Loan-to-value limits and house prices^{*}

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Abstract

This study evaluates the effect of loan-to-value (LTV) limits on house prices. The identification strategy exploits variation in LTV limits induced by Hong Kong Monetary Authorities' decision to introduce differentiated LTV limits anchored on the value of the property, which allows us to observe the counterfactual house price development. We estimate an elasticity of 0.8 between LTV limits and house prices: A one percentage point decrease in LTV limits reduce house prices by 0.8 percentage points. Overall, our results document that macro-prudential policies, that regulate access to financing, are an effective policy tool to control house price growth.

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The global financial crisis demonstrated that monetary policy and traditional regulation of banks and financial institutions are insufficient to prevent a build-up of systemic risk. Among policy-makers and academics there is a growing consensus that macro-prudential policies should supplement existing policy frameworks to address systemic risk. A key focus area for the new macro-prudential policies is the housing market because real estate and mortgages are the largest assets and liabilities on households' balance sheets. As a result more than 40 countries—for example, China, Hungary, India, Norway, and Sweden—have recently adopted loan-to-value (LTV) limits on mortgages to control the house price growth and reduce system risk in the financial sector. Despite the recent popularity of such policies, evidence on how LTV limits affect house prices is scant.

LTV limits directly affect a household's ability to finance the purchase of real estate, as tighter (looser) LTV limits require more (less) equity to finance a purchase. Whether such policies are effective depend on how important access to financing is for house prices. Accessing this question is difficult, because macroprudential policies hardly are random and tend to affect all houses in a given market, making it difficult to observe the counterfactual development in house prices. In addition, the policy might shift the demand for housing, making it important to control for the quality of houses that are sold. It follows that the ideal experiment is one in which we can estimate the effect of LTV limits while controlling for individual heterogeneity in house prices as well as the macroeconomic development.

The main contribution of this study is to estimate the effect of LTV limits on house prices in a setting that closely resembles the ideal experiment. In contrast, existing studies evaluating the effectiveness of LTV limits use macro data on average house prices, which is problematic for two reasons. First, the counterfactual development in house prices is unobserved, which makes it difficult to convincingly separate the effect of LTV limits on house prices from macroeconomic factors. Second, the quality of

houses is unobserved in macro data, which implies that the estimated effect is biased if policy changes also affect the quality of houses that are sold. To this end, this study exploits the institutional setting of Hong Kong's residential real estate market and HKMA's decision to introduce differentiated LTV limits anchored on house prices to overcome these challenges.

The identification strategy exploits variation in LTV limits that arises from Hong Kong Monetary Authority's (HKMA) decision to anchor LTV limits on house values. A total of six policy changes between 2001 and 2015 changed the LTV limits for houses with a value in a specific range, while keeping it unchanged for houses with a value outside the range. The policy changes implies that we at a given time, can observe the effect of LTV limits on houses that were affected by the policy change as well as the counterfactual development in house prices for houses that were unaffected by the policy change. Using comprehensive transaction data we estimate the effect of LTV limits on house prices while controlling for individual heterogeneity by including property fixed effects as well as the macroeconomic development by including year-month fixed effects. This specification effectively ensures that the effectiveness of LTV limits is evaluated while controlling for the counterfactual development in house prices as well as unobserved heterogeneity in house prices.

Our results demonstrate that macroprudential policies are effective in controlling house price growth. We estimate an elasticity of 0.8 between LTV limits and house prices: A one percentage point decrease in LTV limits reduce house prices by 0.8 percentage points. Considering that monetary authorities tend to change LTV limits by 5 to 10 percentage points, it follows that a typical policy intervention will reduce house prices by 4 to 8 percent. We further show that the effectiveness of LTV limits is weaker for luxury housing, where financial constraints are less likely be less binding, and when household have high opportunity cost of capital, which makes equity financing more expensive. Overall, our results demonstrate

that LTV limits have a large effect on house prices which resonates with the recent popularity of this policy among monetary authorities and regulators.

An important question is the external validity of the results. This study's focus on the housing market in Hong Kong is motivated by identification challenge described above. The housing market in Hong Kong is described by real estate economists as being one of the most volatile markets in the world, with a standard deviation of 14.8 on the real annual house price changes during the 2000s, compared to 11.3 for the 20 largest cities in the United States. The performance of Hong Kong's housing market is also widely believed to be influenced by market sentiment, given Hong Kong's status as an international financial center with free capital mobility. While the current study controls for overall market conditions, including the macroeconomic development and market sentiment, the main caveat is that the estimated elasticity between LTV limits and house prices might be influenced by factors that are specific to Hong Kong.

The rest of the study is organized as follows. Section I details the policy changes affecting the LTV limits of houses in Hong Kong. Section II presents the data and provides descriptive statistics, while Section III details the identification strategy. The empirical design and the results are presented in Section IV, while Section V considers alternative specifications. Finally, Section VI summarizes the conclusions.

