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LOAN-TO-VALUE RATIO AS A MACRO-PRUDENTIAL TOOL – HONG KONG'S EXPERIENCE AND CROSS-COUNTRY EVIDENCE

Eric Wong, Tom Fong, Ka-fai Li and Henry Choi*
Research Department, Hong Kong Monetary Authority

Abstract

This study assesses the effectiveness and drawbacks of maximum loan-to-value (LTV) ratios as a macroprudential tool based on Hong Kong's experience and econometric analyses of panel data from 13 economies. The tool is found to be effective in reducing systemic risk stemming from the boom-and-bust cycle of property markets. Although the tool could impose higher liquidity constraints on homebuyers, empirical evidence shows that mortgage insurance programmes (MIPs) that protect lenders from credit losses on the portion of loans over maximum LTV thresholds can mitigate this drawback without undermining the effectiveness of the tool. This finding indicates the important role of MIPs in enhancing the net benefits of LTV policy. Our estimations also show that the dampening effect of LTV policy on household leverage is more apparent than its effect on property market activities, suggesting that the policy effect may mainly manifest in impacts on household sector leverage.

JEL classifications: G21; G28
Key words: systemic risk, macroprudential policy, loan-to-value ratio, Hong Kong

Authors' E-Mail Addresses: etcwong@hkma.gov.hk; tpwfong@hkma.gov.hk; kfli@hkma.gov.hk; hmhchoi@hkma.gov.hk

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EXECUTIVE SUMMARY:

- *In the aftermath of the global financial crisis, there is a growing consensus that macroprudential policy should complement the existing policy frameworks of central banks to address systemic risk.*

- *Against this backdrop, this study assesses the effectiveness and drawbacks of maximum loan-to-value ratios (i.e., LTV policy) as a macroprudential tool based on the experience of Hong Kong and econometric analyses of panel data from 13 economies.*

- *Both Hong Kong's experience and these empirical results suggest that LTV policy is effective in containing systemic risk by reducing the sensitivity of mortgage default risk to property price shocks. The simulation results suggest that if the maximum LTV ratio were to have been relaxed from 70% to 90% before 1997, the delinquency ratio right after the 40% decline in property prices in 1997-98 would have been 1.7%, compared to the actual level of 0.84% at the end of 1998.*

- *However, the significant use of mortgage insurance programmes (MIP) in Hong Kong seems to suggest that LTV policy could impose significant liquidity constraints on homebuyers. Nevertheless, empirical findings show that MIPs can reduce liquidity constraints without undermining the effectiveness of the tool. This indicates the important role of MIPs in enhancing the net benefits of LTV policy.*

- *To better understand whether LTV policy would be an effective instrument for stabilising property market activities, this study examines the short-term effect of tightening LTV caps on property market activities for Hong Kong, Korea and Singapore.*

- *Of the three economies, only Hong Kong shows mild evidence of a dampening effect of tightening LTV caps on property market activities. This result is contrary to strong empirical evidence indicating that tightening LTV caps will reduce household sector leverage for the three economies.*

- *These results indicate that the main channel through which LTV policy reduces systemic risk should be its effect on household sector leverage rather than property market activities. One caveat is that the indirect effect of LTV policy via the impact of household leverage on the property market is not reflected in this analysis.*

I. INTRODUCTION

The 2008-09 global financial crisis has demonstrated that monetary policy and microprudential banking regulations are not sufficient to prevent the build-up of systemic risk[1]. There is a growing consensus that macroprudential policy should complement the existing policy frameworks of central banks/supervisory authorities to address systemic risk (Bank of England, 2009; European Central Bank, 2010; International Monetary Fund, 2010; Swiss National Bank, 2010). Maximum loan-to-value (LTV) ratios on mortgages (henceforth referred to as "LTV policy") are being considered or have been recently adopted by some countries as a macroprudential instrument to fill the policy gap: for example, in Hungary, Norway, Sweden and the UK.[2]

Despite wider recognition of LTV policy in the policy community, empirical evidence with regard to some key issues remains scant. First, how effective is LTV policy in reducing systemic risk arising from the boom-and-bust cycle of property markets? Secondly, would LTV policy create significant drawbacks for potential homebuyers (i.e., would they be unable to qualify for mortgages because of liquidity constraints) even though they could sustain loan repayment (see Financial Services Authority, 2009)? Thirdly, should mortgage insurance programmes (MIPs)[3] be considered as a means to complement LTV policy to reduce this drawback, creating a way for banks to offer mortgage loans at rates higher than the maximum LTV ratio without incurring additional credit risk? If so, would MIPs reduce the effectiveness of LTV policy? Finally, on top of its role in containing systemic risk in the banking sector, should LTV policy be adopted as a means to stabilise property market activities?

The objective of this study is to provide empirical evidence regarding these key issues, in part based on Hong Kong's experience[4] and in part using panel-data econometric analyses from 13 economies. In Section II, we begin with a brief history of the LTV policy in Hong Kong. Strong evidence is found that the LTV policy has helped

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1 According to Caruana (2010), systemic risk is defined as the risk of disruption to financial services that occurs because of the impairment of all or part of the financial system and can have serious negative consequences for the real economy.

2 Hungary, Norway and Sweden have formally declared that that they will adopt LTV policies (Magyar Nemzeti Bank, 2010; Financial Supervisory Authority of Norway, 2010; Swedish Financial Supervisory Authority, 2010), and the Financial Services Authority in the UK has not ruled out the possibility that it will employ such a policy in the future (see Financial Services Authority, 2009).

3 Throughout this study, MIP refers to insurance that aims to protect lenders from losses due to mortgage payment default by borrowers. In some jurisdictions, such insurance is also called lenders mortgage insurance.

4 Hong Kong's experience offers several advantages with regard to the assessment of LTV policy. The long history of its LTV policy (with almost 20 years in operation), coupled with substantial, frequent swings in property prices and banks' significant exposure to property-related lending, easily indicates the long-run prudential effect of LTV policy on banking stability. In addition, the absence of an independent monetary policy under the Linked Exchange Rate System, which creates a predominant role for Hong Kong's LTV policy in safeguarding banking stability, also makes assessment easier.

the Hong Kong banking sector to weather the boom-and-bust cycle of the property market during the past two decades. However, evidence also indicates that the LTV policy may impose significant liquidity constraints on homebuyers. Nevertheless, to the extent that this drawback exists, the MIP in Hong Kong has assisted homebuyers in overcoming their liquidity constraints without incurring additional credit risk in the banking system.

In Section III, we provide empirical evidence of two key issues using econometric analyses of panel data from 13 economies. Specifically, our estimation results show that (1) LTV policy enhances banking stability mainly by reducing the responsiveness of mortgage default risk to property price shocks and (2) although in principle MIPs may reduce the effectiveness of LTV policy, there is no clear evidence to support this concern.

