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STRESS TESTING THE BANKING SECTOR—TECHNICAL NOTE

This Technical Note on Stress Testing the Banking Supervision was prepared in the context of the Financial Sector Assessment Program for the People's Republic of China—Hong Kong Special Administrative Region.

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STRESS TESTING THE BANKING SECTOR

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program (FSAP) in People's Republic of China—Hong Kong Special Administrative Region (HKSAR). It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations.

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AfS	Available-for-sale
BCBS	Basel Committee on Banking Supervision
BU	Bottom-up
CAR	Capital Adequacy Ratio
CCA	Contingent Claims Analysis
CDS	Credit default swap
CET1	Common Equity Tier 1
ELST	Enhanced Liquidity Stress Test
ES	Expected Shortfall
EVT	Extreme Value Theory
FX	Foreign Exchange
FSAP	Financial Sector Assessment Program
GEV	Generalized Extreme Value
HKMA	Hong Kong Monetary Authority
HKSAR	Hong Kong Special Administrative Region
HQLA	High-quality Liquid Assets
HtM	Hold-to-maturity
ICF	Implied cash flow
LCR	Liquidity Coverage Ratio
LGD	Loss-given-default
LOLR	Lender of Last Resort
LTV	Loan-to-value
MtM	Mark-to-market
NBMCE	Nonbank Mainland China Exposure
NPL	Nonperforming loan
NSFR	Net Stable Funding Ratio
PD	Probability of Default
P&L	Profit and loss statement
QIS	Quantitative Impact Study
RWA	Risk-weighted Asset
SA	Severe Adverse
SCCA	Systemic Contingent Claims Approach
SG	Slow Growth
TD	Top-down
WEO	World Economic Outlook

EXECUTIVE SUMMARY

The HKSAR FSAP Update stress testing exercise comprised a comprehensive analysis of solvency and liquidity risks of the banking sector, using mid-2013 data. Solvency tests consist of a bottom-up (BU) stress test of selected locally incorporated, licensed banks ("local banks") and cross-validation by three top-down (TD) tests covering nearly all local banks. Liquidity stress tests consisted of various sensitivity analyses based on different TD approaches within the existing liquidity reporting framework, using supervisory data and parameters specified by the Hong Kong Monetary Authority (HKMA) and the FSAP team.

The solvency stress tests of the banking sector are based on two adverse macroeconomic scenarios and their deviations from the IMF's World Economic Outlook (April 2013) baseline over a five-year forecast horizon. They comprise a short-lived recession scenario and a prolonged slow growth scenario, with hurdle rates being applied according to the Basel III implementation schedule. These scenarios reflect the possible downside risks faced by the banks in the medium term, including near-term pressures on earning capacity due to declining investment returns, rising asset impairments, and a further narrowing of interest margins due to greater competition for lower-margin, less collateralized consumer finance as mortgage lending slows.

Bank liquidity tests focus on sudden, sizable withdrawals of funding and the sufficiency of existing assets to withstand those shocks under stressed conditions. These tests comprise assumptions on the in- and outflows of existing and contingent assets and liabilities ("funding liquidity risk") and the application of haircuts to assets on the balance sheet ("market liquidity risk"). The HKMA regulatory standards for liquidity, various liquidity tests developed by the FSAP team, and the revised Basel III liquidity risk framework (*Liquidity Coverage Ratio* (LCR) and *Net Stable Funding Ratio* (NSFR) tests) were applied to determine the short- and medium-term resilience of individual banks and the overall system. The above tests are supplemented by a stress test conducted by the HKMA staff incorporating the impact of market and credit risk arising from a prolonged period of negative asset price shocks on cash flow projections.

The stress test results confirm a high degree of resilience of the sector. This reflects the strength of the banks at the starting position, which reduces their fundamental vulnerability to shocks. Banks in HKSAR hold very high levels of capital, are very profitable, and have a low level of asset impairments amid stable funding profiles. Thanks to the macroprudential measures adopted by the HKMA, high collateralization of mortgages and declining loan-to-value (LTV) ratios absorb the impact from even severe near-term shocks to property prices. Analyses based on prudential data suggest that even a severe economic shock would not result in an aggregate capital shortfall over a five-year forecast horizon. While all larger banks exhibit high levels of capitalization and are able withstand a severe deterioration of economic conditions, some smaller banks might be slightly more vulnerable to economic shocks, greater competitive pressures and rising interest rate risks affecting their solvency conditions and funding costs. These smaller institutions may experience a significant

decline in net operating profitability, which might result in capital constraints over the medium-term under a severe economic shock.

The HKMA is encouraged to continue its integration of risk-based supervision in the development of stress test scenarios for macroprudential policy and surveillance. Banking supervisors routinely conduct stress tests and, from time to time, modify relevant assumptions in order to support thematic reviews of identified vulnerabilities against emerging risks. While the HKMA has already aligned some of the assumptions used in both TD and BU stress tests, further integration of the two exercises (e.g., cross-validation of results), which is a direction that the HKMA is moving towards, could pay dividends for its supervisory work of the relevant banks as well as its financial stability analysis. Also extending the stress test horizon would place greater emphasis on potential mitigating effects from profitability and behavioral assumptions of banks, which would allow for a more comprehensive, and potentially more realistic, assessment of the impact of different risk drivers over time.

INTRODUCTION[1]

A. Background and Objective

1. The stress testing exercise of the FSAP for HKSAR comprises a comprehensive vulnerability analysis of the banking sector.[2] The stress test exercise—as part of the FSAP mission's analysis of financial stability—determined the capacity of the banking sector to absorb realization of key macro-financial risks based on the assessment of capital adequacy and sufficiency of liquidity under stress. It was aimed at examining the system-wide resilience to shocks over the medium-term, uncovering vulnerabilities to any rapid deterioration in the macroeconomic environment and, more generally, identifying potential threats to financial stability.

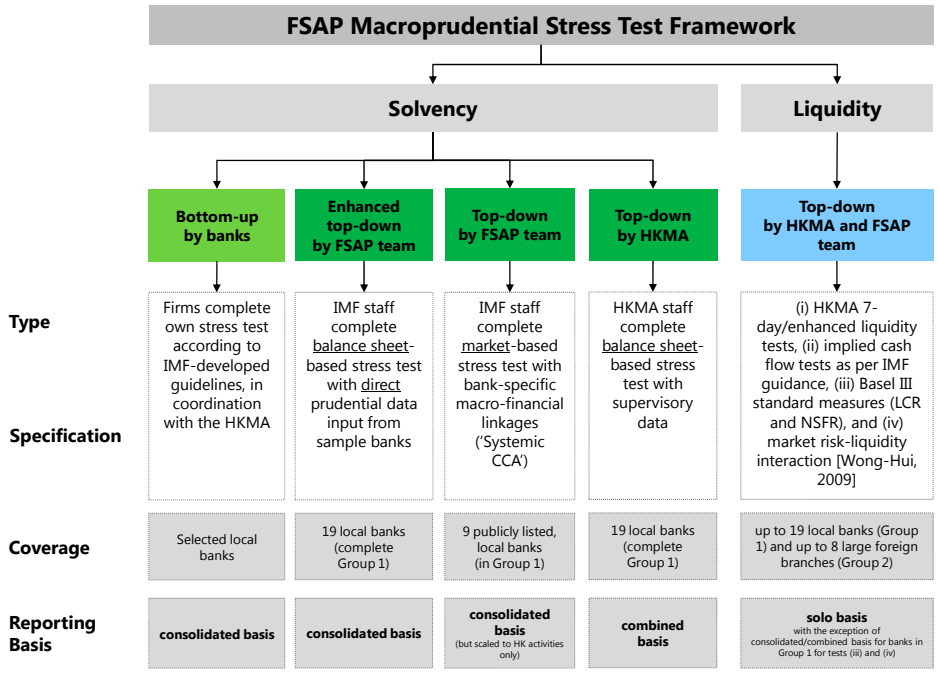
2. This note presents the methodology and results of a detailed examination of solvency and liquidity risks. It follows a multi-pronged approach, reflecting a critical assessment of a large variety of possible vulnerabilities that can affect the viability of individual institutions and system-wide risks in the sector. In this context, different stress tests are combined into a comprehensive analysis of the sector's vulnerability to a considerable economic contraction, including a substantial rise in unemployment, a sharp depreciation of real estate prices, and rising funding pressures. The objective of these tests is to determine the capacity of the banking sector—using mid-2013 financial data—to absorb any realization of key macro-financial risks. Solvency tests consist of a BU stress test by the selected local banks and a cross-validation through several TD tests, undertaken jointly by staff of the HKMA and the FSAP team.

3. Solvency tests are complemented by TD liquidity stress tests using supervisory data and parameters specified by both the HKMA and the FSAP team in the context of different approaches (**Figure 1).** These liquidity stress tests cover both the local banks and the largest foreign branches in the sector. The analysis relies on the prudential assumption that sufficiently high individual capital levels and liquidity buffers lower systemic risk. Given that institutional viability might be insufficient to maintain financial stability during times of extreme stress, one of the stress tests also considered the impact of joint tail risks on system-wide solvency conditions. Overall, the various stress tests conducted for FSAP cover around 50 to around 70 percent of the banking sector's total assets—depending on the type of analysis—accounting for up to 78 percent of total deposits and 66 of total loans). The two TD solvency stress tests cover more than 99 percent of all locally incorporated licensed banks ("local banks") (Table 9).

[1] Prepared by Andreas (Andy) Jobst (MCM, formerly Bermuda Monetary Authority), with assistance from Chikako Baba (MCM). The FSAP team would like to express its deep gratitude to counterparts at HKMA for close collaboration in facilitating this comprehensive stress testing exercise; and to management and the stress testing teams at the banks that participated in the bottom-up solvency stress testing exercises.

[2] It should be emphasized that the stress tests are necessarily based on economic and market conditions as of end-2013: Q2, the cut-off date of the exercise, and do not take into account the most recent developments.

Figure 1. Hong Kong SAR: Macroprudential Stress Tests of Banking Sector



Notes: The "combined basis" of a bank means the position of the bank's Hong Kong office (solo basis) plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries; local bank=locally incorporated, licensed bank. The reference to "enhanced top-down" stress test emphasizes the fact that banks submitted their own (confidential) data (following review by the HKMA); this is typically not the case in top-down exercises, which are normally completed based on supervisory data.

4. Key risks over both the short- and medium-term are incorporated into the design of the stress tests. The assessment is completed by considering three key channels of stress affecting bank balance sheets from a creditor perspective: (i) impairment charges (credit losses, other losses from held-to-maturity assets) and mark-to-market (MtM) valuation changes of fixed income securities (financial and government bonds) in both the trading and banking book[3]; (ii) changes in pre-impairment income, including changes in funding costs; and (iii) changes in risk-weighted assets (RWAs). The impact of general conditions affecting risk factors, such as rising risk aversion in capital markets (via market-implied risk measures) and upcoming regulatory reforms (Basel III) are examined. The stress test also incorporates specific risk factors, including cross-border developments (such as sovereign risk) and foreign currency risk in order to determine the capacity of banks to absorb the manifestation of macro-financial stress, without identifying individual institutions.[4] The findings are to be used flexibly, given the forward-looking perspective and the objective of

[3] For the BU stress test, valuation changes of credit and interest rate derivatives are also taken into account.

[4] Most stress tests are built on a modular design, based on risk management techniques similar to the ones applied by commercial banks for their internal stress tests. This stress test, however, is focused more on capital adequacy of the banking sector under different macroeconomic scenarios (rather than portfolio stresses of individual firms and/or reverse stress tests) using the historical macro-financial linkages affecting parameter sensitivities.

identifying emerging vulnerabilities under extreme but plausible stress scenarios. The completion and reporting of findings have been closely coordinated with the HKMA.

5. The purpose of the stress test exercise differs from that of supervisory stress testing. The multi-period FSAP stress test exercise is designed and completed for surveillance purposes, with a medium-term focus. The exercise typically involves very severe stress scenarios to assess the overall resilience of the banking sector. The results of the stress testing exercise have no immediate supervisory implications but provide input into a broader analysis undertaken by the FSAP, forming the basis for policy discussions with the authorities. This is different from the routine capital reviews undertaken by the authorities, which are aimed at identifying potential capital needs as part of the capital adequacy assessment under Pillar II, and for which management actions may be required. No management action would be expected as a result of the FSAP stress tests.

6. The banking sector is large and concentrated with several banking groups (Figure 2). The sector comprises 201 institutions—156 licensed banks, 21 restricted license banks, and 24 deposit-taking companies—with assets equivalent to 705 percent of GDP. The assets are concentrated in four banks, which account for almost half of the consolidated assets of the banking sector. The sector has been growing rapidly over the recent years, driven by mortgage-related lending and increasing exposure to non-financial corporates in Mainland China. Lending to the corporate sector represents around half of the banking system's total lending, while property-lending accounts for about a third (Figure 6). Banks are primarily funded by customer deposits, which account for 71 percent of local banks' total liabilities at end-2012 (Figure 3). In recent years, the aggregate loan-to-deposit ratio has increased as some banks issued certificates of deposits in the wholesale market to diversify their funding sources. In contrast, foreign branches in general rely more on interbank deposits and borrowing from their parent banks, with customer deposits representing a much smaller part of their total liabilities (31 percent).

7. Liquidity risks for banks are generally low (Figure 10). While banks are not reliant on wholesale funding, it is desirable for banks to develop alternative term funding sources at longer maturity tenors to augment the large deposit base, which creates considerable maturity mismatches beyond one year. Asset encumbrance is relatively low, with total unencumbered liquid assets remaining stable relative to the amount of short-term liabilities.

B. Synopsis

8. Comprehensive and stringent stress tests of the banking sector have been conducted in close cooperation with HKMA staff. Both solvency and liquidity stress tests are based on the mid-2013 financial data of the key institutions as well as the macroeconomic projections and financial market information available at that time. Up to 19 local banks and eight foreign branches were included in the stress tests.[5] The FSAP's close collaboration with the HKMA and banks meant that

[5] The coverage of the banking sector varied across the different stress tests (Table 9).

granular supervisory information as well as banks' own internal data were used in the tests, in addition to publicly available information.

9. The objective of the stress testing exercise was to assess the resilience of the banking sector to solvency and funding shocks under different macroeconomic scenarios. The stress test considers the sector's vulnerability to a renewed economic contraction, including a substantial rise in unemployment, a sharp depreciation of real estate prices, and declining profitability from lending due to competitive pressures on lending rates and rising funding costs. Also the impact of general conditions affecting risk factors, such as rising sovereign risk and upcoming regulatory reforms are examined.

10. The solvency tests are based on three scenarios, determined in collaboration with the HKMA. The scenarios comprise a baseline scenario and two adverse scenarios, specified contingent on the projected economic growth paths of HKSAR, Mainland China, and the United States. These have been identified as the core economies influencing the macro-financial linkages affecting the performance of the banking sector. Hurdle rates are applied according to the Basel III implementation schedule.

