Research Memorandum 05/2018

26 July 2018

A COST-BENEFIT ANALYSIS OF LOSS-ABSORBING CAPACITY REQUIREMENTS FOR THE HONG KONG BANKING SECTOR[1]

Key points:

- *This study provides a cost-benefit analysis of loss-absorbing capacity (LAC) requirements for authorized institutions (AIs) in Hong Kong. The costs of higher LAC-to-risk-weighted assets (RWA) ratios (LAC ratios) are driven by a possible increase in lending spreads, which may dampen investment and output. The benefits of higher LAC ratios result in a lower probability and severity of financial crises.*

- *The estimated net benefits depend crucially on the assumed GDP loss from the different levels of severity of financial crises. Three scenarios, in descending order of severity, are considered: (1) a permanent output loss; (2) a persistent but decaying output loss with a 5% rate of decay; and (3) a temporary output loss fully dissipated 10 years after the onset of a crisis, similar to the Hong Kong experience after the Asian financial crisis.*

- *Across all three scenarios assessed, our empirical results show that a requirement that would increase the aggregate LAC of AIs up to 32% of RWAs would be expected to generate positive net benefits for the Hong Kong economy. However, in the least severe scenario of output loss, increasing total loss-absorbing capacity requirements any higher than 28-30% of RWAs would lead to a smaller net benefit.*

- *As a caveat, this assessment could at best provide a broad overview of the net impact of the LAC requirements rather than an accurate quantification. This is because other potential channels through which the LAC requirements could*

[1] The authors would like to thank colleagues from Resolution Office of the HKMA for helpful comments.

affect the economic output have not been taken into account due to the difficulties in quantification. Nevertheless, the fact that this assessment indicates a positive net economic benefit for higher LAC ratios across all three scenarios provides supportive evidence for introducing LAC requirements for AIs in Hong Kong.

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I. INTRODUCTION

The 2007-2008 global financial crisis demonstrated that some financial institutions (FIs) might be "Too-Big-To-Fail (TBTF)" because their collapse would threaten system-wide financial stability.[2] To prevent such catastrophic outcomes, several foreign governments in the past used taxpayers' money to bail-out failing FIs. The use of public funds to bail-out private firms creates resource misallocation and problems of moral hazard. With an expectation that the TBTF-FIs won't fail, depositors are willing to provide cheap funding as they anticipate the government bail-out will cover their lending. This kind of implicit subsidy granted to the TBTF-FIs encourages excessive risk-taking in the search for the highest possible returns.

To address the moral hazard issues associated with the TBTF, regulators and market participants generally agree that better resolution strategies are required to align market discipline. To this end, the Financial Stability Board (FSB) recommended a new total loss-absorbing capacity (TLAC) requirement for global systemically important banks (G-SIBs) in 2015. Meanwhile, other European banks would be subjected to the Minimum Requirement for Own Funds and Eligible Liabilities (MREL) under the European Bank Resolution and Recovery Directive.[3] Both TLAC and MREL aim at enhancing FIs' loss-absorbing capacity (LAC) in resolution such that critical functions can be continued without resorting to public funds or putting financial stability at risk.[4]

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2 Although some market commentaries noted that the origin of the global financial crisis started from the bursting of the sub-prime mortgage bubble in 2007, the crisis hit its peak in September 2008 when Lehman Brothers filed for bankruptcy.

3 In Hong Kong, the Financial Institutions (Resolution) Ordinance (FIRO) allows a resolution authority to make rules prescribing loss-absorbing capacity requirements for within scope financial institutions. For proposals on the development of rules prescribing loss-absorbing capacity requirements for authorized institutions, see the HKMA's Consultation Paper 18.01 'Rules on Loss-Absorbing Capacity Requirements for Authorized Institutions' (the LAC CP) issued in January 2018, and the conclusion to that consultation issued in July 2018. Details of the consultation paper and its conclusion can be downloaded from the HKMA's website (http://www.hkma.gov.hk/eng/key-functions/banking-stability/resolution/resolution-publications/resolution-publications-2018.shtml)

4 It is noteworthy that TLAC is a requirement over and above the minimum capital requirements stipulated in Basel III, as the latter are principally calibrated to allow banks to absorb losses on a

The essence of both TLAC and MREL requires FIs to hold more LAC eligible instruments to ensure better resolution. Although the LAC requirements can improve the resilience of the financial system in lowering the probability and severity of future financial crises, they may also incur costs. One principal channel through which higher LAC ratios have an impact on the real economy is higher lending spreads. Implementation of the LAC requirements is likely to incur higher funding costs for FIs, which may subsequently be passed on to their borrowers. If the increases in borrowing costs are substantial, the aggregate investment and output growth may be dampened. Hence, whether FIs holding more LAC can generate positive net benefits to the financial system is an empirical question which merits a detailed cost-benefit analysis. By explicitly modelling how a better resolution can affect FIs and the financial system as a whole, Brooke *et al.* (2015) and Firestone *et al.* (2017) find that higher capital can generate positive net benefits for the UK and US banking systems respectively. In a previous work, Wong *et al.* (2010) show that higher capital and liquidity requirements of the Basel III regulatory reform can generate positive net benefits for the Hong Kong banking sector. However, their analyses have not incorporated the impact of better resolution and the post-crisis regulatory reforms that have since taken place.

Against this background, this paper attempts to fill the void by conducting an updated analysis of how an improvement in the loss-absorbing capacity, in the form of higher banks' LAC-to-RWAs ratios (LAC ratios), will impact on Hong Kong's economy.[5]

Our methodology follows Brooke *et al.* (2015) and Firestone *et al*. (2017). Specifically, the formula below stipulates how we model costs and benefits.

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going concern basis, but are not designed to provide resources in resolution.

[5] In this study, we implicitly assume that an increase in LAC-eligible debt instruments has the same benefit as an increase of the same amount of regulatory capital.

Cost = **Increase in lending spread per increase in LAC ratios (i)**
× Reduction in output per increase in lending spreads (ii)

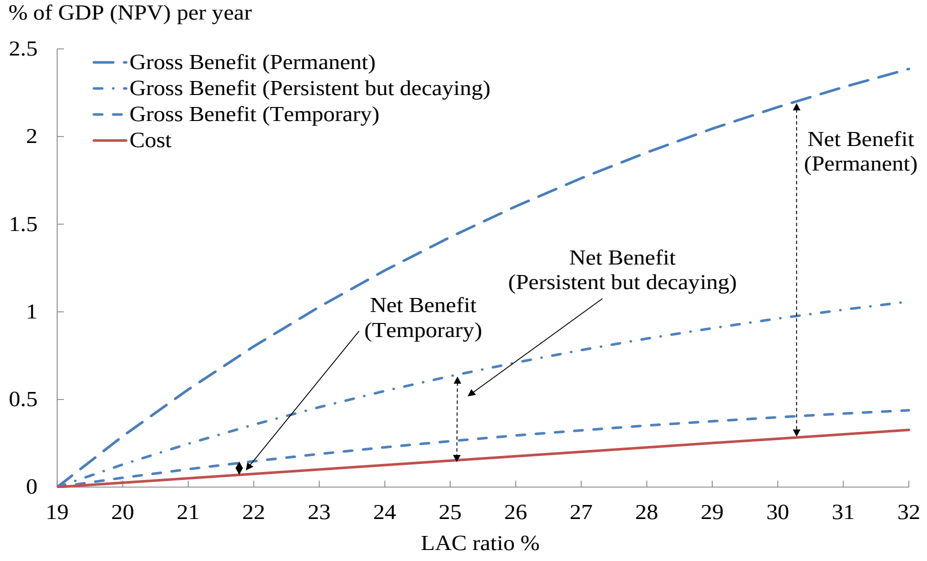
Benefit = **Reduction of the probability of a crisis per increase in LAC ratios (iii)**
× Cost of crisis in net present value (iv)

The estimated net benefits depend crucially on the assumed GDP loss from the different severity of financial crises (i.e., item (iv) in the above formula). The three scenarios, in descending order of severity, are considered in this study: (1) a permanent output loss; (2) a persistent but decaying output loss with a 5% rate of decay; and (3) a temporary output loss fully dissipated 10 years after the onset of a crisis, similar to the experience for Hong Kong after the Asian financial crisis. Based on initial LAC ratios of 18.7% of RWAs[6] and assuming authorized institutions (AIs) will meet the higher LAC requirements with a mixture of 1/3 in LAC debt and 2/3 in equity instruments[7], Chart 1 plots the estimated cost and different benefit schedules under scenarios (1)-(3). The difference between the blue line (benefit) and the red line (cost) represents the net benefit. Table 1 shows the detailed figures for Chart 1.