In an attempt to shed light on whether LTV policy can be used to stabilise property market activities, Section IV conducts another set of econometric analyses based on data from three economies (Hong Kong, Singapore and Korea)[5] that have adopted LTV policies. Overall, we find mixed evidence of the effect of tightening LTV caps on property market activities. However, there is strong empirical evidence indicating that tightening LTV caps will reduce household leverage.

The results presented in this paper contribute to recent discussions on the use of LTV policy in two ways. First, the results in Sections II and III empirically address the question of the main benefits and costs of LTV policy and the importance of MIPs in implementing LTV policy. Secondly, our empirical findings in Section IV provide a better understanding of the transmission mechanism of LTV policy, which should shed light on the issue of whether LTV policy should be adopted as a tool for stabilising property market activities. The policy implications will be discussed in the final section.

II. A BRIEF HISTORY OF THE LTV POLICY AND THE MIP IN HONG KONG

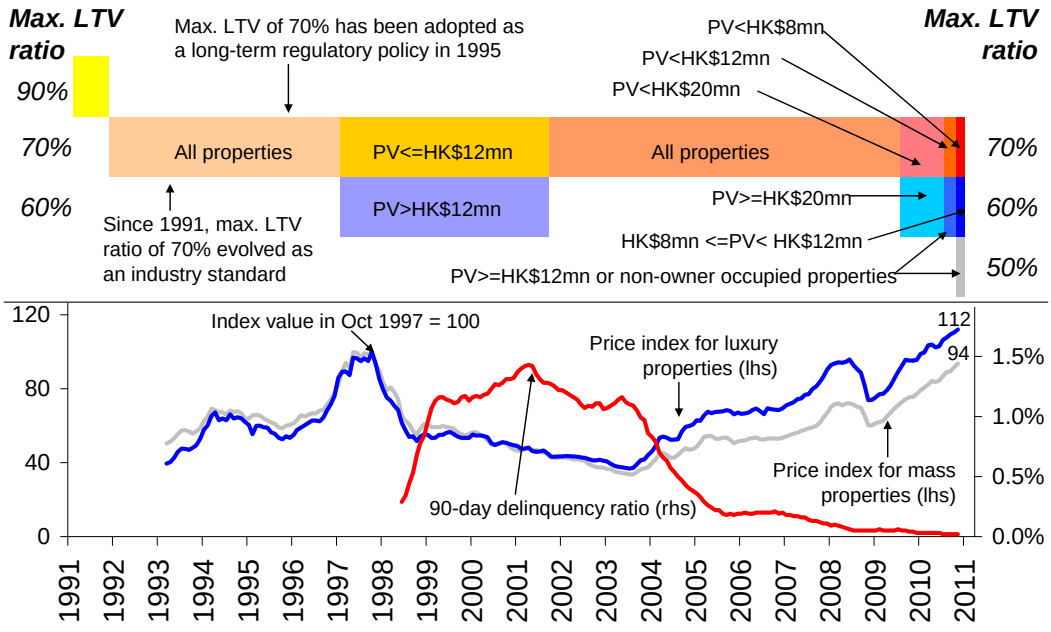
The LTV policy in Hong Kong has long played a vital role in safeguarding banking stability. The policy was created because of some special characteristics of the Hong Kong financial system. First, residential mortgage lending (RML) has always been one of banks' largest areas of risk exposure. Since 1991, the banking sector's RML has never been lower than 20% of its lending for use in Hong Kong, with a maximum of 37% registered in September 2002. Secondly, property prices have historically exhibited strong cyclical patterns such that if bank exposure to the property market were not properly managed, banking stability could be seriously threatened. In fact, previous

[5] Malaysia has also adopted LTV policy. However, the lack of availability of sufficiently long-term time series data precludes the analysis for Malaysia. More specifically, the relevant data series are only available for 1999 and later.

research by Gerlach and Peng (2005) finds that bank lending in Hong Kong is largely driven by property price movements[6], suggesting that systemic risk is largely associated with developments in the property market. Thirdly, in the absence of independent monetary policy under the Linked Exchange Rate System, the Hong Kong Monetary Authority (HKMA) must seek alterative policies for managing the systemic risk stemming from the interaction between the property market and the banking system. The LTV policy was finally introduced as an instrument to strengthen banking system's resilience against asset price volatilities, and to reduce the risk of bank credit becoming a source of cycle amplifier, rather than to manage asset price cycles/market activities or to target asset prices.

Figure 1 provides a succinct graphical summary of the developments in LTV policy together with the movements in property prices and the mortgage delinquency ratio in Hong Kong. The development of LTV policy in Hong Kong can be broadly divided into four phases. The major developments in each phase are summarised below:

Figure 1. The LTV policy, real property prices and mortgage delinquency ratio in Hong Kong



Source: HKMA

[6] Gerlach and Peng (2005) conduct Granger causality tests for property prices and bank lending in Hong Kong. They find that property prices Granger cause bank landing in Hong Kong but not the other way around.

Phase 1: Before 1997

Prior to the adoption of the LTV policy in 1991, Authorized Institutions (AIs)[7] in Hong Kong were allowed to grant mortgage loans up to 90% of the purchase price or the market value of the property (whichever amount was the lower) under the Third Schedule of the Banking Ordinance, the legal framework for banking supervision in Hong Kong. In view of the potential systemic risk of RML, the Commissioner of Banking[8] intended to lower the 90% LTV ratio threshold to 70% in 1991. During a consultation with the banking industry in 1991, banks offered to adopt the 70% LTV policy voluntarily.[9] The policy has since fully endorsed by the Hong Kong Government as a prudential measure and evolved into a banking industry standard intended to guard against over-exposure to the property market. On 2 November 1995, the Hong Kong Government confirmed at a Legislative Council meeting that the 70% LTV policy should adopted as a long-term regulatory policy.

Phase 2: From 1997 to 1999

Against the backdrop of a sharp rise in residential property prices in 1996, signs of speculative activities (particularly at the upper end of the property market) and the rapid increase in RML[10], the HKMA issued guidelines to all AIs on 28 January 1997 recommending that a maximum LTV ratio of 60% be adopted for "luxury" properties with a value of more than HK$12 million.

In the wake of the Asian financial crisis, Hong Kong's property prices fell significantly – by more than 40% in the year from September 1997 to September 1998. Notwithstanding the sharp fall in property prices, the subsequent mortgage delinquency ratio has never exceeded 1.43%, a low level by international standards. This fact alone suggests that the LTV policy is effective in reducing the credit risk that banks face and assuring the quality of banks' mortgage loan portfolios.