11. Cross-border effects are considered in all macroeconomic scenarios. Assumptions about the type of shocks (temporary or permanent) affecting the domestic economy—and the degree to which they also affect economies that banks hold exposures outside HKSAR (i.e., mainly Mainland China, Japan, the United Kingdom, and the United States)—have been aligned by allowing for time-varying patterns of selected macro-financial variables consistent with the forecasts for HKSAR under both baseline and adverse scenarios.

12. Liquidity tests complement the solvency tests and focus on the sudden, sizeable withdrawal of funding (i.e., liabilities run-off) and the sufficiency of existing liquidity buffers to withstand those shocks under stressed conditions. Various implied cash flow (ICF) tests under the HKMA's liquidity risk framework (over the stress horizons of one week and three months) and liquidity tests developed by the FSAP team (over the stress horizons of one week and one month), and the standard liquidity measures under Basel III (the LCR and NSFR) are applied to determine the short- and medium-term resilience of individual banks and the overall system. The liquidity tests are supplemented by a stress test conducted by the HKMA staff incorporating the impact of market and credit risk arising from a prolonged period of negative asset price shocks on cash flow projections.

13. The stress test results confirm that the banking sector would remain sufficiently capitalized and liquid under the current regime. Analyses based on prudential data suggest that even a severe economic shock relative to the baseline would not result in an aggregate capital shortfall over a five-year forecast horizon.[6] The results are consistent across the various different

[6] Note that, even though the total loss of output assumed in the adverse scenarios is very large, growth remains positive even in the more severe scenario. To ensure the assessment was not inadvertently distorted by the assumed path for GDP, the mission confirmed the system's overall resilience by considering an equivalent shock to GDP but which followed an alternative path (calibrated to the relative experience of the Asian financial crisis). In that scenario,

(continued)

stress testing approaches utilized in this exercise. While all larger banks exhibit high levels of capitalization and are able to withstand a severe deterioration of macroeconomic conditions, some smaller banks might be more vulnerable to economic shocks, greater competitive pressures in an increasingly saturated lending market, regulatory changes, and rising interest rate risks affecting both their solvency conditions and funding costs.[7] These smaller institutions may experience a significant decline in net profitability, which might result in capital pressures over the medium-term under a severe economic shock.[8] The results of the liquidity tests show that banks exceed—and in most cases by a large margin—minimum liquidity ratios and threshold requirements of various stress test metrics due to high cash balances and holdings of large stocks of liquid assets at low encumbrance levels, which help mitigate potential stresses from funding shocks.

14. However, the outcome of the stress test also reflects the banking sector's strong solvency conditions at the starting point of the exercise. Banks hold very high levels of capital, are highly profitable, and have a low level of asset impairments amid stable funding profiles. Moreover, the surge of property-related lending in the past several years has not resulted in higher leverage and/or a rise in RWAs. As a result of several macroprudential measures adopted by the HKMA, high collateralization of mortgages and declining LTV ratios can absorb the impact from even severe near-term shocks to property prices in a mortgage-dominated sector. Banks therefore enter the stress test from a position of relative strength, which reduces their fundamental vulnerability to shocks assumed in the stress tests.

15. This note is structured as follows. The next section, Solvency Stress Tests, presents the different components of the FSAP's solvency stress test of the banking sector, analyzes the results of the BU test, and cross-validates the findings with the corresponding TD test results. The findings of the liquidity stress testing exercise are covered in the third section, Liquidity Stress Tests. The fourth section concludes by summarizing the main findings and presenting important policy implications.

SOLVENCY STRESS TESTS

16. Solvency stress tests based on banks' mid-2013 financial data were undertaken in this FSAP exercise. The objective was to determine the capacity of the banking sector to absorb realization of key macro-financial risks, which would result in downside deviations from a defined baseline scenario. The stress tests were based on economic and market conditions as of mid-2013,

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the economy falls into a significant recession in the first year before recovering sharply. The results show that the sector remains resilient to the alternative specification, with no aggregate capital shortfall over the stress horizon. However, capital ratios deteriorate marginally relative to those observed under the original adverse scenario.

[7] Aggregate capitalization of the sector compares favorably to that of other major international banking systems, and profitability remains high (Table 4 and Figure 4).

[8] Under the various stress test scenarios, the impact of term spread compression (i.e., the spread between best lending rate and fixed deposit rate) was mild due to the dominance of floating rate lending and a large share of term deposit funding. Therefore, spread compression under a more competitive market may pose further challenges to the earnings capacity of these banks.

the cut-off date of the exercise, and did not take into account developments in the international capital markets during the completion of the exercise.

17. A three-pronged approach to solvency stress testing of the domestic banking sector comprises (Table 3 and Figure 1):

- *A BU balance sheet stress test* conducted by banks themselves in collaboration with the FSAP team and HKMA staff based on institutions' own data following the calculation method and prescriptive guidelines provided by the FSAP team ("BU exercise"); and

- *A cross-validation of results by two TD balance sheet stress tests* based on the FSAP team's assumptions about macro-financial linkages conducted in collaboration with HKMA staff ("IMF TD exercise") and a modified implementation of the HKMA's supervisory stress test ("HKMA TD exercise"); and

- *A cross-validation of results by a TD market-based stress test* using the FSAP team's application of the "Systemic Contingent Claims Approach, SCCA" (Jobst and Gray, 2013; Gray and Jobst, 2010), which applies the concept of multivariate *extreme value theory* (EVT) to generate an endogenous measure of aggregate capital adequacy for the occurrence of joint tail risks ("IMF SCCA").[9]

18. The solvency stress tests assess banks' vulnerabilities under different adverse scenarios (Figure 8), which are characterized by a prolonged deterioration of macro-financial conditions:

- A *baseline scenario* with macroeconomic projections based on the World Economic Outlook of April 2013 and the Article IV staff report for Mainland China in June 2013 (IMF, 2013a).

- A *slow growth (SG) scenario*, underpinned by a broad-based slowdown of global economic growth, including in Mainland China, triggered by an increase in the cost of capital given markets' accelerated view on the pace of tightening in U.S. monetary policy.[10] Given the negative impact on productivity, the impact persists throughout the forecast horizon. The overall magnitude of the shock, with a cumulative negative deviation of about 9.1 percentage points in real GDP growth over a five-year period, is equal to more than one and a half standard deviations of the long-term (30-year average) two-year cumulative growth rate (5.6 percent), which has been used as unit of measure in other FSAPs.[11] The cumulative deviation from the

[9] See also IMF (2011b).

[10] An increase in U.S. interest rates (especially at longer maturities) would be consistent with both anticipated or actual exit from unconventional monetary policy, and a fiscal policy shock. The scenario is also in line with the plausible downside scenario outlined in the WEO of October 2013 and the threat of "protracted economic and financial volatility triggered by [the] prospective exit from unconventional monetary policies in advanced economies, particularly in the United States …" in the Risk Assessment Matrix of the FSAP (Table 1).

[11] The severity of GDP shock would be almost two thirds of one standard deviation of the five-year cumulative growth rate over the last 30 years (15 percent).

baseline is distributed over the forecast horizon as a result of continued demand shocks amid rising inflation expectations.

- A *severe adverse (SA) scenario*, where the contraction of economic growth under the SG scenario is further aggravated by an intensification of capital outflows affecting HKSAR as an international financial center.[12] The scenario comprises a shock of two standard deviations of the long-term (30-year average) two-year cumulative growth rate from the IMF-projected baseline. This scenario amounts to a cumulative negative deviation of about 12.1 percentage points in real GDP growth over a five-year horizon.[13]

19. Overall, the pass-through of these shocks—under the two adverse scenarios—onto the quality of banks' assets is broadly calibrated to past experience, including the Asian financial crisis. Property prices also decline significantly under the adverse scenarios—by 30 and 40 percent respectively, and equity prices decline by 50 and 65 percent respectively. Under the two adverse scenarios, economic growth deteriorates by 1.8 and 2.4 percentage points (to 2.6 and 2.0 percent, respectively) on average relative to baseline expectations of average annual growth of 4.4 percent (Table 5 and Figure 8).

20. Both scenarios are also comparably reflected in the implementation of the "severe" and "more severe" scenarios of the HKMA's TD solvency assessment over a shorter stress period of two years (Table 6). The shocks assumed in the HKMA TD exercise are more condensed within the two-year stress period, with the magnitude of shocks being similar to those assumed in the BU and IMF TD balance sheet exercises over a five-year forecast horizon.[14] Since the HKMA TD exercise is largely based on the aggregation of single factor shocks, the impact of the macro-financial linkages is not as prominent as that defined for the IMF TD approach.

21. The severity and dynamics of the macro-financial scenarios are in line with the spectrum of shocks considered in the context of other macroprudential and supervisory stress testing exercises. The quarterly supervisory stress test by the HKMA includes a sharp contraction of economic growth over a shorter forecast horizon, which is broadly in line with the cumulative deviation from the expected growth path projected in the SA scenario above. Also, the solvency stress tests completed as part of recent FSAPs for other countries, such as the United States (IMF, 2010), various large European countries within the S-25 Group, including France (IMF, 2012b), Germany (IMF, 2011c), and the United Kingdom (IMF, 2011a), have included a sharp contraction of

[12] This scenario reflects the combined threat of a "sharp slowdown [of economic growth] in Mainland China" and a "significant decline in property prices", which exacerbate the threats underpinning the SG scenario in accordance with the Risk Assessment Matrix of the FSAP (Table 1).

[13] The overall magnitude of shock is equal to more than two standard deviations of the two-year cumulative growth rate (5.6 percent)—or more than three quarters of one standard deviation of the five-year cumulative growth rate over the last 30 years.

[14] For example, over the two-year stress period of the HKMA TD exercise, property prices are assumed to fall by 30 percent and 50 percent under the "severe" and "more severe" scenarios, respectively.

economic growth over an initial period of one or two years prior to a dynamic recovery over a total forecasting horizon of five years—like the SA scenario applied in the case of HKSAR.[15]

22. Macro projections and guidelines on selected parameters are applied as much as feasible in a consistent manner:

- *Based on the economic growth scenarios, related key macro and financial variables are projected by IMF and HKMA staff* (Figure 9). The inputs to the solvency stress tests consist of real GDP, household income, unemployment, inflation, interest rates (3-/12-month HIBOR, term deposit rate, and "best lending rate"), asset swap rates (short-term and long-term), equity prices, commercial property price index, real estate price index, and credit growth.

- *Both the IMF TD and BU exercises include prescriptive assumptions* covering areas such as risk factors (loss rates, profitability, fixed income holdings, exchange rates, taxes, valuation haircuts on direct and indirect sovereign exposures, and funding costs), proxies for behavioral adjustments (dividend payout, credit growth, and deleveraging), and regulatory changes (capital requirements, RWAs, and definition of capital) (Table 3 and Annex).

- *Structural changes to business models and some potential mitigating factors have not been considered within the scope of the exercise*. For example, organizational restructuring and changes in business lines have only been included if they were announced/implemented before the cut-off date of the stress test exercise and did not require further managerial intervention. Other mitigating factors, such as the dynamic management of RWAs and funding structures, strategic decisions resulting in changes to financial obligations vis-à-vis third parties over the forecast horizon as well as contingent capital arrangements, are not considered.

23. Capital adequacy is assessed in accordance with Basel III standard. The hurdle rates for total capital, Tier 1 capital, and Common Equity Tier 1 (CET1) applied in the stress tests follow the internationally agreed schedule for Basel III implementation (Table 3). As the capital conservation buffer will come into full effect in 2015 it is applied in the last three years of the five-year forecast horizon.

[15] Also note that the negative cumulative deviation from the expected growth path by slightly more than two standard deviations of the two-year cumulative real GDP growth rate in the SA scenario is consistent with the severity of the most adverse scenario of the stress tests conducted in these other FSAPs and the system-wide banking stress test conducted by EBA in 2011 (EBA, 2011a and 2011b). In addition, while the stress test in the FSAP for Mainland China (IMF, 2011d) was a more static one-period shock, the scale of the "extreme" scenario (of 2.7 standard deviations of one-year growth) was similar in intention as that of the SA scenario for HKSAR.

A. Summary of All Solvency Stress Tests

24. The results from both BU and TD exercises show a significant drop in banks' capital adequacy ratios under severe stress, but the sector remains sufficiently capitalized even after the transition to the new and more stringent solvency regime under Basel III (Figures 12 and 13). While the impact of interest rate risk remains limited to some smaller banks, results indicate a generally high sensitivity of banks to rising impairment losses, valuation haircuts on investment assets, and the impact of both regulatory changes to the definition of capital and rising default probabilities on RWAs under stress. All capital adequacy measures (capital adequacy ratio (CAR), Tier 1 capital and CET1) are materially affected by both adverse scenarios, but there is no aggregate capital shortfall, even if the impact of joint tail risks from market-implied expected losses of banks were considered (via the IMF SCCA). Under baseline conditions, the aggregate capitalization increases moderately by up to one percentage point of Tier 1 capital (and less so for CET1 capital) as all banks record net operating profits in the BU exercise.[16] Under the two balance sheet-based TD approaches (HKMA and IMF), the aggregate CET1 ratio declines at most by 2.7 percentage points and 0.9 percentage points under the two adverse scenarios. The largest decline of aggregate capitalization occurs under the SA scenario, with CAR contracting by up to 3.7 percentage points under all balance sheet approaches (TD and BU). If joint tail risks to current solvency conditions were considered at a 1-in-200 year probability under a market-consistent valuation, the SCCA results suggest that aggregate CAR and CET1 ratio would decrease by 4.5 and 4.3 percentage points, respectively.

25. While most of the large banks exhibit very solid capital buffers, some smaller banks might be slightly more vulnerable during the final years of the SA scenario. Given the very high capital buffers in the beginning of stress test, the potential capital shortfall in the sector identified in one of the TD approaches is limited to HKD 1.3 billion of Tier 1 capital (as the only hurdle rate being breached by a bank until the end of the forecast horizon), which represents about 0.2 percent of Tier 1 capital in the sector as of end-June 2013.[17] In two out of the three TD approaches, one to two small banks would fall below the hurdle rate towards the end of the forecast horizon. Nevertheless, none of the banks would fail in two TD approaches at the same time. Given that market perceptions of capital adequacy are likely to exceed the regulatory minimum (which is defined based on the minimum capital requirements under Basel III in the context of the stress test), the rapidly declining market-implied capitalization of these banks under the IMF SCCA suggests the potential need for a timely build-up of additional capital buffers over the medium term if the stress scenario were to materialize. The HKMA has already undertaken in-depth discussions with the local banks in the preparation for the adoption of Basel III, including their capital planning to meet the more stringent

[16] The percentage point change refers to the difference between the lowest capital ratio during the five-year forecast horizon and capital ratio at the starting point of the stress test.