I. Policy changes affecting LTV limits

Following the global financial crisis monetary authorities around the world have introduced new macroprudential policies to reduce systemic risk. According to data maintained by IMF, monetary authorities in more than 40 countries have introduced or changed the LTV limits in an attempt to control

house price growth and mortgage lending. Most policy interventions, however, imposes a uniform LTV limit across all houses, making it difficult to separate the effect of LTV limits from the macroeconomic development. In a few markets the policy interventions have introduced differentiated LTV limits based on location, value or size. From an econometric perspective, policy interventions that differentiate LTV limits are ideal as they allow the research to observe a counterfactual development in prices for unaffected houses.

Among the monetary authorities that have intervened in the housing market by changing the LTV limits, only 9 have introduced differentiated LTV limits. China, Korea, and Taiwan have introduced differentiated LTV limits based on location. Hong Kong SAR, India, Malaysia, Nepal, Pakistan, Philippines, and Thailand have introduced differentiated LTV limits anchored on house value, while China and Indonesia have introduced differentiated LTV limits based on house size. Table A in the appendix provides an overview of these policies, including the number and timing of interventions. The table shows that a study of the effect of LTV limits in Hong Kong is particularly suitable to overcome the identification problem. The HKMA has made seven policy interventions, more than twice the number of any other monetary authority, that have changed the LTV limit for houses with a value within a given range, while holding the LTV limit constant for houses with a value outside the range.

Table 2 provides a chronological list of policy changes of the LTV limit by HKMA. The changes are as follows. The LTV limit on properties priced above HKD 12 million was reduced from 70% to 60% on January 25, 1997, before being restored to 70% on October 10, 2001. In 2009, the 60% LTV limit was reintroduced for properties above HKD 20 million and followed by the decision to move the 60% LTV threshold to HKD 12 million on August 13, 2010. Later the same year, the HKMA decided to reduce the LTV limit to 50% for properties above 12 million, and to 60% for properties between 8 and 12 million. In

June 10, 2011 these thresholds were again adjusted, resulting in a LTV limit of 50% for properties above 10 million, and a LTV limit of 60% for properties between HKD 7 and 10 million. The last policy event occurred on February 27, where the LTV limit was reduced to 60% for properties below 7 million.

Figure 1 illustrates the LTV limit over time depending on the value of the property. The sample period is restricted by the availability of data as explained in the following section.

II. Data

The residential real estate market in Hong Kong consists of a private and a public sector. This study focuses on the private sector, which represents around 50% of the market share. We exclude the public sector, because property values are distorted by large government subsidies and sales restrictions.

Our data cover all private residential real estate transactions in Hong Kong between 2000 and 2015. The data are maintained by EPRC Ltd., a commercial real estate agency in Hong Kong, and include the property address and characteristics, transaction date, and price. Table 2 provides descriptive statistics on the 1,058,938 property transactions, equivalent to around 66,000 transactions per year.

The average unit in Hong Kong costs 4.21 million HKD (541,000 USD), and has an interior size of 606.4 square foot (56.3 square meter), making Hong Kong one of the most expensive cities in the world with an average price of 6,208 HKD (798 USD) per square foot, equivalent to 75,100 HKD (9,700 USD) per square meter. Around half of all transactions occur in the New Territories, followed by 27.7 percent in Kowloon and 22.4 percent on Hong Kong Island. Panel C shows that there is limited seasonality, transactions are almost uniformly distributed across quarters of the year. Finally, Panel D shows the LTV limit. While most of the transactions have a 70 percent LTV limit, this is due to the fact that for half of the

sample period (from October 2001 to October 2009) the LTV limit was 70 percent irrespective of the house value. More than 32,000 transactions have a LTV limit of 50 percent and more than 58,000 transactions have a LTV limit of 60 percent.

Table 3 details how the six policy changes affected the LTV limit and number of transactions by comparing the number of transactions with a LTV limit of 50, 60, and 70 percent one year before and one after each policy change. A simple way of measuring the impact of the policy changes is by comparing the fraction of transactions in the affected LTV limits. For instance, policy change 1 increases the LTV limit from 60 to 70 percent for properties with a value above 20 million. One year before the change, only 1.8 percent of the transactions had a LTV limit of 60 percent compared to 0 percent one year after the policy change. Thus, policy change 1 only affects 1.8 percent of all transactions. In similar fashion, policy change 2 decreased the LTV limit from 70 to 60 percent for properties with a value above 12 million. Table 3 shows that the fraction of transactions with a LTV limit increased from 0 to 2.6 percent, implying that 2.6 percent of the transactions were affected. While policy change 1 and 2 affected a relatively modest number of transactions, policy change 3 to 6 affects an increasingly larger proportion of all property transactions. Affected properties increase from 1.8 and 2.6 percent for policy change 1 and 2, respectively to 4.6 percent for policy change 3.¹ Policy change 4 affects 9.2 percent of all transactions, while policy change 5 and 6 affects 9.9 and 70.2 percent of all transactions. Finally, it is worth noticing that the number of transactions generally moves in the same direction as the policy changes. For policy change 1 the total number of transactions increases, whereas the total number of transactions decreases for policy change 3, 4, 5, and 6. The main exception is policy change 2 where the number of transactions increase despite the decision to lower the LTV limit for transactions with a value above 12 million.