Phase 3: From 1999 to 2008

Following a number of measures implemented by the Hong Kong Government intended to stabilise the property market, the earlier 60% LTV ratio

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[7] AIs are institutions authorized under the Banking Ordinance to carry on the business of taking deposits. All AIs in Hong Kong are supervised by the HKMA.

[8] The Office of the Commissioner of Banking was the bank supervisory authority in Hong Kong before the establishment of the HKMA. The HKMA was established on 1 April 1993 by merging the Office of the Exchange Fund with the Office of the Commissioner of Banking.

[9] See the Commissioner of Banking (1991, 1992).

[10] Property prices in Hong Kong increased by 30% in the one-year period from December 1995 to December 1996. RML also increased by 21% in the same period.

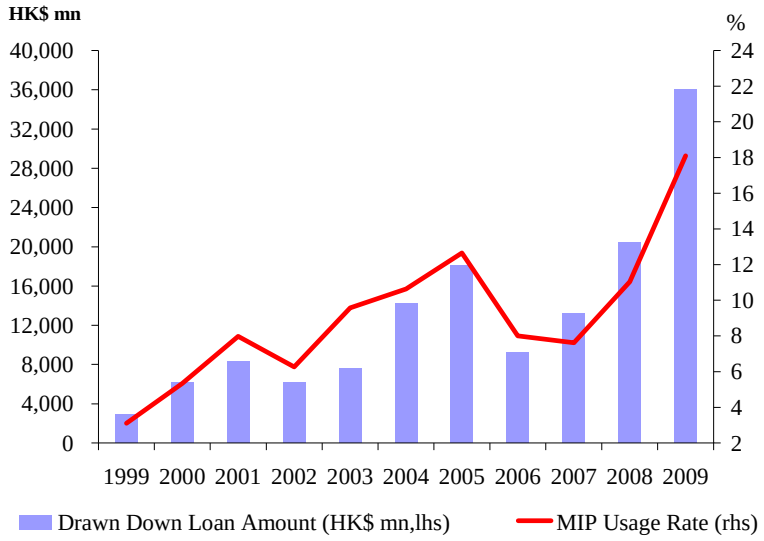
guidelines for the purchase of "luxury" properties (with a value of more than HK$12 million) were withdrawn by the HKMA in October 2001. The maximum LTV ratio of 70% was then restored. At the same time, the HKMA allowed AIs to refinance RML for homeowners in negative equity up to 100% of the current market value of the mortgaged property. Notwithstanding this relaxation of the rules, the HKMA reiterated that the 70% LTV policy remained generally appropriate as a long-term prudential measure.

Because the sharp decline in property prices after the Asian financial crisis was also accompanied by a significant decline in household income, there were significant obstacles for perspective homebuyers in the housing market, which led to continued calls for the relaxation of the 70% LTV policy. In 1999, the Hong Kong Mortgage Corporation (HKMC)[11] launched an MIP aimed at promoting wider homeownership in Hong Kong. Under the MIP, mortgage loans of up to 90% of the LTV ratio are available for homebuyers who meet certain eligibility criteria.[12] The MIP is designed to protect participating banks from credit losses on the portion of loans over the threshold of the 70% LTV ratio in the event of default by mortgagors. At the same time, the MIP avoids the potential drawback associated with the LTV policy: that some homebuyers become unable to qualify for a mortgage because of substantial down payments, even if they could sustain loan repayment. Since the introduction of the MIP, the continued increase in the usage rate from 1999 to 2009 has demonstrated that the MIP has assisted a significant number of homebuyers in overcoming liquidity constraints (Figure 2). The significant use of the MIP indicates that the concern about liquidity constraints imposed by LTV policy should not be lightly dismissed. Nevertheless, to the extent that such drawback exists, the MIP in Hong Kong is shown to be effective in assisting homebuyers in overcoming the hurdle of requiring a substantial down payment for the purchase of properties without incurring additional credit risk in the banking system.

[11] The HKMC was established in 1997 and is owned by the Hong Kong Government. Its primary missions include the following: (1) to enhance the stability of the banking sector by offering a reliable source of liquidity, thereby reducing the concentration and liquidity risk of mortgage lending by banks; (2) to promote wider home ownership in Hong Kong; and (3) to facilitate the growth and development of the debt securities and mortgage-backed securities markets in Hong Kong.

[12] These include maximum debt-to-income ratio, maximum loan amount and maximum term of maturity at origination.

Figure 2. Annual drawn down loan amount and usage rate of the MIP in Hong Kong



Source: HKMC
Note: The MIP usage rate is defined as the ratio of the mortgage loan amount drawn down under the MIP to the total mortgage loan amount drawn down in the Hong Kong banking sector.

One policy concern related to the MIP is that it may reduce the effectiveness of the LTV policy because it enables households to assume higher leverage ratios, which will increase the risk of mortgage defaults and keep banks at risk of a maximum credit loss of 70% of property values. However, the lower delinquency ratio of the HKMC's MIP portfolio as compared to that of the Hong Kong banking sector[13] indicates that with prudent underwriting criteria, the MIP has actually improved banking stability and has not reduced the effectiveness of the LTV policy.

Phase 4: After 2008

As a result of strong capital inflows and unusually low interest rates amid unprecedented quantitative easing by major central banks since early 2009, property prices in Hong Kong have increased sharply, particularly in the upper end of the property market. As a prudential measure, the HKMA issued guidelines in October 2009 requiring all AIs to reduce the maximum LTV ratio for properties with a value of HK$20 million or more from 70% to 60%. In August 2010, to further safeguard banking stability and help banks manage credit risk more prudentially, the HKMA applied the maximum LTV ratio of 60% to properties with a value at or above HK$12 million and also lowered the maximum LTV ratio for properties not intended to be occupied by the owners to 60%.

[13] The delinquency ratio of the HKMC's MIP portfolio reached a historical high of 0.39% at the end of September 2003, whereas the ratio for the Hong Kong banking sector was 1.05%.

To strengthen risk management in RML business in the banking sector, the HKMA implemented the following measures on 19 November 2010: (1) it lowered the maximum LTV ratio for properties with a value at HK$12 million or above from 60% to 50%; (2) it lowered the maximum LTV ratio for residential properties with a value at or above HK$8 million and below HK$12 million from 70% to 60%, but the maximum loan amount is capped at HK$6 million; (3) it maintained the maximum LTV ratio for residential properties with a value below HK$8 million at 70%, but the maximum loan amount is capped at HK$4.8 million; and (4) it lowered the maximum LTV ratio for all non-owner-occupied residential properties, properties held by companies and industrial and commercial properties to 50%, regardless of property values.

In addition to the LTV policy, there were other policies implemented in Hong Kong during that period that had similar macroprudential elements. These included maximum debt servicing ratios[14] for mortgages and maximum exposure to property lending by AIs. The details of the developments in these policies and of those in LTV policy are summarised in Annex A.