[6] This is the consolidated total capital ratios of locally incorporated AIs at the end of June 2017.

[7] In addition to capital, it is envisaged that unsecured debts that are fully paid-in with maturity over one-year will also count towards LAC requirements. For detailed proposals on LAC eligibility criteria, see the LAC CP.

Chart 1: Estimated cost and benefit of higher LAC ratios



Source: HKMA staff estimates.

Table 1: Estimation result of the net benefits

LAC ratios (%)	Cost (%)	Cumulative gross benefit (%)			Cumulative net benefit (%)		
		(1)	(2)	(3)	(1)	(2)	(3)
20	0.03	0.29	0.13	0.05	0.26	0.10	0.03
21	0.05	0.56	0.25	0.10	0.51	0.20	0.05
22	0.08	0.80	0.36	0.15	0.73	0.28	0.07
24	0.13	1.24	0.55	0.23	1.11	0.42	0.10
26	0.18	1.60	0.71	0.29	1.43	0.53	0.12
28	0.23	1.91	0.85	0.35	1.68	0.62	0.12
30	0.28	2.17	0.96	0.40	1.89	0.69	0.12
32	0.33	2.38	1.06	0.44	2.06	0.73	0.11

Note: This table shows the estimated gross and net benefits under the three scenarios of output loss: (1) Permanent; (2) Persistent but decaying; and (3) Temporary.
Source: HKMA staff estimates.

As indicated in Chart 1 and Table 1, higher LAC ratios are expected to generate positive net benefits for Hong Kong across all three scenarios considered. This provides supporting evidence for requiring locally incorporated AIs to meet the LAC requirements.

The remainder of the paper is organised as follows. Section 2 discusses the macroeconomic costs of higher LAC ratios. Section 3 discusses the estimation of benefit. Section 4 reports the resulting net benefit. Section 5 provides various sensitivity analyses and the final section concludes. Technical details of the estimations are presented in various appendices.

II. MACROECONOMIC COSTS OF HIGHER LAC RATIOS

2.1) <u>Increase in lending spreads per increase in LAC ratios</u>

The strategy for estimating the impact of a rise in LAC ratios on lending spreads is as follows: Firstly, we employ the formula used in Firestone *et al.* (2017) to gauge the potential increase in the weighted average cost of funds (WACF) for a representative AI in meeting a one percentage point increase in the LAC ratios with equity funding. The representative AI has characteristics that are the same as the weighted averages of all locally incorporated AIs. Secondly, we repeat the calculation to gauge the impact on WACF if the same rise in LAC ratios is met with non-capital LAC eligible debt (LAC debt) instead of equity. Thirdly, by assuming the higher LAC ratios are met two thirds with equity and one third with LAC debt, the overall increase in WACF can then be obtained. Lastly, by imposing assumptions on how far the AI will pass the increased cost of funds onto their customers, we can estimate the increase in lending spreads.

Eq. (1) below shows the formula used in Firestone *et al.* (2017) for estimating the increase in WACF if the AI meets the LAC requirements with equity:

$$\Delta WACF = \overbrace{1\%}^{\text{1-ppt increase in LAC ratios}} \times \underbrace{\frac{RWA}{Assets}}_{\text{adjust from risk-weighted assets base to total assets base}} \times [(\overbrace{1 - MM}^{\text{adjust for lower credit risk due to higher LAC}}) \times (\underbrace{C^E - C^D}_{\text{higher cost of funds}}) + \underbrace{C^D \times tax}_{\text{forgone tax shield}}] \quad (1)$$

where $\frac{RWA}{Assets}$ is the ratio of banks' risk-weighted assets to total assets, MM is the degree of the Modigliani-Miller offset effect, C^E and C^D are the cost of equity and debt respectively and tax is the corporate tax rate in Hong Kong. In Eq. (1), $C^E - C^D$ accounts for how WACF would increase by substituting equity for non-equity liabilities, while the term $C^D \times tax$ is the associated forgone tax shield. The term $1 - MM$ accounts for the fact that by switching to higher equity funding, banks' credit risk should decrease which would lead to a lower banks' funding cost. MM is estimated by assessing how banks' risk (measured by market betas obtained from the capital asset pricing model) changes with banks' capital ratios based on a panel regression model reported in Appendix 1. Using semi-annual data of 15 listed banks from the first half of 1994 to the second half of 2017, we estimate the MM offset to be around 50%, which is the same value used in Brooke *et al*. (2015) and Firestone *et al*. (2017).

For other variables in Eq. (1), we use their end-2016 values to reflect the current situation.[8] Based on data submitted to the HKMA by locally incorporated licensed banks and a 16.5% tax rate, the right hand side of Eq. (1) is:

$$1\% \times 61\% \times [(1 - 50\%) \times (9\% - 1.7\%) + 1.7\% \times 16.5\%] = 0.0239\%$$

This implies an AI's WACF will increase by 2.4 basis points if the one percentage point increase in LAC ratios is met with equity funding.

In practice, AIs will also meet the LAC requirements through issuing LAC debt. To account for this, we amend Eq. (1) to

[8] Based on end-2016 position, the average $RWA/Assets$, C^E, C^D are 61%, 9% and 1.7% respectively. C^D is proxied by bank's return on liabilities which is calculated as the pre-tax profit over total liabilities.

$$\Delta WACF = 1\% \times \frac{RWA}{Assets} \times [(1 - MM) \times (C^D(H) - C^D)] \quad (2)$$

where $C^D(H)$ is the cost for the new LAC debt which is assumed to be comparable with the cost of banks' Tier 2 capital.[9] The term $C^D(H) - C^D$ represents the extra cost of switching from AIs' non-LAC liabilities to LAC debt. As the interest payment from debts is tax-deductible, the term for tax shield does not appear in Eq. (2).

Based on data submitted to the HKMA by Hong Kong incorporated AIs[10], the cost of Tier 2 capital instruments is estimated to be 4% at the end of 2016. Plugging the numbers into Eq. (2), it gives:

$$1\% \times 61\% \times [(1 - 50\%) \times (4\% - 1.7\%)] = 0.007\%$$

This implies an AI's WACF will increase by 0.7 basis points if the one percentage point increase of LAC ratios is met with LAC debt only.

The FSB (2015a) provides guidance that the use of LAC debt should be at least one-third of the overall LAC requirements. We follow this and assume the AIs would meet the LAC requirements by using a mix of 2/3 equity and 1/3 LAC debt. Hence, the increase in cost can be calculated as the weighted average of the results from the two formulae:

$$2/3 \times 2.4 \text{ basis points} + 1/3 \times 0.7 \text{ basis points} = 1.83 \text{ basis points}$$

The AI's WACF will increase by 1.83 basis points for every one percentage point increase in LAC ratios. Lastly, we assume a full pass-through

9 The cost of non-capital LAC debt should in principle be lower than that of Tier 2 capital, as it ranks above Tier 2 capital in the creditor hierarchy. In order not to overstate the net benefits of higher LAC requirements, the analysis assumes a cost of LAC debt is the same as that of Tier 2 capital.