[17] The number reflects the aggregate shortfall for banks that are below the Tier 1 hurdle rate without considering any surplus capital at banks above the hurdle rate at the time of the capital assessment.

requirements and setting higher "supervisory trigger" capital add-ons to Pillar II progressively along the implementation of Basel III.

26. The IMF TD stress test result is very consistent with the aggregated BU findings. The IMF TD results show a similar evolution of capital ratios to that of BU outcomes in the baseline scenario. Marked differences emerge under the adverse scenarios, especially in the early years of the forecast horizon; however, results converge during the final years. The high severity implied by the combination of different single factor shocks in the HKMA TD stress test over a shorter forecast horizon of two years (vs. five years in the IMF TD stress test and the BU stress test) results in the most severe outcome across all stress tests under the SA scenario. The differences between the BU and all TD stress test results (and in particular between the IMF TD and BU results) are likely attributable in part to the model design and the scope of the exercise. Firm-specific assumptions and the application of internal models applied by banks in the BU exercise (consistent with stress testing guidelines provided by the FSAP team) can lead to differences in the projection of profits and losses for individual banks under the various scenarios. Moreover, differences can also be explained by the fact that the BU tests are undertaken by a smaller number of banks at the consolidated level whereas the TD analyses by the HKMA and the FSAP are performed on a larger sample covering almost all local banks on a combined and consolidated basis, respectively.

27. The results are heavily influenced by the diminished earnings capacity of the sector if economic conditions were to deteriorate and the rise in unexpected losses implied by higher RWAs. Increasing provisions for credit risk and higher loan impairments, the procyclical impact on credit RWAs as well as the impact of capital are the main risk drivers,[18] whose impact on solvency is currently mitigated by extremely robust credit conditions and low leverage of the sector (Figure 16). While credit risk is currently limited due to low marginal loss rates in the sector, nonperforming loan (NPL) balances in the real estate sector rise considerably in relative terms under stress. Rising competition could put further downward pressure on declining interest income, which would limit further build-up of capital buffers, especially after the full adoption of the forthcoming new capital requirements.

B. Bottom-Up Solvency Stress Tests

28. The BU stress tests involving selected local banks formed the core element of the solvency risk assessment. The exercise was administered jointly with the HKMA, with banks conducting the stress tests using their own internal models. Detailed guidelines on assumptions and methodologies were drawn up by the FSAP team. The HKMA facilitated the implementation of the BU stress test by overseeing the completion of the exercise together with the necessary due diligence. The guidelines contained key assumptions relating to the calibration and estimation of important risk drivers, which are necessary to ensure a robust, consistent and credible assessment of system-wide capital adequacy during times of stress.

[18] For the BU stress test, however, the impact of credit risk on banks' net income and that of regulatory changes on RWAs and capital under stress were relatively small.

29. Each bank submitted a "report card" of the outcome to the HKMA, which provided aggregated results for all sample banks to the FSAP team for further analysis. For each bank, the analysis estimates changes in potential losses from asset impairments, profitability, regulatory impact of Basel III on the definition of capital as well as post-shock RWAs and, where applicable, the capital needs (Annex).[19] The FSAP team also met with the risk management and stress testing teams from each participating bank to discuss in detail the stress test design and results.

30. The BU stress test results suggest that the selected local banks are resilient to significant economic shocks, with no individual institution showing any capital shortfall under stress. Specifically, the findings were:

- *All banks pass the capital hurdle rates under all scenarios.* The CET1 ratios diverge by as much as 2.3 percentage points from their pre-stress capitalization. The maximum decline of aggregate capitalization amounts to 3.3 percentage points of CAR.

- *As expected, the SA scenario turned out to be more stringent than the SG scenario.* Both the SG and SA scenarios did not have as negative an impact as initially anticipated—an outcome that banks attributed to the development of the interest rate scenarios given the mild impact from the compression of term spreads (i.e., the spread between best lending rate and fixed deposit rate) over the near term due to a preponderance of floating rate lending that references short-term interbank rates and a large share of term deposit funding (Figure 10). That being said, spread compression in a more competitive market and a gradual increase of impairment balances may challenge their earnings capacity under both adverse scenarios.

C. Top-Down Solvency Stress Tests

31. A balance sheet-based framework was used to generate stress estimates for assessing the system-wide risk based on changes in individual capital adequacy of all sample banks. The approach provided a quantitative assessment of capital adequacy on a bank-by-bank basis using financial data as of end-June 2013, which was directly provided by all 19 local banks via the HKMA (Table 14). Several satellite models were developed for each scenario to determine changes in profitability and credit losses according to the historical sensitivity of bank performance to macro-financial variables. These macro-financial linkages were estimated based on two-stage least (2SLS) squares panel data regressions over quarterly observations between 1996: Q1 and 2013: Q2 (using orthogonal deviations transformation[20] according to Arellano and Bond (1991) as well as Arellano and Bover (1995)) of the profitability components (interest income, interest expenses,

[19] A template of the report card is provided in the Annex (Appendix XIII).

[20] More specifically, up to five quarter lags of endogenous variables and up to two quarter lags of other variables are included as instrumental variables. The risk of over-identification is reduced by restricting the number of instrumental variables such that it would be smaller than the number of cross-sectional units.

fee/commissions income, and operating expenses) as well as the flow of asset impairments and the stock of nonperforming loans (Table 13).[21]

32. The above approach was supplemented with a forward-looking, market-based framework to generate a systemic risk perspective of solvency conditions under stress. Balance sheet-based approaches assume that sufficient institutional capital always reduces the likelihood of insolvency in distress situations. This implies that larger capital buffers at each bank should lower the chances of multiple institutions defaulting simultaneously—but without considering system-wide effects. In order to address this shortcoming, the IMF SCCA model is used to estimate systemic solvency risk. The SCCA framework accounts for the dependence among individual banks in estimating the joint market-implied expected losses in order to estimate potential aggregate capital shortfall (Box 1). Under this approach, the banking sector is essentially viewed as a portfolio of individual expected losses, specified as implicit put options with individual risk parameters, whose joint exposure to common risk factors can be accounted for by including their non-linear dependence structure. By modeling how macroeconomic conditions have influenced the changes in banks' market-implied expected losses—as measured by monthly implicit put option values—it is possible to link a particular macroeconomic path (and the associated financial sector performance) to individual and joint expected losses of the banking sector in the future.[22]

33. The results from both balance sheet-based TD exercises confirm the BU stress test results, while the market-implied capital assessment suggests a potentially higher rate of capital erosion of smaller banks under stress (Figures 14 and 15):

- *The TD approaches reveal important nuances regarding the evolution of the capital impact of different shocks under different scenarios.* Under the baseline scenario, the IMF TD and HKMA TD results are closely aligned with those from the BU exercise, especially during the second year of the forecast horizon, and imply a moderate aggregate profit and loss statement (P&L) impact. Whereas the HKMA TD exercise results in slightly lower capital ratios than the BU exercise under the SG scenario, the selected local banks' internal models for the BU exercise suggest smaller deterioration in the SA scenario, especially for CET1, than that suggested by the HKMA TD exercise. The impact of the SA scenario under the IMF TD approach is far more muted than that under the HKMA TD approach.

- *The results from the application of market-implied expected loss under the SCCA approach indicate a potentially higher decline in aggregate capitalization than that suggested by the balance sheet-based TD approaches.* This is mainly because increased price volatilities resulting from market

[21] Changes in NPLs are modeled independently of changes in loan loss provisions, which provide the starting point for the marginal loss rate at the beginning of the forecast horizon. As NPLs increase under stress, each material loan category includes an increase of default risk (probability of default, PD), with a corresponding increase in RWAs. The change in trading income was mapped to nominal GDP growth.

[22] The individually estimated expected losses of each sample bank are aggregated using the SCCA framework (Jobst and Gray, 2013) with a five-year sliding window and monthly updates over the forecast horizon and assessed as to their potential impact on the aggregate capitalization of the sample over the stress horizon.

perceptions about the effects of potential mergers and acquisitions of these banks have substantially increased their equity price volatilities, which resulted in higher market-implied expected losses. For the conditional tail expectation[23] at a statistical confidence level of 95 percent or higher, the sector remains solvent and stays above all hurdle rates over the entire stress horizon. The CAR and the CET1 ratios decrease significantly by 4.5 and 4.3 percentage points under the SA scenario as well as 4.5 and 4.4 percentage points under the SG scenario, respectively.

D. Reconciliation of Solvency Stress Tests

34. The balance sheet-based TD stress test results are very consistent with the aggregated BU findings. The trends for CET1, Tier 1, and total capital ratios under all three approaches—for the baseline and both adverse scenarios—are similar but show some differences (Figures 12 and 13). While BU results generally show greater sensitivity to the variation in the chosen scenario, with a greater increase (decrease) in capital ratios than the IMF TD outcomes under the baseline (adverse) scenarios, with differences between both approaches becoming less marked in the latter years of the stress test horizon. The distribution of individual capital ratios differs somewhat, but the median result is generally consistent for both approaches.

35. Differences in the two sets of results are likely attributable in part to the model design and the scope of the stress testing exercise. The aggregate BU results are based on bank's own approaches, as long as they are consistent with the common principles stated in the BU stress testing guidelines (Annex). Firm-specific assumptions and the application of internal models based on more granular data can lead to differences in the projection of net operating profits and impairment/valuation losses for individual banks under the various scenarios. For instance, projected net interest income and impairment losses account for much of the differences in the impact of the various adverse scenarios on the capital ratios in both TD and BU exercises. In the context of the IMF TD approach, this can be explained by the fact that the uniform sensitivity of changes in NPL balances for each bank (implied by the panel data estimates of macro-financial linkages) creates less diverse loss results across banks. Moreover, differences can also be explained by the fact that the BU tests are undertaken by selected local banks at the consolidated level whereas the TD analyses are performed on a larger and more diverse sample of almost all local banks on combined (HKMA TD) and consolidated (IMF TD) bases.

LIQUIDITY STRESS TESTS

36. A suite of liquidity stress tests was carried out by HKMA staff in consultation with the FSAP team in order to assess the resilience of the banking sector with respect to sudden, sizable withdrawals of funding. The liquidity risk analysis was completed separately from the

[23] The CTE is expressed as expected shortfall (ES), which quantifies the average probability density beyond a statistical threshold (such as 95 percent in this case).

solvency stress testing based on end-June 2013 data. Due to the stringency of assumptions that were applied consistent with other FSAP stress tests, the findings are informative regarding the dynamics of aggregate funding positions under very severe system-wide distress.

37. The liquidity stress tests aimed to capture the risk that a bank fails to generate sufficient funding to satisfy short-term payment obligations due to one or more of the following channels affecting cash flows: (i) scheduled and unscheduled cash outflows; (ii) cash inflows related to maturing assets and assets that are either repo-able or saleable at stressed market values ("market liquidity risk"); (iii) restricted ability to access funding markets ("funding liquidity risk"); and (iv) the ability to survive funding constraints due to the rollover risk stemming from maturity mismatches. In this regard, assumptions about the decline in asset values, amortization/renewal rates, callback rates on contingent claims and liabilities/funding swap arrangements, and the extent to which assets were subject to haircuts when used as collateral for wholesale funding influence the severity of cash flow calculations and their impact on the various liquidity measures (Tables 2, 11 and 12).

38. Three types of liquidity regimes were examined: (i) the HKMA supervisory liquidity stress testing framework (at one-week and up to three-month risk horizons), (ii) the FSAP team's ICF tests (at one-week and one-month risk horizons)—the IMF cumulative five-day test, and the non-cumulative 30-day test, and (iii) the Basel III standard measures of liquidity risk—the LCR and the NSFR.[24] More specifically, the HKMA liquidity stress testing framework comprise (i) the 7-day test/lender of last resort (LOLR) analysis, which combines a 7-day deposit run scenario with the HKMA's LOLR analysis,[25] and (ii) the Enhanced Liquidity Stress Test (ELST), which expands the scope of cash outflows under the 7-day test/LOLR analysis. The ELST broadly follows the LCR's rationale with risk horizon spanning between one to three months. The two IMF ICF tests simulate a gradual outflow of funding over five consecutive days on a cumulative basis and over a 30-day period on a non-cumulative basis. The underlying assumptions are severe, implying a withdrawal of more than one quarter of unsecured funding within five days and a complete run-off of secured funding within one month in the extreme case. Both HKMA and IMF liquidity stress test results are assessed using the ratio of cash inflows (including proceeds from securities lending, repos and asset sales) to cash outflows (the stress test ratio). Thus, a stress test ratio higher than 100 percent implies a liquidity surplus under the stress scenario implied by the funding and market liquidity risks. The liquidity stress tests under both HKMA and IMF frameworks are applied to all 19 banks in Group 1 (local banks) and all eight banks in Group 2 (foreign branches) on a solo basis, representing 71 percent of the banking sector's total assets.

[24] The sensitivity of both HKMA and IMF liquidity stress test results to the absence of a retail deposit run was explored as an alternative scenario in order to assess the impact of the large deposit base of local banks on the variability of test results.

[25] The LOLR analysis represents a supervisory measure of liquid assets available to the authorized institutions for accessing liquidity from the HKMA.

39. The Basel III liquidity framework is based on two quantitative liquidity standards that aim to strengthen liquidity risk management practices in banks. Under the Basel III proposals, banks are expected to maintain a stable funding structure, reduce maturity transformation, and hold a sufficient stock of assets that should be available to meet its funding needs in times of stress (BCBS, 2010c and 2012b). The framework is based on two standardized ratios, which are applied to a selection of local banks on both consolidated and combined bases and foreign branches on a solo basis:[26]

- *LCR*—This ratio is intended to promote short-term resilience to potential liquidity disruptions by requiring banks to hold sufficient high-quality liquid assets (HQLA) to withstand the run-off of liabilities over a stressed 30-day scenario specified by supervisors. LCR requires that banks hold a sufficient stock of unencumbered, HQLA to cover cash outflows less cash inflows (subject to a cap at 75 percent of total cash inflows) that are expected to occur in times of stress. In January 2013, the Basel Committee reached an agreement on a composition of HQLA and parameters for net cash outflows resulting from deposits and contingent liabilities, as well as a transition period for introduction of LCR (BCBS, 2012b and 2013). LCR of less than 100 percent indicates a liquidity shortfall.