III. An Econometric Analysis of the Effect of LTV Policy on Banking Stability

Empirical specifications

This section examines two important issues in LTV policy using econometric analyses of panel data from 13 economies. The economies include Australia, Canada, Greece, Hong Kong, and Korea, Malaysia, the Philippines, Portugal, Singapore, Spain, Thailand, the US and the UK . Two econometric models are specified. Model A is specified to examine the effectiveness of LTV policy by estimating the responsiveness of mortgage delinquency ratios to changes in property prices and to macroeconomic fluctuations for two groups of economies (i.e., those with and without LTV policies), whereas Model B is used to examine whether MIPs have reduced the effectiveness of LTV policy.

Model A:

The following fixed effects model is used to examine the effectiveness of LTV policy:

[14] The debt servicing ratio is defined as monthly repayment obligations as a percentage of monthly income.

$$\begin{aligned}\Delta MD_{i,t} = {} & \alpha_0 + \alpha_1 \Delta P_{i,t} \times I_{LTV_i} + \alpha_2 \Delta P_{i,t} \times I_{NLTV_i} + \\ & \alpha_3 \Delta GDP_{i,t} \times I_{LTV_i} + \alpha_4 \Delta GDP_{i,t} \times I_{NLTV_i} + \\ & \alpha_5 DTGDP_{i,t} + \alpha_6 \Delta Int_{i,t} + \mu_i + \varepsilon_{i,t}\end{aligned} \tag{1}$$

where *i* and *t* index the economy and time, respectively. $I_{LTV}\left(I_{NLTV}\right)$ is a dummy variable for economies with (without) LTV policy. The specification assumes that the change in the mortgage delinquency ratio (ΔMD)[15] for economy *i* at time *t* is correlated with the growth in real property prices (ΔP) and real GDP growth (ΔGDP). The ratio of aggregate mortgage debt to GDP (*DTGDP*) and the change in the interest rate (ΔInt) are included to control for cross-country differences in the aggregate level of household leverage and monetary conditions, respectively.[16] Unobservable economy-specific effects and the remainder disturbance are captured by μ_i and ε_{it} (with zero mean and constant variance σ_ε^2), respectively.

We hypothesise that LTV policy reduces the responsiveness of mortgage default risk to changes in property prices. This implies that the estimated coefficients of $\Delta P \times I_{LTV}$ and $\Delta P \times I_{NLTV}$ (i.e., α_1 and α_2 respectively) should be negative, with the absolute value of α_1 smaller than that of α_2. Similarly, we hypothesise that mortgage default risk for economies with LTV policies is less responsive to macroeconomic fluctuations than those without LTV policies. Therefore, negative estimates for α_3 and α_4 are expected, with the absolute value of the former smaller than that of the latter. The sign of the estimated coefficient of *DTGDP* (i.e., α_5) is expected to be positive; higher aggregate household leverage generally indicates higher default risk when other factors are kept constant. A positive estimate of α_6 is expected because a higher interest rate implies a higher debt-servicing burden for mortgagors.

Model B:

The second model examines whether MIPs will reduce the effectiveness of LTV policy. The model is a modification of Model A with an additional dummy variable J_i included. J_i is defined as one if an MIP is in place and zero otherwise. The inclusion of the additional dummy variable allows us to examine whether the

[15] Δ denotes the change operator. Throughout this study, a change is measured in a quarter to quarter difference.

[16] Other institutional factors such as recourse rules and personal bankruptcy regulations are likely to affect mortgage defaults. The effect of such factors on mortgage delinquency ratio is assumed to be captured by the fixed-effect coefficients of the countries.

coefficient estimates of the economies with both an LTV policy and an MIP are statistically different from those for economies with only an LTV policy. The model is specified as follows:

$$\begin{aligned}\Delta MD_{i,t} = {} & \alpha_0 + (\alpha_1 + \gamma_1 J_i) \times \Delta P_{i,t} \times I_{LTV_i} + \alpha_2 \Delta P_{i,t} \times I_{NLTV_i} + \\ & (\alpha_3 + \gamma_3 J_i) \times \Delta GDP_{i,t} \times I_{LTV_i} + \alpha_4 \Delta GDP_{i,t} \times I_{NLTV_i} + \\ & \alpha_5 DTGDP_{i,t} + \alpha_6 \Delta Int_{i,t} + \pi_i + \delta_{i,t}\end{aligned} \tag{2}$$

where π_i and δ_{it} (with zero mean and constant variance σ_ε^2) capture economy-specific effects and remainder disturbance, respectively. Note that there are two new coefficients, γ_1 and γ_3, in Model B as compared to Model A. γ_1 is the incremental sensitivity of the mortgage delinquency ratio to property prices for economies with both LTV policy and MIPs relative to the economies with only LTV policy. Similarly, γ_3 measures the corresponding incremental sensitivity to macroeconomic fluctuations. The other estimated coefficients can be interpreted in exactly the same way as those in Model A.

Our core interest is in the estimated value and statistical significance of γ_1 and γ_3. A positive and significant estimate of $\gamma_1 (\gamma_3)$ indicates that MIPs will increase the sensitivity of the mortgage delinquency ratio to property prices (macroeconomic fluctuations), suggesting that MIP will reduce the effectiveness of LTV policy.

Data for estimations and the estimation method

The estimation sample consists of unbalanced quarterly panel data on the 13 economies covering the period 1991 Q1 – 2010 Q2. The main descriptive statistics for the data are shown in Table 1. Data on the mortgage delinquency ratio are collected from the respective central banks[17,18], whereas data on property prices, GDP, government bond yields (which is used to proxy for interest rates) and the GDP deflator are taken from various databases, including the Bank for International Settlements, CEIC and the International Monetary Fund (i.e., the International Financial Statistics). Real property prices and real interest rates are derived from the respective nominal variables and the GDP deflator.

[17] The only exception is the data for the UK, which are obtained from the Council of Mortgage Lenders, a non-profit making organisation for the mortgage industry in the UK.

[18] Mortgage delinquency data for the UK and Greece are available biannually and annually, respectively. Quarterly data for these two countries are derived by interpolating the biannual/annual series. We verified that the empirical results are not sensitive to the choice of the interpolation method.

Of the 13 economies, four are identified as having adopted an LTV policy (Hong Kong, Korea, Malaysia and Singapore) according to the Bank for International Settlements (2010) and based on information obtained from the respective central banks/supervisory authorities. Hong Kong, Korea and Malaysia are further identified as having implemented an MIP.[19]

Models A and B are estimated using the generalised least squares (GLS) method instead of the ordinary least squares (OLS) method because in theory, GLS estimates are more efficient than OLS estimates given the panel structure of the data set.[20]

[19] The corresponding institutions are the HKMC, the Korea Housing Finance Corporation, Cagamas Berhad for Hong Kong, Korea and Malaysia. In Malaysia, Cagamas Berhad launched its MIP in 2008.