10 The HKMA collected information from AIs through a survey in September 2017 for the purposes of formulation of rules of LAC requirements under Section 19 of the Financial Institutions (Resolution) Ordinance (Cap. 618).

of this increase in cost to the AIs' customers. With total loans and advances accounting for around 45% of the total assets of all locally incorporated AIs at the end of 2016, a full pass-through of the increased cost would result in a rise in the lending spreads by 4.11 basis points.[11,12]

2.2) <u>Reduction in output per increase in lending spreads</u>

The increase in lending spreads obtained from the previous subsection is used as an explanatory variable in a macroeconomic model to translate the effect of higher LAC ratios into changes in the Hong Kong economic output. Specifically, we update the error-correction model of Wong *et al.* (2010) for the period from 1998 to 2017 and find that a one percentage point increase in the lending spread would result in a 0.61 percentage point decrease in real GDP. Appendix 2 describes the details of the error-correction model.

Taken together, the estimation results suggest that when LAC ratios increase by one percentage point, there will be a 4.11 basis point increase in the lending spreads that will subsequently result in a 2.51 basis point reduction in real GDP in the long run.

Table 2 summarises the estimated impact on output when the mix of LAC is 1/3 LAC debt and 2/3 equity.[13] It is noteworthy that under the assumption of using a mix of equity and LAC debt, we implicitly assume that an increase in LAC debt has the same impact as an increase in the same amount of total regulatory capital instruments when comparing the cost with the gross benefit. Table 3 compares the cost estimates with other studies. The impact is relatively mild for Hong Kong when compared with Firestone *et al*. (2017) and Brooke *et*

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[11] It is calculated by dividing WACF by the ratios of loans to total assets (0.0183%/44.5% = 4.11 basis points).

[12] In practice, AIs are unlikely to be able to pass on 100% of the increased costs. To the extent AIs do not pass on all the costs (for example, as a result of competitiveness considerations, or improved efficiency), the estimates of macroeconomic costs would be smaller. Therefore, the estimated increase in lending spreads should be treated as the upper bound estimates.

[13] The result for an alternative assumption of a mix of 2/3 LAC debt and 1/3 equity is presented in Section 5.

al. (2015), as these studies assume banks would meet the LAC requirements with equity only. This would inevitably lead to larger changes in lending spreads and hence larger output loss.

Table 2: Estimated impact of higher LAC ratios on output, assuming the additional LAC is met with 1/3 LAC debt and 2/3 equity

Changes in LAC ratios (percentage point)	**Changes in lending spread (bps)**	**Changes in output (bps)**
+ 1	+ 4.11	– 2.51
+ 2	+ 8.21	– 5.02
+ 3	+ 12.32	– 7.53
+ 5	+ 20.53	– 12.55
+ 7	+ 28.74	– 17.56
+ 9	+ 36.96	– 22.58
+ 11	+ 45.17	– 27.60
+ 13	+ 53.38	– 32.62

Source: HKMA staff estimates.

Table 3: Estimated increase in lending spreads and output loss due to a one percentage point increase in LAC ratios

Estimation by	**Increase in lending spreads (bps)**	**Output loss (bps)**
This study	2.8^ – 4.1	1.7^– 2.5
Firestone et al. (2017) (Federal Reserve Board)	3.4 – 6.9	3.7 – 7.4
Brooke et al. (2015) (Bank of England)	5 – 10	1 – 5
Basel Committee on Banking Supervision (BCBS) (2010)	13	9

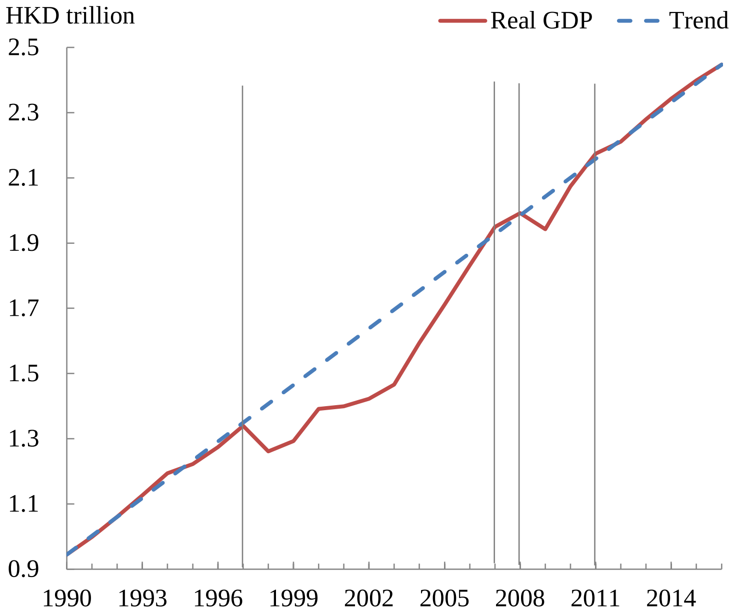
^ These figures correspond to the case when AIs meet the LAC requirements by using 2/3 LAC debt and 1/3 equity. See Section 5 for details.

Sources: HKMA staff estimates, Federal Reserve Board, Bank of England and BIS.

III. MACROECONOMIC BENEFITS OF HIGHER LAC RATIOS

Assessing the benefits of higher LAC ratios involve the estimation of how the probability and severity of a financial crisis change with higher total capital ratios.[14] That said, using Hong Kong's experience alone may not be adequate as historically the frequency of financial crises in Hong Kong has been less than in other economies, and the impact is much milder. To see this, Chart 2 shows the real GDP and its linear trend for Hong Kong from 1990 to the present. It can be seen that the effects of the 1997 Asian financial crisis and the 2008 global financial crisis were only temporary as the real GDP eventually returned to its long-run trend. For a more comprehensive assessment of the severity of crises, our estimation also covers crisis episodes occurring in other countries, including both the Organisation for Economic Co-operation and Development (OECD) and the Executives' Meeting of East Asia-Pacific Central Banks (EMEAP) economies.[15]

Chart 2: Annual GDP of Hong Kong in chained (2015) dollars



Source: Census and Statistics Department and HKMA staff estimates.

3.1) Reduction in probability of a crisis per increase in LAC ratios

We assume the probability of a crisis can be explained by both

14 This is taken as a proxy for the overall LAC ratios, and so assumes that an increase in the LAC ratios has a comparable benefit to the increase in the total capital ratios.

15 EMEAP economies refer to Australia, China, Hong Kong SAR, Indonesia, Japan, South Korea, Malaysia, New Zealand, Philippines, Singapore and Thailand.

bank-specific variables and aggregate variables in a logistic regression. Specifically, we let:

$$Prob(Crisis) = f(CAR, CrGp, LTD, GDP, REER, VIX) \quad (3)$$

where CAR, $CrGp$, LTD, GDP, $REER$ and VIX represent banks' total capital ratios, credit-to-GDP gap, loan-to-deposit ratios, real GDP growth, real exchange rate growth and the CBOE volatility index respectively. f is the logistic function. Appendix 3 describes the estimation result of Eq. (3).

Based on Eq. (3), we can derive a schedule of how the probability of a crisis occurring in Hong Kong varies with different levels of LAC ratios under a typical risk environment.[16]

One caveat on our estimates is that they are based on historical data, thus they may not fully capture the effects of the post-crisis regulatory measures that have been implemented in recent times. For instance, the Financial Institutions (Resolution) Ordinance (FIRO) was passed last year, which gives the HKMA the powers necessary to deal with bank failures in a quick and decisive manner, thereby minimising the consequences and contagious effect. The implementation of FIRO is likely to reduce the likelihood of future crises through various channels. One main channel is through stronger market discipline (i.e. holders of bank debt and equity instruments are more likely to influence bank management to make less risky investments if bailing out is not expected). To adjust for the potential effects of regulatory reform on the estimated probability of a crisis, we follow Firestone *et al.* (2017) to apply a 30% reduction directly to the probability schedule.[17,18]

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16 Average values of other explanatory variables are used when we vary the capital ratios in Eq. (3).

17 Firestone *et al*. (2017) use a 30% reduction based on the estimation by the FSB (2015b). Based on the findings by Brandao-Marques *et al*. (2013) and Afonso *et al*. (2014), the FSB (2015b) estimates that the probability of bank failures would be reduced by approximately one-third if there was no government support.