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¹ Based on the observed number of transactions, policy change 1 increases the LTV limit for 1.8 percent of transactions, while policy change 2 increase the LTV limit for 2.6 percent of the transactions. Policy change 3 increases the fraction of transactions with a LTV limit from 2.6 percent to 7.2 percent, resulting in 4.6 percent of the transactions being affected.

Although the transaction data clearly indicates that the policy changes affect the LTV limit of a significant number of transactions, the policy is only effective if the LTV limit is binding for some households. Unfortunately, this would require data at the household level of both borrowers and potential borrowers. Another way of illustrating the impact of the policy changes is to look at LTV ratio on the average new mortgage during the sample period. HKMA compiles a monthly survey of new mortgages issued by mortgage banks. These data include basic information about the loan terms (interest rate, maturity, etc.) as well as the LTV ratio on the new mortgages.

Figure 2 shows the mapping between the average LTV limit based on transactions during the month and the average LTV ratio in HKMA's survey of new mortgages. The impact of the policy changes that restrict access to financing by reducing the LTV limit is clearly visible. The average LTV ratio declines from around 65 percent in 2009 to 50 percent by the end of 2015. The LTV ratio decreased from 65 to 55 percent following policy changes 2 to 5, while the decrease from 55 to 50 percent occurs after policy change 6. Collectively, the decline in the average LTV ratio suggests that the policy changes reduced the access to financing.

Figure 3 shows the development of the the average price per square feet at a quarterly frequency and the timeline of the six policy changes to the loan-to-value (LTV) limit between 2000 and 2015. Figure 3 highlights the two identification challenges, when evaluation the effect of LTV limits on house prices using a house price index. First, the counterfactual development in house prices is unobserved, making it difficult to gauge about the effect of policy changes on house prices. Second, policy changes that tighten the access to financing (policy change 2 to 6) tend to occur after sharp house price growth, implying the difference in house price growth around a policy change might be confounded by the policy intervention. Finally, the

underlying quality of houses is unobserved, resulting in a potentially biased estimate of LTV limits on prices.

To overcome these challenges, we study the effect of LTV limits on prices using a micro data on property transactions. The micro data allows us to observe the counterfactual development in house prices and control for the quality of houses being sold. To illustrate the advantage of micro data, Figure 4 compares changes in the average price per square feet around the LTV policy changes. For each policy change we calculate the change in the price per square feet for houses that are affected and unaffected by the policy change for a sample of houses that are close to the threshold on house value. For instance, for policy change 1 we calculate the change in price per square feet for houses with a value between 12 and 14 million HKD, and compare it to the change in the price per square feet for houses with a value between 10 and 12 million. The difference in change to the price per square feet captures the effect on prices of increasing the LTV limit by 10 percent for houses valued above 12 million. We note that while house prices decline, the decline is smaller for houses with a value above 12 million. The difference in the change in the average price per square feet, suggest that increasing the LTV limit by 10 percentage points increase the house price by 4 percentage point. Similarly, for policy event 2 to 5, where the LTV limit declined we find that house prices increase by less than houses where the LTV remained unchanged. For all 5 policy changes that restrict the access to financing we find a negative effect on prices.

Collectively, the results in Figure 4 suggest that increasing (decreasing) the LTV limit increases (reduces) house price growth by 4 percent (2 to 14 percent). Unfortunately, these effects are biased as they fail to control for the effect of policy change on the quality of houses sold. If limiting access to financing also reduces the quality of houses sold, it follows that the results in Figure 4 is underestimating the effect

of LTV limits on prices. In the following section, we therefore perform a much more careful analysis that evaluates the effect of LTV limits on house prices.

III. Identification strategy

We estimate the relationship between the price of houses and their characteristics using a hedonic regression which is a standard approach in real estate economics. The main equation for estimating the forced sale discount is specified in Equation (1), where the dependent variable is the log price, y_{it} , of house i in year t :

$$y_{it} = \alpha_i + \alpha_t + \beta'X_i + \gamma'LTV_{it} + \epsilon_{ijt}, \quad (1)$$

where α_i captures property fixed-effects, α_t captures year-month fixed-effects, X_i is a vector of time-varying property characteristics, and LTV_{it} is the LTV limit. Property characteristics include: interior size, building age, indicator for primary transactions and whether the property is sold with a carpark. Note that interior size can be time-varying due to subdivisions (or extension of houses) and that carparks can be sold separately.

The main benefit of this specification is that the inclusion of property fixed-effects allows us to control for unobserved heterogeneity in house prices, while exploiting the variation in LTV limits to estimate the effect on house prices. The identification strategy effectively compares the development of house prices depending on changes to the LTV limit, while controlling for the overall development of house prices and individual heterogeneity. The main disadvantage of this identification strategy is that effect of LTV limits in house prices is estimated using properties with repeated sales and variation in LTV limits. The institutional setting of Hong Kong's residential real estate market is helpful as the market is

quite liquid. As a result, repeated sales occur frequently during our sample period. Figure 5 shows the distribution of sales for properties with at least one transaction during the sample period from 2000 to 2015. Around 45 percent of all properties have repeated sales, of which almost 20 percent have three or more sales. In addition to satisfying the repeated sales requirement, we also need variation in LTV limits. Table 4 shows the mapping between the LTV limit for first and second sales in Panel A, while Panel B shows the difference in LTV limits between the first and second sale.² We note that a large number of repeated sales have variation in LTV limits between the first and the second sale. For close to 10,000 repeated sales the LTV limit decreased by 20 percentage points. In addition, the LTV limit decreased for 25,000 repeated sales, while the LTV limit increased by 10 percentage points for more than 500 repeat sales. We conclude that there appears to be a sufficient number of repeated sales with variation in the LTV limit to estimate the effect of LTV limits on house prices.