[20] In panel data sets, variance in cross-sectional units may be significantly different. The OLS estimation is statistically inefficient and can give misleading inference when the variances in the data are unequal.

Table 1. Descriptive statistics for unbalanced panel data for 13 economies

	Change in mortgage delinquency ratio (%)		Real property price growth (%)		Debt to GDP (%)		Real GDP growth (%)		Change in real interest rates (%)		Period	LTV	MIP
Economies	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev			
Australia	0.011	0.037	1.239	2.68	37.703	6.16	1.239	2.68	-0.075	0.930	2002-2010	No	No
Canada	0.009	0.02	1.061	2.068	51.479	5.69	1.061	2.068	-0.087	1.530	2004-2009	No	Yes
Greece	0.018	0.352	0.343	1.604	23.918	7.299	0.343	1.604	0.018	0.922	2003-2009	No	No
Hong Kong	-0.006	0.093	0.315	6.126	47.29	6.597	0.315	6.126	0.002	1.847	1998-2010	Yes	Yes
Korea	-0.067	0.114	0.638	3.034	22.43	1.568	0.638	3.034	-0.014	3.152	2005-2009	Yes	Yes
Malaysia	-0.198	0.478	-0.122	2.372	17.401	5.011	-0.122	2.372	0.047	3.089	1999-2009	Yes	Yes[#]
Philippines	-0.113	0.495	1.848	3.397	2.069	0.127	1.848	3.397	1.497	4.318	2008-2010	No	No
Portugal	0.007	0.072	-0.106	0.658	55.525	6.324	-0.106	0.658	0.061	0.756	2003-2010	No	No
Singapore	-0.061	0.141	1.007	5.361	31.373	1.983	1.007	5.361	-0.030	4.742	2004-2009	Yes	No
Spain	-0.012	0.179	0.89	2.508	38.23	16.623	0.89	2.508	-0.107	1.223	1995-2009	No	No
Thailand	-0.435	2.382	-0.108	2.834	16.329	1.849	-0.108	2.834	-0.254	3.498	2001-2010	No	No
UK	-0.025	0.129	1.375	2.606	67.756	10.176	1.375	2.606	-0.079	0.925	1995-2009	No	No
US	0.106	0.381	0.346	1.096	54.258	11.898	0.346	1.096	-0.052	0.435	1991-2010	No	Yes
All economies	-0.043	0.697	0.596	3.12	40.197	19.522	0.596	3.12	-0.027	2.126	1991-2010		

Notes: (1) Std dev denotes standard deviation
Malaysia launched a MIP in 2008

Estimation results

We first discuss the estimation results for Model A, which are summarised in Table 2. The estimated sensitivity of the mortgage delinquency ratio to property prices for economies with LTV policies (i.e., α_1) is negative and lower (in absolute term) than that of economies without LTV policies (i.e., α_2). A 1% drop in property prices would increase the delinquency ratio for economies with LTV policies by 0.35 basis points, whereas there would be an increase of 1.29 basis points for economies without LTV policies. The statistical results of the Wald test indicate that the null hypothesis of $\alpha_1=\alpha_2$ can be rejected at the 10% significance level for Model A, suggesting that LTV policy reduces the vulnerability of banking systems to property price shocks.

Mortgage default risk for economies with LTV policies is also estimated to be less responsive to macroeconomic fluctuations (i.e., α_3) than those without LTV policies (i.e., α_4). All other things being equal, a one percentage-point decrease in GDP growth should increase the delinquency ratio by 3 basis points for economies with LTV policies compared to 5.1 basis points for those without LTV policies. The statistical results for the Wald test, however, suggest that the difference is not significant statistically.

For Model B, the estimation results are similar to those of Model A. In addition, the estimated coefficients γ_1 and γ_3 are found to be statistically insignificant, suggesting that the MIP has not reduced the effectiveness of the LTV policy.

Table 2. Estimation results for Model A (Equation 1) and Model B (Equation 2)

Dependent variable:	Change in mortgage delinquency ratio (ΔMD)	
	Model A	Model B
Constant (α_0)	-0.2013**	-0.2003**
ΔP		
with LTV policy (α_1)	-0.0035*	-0.0021**
without LTV policy (α_2)	-0.0129**	-0.0129**
Incremental effect of MIP (γ_1)	NA	-0.0016
ΔGDP		
with LTV policy (α_3)	-0.0303**	-0.0487*
without LTV policy (α_4)	-0.0508**	-0.0506**
Incremental effect of MIP (γ_3)	NA	0.0228
DTGDP (α_5)	0.0051**	0.0051**
ΔInt (α_6)	0.0022	0.0024
Adjusted R-squared	0.2460	0.2435

Null hypothesis for the Wald Test	**Chi-square Statistics (P-value)**	**Chi-square Statistics (P-value)**
$\alpha_1 = \alpha_2$	3.420* (0.065)	4.971** (0.026)
$\alpha_3 = \alpha_4$	0.589 (0.443)	0.002 (0.960)

Note: ** and * denote the 5% and 10% levels of significance, respectively.

A simulation exercise

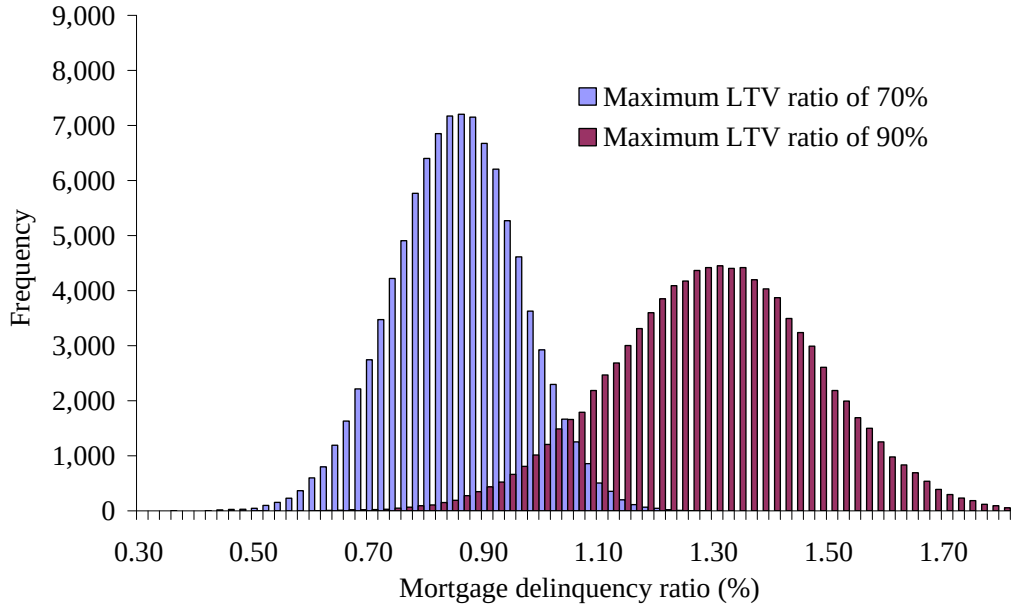
To further visualise the effect of LTV policy on banking stability, we conduct the following simulation exercise for Hong Kong's banking sector. In the simulation, we assess relaxing the maximum 70% LTV policy on property lending may affect the losses in the banking sector resulting from a severe property price shock. Toward this end, we consider a hypothetical scenario in which the 70% LTV policy were to have been withdrawn at some time before 1997. We also assume that all banks would aggressively exploit this change to expand their business by extending mortgage loans to cover 90% of property value (i.e., an average of 90% of the LTV ratio). We then assume a 40% drop in real property prices[21]. With the assumed shock, we simulate the