18 The adjustment in the probability of a crisis in this analysis of the cost of higher LAC requirements has an element of circularity, because higher LAC requirements themselves make a major contribution to enhancing the credibility of a resolution regime. However, this will lead to an understatement, rather than an overstatement, of the net benefits of higher LAC requirements, and is

Table 4 presents the schedule for both unadjusted and adjusted probabilities.

Table 4: Estimation of the probability of a crisis occurring in Hong Kong in a 12-month period adjusted for the effect of regulatory reform

LAC ratios (%)	Probability of crisis (unadjusted) (%)	Probability of crisis (adjusted for effect of regulatory reform) (%)
19	5.20	3.64
20	4.77	3.34
21	4.37	3.06
22	4.00	2.80
24	3.36	2.35
26	2.81	1.97
28	2.36	1.65
30	1.97	1.38
32	1.65	1.15

Source: HKMA staff estimates.

3.2) <u>Cost of crisis in net present value</u>

To gauge the cost of the financial crisis, we follow other studies in using the model in Romer and Romer (2017), which assesses how a financial distress shock will impact on real GDP. Specifically, based on the narrative description reported in the *OECD Economic Outlook*, Romer and Romer (2017) construct an index of financial distress ranging from 0 to 15, with 0 representing no financial distress and 15 representing an extreme crisis–plus.[19] The index is used as an explanatory variable in a panel regression model to quantify the impact of financial distress on real GDP. Chart 3 shows the five-year impulse response for our sample, which includes both EMEAP and

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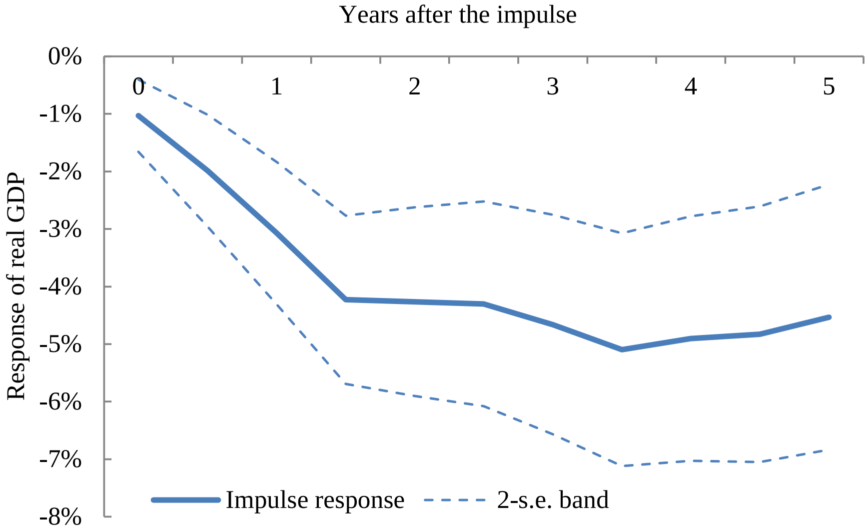
in keeping with the conservative approach adopted in this cost-benefit analysis.

[19] There are five classes of financial distress: Credit disruption, Minor crisis, Moderate crisis, Major crisis and Extreme crisis. Each class can be further divided into three sub-classes: minus, regular and plus. For instance, the index value of the US in the second half of 2008 was 14, indicating it fell into the class of "extreme crisis–regular". An index value of seven (moderate crisis–minus) is chosen by previous studies as it represents the lower end of the range of high distress levels.

OECD economies.[20] Appendix 4 describes the methodology and estimation results in detail.

Chart 3: Impulse response of a crisis and the two-standard error (2-s.e.) band



Note: This chart shows the impulse response of the annualised real GDP (i.e. the deviation of the GDP from the one in the no-crisis scenario) on a moderate crisis–minus as defined in Romer and Romer (2017), representing the lower end of the range of high distress levels.

Source: HKMA staff estimates.

The real GDP loss in Chart 3 can be used to compute the net present value (NPV) of the cost of the crisis by discounting the loss with an appropriate long-run real risk-free interest rate. Similar to previous studies, we use the real 10-year government bond yield as the discount rate, which is 3.0%.[21] The resulting NPV of the output loss in the first five years is –19.7%. After the first five years, estimation of the NPV of the output loss depends largely on whether the effect is permanent or temporary. Three scenarios are considered:

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[20] We follow Romer and Romer (2017) to estimate the impulse response up to five years after the occurrence of a crisis to capture the short to medium term impact. While the impulse response can theoretically be estimated for longer horizons, the standard error of the estimates would generally be larger further out from the horizon, which reduces its explanatory power and statistical reliability.

[21] The discount rate is calculated as the average yield on 10-year Exchange Fund Notes in the period from 29 October 1996 to 27 February 2015 (4.3%) minus the average inflation rate in the same period (1.3%).

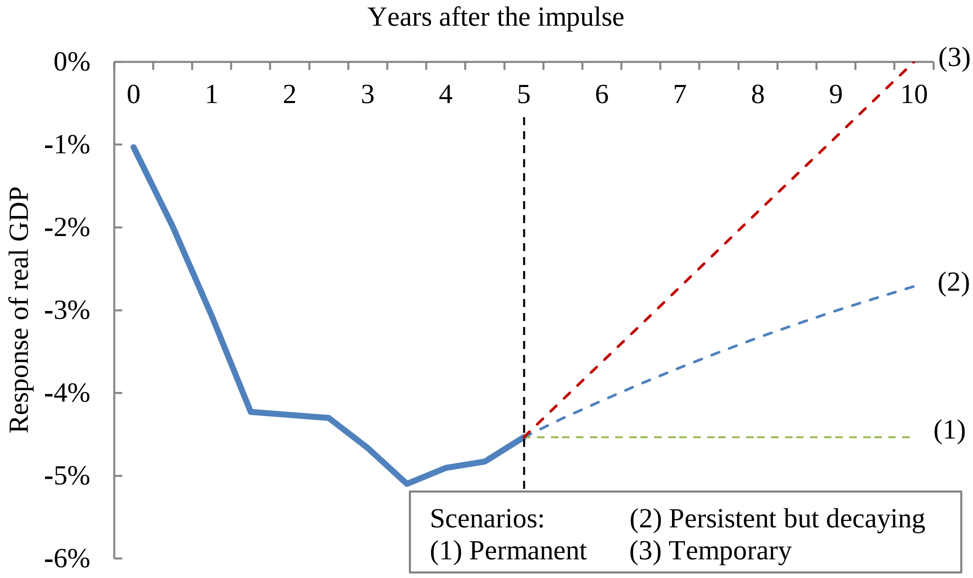
(1) A permanent output loss;

(2) A persistent but decaying output loss with a 5% rate of decay, following Firestone *et al.* (2017);[22] and

(3) A temporary output loss that is fully dissipated 10 years after the onset of a crisis, which is similar to Hong Kong's experience following the Asian financial crisis (see Chart 2).

Chart 4 and Table 5 summarise the output loss under the three scenarios.

Chart 4: Scenarios after the fifth year



Source: HKMA staff estimates.

Table 5: Estimated NPV of output loss

Scenarios for output loss	NPV of output loss
(1) Permanent	–150.6%
(2) Persistent but decaying with a rate of 5%	–68.6%
(3) Temporary	–27.1%

Source: HKMA staff estimates.