IV. Empirical results

Table 5 reports from the regression of LTV limits on house prices. In column 1 we include the LTV limit in percentage points and find a positive and statistically significant effect on house prices. A 10 percentage points increase in the LTV limit results in 8.2 percent higher house prices. We also note that the control variables have the expected sign. Property size is positively related to house prices, while building age is negatively related to house prices. New apartments are sold at 14.7 percent higher prices, $1 - \exp(-0.1598) = 14.7\%$, whereas a carpark increases the property price by 6.1 percent.

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²Note that for properties with e.g. 3 sales, Table 3 both reports the mapping of the LTV limit for the first and second sale, and the mapping for the second and third sale.

In Column 2 we include indicators for LTV limits of 50 and 60 percent, while the reference group is LTV limits of 70 percent. We note that properties that are sold with a LTV limit of 50 percent have 14.8 percent lower prices, while properties with a LTV limit of 60 percent have 8.5 percent lower prices. Finally, Column 3 includes indicators for LTV increase and LTV decreases. We find a positive coefficient of 0.1715 for LTV limit increases, corresponding to 15.8 percent higher prices. The coefficient of -0.0829 for LTV limit decrease reveals that houses are sold at 8 percent lower prices when the LTV limit has decreased. In summary, the results in Tables 5 shows an elasticity of 0.8 between LTV limits and house prices in Hong Kong's residential real estate market. The estimated elasticity reveals that LTV limits have a strong influence on house price, which suggest that macro-prudential policies in the form of LTV limits are effective at controlling house prices.

In Table 6 we investigate the effect of LTV limits on house prices further by considering whether the elasticity depends on the opportunity cost of capital and whether the property is a luxury unit where pricing might be less sensitive to access to financing.

In Column 1 of Table 6 we include an interaction term between the LTV limit and the interest rate. The coefficient on the interaction term is positive and statistically significant, indicating that the elasticity between the LTV limit and house prices increases with the interest rate. Thus, changes to the LTV limit have a stronger effect on house prices when the opportunity cost of capital is high. In column 2 we interact the LTV limit with an indicator for high interest rates, defines as months with where the interest rate is above median interest rate during the sample period. Again we note that the interaction term is positive and statistically significant.

To further shed light on the effect of opportunity cost of capital and the elasticity between LTV limits and house prices, Column 3 and 4 looks into the effect of luxury units where the effect of LTV limits

is expected to be smaller. In Column 3 we focus on properties on Hong Kong Islands, which is the most exclusive territory in Hong Kong. Column 3 shows that the elasticity of LTV limits to house prices is weaker for properties located on Hong Kong Island, compared properties located in Kowloon or the New Territories. In Column 4 we go one step further by interacting the LTV limit with an indicator for luxury units. Luxury units are identified in an auxiliary hedonic regression model of house prices per square feet on observable property characteristics. Based on the residual from this regression, we define properties that have a price per square feet that is 25 percent about the predicted level the auxiliary hedonic regression model as a luxury unit. To avoid spurious correlation the specification in Column 4 includes both the interaction term between LTV limit and luxury units, as well as the indicator for luxury units. Consistent with our conjecture, the effect of LTV limits on the house price of luxury units is smaller than for ordinary units. It follows that the elasticity of house prices to LTV limits is weaker for luxury unit, because high net worth individuals are unlikely to be constrained by access to mortgage financing.

V. Alternative specifications

In this section we address concerns related to the identification strategy and the hedonic pricing model. A potential concern with the specification in equation (1) is that houses affected by policy changes to the LTV limit are located in different areas than houses that are unaffected. If the demand for houses and/or the supply of houses in these locations are different, time-varying location effects might drive the results.

For instance, one might be concerned about the staggered nature of LTV limits anchored by house prices, potentially affecting houses in expensive districts before houses in less expensive districts. If the house price growth is stronger in less expensive district, this effect might confound the estimated elasticity

of LTV limits on house prices. We address such concerns by introducing high-dimensional fixed-effects to control for time-variant location effects. Table 7 reports the results, when we change the estimation by considering variation in house prices in location j :

$$y_{ijt} = \alpha_{ij} + \alpha_{jt} + \beta'X_{ijt} + \gamma'LTV_{ijt} + \epsilon_{ijt}, \quad (1)$$

Where the dependent variable is the log. of value of house i in location j at time t , α_{ij} captures property fixed-effects, α_{jt} captures location-time fixed-effects, X_{ijt} is a vector of time-varying property characteristics, and LTV_{ijt} is the LTV limit.