[21] The shock is comparable to that occurred in Hong Kong for the period of Q4 1997-Q3 1998.

movement of other variables (i.e., *GDP*, ΔInt and *DTGDP*) based on their historical relationships.[22] Together with the estimated coefficients α_2, α_4, α_5 and α_6 in Model A, we compute the overall impact of the shock on the delinquency ratio. We repeat the process 100,000 times to generate a distribution of the delinquency ratio. For comparison, another distribution that assumes an initial value of 70% of the LTV ratio is also simulated. The distribution is simulated based on the estimated coefficients α_1, α_3, α_5 and α_6 in Model A. These two simulated distributions are shown in Figure 3. It is found that if the 70% guideline had been relaxed before 1997, the delinquency ratio after the 40% decline in property price would have increased from 0.6% to 1.71% (at the 95% confidence level). In contrast, with the 70% LTV policy in place, the delinquency ratio would only have increased moderately to 1.11%. This result is largely consistent with the empirical finding by Wong et al. (2004).

Based on the amounts of RML and the total capital in Hong Kong's banking sector in 1997, we compute the credit losses based on the simulation results (Table 3). The calculation of credit losses take into account the effect of the drop in property prices on the loss-given-default. Based on the tail risk, it is found that if relaxation were to occur (see column "LTV 90%"), the credit loss as a percentage of total capital would be around 1.87% (at the 95% confidence level) as compared to a level of around 0.46% for the actual maximum LTV ratio of 70%.

Figure 3. Simulated distribution of the mortgage delinquency ratio for Hong Kong



Source: Authors' estimates.

[22] We follow the simulation method adopted by Wong et al. (2008). The model consists of a seemingly unrelated regression for the growth rate of GDP, interest rate and real property prices. For the variable *DTGDP*, the value is simulated based on the simulated growth rate of GDP and an initial value of 50% of *DTGDP*.

Table 3. Simulated credit losses with and without relaxation of the maximum LTV policy

	Credit loss (HK$ mn)		Credit loss (as % of total capital)		Credit loss (as % of tier-1 capital)	
Statistics	LTV 70%	LTV 90%	LTV 70%	LTV 90%	LTV 70%	LTV 90%
Mean	998.79	3991.05	0.3579	1.4300	0.4550	1.8183
50th percentile	1159.45	4681.32	0.4154	1.6774	0.5282	2.1327
90th percentile	1204.70	4876.01	0.4317	1.7471	0.5488	2.2214
95th percentile	1286.65	5226.50	0.4610	1.8727	0.5862	2.3811
99th percentile	1382.15	5631.18	0.4952	2.0177	0.6297	2.5655

Note: "LTV 70%" refers to the case of actual policy capping the maximum LTV ratio at 70%, whereas "LTV 90%" refers to the hypothetical maximum LTV ratio of 90%

IV. An econometric analysis of the effect of LTV policy on property market activities

This section assesses the effectiveness of LTV policy as a tool for stabilising property markets. Although LTV policy was shown in Section III to be effective in enhancing the resilience of the banking system to property price shocks, it remains unclear whether LTV policy may be an appropriate tool for stabilising property market activities. On an empirical level, the experience in Hong Kong, Korea and Singapore may shed light on this issue. Specifically, LTV caps in these three economies were tightened in past periods when there was significant concern about the risk of overheating property markets. By quantifying the immediate effect of the tightening LTV caps on property market activities, we can evaluate the effect of LTV policy on property market activities.

For this purpose, the following generalised autoregressive conditional heteroskedasticity (GARCH) model is specified:

$$Y_t = C_0 + C_b Dum_t^B + C_a Dum_t^A + C_3 IR_t + \sum_{k=1}^{n} \theta_k Y_{t-k} + e_t$$

$$e_t \sim N(0, \sigma_t^2) \quad \text{and} \quad \sigma_t^2 = a_0 + \sum_{i=1}^{p} a_i e_{t-1}^2 + \sum_{j=1}^{q} b_j \sigma_{t-1}^2 \qquad (3)$$

where Y_t is an indicator of property market activities such that a higher Y_t indicates a higher level of property market activities. The model assumes that the conditional mean of Y_t follows an autoregressive process with a maximum lag of *n*: i.e., AR(*n*).[23] Dum_t^B is

[23] In the literature, using GARCH models to analyse the impact of policy interventions is common, particularly for exchange rate policy interventions. Earlier work includes Baillie and Osterberg (1997), and Hillebrand and Schnabland (2003). In general, including a dummy variable or a two-period estimation method can help to identify the effect of policy actions on the financial variables concerned. Recent work such as Baba and Packer (2009), Baba and Shim (2010), Fung and Yu (2009), and Genberg and Hui (2011) also specifies the models used in a similar fashion.

defined as one for observations within the six-month period right *before* the tightening LTV caps and zero otherwise, whereas Dum_t^A is defined as one for observations within the six-month period right *after* the tightening LTV caps and zero otherwise. The change in real interest rates (*IR)* is included to control for differences in monetary conditions. The error term e_t is assumed to follow a conditional normal distribution with zero mean and time varying variance σ_t^2.

If the tightening LTV caps reduced property market activities, the estimated coefficient C_a should be significantly smaller than the estimated coefficient C_b given that a higher Y_t indicates a higher level of property market activity. The statistical significance of the difference between C_b and C_a can be examined using the Wald test.