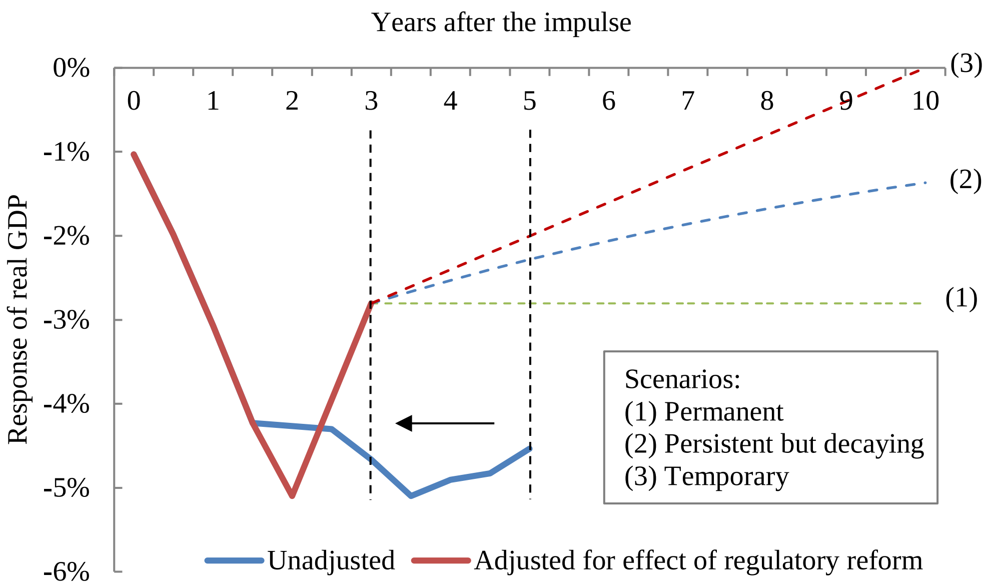
[22] The persistent but decaying effect is estimated by a formula similar to the Gordon growth formula, with the rate of decay being treated as a negative growth rate: $PV = Annual\ output\ loss/(Discount\ rate + Rate\ of\ decay)$.

Similar to the estimation of the probability of a crisis, the model estimates of the impact of the crisis may not fully capture the effects of the new regulatory measures under the resolution regime which provide banks with a greater degree of soundness. In Hong Kong, for instance, the resolution regime enables the continued provision of critical financial functions without significant adverse consequences for the financial system. As these measures can reduce the severity and duration of the effects of a crisis, adjustments are imposed to both the impulse response and the long-run effect. We follow the adjustments made by Firestone *et al*. (2017), which in turn are based on the findings by Homar and van Wijnbgergen (2017), who find that with prompt re-capitalisations, the time to a GDP trough is two years, as opposed to three and a half years, and the duration of the effects is three years, rather than five. Taking into account the increased resolvability brought by the post-crisis measures, we make two adjustments and the result is illustrated in Chart 5. First, in view of the shorter time to a GDP trough, we made an adjustment whereby the impulse response reaches the trough in two years instead of three and a half years. Secondly, taking into account the shorter duration of the effects of the crisis, the duration of effects is assumed to be shortened from five years to three years. The output loss at the end of the third year is set similar to the values reported in Firestone *et al*. (2017). The authors report that the end-value at the third year is roughly equal to 55% of the trough at the end of the second year. Given the trough in our sample is –5.1%, this amounts to an end-value of –2.8%.[23] Table 6 summarises the estimation results under different assumptions after the adjustment.[24] Table 7 compares our results with other studies.

[23] Brooke *et al*. (2015) use a different approach in adjusting the cost under increased resolvability. They split the economics into two subsamples and estimate their impulse responses separately. They find that the impulse response declines significantly to 1-2% at the sixth year and the total cost of crisis would be reduced by more than 60% for the higher resolvability subsample. However, not all the countries in the subsample are reported in their analysis and we cannot replicate their result.

[24] Following the same reasoning as set out in footnote 16, it is noted that the adjustments made to the impulse response of a crisis will lead to an understatement, rather than an overstatement, of the net benefits of higher LAC requirements, and so is in keeping with the conservative approach adopted in this cost-benefit analysis.

Chart 5: Impulse response of a crisis, adjusted for effect of regulatory reform



Source: HKMA staff estimates.

Table 6: Estimated NPV of output loss, adjusted for effect of regulatory reform

Scenarios for output loss	NPV of output loss
(1) Permanent	–96.0%
(2) Persistent but decaying with a rate of 5%	–42.6%
(3) Temporary	–17.6%

Source: HKMA staff estimates.

Table 7: Estimations of the cost of a crisis from different studies

Estimation by	Cost of crisis (% of GDP)	Discount rate
This study	18% – 151%	3.0%
Firestone et al. (2017) (Federal Reserve Board)	41% – 99%	2.7%
Brooke et al. (2015) (Bank of England)	43%	3.5%
BCBS (2010)	19% – 158%	5%

Sources: HKMA staff estimates, Federal Reserve Board, Bank of England and BIS.

The gross benefits of higher LAC ratios can be calculated by multiplying the estimated cost of a crisis to the reduction in the probability of a crisis. Table 8 summarises the estimation of gross benefits adjusted for the effect of the post-crisis regulatory reform.

Table 8: Estimated gross benefit of LAC ratios, adjusted for the effect of regulatory reform

LAC ratios (%)	Cumulative changes in probability of crisis (%)	Cumulative gross benefit (%)		
		(1) Permanent output loss	(2) Persistent but decaying output loss	(3) Temporary output loss
20	– 0.30	0.29	0.13	0.05
21	– 0.58	0.56	0.25	0.10
22	– 0.84	0.80	0.36	0.15
24	– 1.29	1.24	0.55	0.23
26	– 1.67	1.60	0.71	0.29
28	– 1.99	1.91	0.85	0.35
30	– 2.26	2.17	0.96	0.40
32	– 2.48	2.38	1.06	0.44

Source: HKMA staff estimates.

IV. NET MACROECONOMIC BENEFITS OF HIGHER LAC RATIOS

Taking together the estimated costs and benefits, we can calculate the net benefits under different LAC ratios. We take the average total capital ratios of locally incorporated AIs at the end of June 2017, which is 19%, as our initial value and proxy for LAC ratios. Table 9 presents the estimated net benefit schedules before and after the adjustments for a mix of 1/3 debt and 2/3 equity.

Table 9: Estimated net benefits under different LAC ratios, assuming the additional LAC is met with 1/3 LAC debt and 2/3 equity

LAC ratios (%)	Cost (%)	Cumulative gross benefit (%)			Cumulative net benefit (%)		
		(1)	(2)	(3)	(1)	(2)	(3)
(A) Benefit adjusted for effect of regulatory reform							
20	0.03	0.29	0.13	0.05	0.26	0.10	0.03
21	0.05	0.56	0.25	0.10	0.51	0.20	0.05
22	0.08	0.80	0.36	0.15	0.73	0.28	0.07
24	0.13	1.24	0.55	0.23	1.11	0.42	0.10
26	0.18	1.60	0.71	0.29	1.43	0.53	0.12
28	0.23	1.91	0.85	0.35	1.68	0.62	0.12
30	0.28	2.17	0.96	0.40	1.89	0.69	0.12
32	0.33	2.38	1.06	0.44	2.06	0.73	0.11
(B) Benefit unadjusted for effect of regulatory reform							
20	0.03	0.65	0.30	0.12	0.62	0.27	0.09
21	0.05	1.25	0.57	0.22	1.20	0.52	0.17
22	0.08	1.80	0.82	0.32	1.72	0.74	0.25
24	0.13	2.77	1.26	0.50	2.64	1.14	0.37
26	0.18	3.59	1.64	0.64	3.41	1.46	0.47
28	0.23	4.28	1.95	0.77	4.05	1.72	0.54
30	0.28	4.86	2.21	0.87	4.58	1.94	0.60
32	0.33	5.34	2.44	0.96	5.02	2.11	0.63

Note: This table shows the estimated gross and net benefits under the three scenarios of output loss: (1) Permanent; (2) Persistent but decaying; and (3) Temporary. Panel (A) reports the benefits adjusted for the effect of regulatory reform, panel (B) reports the benefits without adjustments.

Source: HKMA staff estimates.

The estimated net benefit for Hong Kong is positive for a wide range of LAC ratios under most of the scenarios. Yet, the estimated value is crucially dependent on whether the impact of a crisis is long-lasting or not, and whether the AIs could fund the additional LAC from a cheaper source. If the impact of a crisis is only temporary and the funding cost for additional LAC is in the form of more expensive instruments, the net benefit would be smaller.