- *NSFR*—Final agreement on this structural ratio, which would limit the stock of unstable funding by encouraging longer-term borrowing in order to restrict liquidity mismatches from excessive maturity transformation, has not yet been reached by the Basel Committee (BCBS, 2014).[27] Based on existing proposals, it would require banks to establish a funding profile that is expected to be stable over a one-year horizon under an extended stress scenario to support their lending and investment activities on an ongoing basis. The NSFR would reflect the proportion of long-term assets that are funded by stable sources of funding, which includes customer deposits, long-term wholesale funding with maturities of more than one year, and equity (but excludes short-term funding). A value of this ratio of less than 100 percent indicates a shortfall in stable funding (BCBS, 2010c).

[26] The sample does not necessarily represent the institutions that will be subject to the Basel III liquidity standards. The local liquidity standards will continue to regulate institutions that are not subject to the Basel III liquidity standards. For the purpose of the FSAP, the results for foreign branches are grouped with the local banks' results on a combined basis.

[27] In January 2014, the Basel Committee issued proposed revisions to the NSFR for public comments. These revisions to the original NSFR proposal seek to (i) reduce "cliff effects" within the measurement of funding stability by introducing a new category of assets and liabilities with remaining maturities between six months and one year, (ii) align the application of required stable funding weights to the LCR's definition of HQLAs, and (iii) alter its calibration to focus more on shorter-term, potentially more volatile funding sources. The revisions align the NSFR closer to the LCR and are expected to be more accommodative to banks' business models (Gobat and others, *forthcoming*).

40. Finally, the examination of these conventional liquidity risk indicators is complemented by additional analysis based on the market risk-contingent liquidity approach by Wong and Hui (2009), which is applied to 17 local banks on a consolidated basis (i.e., including their overseas branches and subsidiaries). The test aims to capture how MtM losses on banks' holding of risky assets due to a prolonged period of negative asset price shocks would increase banks' solvency risk and reduce the ability to generate liquidity from asset sales. In the framework, the banks' default risk is endogenously determined using a Merton-type firm value model, which determines potential retail and wholesale deposit outflows. With the estimated deposit outflows and contingent drawdowns, daily cash outflows of individual banks can be derived to assess the risk of cash shortage and default for given paths of asset price shocks. The framework employs a Monte Carlo simulation to generate random asset price changes for all major asset classes (corporate debt securities, equities, and structured financial securities) on banks' balance sheets.[28] After 1,000 iterations, the probability of cash shortage and the probability default due to liquidity problem are estimated based on the difference between cumulative inflows and outflows over a one-year horizon.

41. Liquidity risks for banks are low. Stress test shows that banks exceed—and in most cases by a large margin—the minimum acceptable ratios due to high cash balances and holding of large stocks of liquid assets at low encumbrance levels, which help mitigate potential stresses from funding shocks. The results obtained through HKMA and IMF liquidity stress tests are robust to a variation of the type and magnitude of funding shocks.

42. The stress test results for both the HKMA and IMF's liquidity risk measures show that all banks are able to withstand short-lived shocks to cash flows (**Figure 11).** Despite a large contraction of deposits, the average stress test ratio stood at 279 percent and 338 percent under the HKMA's 7-day/LOLR analysis and the IMF's five-day ICF test, respectively. Larger banks appear to have better liquidity positions. Extending the risk horizon to one month (and even beyond in the case of HKMA's ELST) shows no overall liquidity shortage, with the average liquidity ratio of 162 percent and 235 percent under the HKMA's ELST and the IMF's 30-day ICF tests, respectively. The differences in magnitude of the ratios reflects the higher (lower) run-off (callback) rates in HKMA's tests, which are applied to the entire deposit base whereas the IMF tests limit the amount of potential liabilities run-off to open maturities and maturity terms not exceeding the stress period of one week or one month.

[28] The severity of the shocks is comparable to that of the "severe" scenario of the HKMA TD solvency stress test. At the 90th percentile, the credit spreads of corporate bonds with credit ratings of "AA" or higher, "A" and "BBB" rise by around 0.4, 1.7 and 1.74 percentage points, respectively. The credit spreads of non-investment grade (and unrated) corporate bonds increases by 10.5 percentage points. Equity prices and the market value of structured financial securities decline by 27 percent and 32 percent, respectively. Based on these inputs, the cash outflow side, deposit outflows and drawdown of commitments are endogenously derived. The maximum monthly run-off rate for retail deposits is set at 42 percent, while that for wholesale deposit is 100 percent. 15 percent of committed credit lines are assumed to grant to SIVs and the drawdown rate is assumed to be negatively correlated with the price of structured financial securities. No risk mitigation measures by parent banks and the central bank is assumed in the stress horizon.

43. Most banks also hold sufficient liquidity and stable funding sources under the Basel III standard liquidity measures.[29] The standard liquidity measures (LCR and NSFR) were examined on a limited sample of local banks and foreign branches. On both consolidated and combined bases (for end-June 2013 positions), the average LCR and NSFR are above the 100 percent threshold. Most institutions clear the 100 percent threshold of each indicator with ease, especially on a consolidated basis. On a combined basis, however, a few banks show potentially insufficient liquidity buffers to meet negative net cash outflows over a 30-day horizon according to the LCR measure.[30] Nonetheless, most of them report LCR ratios above 60 percent, which is the initial minimum requirement set out in the first year (2015) of the transition schedule for the adoption of the Basel III framework.[31] Many of these banks already report LCR ratios close to 100 percent.[32] In addition, most of the sample banks report NSFR values of 100 percent or higher, indicating a stable funding profile to support long-term lending. A couple of banks show NSFR ratios lower than 100 percent, but the shortfall was not material.[33] The contractual maturity mismatches of local banks increase significantly beyond one year, which reflects the combination of long maturity tenors of substantial residential mortgage portfolios and a large retail deposit base. That being said, supplementary, longer term sources of funding could help reduce rising cash flow mismatches at maturities of one year and longer.

44. Overall, the stringency of the HKMA and IMF liquidity stress tests is consistent with the LCR with differences stems from assumptions on net stressed outflows and scope of the liquidity buffer. For instance, HKMA liquidity stress test is generally less restrictive with regard to the definition of the liquidity buffer (i.e., the evaluation of HQLA), which is compensated by stricter assumptions on the stress scenario and contingent cash outflows. The HKMA's ELST and the IMF's 30-day test allow for a wider range of assets that might not qualify as HQLA in the calculation of LCR.

[29] Note that the consultation on Basel III implementation in HKSAR was not completed at the time of the FSAP. Thus, the test results do not reflect any possible behavioral changes of the tested banks in response to the implementation of the new regime.

[30] Further investigation of these banks' balance sheet data suggested that the shortfall was mainly contributed to their substantial holdings of liquid assets that did not qualify as HQLA for the calculation of LCR, such as debt securities issued by financial institutions.

[31] The HKMA plans to follow the Basel phase-in arrangement introduced in January 2013. Under the transitional arrangement, the initial regulatory minimum LCR is set at 60 percent in 2015, followed by an annual increase of 10 percentage points to 100 percent by 2019.

[32] It should be noted that as the consultation on LCR implementation in HKSAR had not been completed and the HKMA was still deliberating the scope of application when the test was conducted, the industry (including the tested banks) had yet to know who exactly would be required to meet the relevant standards. Thus the test results did not reflect any possible behavioral changes of the tested banks in response to the implementation of the new regime. Given the remote implementation timeline of the Basel III liquidity measures, it is assessed that banks will have sufficient time to restructure their balances and liquidity profile by, for example, switching their holding of debt securities issued by financial institutions to increase the amount of HQLA under the LCR.

[33] Similar to the case of LCR, the test results for NSFR did not reflect any possible behavioral changes of the tested banks in response to the implementation of the new regime. With an even more remote implementation timeline of NSFR than LCR, the risk that banks cannot meet the NSFR standards by that time is minimal.

45. No bank is found to trigger cash shortage or default due to liquidity problems over a one-year stress horizon according to the Wong and Hui (2009) test. In the face of the severe asset price shocks specified, banks' default risk remains at a low level over the stress horizon, and, thus, results in only a small insignificant deposit outflows both in the retail and wholesale markets. For all banks, cash inflows are found to be sufficient to cover cash outflows, which are estimated to be partly driven by drawdowns of contingent liabilities. The overall result attributes a low probability of a liquidity shock over the stress horizon that would be sufficient to trigger solvency concerns.

46. While the stress test results confirm the sector's resilience to liquidity shocks, some sample banks would benefit from alternative funding sources that can augment their deposit base at longer maturity tenors. Banks are generally not reliant on wholesale funding, especially term funding over maturities beyond one year. Nevertheless, the broadening of funding sources, especially those at longer maturities, could mitigate potential funding pressures from deposit run-offs in times of stress.[34]

47. The results also show that foreign branches would be exposed to different risk drivers than local banks in a liquidity shock scenario. The differences in the balance sheet structure (especially on the liabilities side) of local banks and foreign branches results in heterogeneous sensitivity to liquidity shocks. The main risk driver for local banks is a shrinking deposit base, and their liquidity positions improve substantially if customer deposits (especially retail deposits) remained stable. In contrast, foreign branches are more dependent on wholesale funding and show greater susceptibility to outflows from related party lending and contingent claims.[35] While different business models of local banks and foreign branches explain level difference in stress test ratios, the impact of liquidity shocks varies significantly among foreign branches, reflecting heterogeneous funding and liquid asset structures among them. The IMF liquidity risk analysis suggests that intragroup claims are an important distinguishing feature in the characterization of projected cash outflows under stress, which—in the case of foreign branches—are accompanied by considerable decline in wholesale funding.

48. The HKMA has further strengthened liquidity risk monitoring and management. Stricter liquidity regulations by the HKMA have been conducive to greater focus on liquidity risk management (Figures 10). The HKMA recently introduced the ELST as an essential element of routine liquidity monitoring including more severe scenarios compared to the previous liquidity 7-day test that assumes only a deposit run-off. In addition, the HKMA is undergoing a consultation process with

[34] In the second half of 2011, the HKMA introduced a matched term funding requirement, which obliges banks experiencing high credit growth to obtain matched term funding to support their lending. Furthermore, in view of the possible impact of U.S. monetary policy normalization on banks' liquidity conditions, the HKMA introduced a stable funding requirement in late 2013, which complements the matched term funding requirement.

[35] In the HKMA ELST test, around 80 percent of outflows from local banks are caused by withdrawals of deposits. Outflows from foreign branches are more driven by a run on wholesale funding (around 70 percent of total outflows).

industry on the details of the LCR with a view towards implementing minimum criteria by January 1, 2015.[36]

49. Overall, the liquidity stress test results need to be put into context given their static nature and the assumption that all banks would face escalating liquidity risk at the same time under the stress scenario. Given the assumptions and modeling technique, identified liquidity risk should be interpreted in terms of a general vulnerability to the particular set of assumptions, rather than it being representative of an actual liquidity need in a general stress situation. The results would need to be qualified based on mitigating considerations, such as, for example, the likely reallocation of deposits within the banking sector in a situation when not all banks experience funding shocks simultaneously (and assuming that (at least retail) deposits largely remain in the banking system, which has been examined as alternative scenario in this stress testing exercise).

SUMMARY AND POLICY IMPLICATIONS

50. Overall, the stress test exercise confirms a high degree of resilience of the sector as banks enter the exercise from a position of relative strength. Banks in HKSAR hold very high levels of capital, are very profitable, and have a low level of asset impairments amid stable funding profiles. Analyses based on both prudential and market data suggest that even a severe economic shock would not result in an aggregate capital shortfall over a five-year forecast horizon. While larger banks are sufficiently capitalized to withstand a severe deterioration of economic conditions, there are some vulnerabilities among some smaller institutions. The solvency conditions and funding costs of those banks are significantly affected by economic shocks, greater competitive pressures in the domestic lending market, and rising interest rate risks. A significant decline in their profitability might result in capital pressures over the medium term under a severe economic shock. In general, a substantial price correction of residential and commercial real estate would put downward pressure on the net operating income of the sector and could increase the estimated decline of capitalization under stress conditions.

51. Going forward, the HKMA is encouraged to continue its integration of risk-based supervision in the development of stress test scenarios for macroprudential policy and surveillance. Banking supervisors routinely conduct stress tests and from time to time modify relevant assumptions in order to support thematic reviews of identified vulnerabilities against emerging risks as a result of macroprudential surveillance efforts within the HKMA.[37] While current stress tests have been designed to cover the most salient risk drivers, other sources of vulnerability may require more granular prudential information, e.g., intragroup transactions within

[36] The consultation paper from the recent round in July-September 2013 is available at: http://www.hkma.gov.hk/media/eng/doc/key-functions/banking-stability/basel-3/consultation_on_local_implementation_of_basel-3_liquidity_standards/Consultation_paper.pdf

[37] A recent example of such analysis within the existing stress testing framework includes the assessment of the impact of a major collapse in the property sector in Mainland China on banks that have significant exposures.

conglomerates, which could be incorporated within the current framework. While the HKMA has already aligned some of the assumptions used in both TD and BU stress tests, further integration of the two exercises (e.g., periodic cross-validation of results), which is a direction that the HKMA is moving towards[38], could pay dividends for its supervisory work of the relevant banks as well as its financial stability analysis.

52. On a technical level, the HKMA is encouraged to extend single-period shocks of its current stress testing framework to multiple-period scenarios (possibly in combination with an assessment of feedback effects). The current stress test comprises mostly single factor shocks, which are calibrated to generate a very adverse impact on banks over a two-year forecast horizon. Extending the forecast horizon over longer periods (and incorporating macro-financial transmission channels) would place greater emphasis on potential mitigating effects from profitability and behavioral assumptions of banks on medium- and long-term vulnerabilities. This would allow for a more comprehensive and potentially more realistic assessment of the impact of different risk drivers on the solvency position of banks over time. Secondary impacts emanating from a deteriorating financial position can be material and may be added to the current framework. In particular in situations of prolonged financial stress or distress, secondary impacts, higher cost of capital, constrained capital mobility, can become important for potential mitigating actions.

[38] For instance, the current TD stress test exercise has made reference to the BU stress test results in devising the procyclicality assumption of RWAs in the adverse scenarios.

Box 1. Overview of the Systemic Contingent Claims Approach Framework for Stress Testing and the Implementation in the Context of Hong Kong SAR

SCCA models systemic solvency risk by combining the multivariate extension to contingent claims analysis (CCA) with the concept of EVT in order to generate a system-wide tail risk (Jobst and Gray, 2013).[1/] The magnitude of risk jointly posed by multiple firms falling into distress is modeled as a portfolio of individual expected losses (with individual risk parameters) calculated from equity market and balance sheet information using an enhanced form of CCA, which has been widely applied firm value model to measure and evaluate credit risk.[2/] More specifically, CCA is applied to construct risk-adjusted (economic) balance sheets of financial institutions and estimate their market-implied expected losses.3/ The firm-specific distributions of these expected losses and the dependence between them are combined to generate a multivariate distribution that formally captures the potential of extreme realizations of joint expected losses.

