatment); and the well-identified treatment impact.In this paper, we use the fact that purchases of new dwellings were exempt from the LVR policies in December 2013. This allows us to use 'new builds' as the control group relative to 'existing homes' as the treatment group.

3.1 Data

The data used in this study are unit-record data from CoreLogic. CoreLogic is an international property data and analytics firm, with a strong presence in New Zealand. They use several property datasets to link together a range of property and buyer information, including price and valuation data, property characteristics (capital value, age, etc), and the mortgage characteristics of the seller and buyer (such as whether the buyer is a first-home buyer, a multiple property owner, etc). Such micro-data provide a rich set of information for examining the impact of the changes in LVR restrictions. We use data over the sample January 2013 through May 2017 (in total 380,656 observations, with each sale of a property corresponding to a single observation). Some sample statistics for the data are shown in table 2 below.

Table 2: Summary statistics (averages) over the sample period*

	All transactions		Existing homes		New builds	
	Auckland	Rest of NZ	Auckland	Rest of NZ	Auckland	Rest of NZ
Price (NZD)	837,321	432,256	834,108	429,641	930,274	545,531
CV** (NZD)	715,940	416,580	712,898	413,978	803,957	529,283
Price/CV ratio	1.17	1.04	1.17	1.04	1.16	1.03
Volume	120,770	259,886	116,735	254,022	4,035	5,864
Avg. year built	1980	1974	1978	1973	2015	2015

Source: CoreLogic, RBNZ. Note: *The sample period is from January 2013 to September 2017. **CV stands for capital value, which is the probable price that would be paid for the property at the valuation date, assessed by the regional councils in New Zealand, ie the total of the land value and improvements value. These capital valuations are used to assess the city and regional council rates that must be paid by home-owners.

Over the entire sample period, the average sale price for a house in Auckland is around NZ$840,000, which is almost twice as expensive as the average house price in the rest of the country. Auckland houses are sold on average 17 percent above their capital value, while the price premium is only 4 percent in the rest of New Zealand. This difference reflects the relative demand pressure across regions over this period, and differences in the timing of capital value revisions across regions. The price/CV ratio of existing homes is slightly higher than that of new buildings. In terms of transaction numbers, the Auckland housing market makes up roughly one third of total housing transactions across New Zealand. This ratio is even higher for new builds, consistent with the greater rate of residential building in Auckland in recent years.[12] Regarding the average age of properties, Auckland has a slightly newer housing stock relative to the rest of New Zealand with an average age of 37 years versus 43 years.

3.2 Identification strategy

Our identification of the effect of the LVR hinges on the fact that the policies exempted new builds from the LVR restriction.[13] The motivation for the exemption was to limit the impact of LVR restrictions on housing supply. Two types of housing construction activity are subject to

[12] Due to the way in which we identify new builds (see below), our control group includes only a subset of newly built houses. However, we have no reason to believe that this should induce material bias into our estimates. Genuine new builds that are included in the group of existing homes may impart downward bias on our estimates, but the sample of existing homes is sufficiently large that this effect should be minimal.

[13] See policy document 'Construction exemption categories from LVR restrictions' at http://www.rbnz.govt.nz/-/media/ReserveBank/Files/Financial%20stability/LVR/Construction-exemption-categories-from-LVR-restrictions-QandAs.pdf?la=en

this exemption. The first exemption is available for new dwellings or dwellings under construction. The second exemption applies to non-routine/deferred property maintenance on a dwelling that is subject to a pre-existing residential mortgage. The latter exemption supports the restoration of value to dwellings in exceptional circumstances such as fire, natural disaster, weather-tightness, or alignment to revised structural standards (e.g. seismic standards). In this study, we are most interested in the first type of exemption (on new dwellings). As such, we use new builds as the control group for identifying the effect of the LVR policy on house prices.