V. ALTERNATIVE ASSUMPTION ON THE DEBT/EQUITY MIX

In practice, we would largely expect AIs in Hong Kong to raise the additional LAC more in the form of LAC debt than equity in meeting the LAC requirements, as LAC debt is usually less costly than equity. To quantify the impact for this scenario, we repeat the same calculation as shown above but assume that AIs will meet the LAC requirements with a mix of 2/3 in LAC debt and 1/3 in equity. From the results in Section 2.1, the increase in cost under such an assumption is

$$1/3 \times 2.4 \text{ basis points} + 2/3 \times 0.7 \text{ basis points} = 1.27 \text{ basis points}$$

The corresponding increases in lending spreads and output loss are 2.85 basis points and 1.74 basis points respectively. The estimated impact on lending spread and output is presented in Table 10. Table 11 presents the corresponding net benefits under this assumption of debt and equity mix.

Table 10: Estimated impact of higher capital ratios on output, assuming the additional LAC is met with 2/3 LAC debt and 1/3 equity

Changes in LAC ratios (percentage point)	Changes in lending spreads (bps)	Changes in output (bps)
+ 1	+ 2.85	– 1.74
+ 2	+ 5.69	– 3.48
+ 3	+ 8.54	– 5.22
+ 5	+ 14.23	– 8.70
+ 7	+ 19.92	– 12.17
+ 9	+ 25.62	– 15.65
+ 11	+ 31.31	– 19.13
+ 13	+ 37.00	– 22.61

Source: HKMA staff estimates.

Table 11: Estimated net benefits under different LAC ratios, assuming the additional LAC is met with 2/3 LAC debt and 1/3 equity

LAC ratios (%)	Cost (%)	Cumulative gross benefit (%)			Cumulative net benefit (%)		
		(1)	(2)	(3)	(1)	(2)	(3)
(A) Benefit adjusted for effect of regulatory reform							
20	0.02	0.29	0.13	0.05	0.27	0.11	0.04
21	0.03	0.56	0.25	0.10	0.52	0.21	0.07
22	0.05	0.80	0.36	0.15	0.75	0.30	0.10
24	0.09	1.24	0.55	0.23	1.15	0.46	0.14
26	0.12	1.60	0.71	0.29	1.48	0.59	0.17
28	0.16	1.91	0.85	0.35	1.75	0.69	0.19
30	0.19	2.17	0.96	0.40	1.98	0.77	0.21
32	0.23	2.38	1.06	0.44	2.16	0.83	0.21
(B) Benefit unadjusted for effect of regulatory reform							
20	0.02	0.65	0.30	0.12	0.63	0.28	0.10
21	0.03	1.25	0.57	0.22	1.21	0.53	0.19
22	0.05	1.80	0.82	0.32	1.75	0.77	0.27
24	0.09	2.77	1.26	0.50	2.68	1.18	0.41
26	0.12	3.59	1.64	0.64	3.47	1.51	0.52
28	0.16	4.28	1.95	0.77	4.12	1.79	0.61
30	0.19	4.86	2.21	0.87	4.67	2.02	0.68
32	0.23	5.34	2.44	0.96	5.12	2.21	0.73

Note: This table shows the estimated gross and net benefits under the three scenarios of output loss: (1) Permanent; (2) Persistent but decaying; and (3) Temporary. Panel (A) reports the benefits adjusted for the effect of regulatory reform, panel (B) reports the benefits without adjustments.

Source: HKMA staff estimates.

When compared with the results in Table 9, the assumption of using more debt to fulfil the LAC requirements clearly resulted in higher net benefits since the cost is lower.

VI. CONCLUSION

This study provides a cost-benefit assessment of higher LAC requirements for locally incorporated AIs. The costs of higher LAC ratios are driven by a possible increase in lending spreads, which may dampen investment and output. The benefits of higher LAC ratios are brought by lower probability and severity of financial crises. Across all three scenarios considered in this study, our assessment suggests that the beneficial effects of a lower likelihood and severity of future crises outweigh the costs of output loss due to higher lending spreads. However, in the least severe scenario of output loss, increasing the LAC ratios any higher than 28-30% of RWAs leads to a smaller net benefit.

However, it should be noted that this cost-benefit assessment has not exhaustively incorporated all possible channels through which higher LAC ratios would affect the economy due to difficulties in their empirical quantification.[25] Therefore, this assessment can at best only provide a broad assessment of the likely net impact of higher LAC ratios. Nevertheless, the fact that this assessment indicates a positive net economic benefit for higher LAC ratios across all three scenarios provides supportive evidence for introducing LAC requirements for AIs in Hong Kong.

[25] Brooke *et al*. (2015) lists a number of potential channels in which higher capital arising from the LAC requirements could affect the economic output.

APPENDIX 1

GAUGING THE DEGREE OF MODIGLIANI-MILLER OFFSET EFFECT FOR LOCALLY INCORPORATED AIS IN HONG KONG

This appendix provides details on how the degree of Modigliani-Miller (MM) effect in Hong Kong is estimated. The Modigliani-Miller theorem states that, any increase in the cost of funds arise from financing more by equity would be offset by a decrease in the cost due to lower risks (Modigliani and Miller, 1958). However, the degree of this offset effect varies among economies, amid the difference in institutional factors and market frictions. Table A1.1 summarises the empirical estimation results of the MM effect from related studies.

Table A1.1: Estimation of the degree of MM offset in various related studies

Estimation by	Geography of Sample	MM Offset
Junge and Kugler (2013)	Switzerland	36%
Toader (2015)	Europe	42%
Miles, Yang and Marcheggiano (2013)	UK	45%
European Central Bank (2011)	International	41% – 73%
Clark, Jones and Malmquist (2015)	US	65% – 100%

Empirically, a panel regression model is used to estimate the relationship between the market beta, a proxy of the bank's risk, and the bank's ex-ante equity-to-asset ratios:

$$Beta_{j,t} = \beta_0 + \beta_1 (Common\ Equity/Assets)_{j,t-1} + e_{j,t} \qquad \text{(A1.1)}$$

However, given that not all locally incorporated licensed banks in Hong Kong are listed banks, we ought to use market data of their parent banks listed in the Hong Kong Stock Exchange in our estimation. We also need to assume that the market data of the parent banks provide useful proxies for their subsidiary banks in Hong Kong. Our estimation sample contains 15 listed banks spanning from the first half of 1994 to the second half of 2017 for estimating Eq. (A1.1).[26,27] The market data are obtained from Bloomberg. Detail of the variables and the data sources are available in Appendix 5. Table A1.2 summarises the estimation result of Eq. (A1.1).

Table A1.2: Estimation result of equation (A1.1)

	Dependent variable: $Beta_{i,t}$
($Common\ Equity$ / $Assets$)$_{i,t-1}$ (%)	–0.029***
Constant	1.407***
Bank fixed effect	Yes
Time fixed effect	Yes
Number of banks	15
Number of observations	399
Adjusted R^2	0.2016

Notes: *** indicates significance at the 1% level.

The degree of MM offset can then be inferred by how the beta would react to an increase in the capital ratios. First, we calculate the average equity-to-asset ratio and the average beta in our sample. The average equity-to-asset ratio is 9.422% and the average beta is 1.074. We then consider a case of a 100% increase in the equity-to-asset ratios. Theoretically, under a full MM effect, the beta would drop by half, i.e. 0.537. Based on the estimation result of Eq. (A1.1), we can calculate the empirical expected fall in beta. The beta would drop by 9.422% × 0.029 = 0.274. This implies that the MM effect for banks in Hong Kong is 0.274/0.537 ≈ 50%. Table A1.3 summarises the result.

[26] The 15 listed banks are: Bank of China (ultimate parent of Nanyang Commercial Bank until 30 May 2016), Bank of China (Hong Kong), Bank of East Asia, Bank of Communications, China Citic Bank, China Construction Bank, Chong Hing Bank, Dah Sing Bank, Hang Seng Bank, Hongkong and Shanghai Banking Corporation, Industrial and Commercial Bank of China, Public Bank, Standard Chartered Bank, Wing Hang Bank (delisted after 16 October 2014), and Wing Lung Bank (delisted after 16 January 2009).