In Column 1 of Table 7 we include territory-year fixed-effects to absorb time-varying differences in house prices in the three territories; Hong Kong Island, Kowloon, and New Territories. We note that the coefficient on LTV limit increases from 0.0082 to 0.0090 after the inclusion of territory-year fixed-effect, and remain statistically significant at the one percent level. In Column 2 we add month-fixed effects and note that the coefficient on LTV limit remains robust after controlling for seasonal patterns in house prices. In Column 3 we increase the dimension of the location-time fixed effects by adding territory-year-month fixed effects. Again we note that the estimated elasticity increases when we absorb heterogeneity in house prices driven by differences in local market conditions.

In Column 4 and 5 we further increase the dimension of the location-time fixed-effects by moving the location level from territories to districts. In total there are 18 districts in Hong Kong (four on Hong Kong Island, five in Kowloon, and nine in New Territories), implying that the specification in Column 5 includes 3,456 district-year-month fixed-effects (18 districts times 192 year-months). We note that the results are robust to controlling for high-dimensional location-time fixed-effects. When we absorb heterogeneity in house prices in the same location at the same time, we find an elasticity of 0.93 between

the LTV limit and house prices. Thus, a 10 percent lower LTV limit result in 9.3 percent lower house prices. We conclude that our results are unaffected when we include high-dimensional fixed-effect that effectively controls for the development in house prices at the district level over time.

VI. Conclusions

This study evaluates the effectiveness of LTV limits in controlling house price growth. The study exploits an identification strategy based on Hong Kong Monetary Authority's decision to differentiate LTV limits based on the value of the house, which allow us to observe the counterfactual development in house prices.

Our results demonstrate that macroprudential policies are effective in controlling house price growth. We estimate an elasticity of 0.8 between LTV limits and house prices: A one percentage point decrease in LTV limits reduce house prices by 0.8 percentage points. Considering that monetary authorities tend to change LTV limits by 5 to 10 percentage points, it follows that a typical policy intervention will reduce house prices by 4 to 8 percent.

Overall, our results demonstrate that LTV limits have a large effect on house prices which resonates with the recent popularity of this policy among monetary authorities and regulators.

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Table 1, Timeline of changes of loan-to-value (LTV) limits

This table outlines the timing of the changes of the loan-to-value (LTV) limit for residential real estate mortgages by the Hong Kong Monetary Authorities (HKMA). Two LTV policy changes (November 2, 1995 and January 28, 1997) occur before and six policy changes occur within the sample period covering transaction prices on residential real estate transaction from 2000 to 2015. Policy changes within the sample period are numbered chronologically from 1 to 6. Policy change 1 increases the LTV limit from 60% to 70% for houses with a value above 20 million HKD. Policy change 2 decreases the LTV limit from 70% to 60% for houses with a value above 20 million HKD. Policy change 3 decreases the LTV limit from 70% to 60% for houses with a value between 12 and 20 million HKD. Policy change 4 decreases the LTV limit from 60% to 50% for houses with a value above 12 million, and from 70% to 60% for houses with a value between 8 and 12 million. Policy change 5 decreases the LTV limit from 60% to 50% for houses with a value between 10 and 12 million, and from 70% to 60% for houses with a value between 7 and 8 million. Policy change 6 decreases the LTV limit from 70% to 60% for houses with a value below 7 million HKD. One USD equals 7.78 HKD.

Policy change #	Date	House value	LTV limit
-	November 2, 1995	All	70%
-	January 28, 1997	<12M	70%
		>12M	60%
1	October 10, 2001	All	70%
2	October 23, 2009	<20M	70%
		>20M	60%
3	August 13, 2010	<12M	70%
		>12M	60%
4	November 19, 2010	<8M	70%
		8-12M	60%
		>12M	50%
5	June 10, 2011	<7M	70%
		7-10M	60%
		>10M	50%
6	February 27, 2015	<7M	60%
		7-10M	60%
		>10M	50%

Table 2, Descriptive statistics

This table reports descriptive statistics for residential real estate transactions between January 1, 2000 and December 31, 2015. Panel A reports the following transaction characteristics: *Price* is in million HKD (one USD equals 7.78 HKD), *size* is measured in square feet (one square meter equals 10.76 square feet), *price per square feet* is in HKD, *building age* is measured in years, *primary transaction* is an indicator for new developments, and *carpark* is an indicator for whether a carpark is sold together with the property. Panels B, C and D report the distribution of transactions on territory (i.e. region), quarter of sale, and loan-to-value (LTV) limit, respectively.