The new house exemption to the policy is applied differently over time, which allows us to further investigate the differing impacts of the three policies. In LVR 1 and LVR 2, the RBNZ required that borrowers had committed to a new build at an early stage of the process. This prevented the exemption being used to purchase recently built houses, or to buy off-the-plan apartments when building work was already underway. This definition of the exemption leads us to define our 'new-build' dummy variable as those housing transactions for which the sale date is at least one year earlier than the date of construction completion. For LVR 3, however, the RBNZ broadened the scope of the construction exemption, such that recently built houses would also be exempt from the policy. To fit to this definition, we define a new 'new-build' dummy variable for LVR 3, with a value of one if the sale date is in the same year as the date of construction completion. Based on the definition of new homes, we define the existing-home dummy as any house other than new builds.

The specification we use to examine the effect of LVR policy on house prices takes the following form:

$$log(SPAR_i) = \beta_{EH}\delta_{EH} + \beta_{LVR}\delta_{LVR} + \beta_{DiD}\delta_{DiD} + \sum_{k=1}^{K} \beta_k Z_i^k + \mu_i \,, \qquad (1)$$

The dependent variable $log(SPAR_i) = \log(HP_i) - \log(CV_i)$ is the SPAR index for house prices, using the capital value to control for quality of the property. It can be interpreted as the price premium above the fundamental value of the house.[14] The explanatory variables include the existing-home dummy (δ_{EH}), which takes a value of 1 for existing homes and 0 otherwise. The after-LVR dummy (δ_{LVR}) takes a value of 1 for time periods after the LVR policy, and 0 otherwise. There is some contention around the precise timing of the LVR, due to the different timing of

[14] The (log) capital valuation of the property is sourced from the regional councils, who produce valuations approximately every three years for property tax purposes. The CV is found to be a very good predictor of house prices (Armstrong, Dunstan, and Irrcher, 2017), and so including the CV is a way of accounting for property-specific characteristics (such as age, size, and proximity to amenities).

announcement, implementation, and exemption (of new builds). As a baseline, we adopt timing that corresponds with the announcement of the new build exemption, with some robustness checks of alternative timings. The announcement date was used as any future change in house prices resulting from the LVR policy would be expected to be capitalised shortly after the change was announced.

The diff-in-diff dummy (δ_{DiD}) is the interaction between δ_{EH} and δ_{LVR}. Thus, it takes a value of 1 for existing homes after the LVR policy, and a value of 0 otherwise. For the hypothesis that the LVR negatively impacted housing market activity and pricing, we would expect the coefficient on this dummy to be negative – existing homes were impacted by the LVR while new builds were not, so the value of existing homes relative to new builds would be *lower* after the LVR. We also include several control variables Z_i^k in our regression models. We use regional fixed effects. These are included in Z_i^k as either territorial authority (TA) dummies or regional dummies. [15] In addition, the buyer's 'type' (such as first-home buyer or investor) and whether the purchase is financed by a mortgage are also included. In robustness tests, we also consider additional control variables, such as interest rates, building consents and regional net migration numbers. These variables were entered as the period-average corresponding to the sale period. Interest rates were included to capture the monetary policy impact on house prices, while regional net migration (see McDonald, 2013), and building consents capture relative demand and supply pressures.

4. Empirical analysis

In this section, we present the empirical results regarding the effect of LVR policy on house prices. House prices are one of the most important metrics to evaluate the effect of LVR restrictions (alongside credit growth). We first study three rounds of LVR policies in turn, and then discuss how to use the empirical results for calibrating future LVR policy.

4.1 The first LVR policy

Of the three LVR policies under consideration, the first policy is the simplest to analyse using DiD, because it imposed a nationwide LVR restriction requiring a 20 percent down-payment with a 10 percent speed limit. We use a simple DiD regression to quantify the effect of the

[15] New Zealand has 76 territorial authorities, which are aggregated up into 13 regions.

policy on the treatment group (existing homes) relative to the control group (new builds). Table 3 shows the empirical results from this regression.