The SCCA framework can be decomposed into two sequential estimation steps. First, the market-implied expected losses (and associated change in existing capital levels) are estimated for each sample bank for daily observations of market prices and quarterly balance sheet information over a pre-defined estimation period using an advanced form of CCA. After forecasting these individual expected losses over the stress horizon using their historical sensitivity to changes in firm- specific and changes in macro-financial conditions, the individual estimates are summed up or aggregated in a multivariate set-up in order to derive estimates of joint expected losses, which considers the time-varying dependence structure between expected losses among sample banks. In the reported capital results for SCCA, changes in capital levels affecting CAR and CET1 ratios over the stress horizon are shown for each of the outputs above—individual expected losses, the sum of individual expected losses, and the joint expected losses as conditional tail expectation at 95 percent statistical confidence (which also commonly referred to as ES or "Tail Value-at-Risk" (Tail VaR)).

In order to understand individual risk exposures in times of stress, first, CCA is applied to construct risk-adjusted (economic) balance sheets of financial institutions. In its basic concept, CCA quantifies default risk on the assumption that owners of corporate equity in leveraged firms hold a call option on the firm value after outstanding liabilities have been paid off.[4/]So, corporate bond holders effectively write a European put option to equity owners, who hold a residual claim on the firm's asset value in non-default states of the world. CCA applies this concept to determine the risk-adjusted balance sheet of firms whose assets are stochastic and may be above or below promised payments on debt. When there is a chance of default, the repayment of debt is considered "risky"—to the extent that it is not guaranteed in the event of default. Higher uncertainty about changes in future asset value, relative to the default barrier, increases default risk which occurs when assets decline below the barrier.

In this framework, market-implied potential losses associated with outstanding liabilities can be valued as an implicit put option in the form of a credit spread above the risk-free rate that compensates investors for holding risky debt. The put option value is determined by the duration of the total debt claim, the leverage of the firm, and the volatility of its asset value.[5/] The put option was modeled based on a jump diffusion process to achieve robust and reliable estimation results in light of empirical shortcomings of the commonly used in the underpinning Merton (1973 and 1974) model.[6/]This approach is an alternative to other proposed extensions aimed at imposing more realistic assumptions, such as the introduction of stationary leverage ratios (Collin-Dufresne and Goldstein, 2001) and stochastic interest rates (Longstaff and Schwartz, 1995).

Box 1. Overview of the Systemic Contingent Claims Approach Framework for Stress Testing and the Implementation in the Context of Hong Kong SAR (continued)

The CCA-generated, market-implied expected losses of individual firms can be transposed into estimates of capital shortfall and generalized to estimates of extreme system-wide solvency risk. In order to establish greater comparability with balance sheet-based analysis of capital adequacy, the market-implied capital result is calculated after subtracting individual and joint expected losses from the individual and aggregate capitalization (CET1 and total regulatory capital) in each year of the forecast horizon in line with minimum requirements under Basel III. The aggregation methodology underpinning SCCA is applied to derive point estimates of the market-implied joint expected losses from the multivariate density of each bank's individual marginal distribution of market-implied expected losses (if any) and their dependence structure among all sample firms.[7/]

The implementation of the Systemic CCA framework as market-based TD stress testing approach for the purposes of examining the resilience of listed local banks to tail risks comprised a three-step estimation process:

- Calculation of market-implied expected losses. The historical market-implied expected losses are estimated (at daily frequency) using CCA based on equity/equity options data and balance sheet information of nine local banks, which represent 54 percent of total banking sector assets on a consolidated reporting basis as of end-June 2013 (Figure 17). Data between January 1997 and August 2013 are used to estimate the central case (median) market-implied expected losses as well as the losses during extreme market stresses at a statistical probability of 5 percent or less (expressed as "tail risk").[8/]

- Specification of macro-financial linkages and estimation of individual expected losses. Forecast series of expected losses for each sample bank are generated for all three scenarios over a five-year horizon based on the historical dynamics of expected losses conditional on changes in economic conditions and bank performance estimated from a dynamic panel-data estimation (Arellano and Bover, 1995) using monthly observations over at least 10 years. These individual expected losses can be applied to the capitalization of each sample bank at the starting point (at end-June 2013) in order to determine the potential of individual capital shortfall over the stress horizon (Figure 17).

Estimation of joint expected losses and tail risk. The forecast series of joint expected losses of all banks are derived at a high percentile level ("Expected Shortfall"/"Tail VaR" at 95 percent statistical confidence) by considering the time-varying dependence structure of forecasted expected losses of all banks (under the assumption that their univariate marginal density functions converge to a Generalized Extreme Value (GEV) distribution as defined in Jobst and Gray (2013) (Figure 17). Finally, the impact of the joint expected losses on the aggregate capitalization (CAR and CET1) of all nine sample banks can be determined and compared to the impact of the sum of individual expected losses (which ignores the dependence structure of individual expected losses) (Figure 17).

Box 1. Overview of the Systemic Contingent Claims Approach Framework for Stress Testing and the Implementation in the Context of Hong Kong SAR (concluded)

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1/ EVT is a useful statistical concept to study the tail behavior of heavily skewed data, which specifies residual risk at high percentile levels through a generalized parametric estimation of order statistics.

2/ The CCA is a generalization of option pricing theory pioneered by Black and Scholes (1973) and Merton (1973 and 1974). It is based on three principles that are applied in this paper: (i) the values of liabilities are derived from assets; (ii) assets follow a stochastic process; and (iii) liabilities have different priorities (senior and junior claims). Equity can be modeled as an implicit call option, while risky debt can be modeled as the default-free value of debt less an implicit put option that captures expected losses. In the Systemic CCA model, advance option pricing is applied to account for biases in the Black-Scholes-Merton specification.

3/ Other common credit risk models are: (i) the Gaussian Single Factor Model, which was developed by Vasiček (1987), Finger (1999) and Gordy (2003) among others, and approximates the loss distribution of a loan portfolio in which dependence between defaults is driven by a single common latent factor, and (ii) the Jiménez-Mencía (2009) model as one of similar models used by central banks as multifactor extension of the single factor model, which allows for several macroeconomic factors to affect the loss distribution. Shareholders also have the option to default if their firm's asset value ("reference asset") falls below the present value of the notional amount of outstanding debt ("strike price") owed to bondholders at maturity. Bond holders receive a put option premium in the form of a credit spread above the risk-free rate in return for holding risky corporate debt (and bearing the potential loss) due to the limited liability of equity owners.

4/ Shareholders also have the option to default if their firm's asset value ("reference asset") falls below the present value of the notional amount of outstanding debt ("strike price") owed to bondholders at maturity. Bond holders receive a put option premium in the form of a credit spread above the risk-free rate in return for holding risky corporate debt (and bearing the potential loss) due to the limited liability of equity owners.

5/ The value of the put option is subject three principles: (i) the values of liabilities (equity and debt) are derived from assets; (ii) liabilities have different priority (i.e., senior and junior claims); and (iii) assets follow a stochastic process.

6/ The Merton model has been shown to consistently underpredict spreads (Jones and others, 1984; Ogden, 1987; Lyden and Saranti, 2000).

7/ Since point estimates of systemic risk are derived from a time-varying multivariate distribution, it is more comprehensive than the current exposition of both CoVaR (Adrian and Brunnermeier, 2008) and Marginal Expected Shortfall (MES) (Acharya and others, 2009) (as well as extensions thereof, such as Huang and others, 2009).

8/ The correct calculation of expected losses of sample banks for which the balance sheets of the listed entities include activities outside HKSAR required the re-scaling of the market data inputs to the CCA calculation. The implied assets, asset volatility and the default barrier (based on short- and long-term liabilities) of the listed entities were adjusted to reflect the size of the balance sheets of the local entities in HKSAR (Table 7). The adjustment, however, could not fully address the possibly substantial differences in balance sheet strengthens and performances between the local entities in Hong Kong and those in the rest of the world.

Table 1. Hong Kong SAR: Risk Assessment Matrix

Source of Main Threats	Likelihood of Realization of Threats in the next 1-3 Years	Expected Impact on Financial Stability of Threat if Realized
Protracted economic and financial volatility, triggered by prospective exit from unconventional monetary policies in advanced economies, particularly the United States, and resulting in increased risk premia and interest rates.	**High** (short-term)	**Medium** This could lead to capital outflows and a tightening of liquidity. Higher interest rates would require borrowers to allocate an increasing proportion of their income to service debt obligations, and encourage banks to tighten credit standards. The resulting contraction in financial intermediation and investment would adversely affect economic growth.
Sharp slowdown in growth in Mainland China, in the context of the increasing integration between HKSAR and Mainland China	**Medium** (medium-term)	**Medium to High** Economic growth in HKSAR would weaken significantly as a result of a sharp economic slowdown in Mainland China. This would have severe consequences for the Hong Kong financial sector. The quality of Hong Kong banks' assets would deteriorate as lower growth adversely affect borrowers'—both Hong Kong and Mainland—capacity to repay. This pressure would be further aggravated by uncertainty about the recovery of collateral in Mainland China. Liquidity in the offshore renminbi market would be negatively affected by a tightening of liquidity in Mainland China.

Table 1. Hong Kong SAR: Risk Assessment Matrix (concluded)

Source of Main Threats	Likelihood of Realization of Threats in the next 1-3 Years	Expected Impact on Financial Stability of Threat if Realized
Significant decline in property prices	**Medium** (short to medium-term)	**Medium to High** This would reduce the collateral value of mortgages, which would curtain the ability of households and small firms to borrow. In the context of a tightening of banks lending standards, this could have severe macroeconomic consequences and adversely affect banks.
Financial stress in the euro area re-emerges	**Medium** (short-term)	**Low** Again, depending on the impact on economic growth in HKSAR, this may also translate into some deterioration of banks' earnings, asset quality, and, possibly, funding costs.

Table 2. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Liquidity

Domain		Assumptions	
		Top-down by FSAP Team (with data input from HKMA)	Top-down by HKMA
1. Institutional Perimeter	Institutions included	• All large locally incorporated, licensed banks (19) and selected foreign branches (8).	• All large locally incorporated, licensed banks (19) and selected foreign branches (8) [for HKMA 7-day test/LOLR analysis (7-day) and (ELST)]. • Selected locally incorporated, licensed banks and foreign branches [for Basel III standard measures LCR and NSFR (B3)]. • All large locally incorporated, licensed banks (17) (all Group 1 banks but without separate treatment of Nanyang Commercial Bank Ltd. and Chiyu Banking Corporation Ltd., which are consolidated under Bank of China (HK)) [for credit-liquidity interaction (Wong-Hui, 2009) (WH)].
	Market share	• 70.9 percent of total banking sector assets	• 70.9 percent of total banking sector assets [for 7-day and ELST]. • About 60 percent of total banking sector assets [for B3]. • 63.0 percent of total banking sector assets [for WH].
	Data and baseline date	• Source: supervisory data from liquidity reporting. • Date: end-June 2013. • Scope: solo basis; only unencumbered liquid assets (generating cash inflows), i.e., that can be sold or used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope").	• Source: supervisory data from liquidity reporting for 7-day and ELST, individual banks' data for B3 and WH. • Date: end-June 2013. • Scope: solo basis (with the exception of consolidated/combined basis for selected locally incorporated, licensed banks for B3 and consolidated basis for WH); only unencumbered liquid assets (generating cash inflows), i.e., that can be sold or used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope").

Table 2. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Liquidity (continued)

Domain		Assumptions	
		Top-down by FSAP Team (with data input from HKMA)	Top-down by HKMA
2. Channels of Risk Propagation	Methodology	• Calculation of FSAP team's 5-day ICF test (cumulative) and 30-day ICF test (non-cumulative), with focus on the sudden, sizeable withdrawal of funding (liabilities) and the sufficiency of existing assets to withstand those shocks under stressed conditions; also maturity mismatch analysis (both local and foreign currencies).	• Calculation of 7-day and ELST, with focus on the sudden, sizeable withdrawal of funding (liabilities) and the sufficiency of existing assets to withstand those shocks under stressed conditions. • Calculation of standard measures for liquidity risk as per Basel Committee on Banking Supervision (BCBS) guidance: definition of LCR as per revised guidance published on January 2013 (BCBS, 2013a) (including assessment of haircuts on liquid assets, assumption on expected and contingent cash in- and outflows), with exception of a higher outflow rate (5 percent instead of a reduced level of 3 percent) for retail "stable deposits" and retail term deposits with tenors beyond 30 days; NSFR based on latest guidance (BCBS, 2010c).[39] • Calculation of expected first cash shortage time, probability of cash shortage), expected default time due to liquidity problems, and PD due to liquidity problems according to the model by Wong and Hui (2009).
3. Risks and Buffers	Risks	• Market liquidity risk (asset amortization, liquidity and encumbrance). • Market funding risk (liabilities run-off). • Maturity-mismatch, rollover risk, and foreign exchange (FX) funding risk [for mismatch analysis].	• Market liquidity risk (asset amortization, liquidity and encumbrance). • Market funding risk (liabilities run-off). • Maturity-mismatch and rollover risk [for NSFR].

[39] This does not include considerations of the revised guidance regarding the calculation of the NSFR (BCBS, 2014).

Table 2. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Liquidity (concluded)

Domain		Assumptions	
		Top-down by FSAP Team (with data input from HKMA)	Top-down by HKMA
	Buffers	• Constant funding structure; no counterbalancing capacity. • Ability to respond to withdrawals and funding needs with access to HKMA/central bank facilities only via collateralized funding.	• Constant funding structure; no counterbalancing capacity. • Ability to respond to withdrawals and funding needs with access to HKMA/central bank facilities only via collateralized funding
4. Tail Shocks	Size of the shock	• Bank run and dry up of retail/wholesale funding markets, taking into account valuation haircuts to liquid assets, amortization of outstanding assets, related party lending, and contingent claims/liabilities. • Very low expected/potential net cash inflows related to credit extension/funding, (i) without liquid financial assets, (ii) with liquid securities and bank loans, (iii) derivatives (excl. credit derivatives), and (iv) committed/uncommitted credit lines to/from related and third parties. • One alternative scenario [for both 5-day and 30-day test], which assumes the absence of a retail deposit run.	• 7-day: Bank run, taking into account haircuts to liquid assets. • ELST: Bank run and dry up of retail/wholesale funding markets, taking into account haircuts to liquid assets, related party lending/borrowing. • One alternative scenario [for ELST], which assumes the absence of a retail deposit run.
5. Regulatory and Market-based Standards and Parameters	Regulatory standards	• n.a. (but cash flow monitoring part of the Basel III liquidity risk framework)	• Basel III ratios: LCR and NSFR.
6. Reporting Format for Results	Output presentation	• Hurdle metrics: distribution of ratios, number of failed banks (i.e., ratio < 100%), liquidity shortfall relative to unencumbered assets.	• Hurdle metrics: distribution of ratios, number of failed banks (i.e., ratio < 100%), liquidity shortfall relative to unencumbered assets.