A. Transaction characteristics	Mean	Median	Std. dev.
Price (million HKD)	4.23	2.66	7.00
Size (square feet)	606.4	517.0	367.0
Price per square feet (HKD)	6,207.7	5,053.2	4,203.8
Building age (years)	14.2	13.0	12.4
Primary transaction (%)	0.176	0.0	0.380
Carpark (%)	0.065	0.0	0.247
B. Territory (%)	N	%	
Hong Kong Island	236,734	22.4	
Kowloon	292,982	27.7	
New Territories	529,222	50.0	
C. Season (%)	N	%	
First quarter	272,297	25.7	
Second quarter	272,984	25.8	
Third quarter	261,310	24.7	
Fourth quarter	252,347	23.8	
C. Loan-to-value limit	N	%	
50%	32,118	3.0	
60%	58,287	5.5	
70%	968,533	91.5	

Table 3, Number of transactions by loan-to-value limit around policy changes

We report the number and composition of transactions by the loan-to-value (LTV) limit one year before and one year after for each of the 6 policy changes between 2000 and 2015. Policy changes are numbered chronologically from 1 to 6. Policy change 1 increases the LTV limit from 60% to 70% for houses with a value above 20 million HKD. Policy change 2 decreases the LTV limit from 70% to 60% for houses with a value above 20 million HKD. Policy change 3 decreases the LTV limit from 70% to 60% for houses with a value between 12 and 20 million HKD. Policy change 4 decreases the LTV limit from 60% to 50% for houses with a value above 12 million, and from 70% to 60% for houses with a value between 8 and 12 million. Policy change 5 decreases the LTV limit from 60% to 50% for houses with a value between 10 and 12 million, and from 70% to 60% for houses with a value between 7 and 8 million. Policy change 6 decreases the LTV limit from 70% to 60% for houses with a value below 7 million HKD. One USD equals 7.78 HKD.

	Loan-to-value limit						All N
	50%		60%		70%		
	N	%	N	%	N	%	
Policy change 1							
Before	-	-	887	1.8	47,189	98.2	48,076
After	-	-	-	-	60,417	100.0	60,417
Policy change 2							
Before	-	-	-	-	86,205	100.0	86,205
After	-	-	2,687	2.6	101,089	97.4	103,776
Policy change 3							
Before	-	-	2,762	2.6	102,061	97.4	104,823
After	-	-	6,061	7.2	77,890	92.8	83,951
Policy change 4							
Before	-	-	6,475	6.0	100,848	94.0	107,323
After	5,443	8.1	4,767	7.1	57,552	84.9	67,552
Policy change 5							
Before	6,645	6.8	5,739	5.9	98,051	87.4	98,051
After	6,417	11.6	5,497	9.9	43,594	78.5	55,508
Policy change 6							
Before	7,905	14.3	8,611	15.6	38,832	70.2	55,348
After	5,466	16.7	27,243	83.3	-	-	32,709

Table 4, Changes in loan-to-value (LTV) limits for units with repeated sales

This table maps the LTV limit for repeated sales. Panel A reports the number of observations conditional on the LTV limit for the first and second sale, respectively. Panel B reports the number and fraction of total observation conditional on the change in the LTV limit from first to second sale. *Decrease by 20 (10) percentage points* summarizes the number of observations where the LTV limit for the second sale is 20 (10) percentage points lower than the first sale. *Unchanged* summarizes the number of observations where the LTV limit remained the same for the first and second sale, while *increase by 10 percentage points* summarizes the number of observations where the LTV limit increased by 10 percentage points from the first to the second sale.

A. Mapping between LTV limit for first and second sale				
First sale	Second sale			
	50%	60%	70%	All
50%	861	0	0	861
60%	1,027	843	572	2,442
70%	9,725	24,191	405,647	439,563
All	11,613	25,034	406,219	442,866
B. Change in LTV limits from first to second sale				
	N	%		
Decrease by 20 percentage points	9,725	2.2		
Decrease by 10 percentage points	25,218	5.7		
Unchanged	407,351	92.0		
Increase by 10 percentage points	572	0.1		
All	442,866	100		

Table 5, LTV limits and house prices

This table reports the effect of loan-to-value limits on house prices. We estimate the following equation:

$$y_{it} = \alpha_i + \alpha_t + \beta'X_{it} + \gamma'LTV_{it} + \epsilon_{it},$$

where the dependent variable y_{it} is log. of value of house i at time t , X_{it} is a vector of time-varying house characteristics, and LTV_{it} captures the loan-to-value limit of house i at time t . In addition, the specification controls for house fixed-effects, α_i , as well as year-month fixed-effects, α_t . In specification (1) the *LTV limit* is measured in percentage points. In specification (2) we include indicators for LTV limits of 50% and 60%, respectively. In specification (3) we include indicators for *LTV limit increases* and *decreases*. All Specifications include the following time-variant house characteristics: *Size* is measured in square-feet, *building age* is measured in years, *primary transaction* is an indicator for new developments, and *carpark* is an indicator for whether a carpark is sold together with the property. Standard errors clustered at the year-month level are reported in parentheses. ***, **, * indicate coefficients that are significant at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
LTV limit	0.0082*** (0.0011)		
LTV limit of 50%		-0.1607*** (0.0022)	
LTV limit of 60%		-0.0884*** (0.0015)	
LTV limit increase			0.1715*** (0.0147)
LTV limit decrease			-0.0829*** (0.0156)
Size	0.0002*** (0.0001)	0.0002*** (0.0001)	0.0002*** (0.0001)
Building age	-0.0037 (0.0114)	-0.0039 (0.0114)	-0.0034 (0.0111)
Primary transaction	0.1598*** (0.0091)	0.1592*** (0.0091)	0.1591*** (0.0091)
Carpark	0.0632*** (0.0073)	0.0626*** (0.0073)	0.0566*** (0.0058)
Apartment fixed-effects	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes
Adj. R ²	0.974	0.974	0.974
N	1,058,938	1,058,938	1,058,938