Three property market indicators are selected in this study. They are (i) the real property price growth, Y_t^P; (ii) the deviation of actual property prices from the trend value[24] as a percentage of the actual level of property prices, Y_t^{HP}[25]; and (iii) the number of property transactions (in logarithmic form), Y_t^V. In addition, we also evaluate the impact of tightening the maximum LTV ratios on household mortgage debt leverage, which is defined as the ratio of mortgage loans to GDP, Y_t^{Lev}.

Quarterly time series Y_t for Hong Kong, Korea and Singapore are used for the estimations. These data are mainly from the panel data used in Section III. The sample period for the economies is presented in Table 4 along with the statistical results of the augmented Dickey-Fuller (ADF) test for Y_t and the definition of the dummy variables Dum_t^B and Dum_t^A for the economies. Overall, the ADF tests indicate that Y_t^P and Y_t^{Lev} are non-stationary time series, and therefore, the first-difference form is used in estimating equation (3). In contrast, Y_t^{HP} and Y_t^V are stationary time series, and thus the level form is used. In estimations, the order of the GARCH model (i.e., *n*, *p* and *q*) is determined using the sample autocorrelation function and the sample partial autocorrelation function of Y_t, e_t and e_t^2. The estimated model is further diagnosed by checking the Ljung-Box Q statistics e_t and e_t^2.

[24] The trend level is derived using the Hodrick-Prescott filter.

[25] Y_t^{HP} is a commonly used indicator of property price bubbles.

Table 4. Augmented Dickey-Fuller (ADF) unit root test results of property market indicators and definitions of Dum^A and Dum^B

	Hong Kong		Singapore		Korea	
Dependent variable	Level	First Diff	Level	First Diff	Level	First Diff
Real property price (Y^P)	-1.07	-10.28*	-1.31	-5.90*	-1.78	-2.85*
Gap between property price and its HP filtered trend (Y^{HP})	-5.34*	-6.71*	-4.94*	-6.95*	-4.61*	-9.75*
Transaction volume (in log, Y^V)	-2.86*	-8.03*	-3.69*	-9.65*	-3.56*	-3.31*
Ratio of mortgage loan to GDP level (Y^{Lev})	-0.90	-5.09*	-0.60	-6.12*	-0.57	-3.09*
Sample period	(1982 Q1–2010 Q2)		(1981 Q1–2010 Q2)		(1987 Q1–2010 Q2)	
Periods with $Dum_t^B = 1$	1991 Q2 – 1991 Q3 1996 Q3 – 1996 Q4 2009 Q2 – 2009 Q3		1995 Q3 – 1995 Q4 2009 Q3 – 2009 Q4		2002 Q1 – 2002 Q2 2009 Q2 – 2009 Q3	
Periods with $Dum_t^A = 1$	1991 Q4 – 1992 Q1 1997 Q1 – 1997 Q2 2009 Q4 – 2010 Q1		1996 Q1 – 1996 Q2 2010 Q1 – 2010 Q2		2002 Q3 – 2002 Q4 2009 Q4 – 2010 Q1	

Notes:
- * denotes the 10% level of significance. The critical value at the 10% level of the ADF test is -2.5940.
- - The lag length of the ADF test is determined by the Schwarz information criterion.

Panels A to C in Table 5 report the estimation results for Hong Kong, Korea and Singapore, respectively. The main findings are summarised as follows:

(1) Empirical evidence that tightening LTV caps would have a significant dampening effect on real property price growth (measured by Y_t^P) is mixed across the economies. Whereas the coefficient of Dum_t^A (i.e., C_a) is estimated to be smaller than that of Dum_t^B (i.e., C_b) for the three economies, the statistical results of the Wald test indicate that the null hypothesis of $C_a = C_b$ can be rejected at the 1% significance level only for the case of Hong Kong.

(2) Statistically, there is no clear evidence that tightening LTV caps would lead to a lower property price gap (Y_t^{HP}). C_a is estimated to be lower than C_b for Hong Kong and Korea, whereas C_a is estimated to be larger than C_b for Singapore. Nevertheless, the null hypothesis of $C_a = C_b$ cannot be rejected for all of the economies, suggesting that the mean levels of Y_t^{HP} in the six-month periods *before* and *after* the tightening of the LTV caps are not statistically different. Similar empirical results are found when property transactions (Y_t^V) are considered.

(3) We find strong empirical evidence that a higher LTV cap will lead to a lower level of mortgage debt leverage (measured by Y_t^{Lev}). C_a is estimated to be lower than C_b for all the three economies when Y_t^{Lev} is used as the dependent variable. The null hypothesis of $C_a = C_b$ can be rejected at the 1% significance level for Hong Kong and Korea and at the 5% significance level for Singapore.

(4) Overall, although there is clear empirical evidence that tightening LTV caps will reduce household leverage, evidence that tightening LTV caps will lead to a lower level of property market activities is mixed across the economies. These findings suggest that the effect of LTV policy on systemic risk may be primarily transmitted through effects on the household sector leverage, with the property market playing a minor role.

Table 5. Estimation results on the impact of tightening LTV caps on property market activities (Equation 3)

Economy	Coefficient of	Dependent variable: Real property price growth (Y^P)	Gap between price and trend (Y^{HP})	Transaction volume (Y^V)	Mortgage loans to GDP (Y^{Lev})
Panel A: Hong Kong	*Conditional mean equation*				
	Constant (C_0)	0.39	-0.90**	3.47**	0.0007
	Dum_t^B (C_b)	7.94**	4.30**	0.41**	0.0063**
	Dum_t^A (C_a)	2.62	3.74	0.18*	-0.0033
	IR_t (C_3)	-0.59*	-0.50	-0.02	-0.0005*
	Conditional variance parameter				
	Constant (a_0)	5.90		0.00	0.0000
	e_{t-1}^2 (a_1)	0.19**		0.04	0.0684
	σ_{t-1}^2 (b_1)	0.54**		0.86*	0.8763**
	Adjusted R-squared	0.34	0.79	0.56	0.46
	Wald test for C_b=C_a (P-value)	***0.01***	*0.84*	*0.30*	***0.0003***
Panel B: Singapore	*Conditional mean equation*				
	Constant (C_0)	0.11	-0.07	3.20**	0.0019**
	Dum_t^B (C_b)	5.16*	2.27**	0.23*	0.0050**
	Dum_t^A (C_a)	1.79**	3.12**	0.35**	-0.0013
	IR_t (C_3)	0.21	0.33*	-0.05	-0.0019
	Conditional variance parameter				
	Constant (a_0)		2.55**		0.0000
	e_{t-1}^2 (a_1)		0.33		-0.0374
	e_{t-2}^2 (a_2)		0.63**		
	σ_{t-1}^2 (b_1)		-0.08		0.9748**
	σ_{t-2}^2 (b_2)		-0.01		
	Adjusted R-squared	0.39	0.88	0.43	0.09
	Wald test for C_b=C_a (P-value)	*0.21*	*0.45*	*0.24*	***0.0498***
Panel C: Korea	*Conditional mean equation*				
	Constant (C_0)	-0.08	-0.25	6.45**	
	Dum_t^B (C_b)	2.52	1.60	0.34**	0.0000
	Dum_t^A (C_a)	0.88	1.08	0.19	-0.0036**
	IR_t (C_3)	-0.13	0.05	-0.08	0.0013**
	Adjusted R-squared	0.16	0.70	0.37	0.56
	Wald test for C_b=C_a (P-value)	*0.50*	*0.74*	*0.37*	***0.0086***

Notes:
- ** and * denote the 5% and 10% levels of significance, respectively.
- All p-values for the Ljung-Box test for adequacy in mean and variance equations are larger than 10%, suggesting that all models are adequate at an reasonable confidence level.
- Estimates for the lag terms for Y are not reported in this table.
- For panel C, all time series are found to be homoscedastic, so a simple AR model instead of a GARCH model is adopted as the final model.