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
1.Institutional Perimeter	Institutions included	• Selected local banks.	• All large locally incorporated licensed banks (16), excluding those which are subsidiaries of another licensed bank.	• All large locally incorporated licensed banks (19).	• 9 publicly listed, locally incorporated licensed banks.
	Market share	• About 50 percent of total banking sector assets on a consolidated basis (as of end-June 2013).	• 63.0 percent of total banking sector assets on a consolidated basis (as of end-June 2013).	• 58.0 percent of total banking sector assets on a combined basis (as of end-June 2013).	• 53.8 percent of total banking sector assets on a consolidated basis (as of end-June 2013).
	Data and baseline date	• Source: institutions' own granular data. • Date: end-June 2013 (projected to end-2013). • Scope: consolidated banking group.	• Source: institutions' own granular data. • Date: end-June 2013 (projected to end-2013). • Scope: consolidated banking group.	• Source: supervisory data. • Date: end-June 2013 (projected to end-2013). • Scope: combined basis.	• Source: institutions' own granular data and capital market data. • Scope: consolidated banking group.
2.Channels of Risk Propagation	Measurement	• Banks' internal models • BU guidance (IMF, 2011a, 2012a and 2013b). • Valuation haircut model for sovereign risk (Jobst and others, *forthcoming*; IMF, 2013b).	• Balance sheet-based model (IMF, 2010, 2011 and 2012). • Valuation haircut model for sovereign risk (Jobst and others, *forthcoming*; IMF, 2013b).	• Balance sheet-based model (HKMA, 2013).	• Systemic CCA model (Gray and Jobst, 2010; Jobst and Gray, 2013). • Valuation haircut model for sovereign risk (Jobst and others, *forthcoming*; IMF, 2013b).

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
	Satellite Models for Macro-Financial linkages	• Macro-financial linkages estimated based on firm's internal models to forecast the profitability components (interest income, interest expenses, fee/commissions income, trading income and operating expenses) as well as the flow of asset impairments and charge-offs; each material loan category includes an increase of loss-given-defaults (LGDs) under stress according to the increase of default risk (PD), after controlling down-cycle LGDs that are based on a long-term average, i.e., "through the cycle."	• Macro-financial linkages estimated based on dynamic 2SLS panel data regression (using GMM with orthogonal deviations over quarterly observations between 1996: Q1 and 2013: Q2) to forecast the profitability components (interest income, interest expenses, fee/ commissions income, and operating expenses) as well as the flow of asset impairments and charge-offs; each material loan category includes an increase of LGDs under stress according to the increase of default risk (PD), after controlling down-cycle LGDs that are based on a long-term average, i.e., "through the cycle"; the change in trading income was mapped to	• Macro-financial linkages estimated for asset impairments/ charge-offs for certain loan categories ("Nonbank Mainland China Exposures (NBMCE)", other loans (excl. residential mortgages, property investment loans, and credit card lending), and off-balance sheet credit exposures derived from their historical sensitivity to changes in real GDP at specified statistical confidence level; other shocks to default probabilities (for stock-related lending, credit card lending, off-balance sheet derivatives exposures, debt securities) and asset prices by means of statistical mapping to specified historical	• Macro-financial linkages estimated based on dynamic 2SLS panel data regression (→ other TD test by FSAP team) • Key macroeconomic and financial variables include GDP (nominal and real), household income, unemployment, inflation, interest rates/asset swap rates (short-term and long-term), equity prices, commercial property price index, and real estate price index, and were projected using the HKMA's macro model and IMF staff estimates based on G20MOD model. • Cross-border effects are not explicitly considered in any macro scenario but are implicit in

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		• Key macroeconomic and financial variables include GDP (nominal and real), household income, unemployment, inflation, interest rates/asset swap rates (short-term and long-term), equity prices, commercial property price index, real estate price index, and credit growth, and were projected using the HKMA's macro model and IMF staff estimates based on G20MOD model.[40]	nominal GDP growth • Key macroeconomic and financial variables include GDP (nominal and real), household income, unemployment, inflation, interest rates/asset swap rates (short-term and long-term), equity prices, commercial property price index, real estate price index, and credit growth, and were projected using the HKMA's macro model and IMF staff estimates based on G20MOD model.	severity (90th or 99th percentile); expert judgment on other risk factors (interest rate shocks, floors on asset impairments/charge-offs, procyclical impact on credit RWA). • Aggregation of single factor shocks. • Key macroeconomic and financial variables included real GDP for HKSAR and Mainland China, interest rates, equity prices, commercial and residential property price index.	estimated dependence between market-implied expected losses and their impact on capital adequacy.

[40] G20MOD is the IMF's new macroeconomic model, which has been developed to help support the *G20 Mutual Assessment Process*, covering 24 regions—the 19 individual member countries of the G20, the remainder of the euro area, and four additional regions (the non-euro-area members of the European Union, other industrialized countries, oil exporters, and rest of the world). G20MOD is an annual, multi-region, general equilibrium model, which combines both micro-founded and reduced-form formulations of various economic sectors based on a fully articulated demand side and some supply side features. All the model's parameters, except those determining the cost of adjustment in investment, have been estimated using a range of empirical techniques. International linkages are modeled in aggregate for each region. A key feature is the use of overlapping-generations households. This implies that the level of public debt in each country and the resulting implications for national savings determine the global real interest rate in the long run. The rules governing the operation of both monetary and fiscal policy are determined endogenously.

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		• Cross-border effects are considered in all macro scenarios: IMF staff provided estimates for real GDP growth rates consistent with the macroeconomic forecast for HKSAR under both baseline and adverse scenarios for all relevant countries (Mainland China, Australia, France, Germany, India, Japan, South Korea, Singapore, the United Kingdom, and the United States) • Sovereign risk assessed by applying valuation haircuts on all direct and indirect net exposures to sovereign risk (including home country) and financial bonds (i.e., bonded debt issued by financial institutions) in trading book as well as	• Cross-border effects are considered in all macro scenarios: IMF staff provided estimates for real GDP growth rates consistent with the macroeconomic forecast for HKSAR under both baseline and adverse scenarios for all relevant countries (Mainland China, Australia, France, Germany, India, Japan, South Korea, Singapore, the United Kingdom, and the United States). • Sovereign risk assessed by applying valuation haircuts on all direct and indirect net exposures to sovereign risk (including home country) and financial bonds (i.e., bonded debt issued by financial institutions) in trading book as well as	• Cross-border effects are considered in relation to Mainland China: real GDP growth rate for Mainland China is incorporated in projections of loan losses. • Sovereign risk assessed as part of the general credit risk shock to debt securities (securitized and non-securitized).	

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		available-for-sale (AfS) and hold-to-maturity (HtM) assets over the entire time horizon; cash at central banks as well as repos or asset swaps where there is no economic interest in the security (for instance, instruments held against assets pledged to the HKMA) are excluded.	AfS and HtM assets over the entire time horizon; cash at central banks as well as repos or asset swaps where there is no economic interest in the security (for instance, instruments held against assets pledged to the HKMA) are excluded; assumption of exposure-weighted average duration of three years	•	•
	Stress test horizon	• 2014–2018 (five years).	• 2014–2018 (five years).	• 2014–2015 (two years) but single-period set-up.	• 2014–2018 (five years).
3.Tail Shocks	Scenario analysis	• Three different macroeconomic scenarios: (i) a baseline scenario with projections in line with the World Economic Outlook (April 2013); (ii) a "slow growth" scenario, underpinned by a broad-based slowdown of global growth triggered by markets' accelerated view on the pace of tightening in U.S. monetary policy; and (iii) a "severe adverse" scenario, where the contraction of economic activity (ii) is further aggravated by a severe intensification of capital outflows in emerging market countries, impacting Hong Kong's major trading		• Three different macroeconomic scenarios: (i) a baseline scenario with projections and risk parameters in line with those used for the TD solvency by the FSAP team, (ii) Scenario A ("Severe"), and (iii) Scenario B ("More	• Same three macroeconomic scenarios as for the BU and TD tests (→ other TD test by FSAP team).

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		partners. Under the two adverse scenarios, economic growth in HKSAR deteriorates to 2.6 and 2.0 percent on average relative to baseline expectations of average annual growth of 4.4 percent (which is slightly above the long-term (30-year) annual growth rate of 4.1 percent). Overall, the magnitude of these shocks—at cumulative negative deviations of about 9.1 and 12.1 percentage points in real GDP, which equate to about 1.6 and 2.1 standard deviations of the average cumulative two-year growth rate over the last 30 years, respectively—is in line with the spectrum of economic adversity considered in the context of other stress testing exercises.		Severe"), which include single factor shocks to credit losses, market risk (interest rates, equity prices), profitability (net interest income and non-interest income), asset risk-weighting, and interest in land & buildings at the 90 percent (Scenario A) and 99 percent (Scenario B) statistical confidence levels (Table 6).	
	Sensitivity analysis	• FX shock: shock to FX net open positions (both through the P&L and on RWAs): Chinese renminbi, euro, Japanese yen, pound sterling, Singapore dollar, and other material currencies for the firm vis-à-vis the U.S. dollar; for each currency should be four times the maximum deviation of the annualized FX volatility during the 2008–11 period from the long-term FX volatility (>10 years) for the adverse scenarios (not baseline) and impact the trading book in 2014 (100 percent) and 2015 (50 percent) only.		• RWAs increase not only for derivatives but all credit risk-sensitive exposures.	• Variability of statistical confidence level of risk measure. • Quantification of contribution of individual banks to systemic risk

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
4.Risk Factors	Risks/factors assessed	• Credit risk (households and corporates, domestic and foreign exposures, local currency and FX). • Counterparty risk of off-balance sheet exposures in the banking book.[41] • Sovereign risk of *all* government bonds, indirect sovereign exposure as well as all financial bonds. • Funding risk (additional add-on to interest expenses, contingent on Tier 1 capitalization). • Market risk: interest rates and FX. • Tax rate: 16.5 percent.		• Credit risk (loans and advances (incl. NBMCE, residential mortgages and property investment loans, credit card lending, stock-related lending, other loans, off-balance sheet exposures) and debt securities (non-securitization/ securitization). • Market risk: interest rates and equity prices.	• Same three macroeconomic scenarios as for the BU and TD tests (→ other TD test by FSAP team).
	Balance sheet assumption	• Static balance sheet with constant credit growth (i.e., lending and funding increases in line with nominal GDP (if positive)) without changes in the funding structure, subject to a "deleveraging rule" (i.e., credit growth decreases by 2 percentage points for each decrease in		• Static balance sheet without any adjustments.	• Static balance sheet without any adjustments.

[41] In the BU stress test, only counterparty risk to sovereign and financial institutions from on-and off-balance sheet exposures in the both banking and trading book is stressed (i.e., exposures with corporate counterparties are not included).

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		Tier 1 capital by 1 percentage point once the buffer is less than 2.5 percentage points; no asset disposals/ divestments after cut-off date; defaulted loans are *not* replenished.			
	Treatment of Dividends	• Dividend payout is limited if the firm reports profits over the past year (and exhibits sufficient Tier 1 capitalization) but falls below 10.5 percent (which reflects the magnitude of the CAR and "capital conservation buffer" under Basel III); however, firms that are not capital constrained will have to pay out at least 40 percent of earnings after tax each year.	• Dividend payout is limited if the firm reports profits over the past year (and exhibits sufficient Tier 1 capitalization) but CAR falls below a certain threshold (which reflects the average Pillar 2 minimum CAR requirement imposed by the HKMA on the local banks under Basel III and the historical capital buffer of local banks over that requirement (3.2 percent)). Firms that are not capital constrained will have to pay out at least 45 percent of earnings after tax each year. The payout ratio declines by 10 percentage points for each 0.5 percentage point decline in the capital buffer; 100 percent retention if capital buffer is lower than the threshold.		• Dividend payout: discounted from the current share price when deriving implied asset values.
5. Regulatory and Market-based Standards and Parameters	Calibration of risk parameters	• PDs and LGDs: internal models for point-in time-PDs and down-cycle LGDs (or adjustment to long-term average LGDs); in absence of an internal model, LGDs	• PDs and LGDs: PDs (not LGDs) change over time; through-the-cycle PDs based on prudential data and stressed PDs based on the change in the stock of NPLs (via	• Credit loss rates, PDs and LGDs: change in response to shock (either based on estimated sensitivity to macro-financial variables (in the case of NBMCE,	• Market-implied expected losses (with endogenously determined PD and LGD) inform the amount of capital shortfall (if any)

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		increase under stress according to the following specification: LGD(under stress)=0.3502+2.3408*PD. In case of over-collateralization (or supervisory LGDs below the intercept value), the increase of LGDs is limited to the trend coefficient (beta) of the LGD elasticity to PDs, which allows banks to calibrate the LGD at the starting point to their own LGD estimate. • RWAs were estimated in accordance with IRB method under Basel III using through-the-cycle PDs, plus adjustments for loan portfolio concentration and changes in default risk.	satellite model) while provisioning levels at the start of the forecast horizon are maintained. • RWAs were estimated in accordance with AIRB method under Basel III, plus adjustments for loan portfolio concentration and changes in default risk (i.e., RWAs for credit risk are reduced by the RWAs of defaulted exposures, which are assumed to be 2.5 times the average RWAs for non-defaulted exposures (accounting for the fact that risk-weights for defaulted exposures were higher prior to default)).	residential mortgages, property investment loans, and other loans) or historical loss at specified statistical confidence level (for credit card lending, stock related lending, debt securities)). • RWAs for derivatives remain constant under the baseline scenario but increase by 30 and 50 percent under the "severe" and "more severe" scenario, respectively. • Increase in IRB credit RWAs based on IRB banks' historical data and stress test estimates, external data and internal analysis.	for each firm and jointly for the entire sample.

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					

	Regulatory/Accounting and Market-based Standards	• Full Basel III transition schedule.
		• Capital definition according to the Basel III framework; includes phase-in of capital deductions and the phase-out of non-eligible forms of capital, without consideration of grandfathering, during the forecast horizon:
		  • *Phase-in of adjustments to common CET1 capital:* reduction of CET1 capital (such as goodwill, deferred tax assets and minority interests that exceed the permissible limit) deducted at a rate of 20 percent p.a. between 2014 and 2018; in the BU exercise, firms must document deductions if the total amount is less than 20.1 percent (which is the average value for Group 2 (small banks) according to the results from the latest Basel III monitoring exercise as of 30 June 2012 (BCBS, 2013b)).
		  • *Phase-out of non-Tier 1 and Tier 2 capital elements:* the higher of either (i) 10 percent (per annum) of the amount of capital to be phased-out based on results of the quantitative impact study (QIS) (BCBS, 2010) at 16.6 percent (≈1.7 percent p.a.) or (ii) the amount of capital maturing each year of the stress test horizon between 2014 and 2018 (BCBS, 2010a).
			• Basel III hurdle rate for 2015.
			• Capital definition according to the Basel III framework, including phase-in of adjustments to common CET1 capital and phase-out of non-eligible forms of capital, without consideration of grandfathering, during the forecast horizon (same as "Bottom-up by Banks").
			• RWAs:
			  • *RWAs for operational and market risk* remain constant throughout the forecast period.
			  • *RWAs for credit risk* are sensitive to the regulatory impact due to
				• Full Basel III transition schedule.
				• Capital definition according to the Basel III framework.
				• RWAs: not applicable; however, under the concept of market-implied capital adequacy (MCAR) of the Systemic CCA model, the implied asset value of a firm corresponds to Pillar 1 RWAs.