Table 6, LTV limits, opportunity costs of capital and house prices

This table reports the effect of loan-to-value limits on house prices. We estimate the following equation:

$$y_{it} = \alpha_i + \alpha_t + \beta'X_{it} + \gamma'LTV_{it} + \epsilon_{it},$$

where the dependent variable y_{it} is log. of value of house i at time t , X_{it} is a vector of time-varying house characteristics, and LTV_{it} captures the loan-to-value limit of house i at time t . In addition, the specification controls for house fixed-effects, α_i , as well as year-month fixed-effects, α_t . In all specifications the *LTV limit* is measured in percentage points. Specification 1 to 4 interact the LTV limit with the following variables, respectively: *Interest rate* measured in percentage points, indicator for *high interest rate* based on the median interest rate in the time period, an indicator for location on *Hong Kong Island*, and an indicator for being a *luxury unit*. Luxury units are defined as units that have a price per square feet that is 50% above the level explained by property characteristics. All specifications include the following (unreported) time-variant house characteristics: *Size*, *building age*, *primary transaction*, and *carpark*. Standard errors clustered at the year-month level are reported in parentheses. ***, **, * indicate coefficients that are significant at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
LTV limit	0.0072*** (0.0011)	0.0080*** (0.0011)	0.0100*** (0.0011)	0.0081*** (0.0012)
LTV limit * Interest rate	0.0036*** (0.0055)			
LTV limit * High interest rate		0.0165*** (0.0034)		
LTV limit * Hong Kong Island			-0.0039*** (0.0007)	
LTV limit* Luxury unit				-0.0030*** (-0.0008)
Luxury unit				0.4512*** (0.0812)
Controls variables	Yes	Yes	Yes	Yes
Apartment fixed-effects	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes
Adj. R ²	0.974	0.974	0.974	0.976
N	1,058,938	1,058,938	1,058,938	1,058,938

Table 7, LTV limits and house prices controlling for high-dimensional fixed-effects

This table reports the effect of loan-to-value limits on house prices with additional high dimensional fixed-effects capturing variation in house prices due to location and/or time effects. We estimate the following equation:

$$y_{ijt} = \alpha_i + \alpha_{jt} + \beta'X_{ijt} + \gamma'LTV_{ijt} + \epsilon_{ijt},$$

where the dependent variable y_{ijt} is log. of value of house i in location j at time t , X_{it} is a vector of time-varying house characteristics, and LTV_{it} captures the maximum loan-to-value limit of house i at time t . variables. In all specifications the *LTV limit* is measured in percentage points, while α_i captures unit fixed-effects. In specification (1) to (5) the following high-dimensional fixed-effects are included to control for variation in house prices driven by location and/or time: Specification (1) includes territory-year fixed effects. Specification (2) includes territory-year fixed-effects and month fixed-effects. Specification (3) includes territory-year-month fixed effects. Specification (4) includes district-year fixed-effects. Specification (5) includes district-year fixed-effects and month fixed-effects. All specifications include the following (unreported) time-variant house characteristics: *Size*, *building age*, *primary transaction*, and *carpark*. Standard errors clustered at the year-month level are reported in parentheses. ***, **, * indicate coefficients that are significant at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
LTV limit	0.0090*** (0.0009)	0.097*** (0.0009)	0.0107*** (0.0010)	0.0093*** (0.0008)	0.0093*** (0.0008)
Control variables	Yes	Yes	Yes	Yes	Yes
Unit fixed-effects	Yes	Yes	Yes	Yes	Yes
Territory-year fixed-effects	Yes	Yes	No	No	No
Territory -year-month fixed-effects	No	No	Yes	No	No
District-year fixed-effects	No	No	No	Yes	Yes
Month fixed-effects	No	Yes	No	No	Yes
Adj. R ²	0.973	0.974	0.977	0.978	0.978
N	1,058,938	1,058,938	1,058,938	1,058,938	1,058,938

Figure 1, Maximum loan-to-value ratio by house value, 2000-2015

This figure shows the timeline of the six policy changes to the loan-to-value (LTV) limit between 2000 and 2015. Policy changes are numbered chronologically from 1 to 6. Policy change 1 increases the LTV limit from 60% to 70% for houses with a value above 20 million HKD. Policy change 2 decreases the LTV limit from 70% to 60% for houses with a value above 20 million HKD. Policy change 3 decreases the LTV limit from 70% to 60% for houses with a value between 12 and 20 million HKD. Policy change 4 decreases the LTV limit from 60% to 50% for houses with a value above 12 million, and from 70% to 60% for houses with a value between 8 and 12 million. Policy change 5 decreases the LTV limit from 60% to 50% for houses with a value between 10 and 12 million, and from 70% to 60% for houses with a value between 7 and 8 million. Policy change 6 decreases LTV limit from 70% to 60% for houses with a value below 7 million HKD. One USD equals 7.78 HKD.