Table 3: Effect of LVR 1 on house prices

Dependent variable	Log(SPAR)						
	I	II	III	IV	V	VI	VII
LVR 1 dummy	0.059*** (0.006)	0.053*** (0.005)	0.039*** (0.003)	0.034*** (0.005)	0.059*** (0.006)	0.076*** (0.004)	0.046*** (0.007)
Existing Home	-0.016*** (0.003)	-0.021*** (0.003)	-0.010** (0.002)	-0.016*** (0.004)	-0.016*** (0.003)	-0.022*** (0.002)	-0.013*** (0.003)
Diff-in-diff	-0.030*** (0.005)	-0.021*** (0.003)	-0.010*** (0.003)	-0.006 (0.005)	-0.031*** (0.006)	-0.023*** (0.003)	-0.031*** (0.007)
Data coverage	NZ	NZ	NZ	NZ	NZ	AKL	RONZ
Building consents	X	X	X	X	-0.003*** (0.000)	X	X
Buyer-type dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	TA	TA	TA	TA	TA	TA	TA
Observations	108,909	114,778	108,909	96,699	108,909	39,331	69,578
R^2	0.245	0.253	0.245	0.255	0.248	0.089	0.336

Notes: Results are based on Equation (1). The dependent variable is the logarithm of the SPAR. Independent variables are explained in the notes under Equation (1). Data coverage indicates regional data used in the regression. NZ stands for New Zealand; AKL means Auckland and RONZ means the rest of New Zealand excluding Auckland. All regressions are based on data 12 months before and 6 months after the LVR policy dummy.

In specification I, we run a regression on the logarithm of SPAR on the LVR dummy, existing home dummy, and DiD covariate. In addition, we use buyer-type dummies, a cash-buyer dummy, and regional dummies at the territorial authority level (TA)[16] to control for different types of heterogeneity in the housing market. The LVR dummy takes a value of one after the building exemption was implemented in February 2014. The regression results are obtained using the sample of data 12 months before and 6 months after the exemption implementation. This time period is chosen based on data availability and our expectation that the policy effects will be largest over the first six months of the policy.

The estimates from the regression are highly statistically significant. They show that, 6 months after the new build exemption being implemented, overall house prices are on average 5.9

[16] For more information on geographic boundaries in New Zealand and the definition of TAs, please visit the website: http://m.stats.govt.nz/browse_for_stats/Maps_and_geography/Geographic-areas/digital-boundary-files.aspx.

percent higher than before the new build exemption. And over the whole period, prices of existing homes are 1.6 percent lower than newly constructed houses. The key DiD coefficient should be interpreted as the change between house prices for existing homes before and after the new build exemption being implemented relative to the change between house prices for new builds before and after the exemption. We find that price changes of existing homes (the treatment group), which are under the influence of the LVR restrictions, are 3 percent lower than the price changes of new builds (the control group). This is the difference that we attribute to the LVR policy effect. The estimated LVR effect is both statistically and economically significant, because, compared to the overall house price increase during the same period of time, the LVR policy has eased house price pressures by almost 50 percent.

In specification II, we check if the differential effect between new builds and existing homes has already appeared when the building exemption was announced in December 2013. In this case, we set the LVR dummy to a value of 1 from December 2013 onwards. The regression results show that prices of existing homes grew less than the new builds by about 2 percent around the announcement window. A slightly weaker effect is expected, because, after the announcement and before the policy implementation, new builds were still subject to the LVR restriction, while the price of new homes would have been affected immediately by the higher demand of new builds generated by the exemption announcement.

For specifications III – V we run a series of robustness tests on the benchmark DiD regression. In particular, column III changes the new-build dummy to the one defined as sale year is equal to building year, compared to the one in column I, which is defined such that the sale year has to be at least one year earlier than the building finish year. This broader definition of new builds significantly weakens our DiD estimate to 1 percent. However, this new-build definition is not appropriate for LVR 1 and LVR 2, because the Reserve Bank required borrowers who wanted to take advantage of the exemption to commit to the purchase at an early stage of the process. This was to prevent the exemption being used to purchase recently built houses. This means that under the broad definition, many of the new builds that this new build dummy picks up in the data were not actually exempted, which biases the DiD estimate downwards.

Specification IV changes the policy dummy to reflect the date at which the LVR policy was implemented (October 2013), as opposed to the new-build exemption being implemented. As the new build exemption was not in place when the policy first came into effect, we find an insignificant estimate for the DiD coefficient. This boosts the credibility of our identification

strategy: the key result is driven by the new build exemption, which is at the heart of our identification strategy. To further validate our control group, in specification V we add a variable for TA-level building consents to the baseline specification and a control variable for net migration. These additional regressors serve to control for housing supply and demand factors. Including these new control variables does not materially affect our DiD estimate, which suggests that our control group and treatment group are similar apart from the LVR effect.