V. CONCLUSION

Some key issues related to the use of maximum LTV ratios as a macroprudential tool, including their effectiveness and potential drawbacks, are assessed in this paper. Both Hong Kong's experience and empirical findings of the panel-data econometric analyses suggest that LTV policy is effective in reducing systemic risk arising from the boom-and-bust cycle of property markets. However, the significant usage of the mortgage insurance programme (MIP) in Hong Kong indicates that the liquidity constraints generated by the LTV policy may be material. Nevertheless, empirical evidence shows that MIPs can mitigate this drawback without undermining the effectiveness of the tool. This finding indicates the important role of MIPs in enhancing the net benefits of LTV policy. More importantly, potential liquidity constraints on homebuyers generated by LTV policy should not be seen as a strong reason for not adopting an LTV policy to contain the systemic risk associated with property price shocks.

This study also contributes to recent discussions of the role of LTV policy and particularly of whether it should be used to stabilise property market activities and address concerns regarding property price bubbles. The empirical findings based on data from the three economies that have adopted their LTV policies suggest that although there is strong evidence that tightening LTV caps in general would reduce household leverage, evidence that tightening LTV caps will have significant dampening effects on property market activities is mixed across the economies. These findings suggest that the effect of LTV policy on systemic risk is transmitted mainly through impacts on the household sector rather than on property market activities.

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Annex A: Summary of the history of the LTV policy in Hong Kong

Year	Major developments
Before 1991	"Residential mortgage" was defined in the Third Schedule of the Banking Ordinance as a mortgage where, among other things, "the principal sum does not exceed 90% of the purchase price or the market value of the property, whichever amount is the lower".
1991	The maximum LTV ratio of 70% was adopted by the banking industry in November 1991 and has since been fully endorsed by the Commissioner of Banking as a prudent measure adopted by banks against over-exposure to the property market. Source: http://www.info.gov.hk/hkma/eng/viewpt/20090604e.htm
1994	A 40% guideline for property lending was introduced at the beginning of 1994 when property lending was rising rapidly. It advised that AIs whose property exposure as a percentage of loans for use in Hong Kong was above the average for the industry as a whole (about 40%) should seek to stabilise or reduce that percentage. Source: http://www.info.gov.hk/hkma/eng/press/1998/980728e2.htm
1995	The Government confirmed at a Legislative Council meeting that the 70% LTV ratio should be adopted as a long-term regulatory policy. Source: http://www.info.gov.hk/hkma/eng/viewpt/20090604e.htm
1997	• The HKMA recommended that a maximum LTV of 60% should be adopted for “luxury” property with a value of more than HK$12 million. Source:http://www.info.gov.hk/hkma/eng/guide/guide_no/guide_593b.htm • All AIs were required to have a clearly defined and documented policy to assess the repayment capability of residential mortgage borrowers. This should include the use of a debt servicing ratio (DSR) test. The DSR is defined as the monthly repayment obligations of the borrower as a percentage of monthly income. The ratio should be no higher than 50-60% of income, though the upper end of this range should be confined to higher income earners. Source:http://www.info.gov.hk/hkma/eng/guide/guide_no/guide_594b.htm
1998	The "40% guideline" for property lending on the property exposure of authorized institutions in Hong Kong was withdrawn. Source: http://www.info.gov.hk/hkma/eng/guide/guide_no/guide_595b.htm

Year	Major developments
2001	• While the 70% LTV guideline remained generally appropriate as a long-term prudential measure, and continued to apply to new RMLs, the HKMA did not object if AIs that judge it commercially desirable to do so choose to depart from the 70% LTV guideline in the case of refinancing RMLs in negative equity. However, such loans should not exceed 100% of the current market value of the mortgaged property. • The 60% LTV guideline for the purchase of "luxury" property (with a value of more than $12 million) had been withdrawn. The maximum LTV ratio for such loans was restored to 70%. Source: http://www.info.gov.hk/hkma/eng/guide/circu_date/20011010a.htm
Oct 2009	All AIs were required to reduce the maximum LTV ratio for properties with a value of HK$20 million or more from 70% to 60%. Source:http://www.info.gov.hk/hkma/eng/guide/circu_date/20091023e1.htm
Aug 2010	The HKMA further implemented a set of prudential measures for RML: 1. Applying a maximum LTV ratio of 60% to properties with a value at or above $12 million. For properties valued below $12 million, the 70% LTV guideline continued to apply, but the maximum loan amount will be capped at $7.2 million; 2. Lowering the maximum LTV ratio for properties which are not intended to be occupied by the owners to 60%. Banks should require mortgage applicants to declare whether they intend to occupy the mortgaged property; and 3. Standardising the limit on DSRs of mortgage applicants to 50%, instead of the current range of 50% to 60%. In addition, banks should stress-test mortgage applicants' repayment ability, assuming an increase in mortgage rates of at least two percentage points, and limit the stressed DSR to a cap of 60%. Source: http://www.info.gov.hk/hkma/eng/press/2010/20100813e7.htm
Nov 2010	To strengthen risk management in RML business of the banking sector, the HKMA implemented the following measure: 1. Lowering the maximum LTV ratio for properties with a value at HK$12 million or above from 60% to 50%; 2. Lowering the maximum LTV ratio for residential properties with a value at or above HK$8 million and below HK$12 million from 70% to 60%, but the maximum loan amount is capped at HK$6 million; 3. Maintaining the maximum LTV ratio for residential properties with a value below HK$8 million at 70%, but the maximum loan amount is capped at HK$4.8 million; and 4. Lowering the maximum LTV ratio for all non-owner-occupied residential properties, properties held by a company and industrial and commercial properties to 50%, regardless of property values. Source: http://www.info.gov.hk/hkma/eng/press/2010/20101119e5.htm