[27] Data for the second half of 2017 is the latest data available at the end of September 2017.

Table A1.3: Gauging the degree of the MM effect

Estimated β_1 in Eq. (A1.1)	–0.029
Average common equity / assets (%) Average beta	9.422 1.074
Δ in average beta given a 100% increase in capital, based on regression result Δ in average beta given a 100% increase in capital, under full MM effect	–0.274 –0.537
MM effect	50%

APPENDIX 2

ERROR-CORRECTION MODEL FOR THE ESTIMATION OF REDUCTION IN OUTPUT PER INCREASE IN LENDING SPREADS

We update the error-correction model in Wong et al. (2010) that links up the lending spreads and output.[28] The model is specified as:

$$\Delta Output_t = \beta_0 + \beta_1 R_{t-1} + \Theta' \Upsilon + e_t \qquad \text{(A2.1)}$$

where

$$R_t = Output_t - \gamma LSpread_t \qquad \text{(A2.2)}$$

describes the long-run relationship between *Output* and *LSpread*, and

Output: logarithm of Hong Kong's real GDP;

LSpread: lending spreads, proxied by the net interest margin of retail banks;

Υ: vector of the lagged terms in first-difference form; and

e_t: error term with mean 0 and a constant variance.

Detailed definition of the variables and the data sources are available in Appendix 5. While an increase in lending spreads is postulated to depress economic activities, we would expect a negative relation between *Output* and *LSpread* in our model. We use quarterly data from the first quarter of 1998 to the first quarter of 2017 in the estimation. Table A2 summarises the estimation results of other coefficients in Eq. (A2.1) and (A2.2).

[28] We drop the variable *HIBOR* in Wong et al. (2010), which is the 3-month HIBOR, because the correlation between the output and the interest rate level has become much smaller in the post-crisis low interest rate environment.

Table A2: Estimation results of equations (A2.1) and (A2.2)

Eq. (A2.1): Short-run dynamics	Dependent variable: $\Delta Output_t$
R_{t-1}	–0.0161**
$\Delta Output_{t-1}$	1.0004***
$\Delta Output_{t-2}$	–0.2619**
$\Delta LSpread_{t-2}$	0.0233**
Constant	–0.2513**
Eq. (A2.2): Long-run relationship	Dependent variable: $Output_t$
$LSpread_t$	–0.6110***
Number of observations	74
Adjusted R^2	0.7644

Note: *** and ** indicate significance at the 1% and 5% levels respectively.

APPENDIX 3

LOGISTIC MODEL FOR THE ESTIMATION OF THE PROBABILITY OF A CRISIS

The probability of a crisis can be estimated by a logistic model[29] based on a dataset of OECD and EMEAP economies (including Hong Kong):

$$\log\left(\frac{p_{j,t}}{1-p_{j,t}}\right) = c + \alpha_1 CAR_{j,t-1} + \alpha_2\, CrGp_{j,t-1} + \alpha_3 LTD_{j,t-1} + \alpha_4 VIX_{t-1} + \alpha_5 GDP_{j,t-1} + \alpha_6\, REER_{j,t-1} \quad \text{(A3.1)}$$

where

$p_{j,t}$: Probability of economy *j* having a financial crisis in year *t*
CAR: Total capital ratios;
$CrGp$: Credit-to-GDP gap;
LTD: Loan-to-deposit ratios;
VIX: CBOE volatility index;
GDP: Real GDP growth rate; and
$REER$: Real exchange rate growth rate.

Detailed definition of the variables and the data sources can be found in Appendix 5. The estimation sample, which is in annual frequency, covers the period of 1998 to 2016. The estimation results are shown in Table A3.

29 Following Demirgüç-Kunt and Detragiache (1998), no fixed effects are specified as in panel logistic model to avoid selection bias and incidental parameters problem. See Navajas and Thegeya (2013) for more discussions on this.

Table A3: Estimation result of equation (A3.1)

	Dependent variable: $\log(p_{j,t}/1 - p_{j,t})$
CAR_{t-1}	–0.091*
$CrGp_{t-1}$	0.035***
LTD_{t-1}	0.003
VIX_{t-1}	0.065**
GDP_{t-1}	–0.163*
$REER_{t-1}$	0.049*
Constant	–2.432
Number of observations	354
Pseudo R^2	0.15
Log likelihood	–114.99

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Based on the estimated coefficients in Table A3.1, we can derive a schedule of the probability of a crisis occurring in Hong Kong. We assume a typical risk environment where other explanatory variables except the total capital ratios are at their sample average figures. The probability of a crisis is then fitted with respect to different levels of capital ratios.

ROMER AND ROMER'S MODEL FOR THE ESTIMATION OF THE COST OF A CRISIS

To quantify the impact of financial distress on real GDP, the index of financial distress descripted in Romer and Romer (2017) is used as an explanatory variable in the following panel regression model:

$$y_{j,t+i} = \beta^i F_{j,t} + \varphi^{i\prime} \mathrm{Y}_{j,t} + \text{fixed effects} + e^i_{j,t} \qquad \text{(A4.1)}$$

for i = 0 to 10,

where

$y_{j,t+i}$: logarithm of the annualised real GDP of economy j at time $t + i$;

$F_{j,t}$: index of financial distress for economy j at time t, compiled based on the discussion at time t in the *OECD Economic Outlook*; and

$\mathrm{Y}_{j,t}$: vector of the lagged terms; and

$e^i_{j,t}$: error term with mean 0 and a constant variance.

As the original sample in Romer and Romer (2017) only include OECD economies, we augment the sample by include EMEAP economies to make the analysis more suitable for the region.[30] We first obtain the indices of financial distress for EMEAP economies. We estimate the inverse of Eq. (A4.1) by regressing $F_{j,t}$ on real GDP based on the original sample. The indices for EMEAP economies are then fitted by using the estimated coefficients from the inverse regression and the respective GDP data. Minor adjustments are made to the fitted indices with reference to the severity index in Reinhart and Rogoff (2014). We then pool the resulting indices for EMEAP economies with the original sample in Romer and Romer (2017) and repeat the estimation of the model. The data cover the time period from the first half of 1967 to the second half of 2017.[31]

[30] The GDP data of the OECD economies are from the OECD Quarterly National Accounts Dataset, series VPVOBARSA. The GDP data of the non-OECD EMEAP economies are comparable seasonally adjusted annualised real GDP data from national sources.

[31] GDP data for the first and second half of 2017 are the projected numbers using the forecast growth

Since heteroscedasticity presents across different economies, we estimate Eq. (A4.1) by a generalised least square method. Table A4 reports the estimation results. Based on the estimated value of β, the impulse response function in Chart 3 is estimated based on the local projection method descripted in Jordà (2005).

Table A4: Estimation results of equation (A4.1)

	Dependent variable: $y_{j,t+i}$					
	$i = 0$	$i = 1$	$i = 2$	$i = 3$	$i = 4$	$i = 5$
$F_{j,t}$	–0.0015***	–0.0028***	–0.0044***	–0.0060***	–0.0061***	–0.0061***
$F_{j,t–1}$	0.0003	–0.0002	–0.0007	0.0004	0.0003	–0.0001
$F_{j,t–2}$	–0.0004	–0.0009	0.0001	–0.0000	–0.0004	–0.0008
$F_{j,t–3}$	–0.0003	0.0009	0.0008	0.0003	–0.0001	0.0007
$F_{j,t–4}$	0.0007	0.0004	0.0002	0.0005	0.0011	0.0011
$y_{j,t–1}$	1.1400***	1.1624***	1.1822***	1.1583***	1.1377***	1.1684***
$y_{j,t–2}$	–0.1215***	–0.1021**	–0.1487**	–0.1511**	–0.0919	–0.1645**
$y_{j,t–3}$	0.0121	–0.0609	–0.0390	0.0194	–0.0571	–0.0456
$y_{j,t–4}$	–0.0417**	–0.0241	–0.0321	–0.0783*	–0.0538	–0.0387
Fixed effects						
time	Yes	Yes	Yes	Yes	Yes	Yes
economy	Yes	Yes	Yes	Yes	Yes	Yes
Number of						
economies	32	32	32	32	32	32
observations	2572	2572	2572	2572	2572	2572
Wald χ^2 (*df*: 127)	2.14×10^7	8930999	5440086	3981165	3119235	2640340

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

rates in IMF World Economic Outlook Database.