In the last two columns, we separately run DiD regressions on Auckland (VI), and on the rest of New Zealand excluding Auckland (VII). These results show heterogeneous effects of LVR policy in different housing markets. The Auckland housing market is particularly interesting and policy relevant, because Auckland is the largest city in the country, and because developments in the Auckland housing market have led other markets in New Zealand in the current cycle (as shown in figure 1). Columns VI and VII show that overall house prices increased by 7.6 percent in Auckland, but by only 4.6 percent in the rest of country. The LVR effect, however, is slightly stronger in RONZ than in Auckland. The moderating effect of LVR policy is about 2.3 percent in Auckland compared to 3.1 percent in RONZ.

Overall, our regression results suggest that, over the 18-month window around the new-build exemption, LVR policy implemented in 2013 had on average a 3 percent moderating effect on house prices in New Zealand. This effect was broadly similar across the country, albeit modestly larger outside of Auckland.

4.1.1 Time-varying effects of LVR policy on house prices

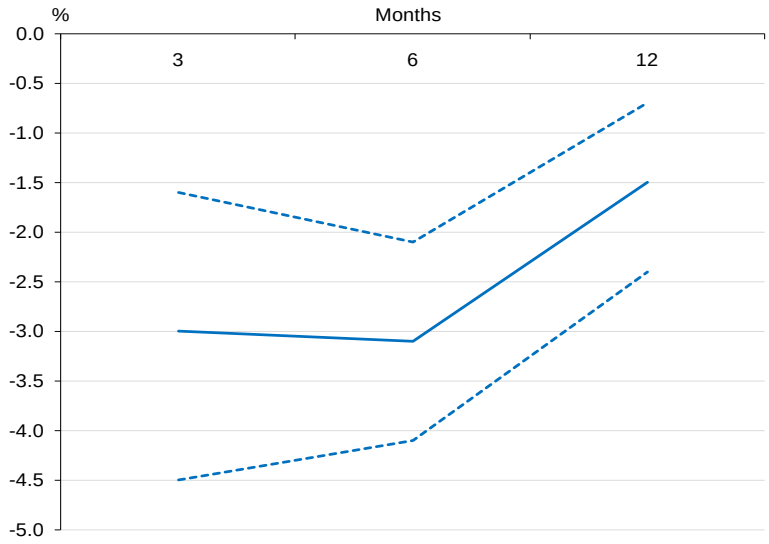
To accurately assess the effect of LVR policy, it is also useful to know the time profile of the policy effects on house prices. In this sub-section, we show empirical results on the time-varying effects of LVR restrictions on house prices. In particular, we re-run our benchmark regression on data covering windows of three, six, and twelve months of data after the new build exemption was announced.[17]

Figure 5 plots the point estimates with 95 percent confidence intervals. Overall, the effect of the first LVR policy on house prices occurs within the first three months and is relatively stable over a six-month period. Thereafter, the moderating effect declines somewhat (to around 1.5 percent after 12 months), perhaps owing in part to individuals having saved up the required deposit

[17] In all regressions, we fix the number of periods before the new build exemption at 12 months to make the estimates comparable.

under the policy and a price differential having opened up between existing and newly built houses.

Figure 5: Time-profile of LVR policy effects



4.2 Effects of subsequent LVR restrictions

As discussed in section 2, the second and third rounds of LVR policy entailed policy changes that varied across regions. In particular, the second LVR adjustment implemented in November 2015 tightened LVR restrictions on Auckland investors and at the same time loosened LVR restrictions on investors and owner-occupiers outside of Auckland, as shown in table 1. The third LVR adjustment in October 2016 tightened restrictions on property investors nationwide and also tightened LVR restrictions on owner-occupiers outside of Auckland.