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		• RWAs: • *RWAs for operational risk* remain constant throughout the forecast period. • *RWAs for credit risk and market risk* are sensitive to the regulatory impact due to Basel III based on firm's own data; in addition, credit RWAs are subject to the Basel I floor and sensitive both changes in PDs and portfolio concentration: (a) nonlinear effect of changes in PDs and (b) concentration risk impact on RWAs. • *RWA impact of defaulted loans:* The risk-weights for credit risk are subsequently reduced by the RWAs of defaulted exposures, which are calculated by banks' internal models or approximated by taking 2.5 times the average RWAs for non-defaulted exposures (accounting for the fact that risk-weights for defaulted exposures were higher prior to default).		Basel III and are subject to the Basel I floor. • *RWA impact of defaulted loans:* no replenishment of loan portfolio. • Risk-weighted assets (RWAs): • *RWAs for market and operational risk* remain constant throughout the forecast period. • *RWAs for credit risk change* due to higher PD and LGD for the major asset classes under the IRB approach, and	

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (continued)

Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
				the counterparty risk valuation of OTC derivatives and • *Regulatory impact due to Basel III based on HKMA's own data.*	
6.Reporting Format for Results	Output presentation	• Basel III (Common Equity Tier 1, Tier 1, Total Capital, plus conservation buffer) for each year of the risk horizon. • Firms reported capital adequacy for each year over the forecast horizon based on an output template. In case of a	• Basel III (Common Equity Tier 1, Tier 1, Total Capital, plus conservation buffer) for each year of the risk horizon. • Staff determined capital adequacy for each year over the forecast horizon. In case of a capital shortfall, recapitalization needs were calculated. The major risk drivers (profitability, haircuts on sovereign debt holdings, capital phase-in/phase-out and increases of RWAs according to Basel III) were identified.		• Basel III (Common Equity Tier 1, Tier 1, Total Capital, plus conservation buffer) for each year of the risk horizon.

Table 3. Hong Kong SAR: Stress Test Matrix (STeM) for the Banking Sector—Solvency (concluded					
Domain		Assumptions			
		Bottom-up by Banks (with guidelines by FSAP Team)	Top-down by FSAP Team (balance sheet-based)	Top-down by HKMA (balance sheet-based)	Top-down by FSAP Team (market-based, 'Systemic CCA')
BANKING SECTOR: SOLVENCY RISK					
		capital shortfall, firms calculated the recapitalization needs. Firms reported the major risk drivers (profitability, credit/trading losses, RWAs) and showed the impact of including (i) haircuts on sovereign debt holdings, and (ii) capital phase-in/phase-out according to Basel III			

Table 4. Hong Kong SAR: Financial Soundness Indicators of the Banking Sector, 2007–13

(In percent unless otherwise indicated)

	2007	2008	2009	2010	2011	2012	2013H1
Earnings and profitability 1/							
Return on average assets	1.4	0.6	0.8	0.9	0.8	0.9	1.2
Return on average equity 2/	23.2	13.4	15.4	15.2	15.8	15.3	15.1
Interest margin to gross income	42.8	57.5	47.7	44.0	45.2	47.9	44.2
Interest margin 7/	2.1	2.1	1.6	1.5	1.7	1.9	1.8
Average yield on assets	5.0	3.7	2.2	2.0	2.4	2.6	2.5
Average cost of funding	3.0	1.7	0.6	0.6	0.7	0.7	0.6
Noninterest income to gross income	57.4	46.4	52.8	56.7	55.4	52.9	56.3
Of which: Net fee and commission income 7/	59.5	53.3	44.4	44.1	48.5	46.3	27.4
Noninterest expenses to gross income	46.1	55.7	57.5	57.1	54.8	54.1	46.1
Cost/income ratio	46.7	55.6	58.0	58.1	55.4	54.8	46.5
Structure of assets 1/							
Total assets (in percent of GDP) 9/	627.0	629.8	641.0	691.7	709.8	727.7	704.8
Of which (in percent of total assets):							
Loans to credit institutions	43.6	37.4	35.3	33.7	32.5	29.6	26.2
Loans to customers	28.6	30.6	30.9	34.4	37.0	37.5	39.9
Of which (in percent of total loans):							
Residential real estate loans	19.0	18.0	19.7	17.6	15.8	15.7	14.8
Commercial real estate loans	7.6	8.0	8.1	7.0	6.8	6.6	6.4
FX loans	26.2	28.3	27.0	33.2	37.8	40.1	42.8
Note: FX liabilities (in percent of total liabilities)	55.0	59.6	56.0	59.0	61.1	59.7	60.7
Debt securities	17.2	17.8	23.1	22.5	21.3	21.7	23.1
Equity instruments	1.3	0.9	1.1	1.1	0.9	1.1	1.1
Other assets	9.2	13.3	9.6	8.4	8.3	10.2	9.7
Funding and liquidity (in percent of total assets) 1/							
Debts to credit institutions	28.6	27.4	27.1	30.0	29.3	26.7	26.0
Bank bonds and other debt securities	2.8	1.9	1.2	1.9	3.4	5.1	5.8
Customer deposits	56.7	56.3	60.0	55.8	55.2	55.8	55.5
Of which: Demand deposits 6/	7.9	7.9	11.1	11.7	11.6	13.2	13.3
Saving deposits	27.9	32.3	42.5	42.6	38.4	41.0	39.7
Time deposits	64.2	59.8	46.4	45.8	50.0	45.8	47.0
Liquid assets	29.6	25.9	28.5	24.2	22.3	23.6	21.6
Liquid assets to short term liabilities	53.5	49.9	50.1	43.0	44.0	46.4	43.4
Net open position in foreign exchange to capital 2/ 3/	5.6	7.8	5.6	3.1	2.5	6.6	3.5
Asset quality							
Sectoral distribution of loans (in percent of total loans) 2/ 3/							
HK financial corporations	9.1	8.9	6.0	6.0	5.6	5.3	5.3
HK nonfinancial corporations	64.4	64.9	66.1	63.9	60.8	59.5	60.3
HK other domestic sector	9.4	8.6	8.3	7.3	6.6	6.7	6.4
Non-residents	17.0	17.5	19.5	22.8	27.0	28.5	28.0
Non-performing loans (NPL) as percent of gross loans 5/ 8/	0.7	1.2	1.6	0.8	0.7	0.6	0.5
Provisions as percent of NPL 7/	60	73	63	28	23	27	-
NPL net of provisions as percent of capital 2/ 5/	2.8	3.8	3.6	1.9	1.6	1.4	1.5
Capital adequacy							
Regulatory capital to risk-weighted assets 2/ 4/	13.4	14.7	16.8	15.8	15.8	15.7	15.9
Regulatory Tier 1 capital to risk-weighted assets 2/ 4/	10.4	11.0	12.9	12.2	12.4	13.3	13.1
Capital to assets 2/ 5/	8.5	7.5	8.8	8.6	8.1	8.7	8.8

Sources: Bankscope, HKMA and IMF staff calculations.
Notes: 1/ Calculated for all authorized institutions on HK office basis, unless otherwise indicated.
2/ Locally incorporated authorized institutions.
3/ HK office basis.
4/ Consolidated basis. The "combined basis" of a bank means the position of the bank's Hong Kong office plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries.
5/ Combined basis. The "combined basis" of a bank means the position of the bank's Hong Kong office plus its overseas branches
6/ In percent of total customer deposits. Calculated for licensed banks.
7/ Calculated for Hong Kong's four largest banks on consolidated basis
8/ All authorized institutions
9/ WEO data was used for 2013H1 Hong Kong GDP data.

Table 5. Hong Kong SAR: Economic Activity under Different Scenarios

(annual percentage change, unless otherwise indicated)

		Baseline Scenario					Slow Growth (SG) Scenario					Severe Adverse (SA) Scenario				
	2013 (est.)	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
Economic activity and labor market																
Real GDP	2.96	4.39	4.37	4.46	4.46	4.51	1.78	2.66	2.70	2.99	2.95	1.32	0.63	2.38	2.91	2.84
Nominal household income	4.49	4.67	5.13	4.56	4.69	4.82	1.53	2.62	2.33	1.82	2.06	0.88	0.14	1.38	1.33	1.48
Unemployment rate (% of labor force)	3.30	3.46	3.57	3.70	3.82	3.84	4.15	4.78	5.54	6.18	6.75	4.32	5.54	6.43	7.09	7.69
Price and cost developments																
Consumption prices (average CPI)	3.95	3.67	3.57	3.54	3.53	3.53	3.09	2.21	1.81	1.65	1.58	3.04	1.59	0.82	0.91	1.05
Residential house prices	7.97	-1.68	-0.70	-1.20	-1.49	3.28	-9.54	-6.10	-6.51	-6.24	-1.84	-11.97	-12.58	-7.06	-5.98	-1.97
Commercial real estate prices	-1.15	-9.35	-0.26	2.03	1.98	7.95	-17.05	-7.19	-4.99	-3.69	1.20	-19.26	-14.47	-6.96	-3.47	1.02
Equity market index (Hang Seng index)	7.00	8.06	7.94	8.00	8.00	8.04	-13.95	-9.13	-9.39	-7.89	-8.32	-16.42	-20.00	-11.13	-8.28	-8.89
Interest rates																
3-month U.S. Treasury rate	0.10	0.17	0.13	0.26	0.46	0.57	0.10	0.20	0.90	2.10	3.10	0.35	0.53	1.23	2.43	3.90
Time deposit rate (%)	0.15	0.22	0.18	0.31	0.51	0.62	0.15	0.25	0.95	2.15	3.15	0.40	0.58	1.28	2.48	3.95
3-month HIBOR rate (%)	0.38	0.41	0.51	0.62	0.72	0.82	0.66	1.10	2.24	3.39	4.53	0.66	1.10	2.24	3.39	4.53
12-month HIBOR rate (%)	0.87	1.00	1.10	1.20	1.30	1.40	1.25	1.68	2.84	3.99	5.15	1.25	1.68	2.84	3.99	5.15
Best lending rate (%)	5.00	5.00	5.10	5.20	5.30	5.40	5.20	5.57	5.94	6.31	6.68	5.12	5.41	5.71	6.00	6.30
Memo item																
Real GDP (P.R. China)	7.80	7.70	7.60	7.50	7.50	7.50	5.60	5.52	6.96	7.50	7.44	5.23	3.73	6.32	7.32	7.27

Sources: HKMA and IMF staff estimates and calculations. Note: Interest rates shown for 2013 above are recorded as of end-June 2013.

Table 6. Hong Kong SAR: HKMA Solvency Top-down Stress Test-Detailed Assumptions (Scenario Analysis)

	Scenario		
	More severe	**Severe**	**Baseline**
Credit Risk			
Non-bank Mainland China exposures	99% confidence level according to GDP-based model (with floor at 4.0%)	90% confidence level according to GDP-based model (with floor at 2.0%)	0.3% (according to GDP-based model with the baseline scenario same as IMF TD solvency test)
RML & property investment loans	1.24%	0.50%	0.01%
Other loans	99% confidence level according to GDP-based model (with floor at 3.0%)	90% confidence level according to GDP-based model (with floor at 1.8%)	0.17% (according to GDP-based model with the baseline scenario same as IMF TD solvency test)
Off-balance sheet exposures	drawdown rate of 20%; same loss rate as for "other loans"	drawdown rate of 15%; same loss rate as for "other loans"	drawdown rate of 10%; same loss rate as for "other loans"
Debt securities - securitization/non-securitization	99th percentile historical loss rate based on Moody's data	90th percentile historical loss rate based on Moody's data	latest available two-year loss rates provided by Moody's reports
Credit card lending	99th percentile of individual banks' historical loss (floor at 99th percentile of industry's historical loss (20.9%))	90th percentile of individual banks' historical loss (floor at 90th percentile of industry's historical loss (18.8%))	50th percentile of individual banks' historical loss
Stock-related exposures			
investment in listed shares	99th percentile of max drop in HSI within two yrs (-59.6%)	90th percentile of max drop in HSI within two yrs (-47.4%)	+16.64% (according to the baseline scenario same as IMF TD solvency test)
IPO margin lending	3.00%	1.00%	0.0%
Non-IPO margin lending	4.09%	1.55%	0.0%
Other loans to stock brokers	99th percentile of individual banks' historical loss (floor at 99th percentile of industry's historical loss (3.5%))	90th percentile of individual banks' historical loss (floor at 90th percentile of industry's historical loss (2.0%))	50th percentile of individual banks' historical loss
Other loans to non-stock brokers	99th percentile of individual banks' historical loss (floor at 99th percentile of industry's historical loss (2.3%))	90th percentile of individual banks' historical loss (floor at 90th percentile of industry's historical loss (0.4%))	50th percentile of individual banks' historical loss
Asset Prices			
Property prices	-50%	-30%	- 6% (according to the baseline scenario same as IMF TD solvency test)
HKD interest rate	Best lending rate: +400bps savings deposit rate: +400bps time deposit rate: +500bps HIBOR: +500bps	Best lending rate: +200bps savings deposit rate: +200bps time deposit rate: +250bps HIBOR: +250bps	Best lending rate: +10bps savings deposit rate: +0bps time deposit rate: +3bps HIBOR: +18bps (according to the baseline scenario same as IMF TD solvency test)
Profitability elements and other			
Net interest income	the worse of -5% or individual banks' decrease in 97/98	the worse of -3% or individual banks' decrease in 97/98	Projected figures by individual banks
Non-interest income	the worse of -20% or individual banks' decrease in 97/98	the worse of -10% or individual banks' decrease in 97/98	Projected figures by individual banks
Procyclical effect	(IRB banks only) Overall credit RWA under IRB: ~ +35%	(IRB banks only) Overall credit RWA under IRB: ~ +25%	Increase of RWA for credit risk: +17% (according to the credit growth projection under the baseline scenario same as IMF TD solvency test)
Derivatives	RWA +50%	RWA +30%	RWA +0%
Dividend payout	Dividend payout is limited if the firm reports profits over the past year (and exhibits sufficient Tier 1 capitalization) but CAR falls below a certain threshold (which reflects the average Pillar 2 minimum CAR requirement imposed by the HKMA on the local banks under Basel III and the historical capital buffer of local banks over that requirement (3.2 percent)). Firms that are not capital constrained will have to pay out at least 45 percent of earnings after tax each year. The payout ratio declines by 10 percentage points for each 0.5 percentage point decline in the capital buffer; 100 percent retention if capital buffer is lower than the threshold.		
Basel III capital definition (phase-in/phase-out)	according to reported values in line with Basel III transition schedule		

Table 7. Hong Kong SAR: Liquidity Stress Test—Maturity Mismatch Analysis

Maturity tenor	Maturity Mismatch (In percent of assets in each "maturity term bucket")					
	less than 1 week	more than 1 week but less than 1 month	within 1-3 months	within 3-6 months	between 6-12 months	after 12 months
	Total Balance Sheet (All Currencies)					
All sample firms (27)	—	10.59	12.1	13.0	20.5	67.7
Local banks (Group 1) (19)	—	15.75	19.7	16.9	31.0	82.8
Foreign branches (Group 2) (8)	—	—	—	—	—	—
	FX Balance Sheet					
All sample firms (27)	0.81	13.97	14.4	5.7	11.3	15.6
Local banks (Group 1) (19)	1.03	20.41	21.3	9.2	20.1	25.6
Foreign branches (Group 2) (8)	—	—	—	—	—	—

Sources: HKMA and IMF staff estimates and calculations.