Figure 2, Average loan-to-value limit and actual loan-to-value ratio, 2000-2015

This figure compares the average loan-to-value ratio from the Hong Kong Monetary Authorities' monthly surveys of new loans to the average loan-to-value limit based on transaction records in the same month. The average loan to value limit is calculated as average LTV limit for all transactions in each month. Policy changes are numbered chronologically from 1 to 6. Policy changes that increase (decrease) the LTV limit are represented with a blue (red) horizontal line. Policy change 1 increases the LTV limit from 60% to 70% for houses with a value above 20 million HKD. Policy change 2 decreases the LTV limit from 70% to 60% for houses with a value above 20 million HKD. Policy change 3 decreases the LTV limit from 70% to 60% for houses with a value between 12 and 20 million HKD. Policy change 4 decreases the LTV limit from 60% to 50% for houses with a value above 12 million, and from 70% to 60% for houses with a value between 8 and 12 million. Policy change 5 decreases the LTV limit from 60% to 50% for houses with a value between 10 and 12 million, and from 70% to 60% for houses with a value between 7 and 8 million. Policy change 6 decreases the LTV limit from 70% to 60% for houses with a value below 7 million HKD. One USD equals 7.78 HKD.

Figure 3, Average price per square feet and loan-to-value (LTV) policy changes, 2000-2015

This figure shows the average price per square feet and the timeline of the six policy changes to the loan-to-value (LTV) limit between 2000 and 2015. Each quarter we calculate the average price per square feet in 1,000 HKD. Policy changes are numbered chronologically from 1 to 6. Policy changes that increase (decrease) the LTV limit are represented with a blue (red) horizontal line. Policy change 1 increases the LTV limit from 60% to 70% for houses with a value above 20 million HKD. Policy change 2 decreases the LTV limit from 70% to 60% for houses with a value above 20 million HKD. Policy change 3 decreases the LTV limit from 70% to 60% for houses with a value between 12 and 20 million HKD. Policy change 4 decreases the LTV limit from 60% to 50% for houses with a value above 12 million, and from 70% to 60% for houses with a value between 8 and 12 million. Policy change 5 decreases the LTV limit from 60% to 50% for houses with a value between 10 and 12 million, and from 70% to 60% for houses with a value between 7 and 8 million. Policy change 6 decreases the LTV limit from 70% to 60% for houses with a value below 7 million HKD. One USD equals 7.78 HKD.

Figure 4, Changes in average price per square feet around loan-to-value (LTV) policy changes

This figure shows the changes in average price per square feet around LTV policy changes. For each policy change the sample consist of houses with a value +/- 2 million that are sold in a window from 6 months before to 12 months after the policy change. For instance, for policy event 1 that increases the LTV limit for houses with a value above 12M, the sample includes houses with a value between 10M and 14M that are sold between March 10, 2001 and October 10, 2002, where October 10, 2001 is the date of the policy event. Blue (red) bar report change in price per square feet for houses subject to a LTV limit increase (decrease) of 10% around the policy change (6 months before to 12 months after), whereas light grey bar reports the price change for houses that are unaffected by the policy change. Finally, the dark grey bars show, for each policy event, the *difference* in the change in price per square feet between affected and unaffected houses.

Figure 4, Fraction of units with repeated sales 2000-2015

This figure shows the distribution of units on the number of times sold during the sample period from 2000 to 2015, i.e. for each unit, we count the number of times the unit sold during the sample period, and plot the distribution.

Appendix A, Differentiated loan-to-value (LTV) limits by source of variation

This table shows the timing and direction of policy interventions that differentiate LTV limits based on location, value or size of the house. Variation indicates the house characteristic that differentiate the LTV limits: size indicates differentiated LTV limits based on the size of the house, while value indicates differentiated LTV limits based on house value. Finally, the last two columns indicate whether the policy change increased or decreased the LTV limit and as well as the timing of the policy change.

Characteristic		LTV limit	
		Increase	Decrease
China	Size		2006
Hong Kong	Value	2001	1997, 2009, 2010 (x2), 2011, 2015
India	Value		2010
Indonesia	Size		2012
Malaysia	Value		1998
Nepal	Value		2004
Pakistan	Value		One change
Philippines	Value		1997
Thailand	Value	2009	2003

Source: IMF and own calculations

Appendix B, Administrative map of Hong Kong

This figure shows the subdivision of Hong Kong into districts. The three main territories, Hong Kong Island, Kowloon and New Territories are subdivided into 18 districts. New Territories consist of district 1 to 9 (Islands, Kwai Tsing, North, Sai Kung, Tai Po, Tsuen Wan, Tuen Mun, and Yuen Long), Kowloon consist of district 10 to 14 (Kowloon City, Kwun Tong, Sham Shui Po, Wong Tai Sin, and Yau Tsim Mong), and Hong Kong Island consists of district 15 to 18 (Central and Western, Eastern, Southern, and Wan Chai).