The regional-specific policy changes complicate our DiD analysis. In this subsection, we design a DiD regression to identify LVR effects on house prices, accounting for the different regional developments in housing markets. When different LVR restrictions are implemented in different regions, we need to consider an additional layer of difference in house prices (hence we use difference-in-difference-in-differences or DDD). In table 4, we first study the policy effect in each region separately, and then consider the relative effect across regions.

In specification I, we run a simple DiD regression with Auckland data only. The results show that 6 months after the new build exemption was announced, overall house prices had risen on average by 5.6 percent. Over the whole period, prices of existing homes are 5.4 percent lower than new homes. Interestingly, the key DiD coefficient is negative but statistically insignificant.

This tells us that despite tighter LVR restrictions on investors, the Auckland housing market does not appear to have been significantly affected by the LVR tightening. Instead, the results suggest that the decline in Auckland house prices observed in the aggregate data is driven by other policy changes, such as the introduction of the "Bright-Line Test" by the New Zealand government, and tax residency requirements for non-resident buyers imposed by the Treasury. This effect was likely exacerbated by residential property investment loans being given a separate asset class with higher capital requirements by the Reserve Bank.

Table 4: Effects of the second LVR policy on house prices

Dependent variable	Log(SPAR)		
	I	II	III
LVR 2 dummy	0.056*** (0.017)	0.019** (0.008)	0.018** (0.009)
Existing Home = 1	-0.054*** (0.012)	-0.032*** (0.006)	-0.032*** (0.007)
Diff-in-diff	-0.002 (0.017)	0.035*** (0.008)	-
Diff-in-diff-in-diff	-	-	-0.040** (0.017)
Data coverage	AKL	RONZ	NZ
Controls	Yes	Yes	Yes
Observations	31,418	68,397	99,815
R^2	0.059	0.403	0.537

Notes: Regression results in this table are based on Equation (1). The dependent variable is the logarithm of the SPAR. Independent variables are explained in the notes under Equation (1). Diff-in-diff-in-diff dummy is the multiplication of the LVR dummy, the Auckland dummy, and the existing home dummy.

By contrast, the DiD coefficient estimated for RONZ shows that a 3.5 percent increase in house prices is due to looser LVR restrictions and is highly statistically significant. This result suggests that the loosening of LVR policy in regions outside Auckland contributed significantly to the house price recovery in those regions. In particular, the LVR 2 effect on house prices outside of Auckland is of the opposite sign and roughly equal in magnitude to our estimates of the dampening effect of LVR 1. While this may appear at odds with the relative degree of the policy changes, the loosening took place when population and interest-rate pressures were more pronounced, so would have been expected to have a greater effect on house prices, all else held constant.

In column III, we add another layer of difference, accounting for the regional differential developments in house prices. In particular, the regression equation includes all levels and interactions between existing home, after LVR, and Auckland dummies, and control variables. In this setting, the Diff-in-diff-in-diff coefficient captures the relative magnitude of LVR effects between Auckland and the RONZ. If there is no change in LVR policy in the regions other than Auckland, this DDD coefficient can help us to gauge the effect of LVR restrictions in Auckland relative to the rest of country. For the real policy changes in LVR 2, however, the restrictions were tightened in Auckland, and loosened in the regions outside Auckland. This makes the interpretation of the DDD coefficient quite tricky. The estimate shows that the overall difference is about -4 percent, but it is not because a large moderating effect in Auckland relative to RONZ. Instead, the 4 percent difference is mainly driven by the significant house price increase in RONZ, while the effect of the new LVR restriction on Auckland investors is muted. This suggests that a 70 percent LVR cap on Auckland investors may not have been particularly binding in late 2015, due to investors having benefitted from prior house price growth and banks' own lending standards already acting as a constraint.