Table A4.1 (cont'): Estimaion results of equation (A4.1)

	Dependent variable: $y_{j,t+i}$				
	i = 6	i = 7	i = 8	i = 9	i = 10
$F_{j,t}$	–0.0067***	–0.0073***	–0.0070***	–0.0069***	–0.0065***
$F_{j,t-1}$	–0.0003	0.0005	0.0003	0.0006	0.0010
$F_{j,t-2}$	0.0000	–0.0002	0.0002	0.0006	–0.0002
$F_{j,t-3}$	0.0005	0.0010	0.0013	0.0005	0.0008
$F_{j,t-4}$	0.0013	0.0009	0.0002	0.0003	0.0000
$y_{j,t-1}$	1.1350***	1.1042***	1.0390***	1.0326***	0.9976***
$y_{j,t-2}$	–0.1573*	–0.1849*	–0.1238	–0.1532	–0.1351
$y_{j,t-3}$	–0.0821	–0.0314	–0.0604	–0.0444	–0.0761
$y_{j,t-4}$	0.0080	–0.0003	0.0172	0.0233	0.0571
Fixed effects					
time	Yes	Yes	Yes	Yes	Yes
economy	Yes	Yes	Yes	Yes	Yes
Number of					
economies	32	32	32	32	32
observations	2572	2572	2572	2572	2572
Wald χ^2 (*df*: 127)	2249287	1980170	1762256	1599339	1459404

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

APPENDIX 5

DATA DEFINITIONS AND SOURCES

Variable	Definition	Source
Equations (1) and (2)		
RWA	Aggregate risk-weighted assets of locally incorporated AIs	HKMA
$Assets$	Aggregate total assets of locally incorporated AIs	HKMA
C^E	Cost of equity	Estimate based on HKMA's quantitative impact study on LAC requirements
C^D	Return on liabilities of locally incorporated AIs	Authors' estimate based on HKMA's regulatory data set
tax	Hong Kong's tax rate applicable to corporations	Hong Kong Government
$C^D(H)$	Cost of Tier 2 capital instruments	Estimate based on HKMA's quantitative impact study on LAC requirements
Equations (A1.1)		
$Beta$	Market beta	Bloomberg
$Common\ Equity$	Common equity	Bloomberg
$Assets$	Total assets	Bloomberg
Equations (A2.1) and (A2.2)		
$Output$	Logarithm of Hong Kong's real GDP	Census and Statistics Department, annualised by the sum of the trailing 4 quarters.
$LSpread$	Net interest margin of retail banks	HKMA

Variable	Definition	Source
Equation (A3.1)		
p	A binary variable which is defined as 1 if banking distress occurs, and 0 otherwise	The chronology of banking distress is extracted and updated from various sources: Romer and Romer (2017), Laeven and Valencia (2013) and Wong et al. (2010).
CAR	Total capital / total risk-weighted assets	Aggregated country-level data based on bank-level data from Capital IQ, and national sources
$CrGp$	Deviation of Credit to GDP ratios from its long run trend	Bank for International Settlements
LTD	Loan-to-deposit ratios	Aggregated country-level data based on bank-level data from Capital IQ, and national sources
VIX	CBOE volatility index	Bloomberg
ΔGDP	Year on year percentage change in real GDP	World Bank
$\Delta REER$	Year on year percentage change in real effective exchange rate	Bank for International Settlements
Equation (A4.1)		
y	Logarithm of annualised real GDP	OECD Quarterly National Accounts Dataset: VPVOBARSA, and national sources
F	Index of financial distress ranging from 0 to 15	Romer and Romer (2017) and authors' estimation

REFERENCES

Afonso, G., J. A. C. Santos and J. Traina (2015), "Do 'too-big-to-fail' banks take on more risk?", *Journal of Financial Perspectives*, 3(2), 129–143.

Basel Committee on Banking Supervision (2010), "An assessment of the long-term economic impact of stronger capital and liquidity requirements".

Brandao-Marques, L., R. Correa and H. Sapriza (2013), "International evidence on government support and risk taking in the banking sector", Working Paper 13/94, International Monetary Fund.

Brooke, M., O. Bush, R. Edwards, J. Ellis, B. Francis, R. Harimohan, K. Neiss and C. Siegert (2015), "Measuring the macroeconomic costs and benefits of higher UK bank capital requirements", Financial Stability Paper No. 35, Bank of England.

Clark, B., J. Jones and D. Malmquist (2015), "Leverage and the cost of capital: Testing the relevance of the Modigliani-Miller theorem for US banks", Working Paper, Office of the Comptroller of the Currency.

Demirgüç-Kunt, A., and E. Detragiache (1998), "The determinants of banking crises in developing and developed countries", Staff Papers, 45(1), 81-109, International Monetary Fund.

European Central Bank (2011), "Common equity capital, banks' riskiness and required return on equity", *Financial Stability Review*, December, 125–131.

Financial Stability Board (2015a), "Principles on loss-absorbing and recapitalisation capacity of G-SIBs in resolution – Total loss-absorbing capacity (TLAC) term sheet".

Financial Stability Board (2015b), "Assessing the economic costs and benefits of TLAC implementation".

Firestone, S., A. Lorenc and B. Ranish (2017), “An empirical economic assessment of the costs and benefits of bank capital in the US”, Finance and Economics Discussion Series 2017-034, Board of Governors of the Federal Reserve System.

Homar, T., and S. J. G. van Wijnbergen (2017), "Bank recapitalization and economic recovery after financial crises", *Journal of Financial Intermediation*, 32, 16–28.

Hong Kong Monetary Authority (2017), “Developing rules on loss-absorbing capacity requirements for authorized institutions in Hong Kong”, *Quarterly Bulletin*, September.

Jordà, Ò. (2005), “Estimation and inference of impulse responses by local projections”, *American Economic Review*, 95(1), 161–182.

Junge, G. and P. Kugler (2012), ‘Quantifying the effects of higher capital requirements on the Swiss economy”, Working Paper, University of Basel.

Laeven, L. and F. Valencia (2013), “Systemic banking crises database”, *IMF Economic Review*, 61(2), 225–270.

Miles, D., J. Yang and G. Marcheggiano (2013), “Optimal bank capital”, *Economic Journal*, 123, 1–37.

Modigliani, F. and M. H. Miller (1958), “The cost of capital, corporation finance and the theory of investment”, *American Economic Review*, 48(3), 261–297.

Navajas, M. C. and A. Thegeya (2013), "Financial soundness indicators and banking crises", Working Paper 13/263, International Monetary Fund.

Reinhart, C. M. and K. S. Rogoff (2014), “Recovery from financial crises: Evidence from 100 episodes”, *American Economic Review*, 104(5), 50-55.

Romer, C. D. and D. H. Romer (2017), “New evidence on the aftermath of financial crisis in advanced countries”, *American Economic Review*, 107(10), 3072–3118.

Toader, O. (2014), “Estimating the cost of new capital requirements on the cost of bank capital: An empirical study on European banks”, *International Economic Policy*, 12(3), 411–436.

Wong, E., T. Fong, K. F. Li and H. Choi (2010), “An assessment of the long-term economic impact of the new regulatory reform on Hong Kong”, Research Note 05/2010, Hong Kong Monetary Authority.

Wong, J., T. C. Wong and P. Leung (2010), “Predicting banking distress in the EMEAP economies”, *Journal of Financial Stability*, 6(3), 169–179.