Table 5: Effects of the third LVR policy on house prices

Dependent variable	Log(SPAR)		
	I	II	III
LVR 3 dummy	0.058*** (0.010)	0.059*** (0.008)	0.059*** (0.008)
Existing Home = 1	0.059*** (0.006)	0.006 (0.005)	0.006 (0.005)
Diff-in-diff	-0.027*** (0.011)	0.009 (0.008)	-
Diff-in-diff-in-diff	-	-	-0.038*** (0.013)
Data coverage	AKL	RONZ	NZ
Controls	Yes	Yes	Yes
Observations	24,639	69,345	93,984
R^2	0.021	0.196	0.383

Notes: Regression results in this table are based on Equation (1). The dependent variable is the logarithm of the SPAR. Independent variables are explained in the notes under Equation (1). Diff-in-diff-in-diff dummy is the multiplication of LVR dummy, Auckland dummy, and existing home dummies.

In Table 5, we run the same regression for LVR 3 as we did for LVR 2. We first study the effect of LVR 3 separately. Column I shows results for Auckland. LVR 3 further tightened LVR restrictions on investors to 60 percent of the property value with only a 5 percent speed limit.

This further tightening of LVR policy had a significant impact on the Auckland housing market. Despite the overall house prices increase of by 5.8 percent over this time, LVR 3 caused Auckland house prices to decline by 2.7 percent, a significant easing in house price inflationary pressure.

By contrast, as shown in column II, the further tightening of investor LVR policy showed little effect in the housing markets outside of Auckland. This might be due to the fact that during this time period there was less investor activity outside Auckland, or due to differences in typical borrowing patterns across regions. On the latter, for example, Auckland investors would typically require greater leverage given that house prices are much higher there than in the rest of New Zealand. Finally, in column III, we run DDD regression for the overall relative effect. In this case, the significant -3.8 percent difference is driven by tighter investor LVRs in Auckland.

In summary, in this section, we use the difference-in-differences methodology to identify the effect of the second and third round of LVR policy on house prices. We find that directly using DDD regression for analysing regional LVR restrictions can generate misleading results. It is also important to investigate regional effects separately. We find evidence that LVR 2 policy did not significantly ease Auckland house price inflation, but contributed to an increase in house prices in RONZ by relaxing the LVR restriction. The tighter LVR 3 seems to have had a more significant impact on Auckland investors and hence house prices in Auckland relative to the rest of New Zealand, perhaps in part due to differences in the composition of buyer and regional differences in the use of leverage.

4.3 Implications for calibrating future LVR policy

In this section, we summarise empirical findings of three LVR policies and draw implications for calibrating future policy. Table 6 summarises the effective policy treatment and estimated effects associated with each successive round of LVR policy change. To assess the quantitative effect of LVR policy, it is important to develop a measure of policy treatment. The LVR policy implemented in New Zealand is complex, varying along many dimensions, including LVR cap, speed limit, buyer type, and region. On the former two elements, which are common to all LVR policy changes, the LVR cap specifies which loans are classified as high LVR, while the “speed-limit” restrains the proportion of new loans that can exceed the LVR cap. These two dimensions make developing a policy treatment measure tricky. To overcome this difficulty, we use the mean-above-median LVR of new commitments as an effective measure of the policy treatment

(see figure 6).[18] This captures the effective change in average realised LVR among loans that could be considered to be high-LVR loans.

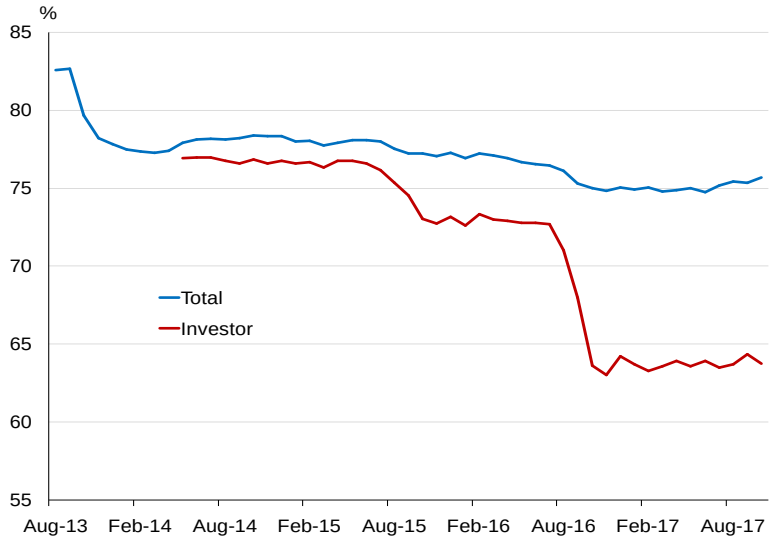
[18] These data come from the Reserve Bank's macroprudential indicator chart pack, available at https://www.rbnz.govt.nz/financial-stability/macro-prudential-indicators.

Table 6: Summary of LVR effects

	LVR 1	LVR 2	LVR3
	I	II	III
Policy treatment on high LVR loans	-4.4%	-0.9%	-8.6% (investor)
Policy effect (AKL)	-2.3%***	-0.2%	-2.7%***
Policy effect (RONZ)	-3.1%***	3.5%***	0.9%

Notes: Effective policy treatment is calculated as the change in mean-above-median LVR of new commitments, measured in percentage points, based on data from the RBNZ's *New Residential Mortgage Commitments Survey*.

Figure 6: Mean-above-median LVR of new commitments



Source: RBNZ.

We use the effective policy treatment on high-LVR loans to measure the magnitude in the change in realised LVRs around policy events. Under this measure, LVR 1 caused a decline of 4.4 percentage points in the mean-above-median LVR. LVR 2, by contrast, led to very little change overall, because it tightened restrictions for investors in Auckland but loosened them in the rest of the country. LVR 3 targeted investors only, therefore it had a large impact on investor LVRs (8.6 percentage points reduction in mean-above-median LVR), but a more muted effect overall.

What we observe in table 6 is that the effect of LVR policy is highly non-linear, depending on the targeted borrower, targeted region, and the magnitude of treatment. From each round, we can draw some interesting lessons. Firstly, as LVR 1 targets all borrowers in the housing market, its

effect depends more on regional factors. Auckland's housing market was affected slightly less than the RONZ, perhaps because of stronger fundamentals supporting the market.

Secondly, LVR 2 provides an interesting case study of loosening policy. Our estimates show that LVR 2 did not significantly slow the increase in Auckland house prices, with other factors appearing to be of greater importance. By contrast, house prices in the RONZ increased by 3 percent due to the relative loosening of LVR restrictions. This suggests that the effect of LVR policy crucially depends on how binding the LVR limit is when changes are introduced. As discussed earlier, this change occurred when fundamental demand pressures were particularly strong outside of Auckland, leading to a larger effect of the change in policy.

Lastly, in LVR 2 and LVR 3, policies were investor-focused. The effect of this type of policy depends on the understanding of where is the limit of LVR for the targeted borrower. In LVR 2, for example, investor LVR in Auckland was reduced to 70 percent. However, the effect was very small. Consequently, the RBNZ further tightened the LVR restrictions on property investors to 60 percent. This time, the moderating effect of LVR policy started appearing in Auckland with a 2.7 percent decrease in house prices.

5. Conclusions

This paper contributes to the international policy debate on the effect of macroprudential policy on housing-market dynamics. We use detailed New Zealand housing market data to evaluate the effect of loan-to-value ratio restrictions on house prices. Our identification relies on the exemption for new builds from the LVR restrictions implemented during 2013 – 2016 by the Reserve Bank of New Zealand. Our empirical findings show that the effect of LVR policy is highly non-linear, depending on the targeted borrower, targeted region, and the magnitude of the LVR treatment. When it becomes binding, both tightening and loosening LVR have very significant effects on house prices, although the effect presents more in the short run and declines about 12 months after implementation.

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Appendix

Table A1: Policies and events around LVR policy times

LVR policy	Other policies/events
LVR1 (Oct 2013)	• Increased capital requirements for high-LVR housing lending • Australia Prudential Regulation Authority APG 223 tightening serviceability requirements for Australian parents • OCR increases in early to mid-2014 • Election in September 2014
LVR2 (Nov 2015)	• Bright-Line Test and Inland Revenue Department personal tax number requirement for non-residents introduced • Residential property investment loans given separate asset class with higher capital requirements • OCR decreases in late 2015 and early 2016
LVR3 (Oct 2016)	• Banks' changes to mortgage serviceability requirements • OCR decrease in November 2016