Table 8. Hong Kong SAR: Systemic Contingent Claims Approach—Comparison of Total Assets for Locally Incorporated Licensed Banks ("Local Banks") and Respective Listed Entities

(In millions of HKD, end-June 2013)

	Total assets of listed entity	Total assets of local bank	Share of local bank*
Bank of China (Hong Kong) Ltd.	17,116,824	1,764,584	10.3
Bank of East Asia, the Ltd.	697,433	697,433	100.0
Chong Hing Bank Ltd.	81,664	81,664	100.0
Fubon Bank (Hong Kong) Ltd.	1,122,118	68,029	6.1
Hang Seng Bank, Ltd.	1,106,657	1,106,657	100.0
HSBC Ltd.	20,518,393	4,874,703	23.8
Industrial and Commercial Bank of China (Asia) Ltd.	23,546,258	523,797	2.2
Standard Chartered Bank (Hong Kong) Ltd.	5,041,391	992,434	19.7
Wing Hang Bank, Ltd.	201,104	201,104	100.0

Sources: Bloomberg, Bankscope and IMF staff calculations.
Notes: * The share of the locally incorporated bank ("local bank") serves as scaling factor for the implied assets derived from the equity price and the implied equity volatility as inputs to the estimation of market-implied expected losses within the SCCA framework. A similar scaling is applied to adjusted liabilities as default barrier (Jobst and Gray, 2013). Note that the amount of total assets shown for HSBC as locally incorporated bank excludes Hang Seng Bank Ltd.

Table 9. Hong Kong SAR: Overview of Sample Banks in the Solvency and Liquidity Stress Testing Exercise (as of end-June 2013)

Bank Name	SOLO BASIS			COMBINED BASIS			CONSOLIDATED BASIS			Basel II approach for credit risk (IRB or Standard) [Group 1]	Solvency			Liquidity 3/	
											TD IMF balance sheet-based, consolidated basis 1/	TD HKMA balance sheet-based, combined basis 1/	TD IMF Systemic CCA, market-based 2/	TD HKMA-IMF Implied Cash Flow 4/	TD HKMA Solvency-Liquidity Linkage 5/
	TOTAL ASSETS *(In million HKD)*	% of peer group	% of banking sector	TOTAL ASSETS *(In million HKD)*	% of peer group	% of banking sector	TOTAL ASSETS *(In million HKD)*	% of peer group	% of banking sector						
Group 1: Locally incorporated, licensed banks (19)															
Hong Kong and Shanghai Banking Corporation (HSBC) Ltd.	—	—	—	—	—	—	5,981,060	51.1%	32.2%	IRB	x	x	x*	x	x
Bank of China (Hong Kong) Limited	—	—	—	—	—	—	1,764,584	15.1%	9.5%	IRB	x	x	x*	x	x
Hang Seng Bank Ltd. (→ HSBC)	—	—	—	—	—	—	1,106,657			IRB	x##	x	x	x	x
Standard Chartered Bank (Hong Kong) Ltd.	—	—	—	—	—	—	992,434	8.5%	5.3%	IRB	x	x	x*	x	x
Bank of East Asia, Limited (The)	—	—	—	—	—	—	697,433	6.0%	3.8%	IRB	x	x	x	x	x
Industrial and Commercial Bank of China (Asia) Ltd.	—	—	—	—	—	—	523,797	4.5%	2.8%	Std	x	x	x*	x	x
DBS Bank (Hong Kong) Ltd.	—	—	—	—	—	—	296,400	2.5%	1.6%	IRB	x	x	—	x	x
Nanyang Commercial Bank Ltd. (→Bank of China)	—	—	—	—	—	—	265,366			IRB	x#	x	—	x	x#
China Construction Bank (Asia) Corporation Ltd.	—	—	—	—	—	—	220,489	1.9%	1.2%	Std	x	x	—	x	x
Wing Lung Bank Ltd.	—	—	—	—	—	—	210,936	1.8%	1.1%	Std	x	x	—	x	x
Wing Hang Bank Ltd.	—	—	—	—	—	—	201,104	1.7%	1.1%	Std	x	x	x	x	x
China Citic Bank International Ltd.	—	—	—	—	—	—	186,196	1.6%	1.0%	Std	x	x	—	x	x
Dah Sing Bank Ltd.	—	—	—	—	—	—	160,967	1.4%	0.9%	Std	x	x	—	x	x
Citibank (Hong Kong) Ltd.	—	—	—	—	—	—	141,164	1.2%	0.8%	Std	x	x	—	x	x
Shanghai Commercial Bank Ltd.	—	—	—	—	—	—	136,492	1.2%	0.7%	Std	x	x	—	x	x
Chong Hing Bank Ltd.	—	—	—	—	—	—	81,664	0.7%	0.4%	Std	x	x	x	x	x
Fubon Bank (Hong Kong) Ltd.	—	—	—	—	—	—	68,029	0.6%	0.4%	Std	x	x	x*	x	x
Chiyu Banking Corporation Ltd. (→ Bank of China)	—	—	—	—	—	—	48,007			IRB	x#	x	—	x	x#
Public Bank (Hong Kong) Ltd.	—	—	—	—	—	—	36,619	0.3%	0.2%	Std	x	x	—	x	x
Subtotal (w/o subsidiaries)	**8,339,750**	**100.0%**	**54.7%**	**9,553,539**	**100.0%**	**58.0%**	**11,699,367**	**100.0%**	**63.0%**		**63.0%**	**58.0%**	**53.8%**	**54.7%**	**63.0%**
Group 2: Foreign branches (8) 6/															
Bank of Communications Co. Ltd.	405,119.0	16.4%	2.7%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
China Construction Bank Corporation	367,521.2	14.9%	2.4%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Bank of Tokyo-Mitsubishi UFJ Ltd. (The)	330,882.8	13.4%	2.2%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Agricultural Bank of China Ltd.	327,630.6	13.3%	2.1%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Citibank, N.A.	308,902.6	12.5%	2.0%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Mizuho Corporate Bank Ltd.	292,372.3	11.9%	1.9%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Sumitomo Mitsui Banking Corporation	238,735.1	9.7%	1.6%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
BNP Paribas	194,553.8	7.9%	1.3%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		—	—	—	x	—
Subtotal	**2,465,717**	**100.0%**	**16.2%**	**2,465,717**	**100.0%**	**15.0%**	**2,465,717**	**100.0%**	**13.3%**		—	—	—	**16.2%**	—
Total sample	**10,805,468**	**—**	**70.9%**	**12,019,257**	**—**	**73.0%**	**14,165,085**	**—**	**76.2%**		**63.0%**	**58.0%**	**53.8%**	**70.9%**	**63.0%**
Memo items															
Other 7/															
Locally incorporated institutions (39)	131,042.1	**3.0%**	**0.9%**	131,042.1	**3.0%**	**0.8%**	106,458.9	**2.4%**	**0.6%**						
Foreign branches (133)	4,309,458.5	**97.0%**	**28.3%**	4,309,458.5	**97.0%**	**26.2%**	4,309,458.5	**97.6%**	**23.2%**						
- License banks (125)	4,275,284.4	**96.3%**	**28.0%**	4,275,284.4	**96.3%**	**26.0%**	4,275,284.4	**96.8%**	**23.0%**						
- Restricted license banks (8)	34,174.1	**0.8%**	**0.2%**	34,174.1	**0.8%**	**0.2%**	34,174.1	**0.8%**	**0.2%**						
Total system	**15,245,968.1**	**100.0%**	**100.0%**	16,459,757.2	**100.0%**	**100.0%**	18,581,002.3	**100.0%**	**100.0%**						

Sources: Banks' disclosure statements, HKMA, and IMF staff calculations.

Notes: The subsidiaries of HSBC and Bank of China in Group 1 are shown separately but are excluded from the reported sample coverage on a consolidated basis in order to avoid double-counting.

1/ The "combined basis" of a bank means the position of the bank's Hong Kong office plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries; reporting on a solo basis refers to the operations of the Hong Kong office only. The consolidated reporting of the TD stress test includes the banks marked (#) and (##) for subsidiaries of Bank of China (HK) and HSBC Ltd., respectively;

2/ Based on Jobst and Gray (2013). Banks marked (*) are subject to an adjustment of their market-implied asset value/asset volatility as the equity price/equity volatility relates to the group-wide performance (which is dominated by activities outside HKSAR);

3/ Apart from the ICF tests and solvency-liquidity linkage analysis, the Basel III standard liquidity measures (LCR and NSFR) are calculated for the purpose of analysing the banking sector's liquidity conditions. It covers a selection of locally incorporated banks on a consolidated and/or combined basis, and foreign branches on a solo basis, which in aggregate accounts for about 60 percent of the banking sector in terms of total assets;

4/ This part of the liquidity stress test includes approaches by both the HKMA and the IMF on a solo basis;

5/ Banks liquidity conditions are tested on a consolidated basis using a pre-defined set of credit and market risk shocks affecting their solvency condition, based on Wong and Hui (2009). Bank of China's consolidated reporting includes the two banks marked (#) while HSBC's consolidated reporting for this test excludes Hang Seng Bank (##), which has been tested separately.

6/ Foreign branches are also referred to as "non-locally incorporated, licensed banks";

7/ The number in parentheses indicates the number of firms in each category, which have been excluded from the stress test;

8/ The 39 locally incorporated institutions comprise two locally incorporated licensed banks, 13 restricted license banks, and 24 deposit-taking companies. Since six deposit-taking companies are subsidiaries of the locally incorporated licensed banks in Group 1, these subsidiaries' assets are removed from the total consolidated firms outside the scope of the stress test.

Table 10. Hong Kong SAR: Overview of Risk Approaches (Basel II) of Sample Banks in TD Solvency Stress Test (as of end-June 2013)

Bank Name	CREDIT RISK 1/							MARKET RISK	OPERATIONAL RISK
	Overall (dominant approach)	Sovereign	Banks/ Institutions	Corporate	Retail	Securitization 2/	Other Exposures		
Hong Kong and Shanghai Banking Corporation (HSBC) Ltd.	AIRB	AIRB	AIRB	AIRB	AIRB	AIRB	AIRB	IM/SA	TSA
Hang Seng Bank Ltd. (→ HSBC)	AIRB	AIRB	AIRB	AIRB	AIRB	-	AIRB	IM/SA	TSA
Bank of China (Hong Kong) Limited	FIRB	Std	FIRB	FIRB	FIRB	FIRB	FIRB	IM/SA	TSA
Nanyang Commercial Bank Ltd. (→ Bank of China)	FIRB	Std	FIRB	FIRB	FIRB	-	FIRB	IM/SA	TSA
Chiyu Banking Corporation Ltd. (→ Bank of China)	FIRB	Std	FIRB	FIRB	FIRB	-	FIRB	IM/SA	TSA
Standard Chartered Bank (Hong Kong) Ltd.	AIRB	AIRB	AIRB	AIRB	AIRB	AIRB	AIRB	SA	TSA
Bank of East Asia, Limited (The)	FIRB	Std	FIRB	FIRB	FIRB	-	FIRB	IM/SA	TSA
Industrial and Commercial Bank of China (Asia) Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
DBS Bank (Hong Kong) Ltd.	FIRB	FIRB	FIRB	FIRB	FIRB	-	FIRB	SA	TSA
China Construction Bank (Asia) Corporation Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Wing Lung Bank Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Wing Hang Bank Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
China Citic Bank International Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Dah Sing Bank Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Citibank (Hong Kong) Ltd.	Std	Std	Std	Std	Std	Std	Std	SA	TSA
Shanghai Commercial Bank Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Chong Hing Bank Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Fubon Bank (Hong Kong) Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA
Public Bank (Hong Kong) Ltd.	Std	Std	Std	Std	Std	-	Std	SA	BIA

Source: HKMA. Notes: credit risk: Std = standardized approach, IRB = internal rating-based (FIRB = foundation IRB, AIRB = advanced IRB) approach; market risk: IM = internal models approach, SA = standardized approach, IM/SA = mixed approach; operational risk: BIA = basic indicator approach, TSA = traditional standardized approach.
1/ Banks using IRB approach for credit risk have some of their exposures subject to the standardized approach; however, the IRB coverage ratio of most IRB banks exceeds 90 percent on a consolidated basis, so the exclusion of these exposures from a particular reporting will not have significant effect on the result;
2/ Some banks do not have exposures to structured finance/securitization transactions.

Table 11. Hong Kong SAR: Supervisory Stress Tests: Implied Cash Flow and Credit/Market Risk Linkages of Liquidity Conditions

	Test	Definition	Basic Assumptions		Other Assumptions
			Asset Side (cash inflows)	Liabilities (cash outflows)	
IMF	**5-day implied cash flow (ICF) test**	cumulative inflow and outflow over 5 consecutive days	liquid financial assets: (i) cash and cash balances with central banks [**haircut**: 0 percent], (ii) securities and bank loans eligible at major central banks/HKMA [0-15], (iii) securities and bank loans which can be mobilized in repo transactions (or another type of lending against financial collateral) [5-30], and (iv) marketable securities [10-35]; cumulative cash inflows: (i) expected cash inflows related to credit extension without liquid financial assets as collateral [**call-back rate**: 20 percent per day], (ii) expected inflows of cash and liquid assets related to maturing transactions with liquid securities and bank loans (e.g., repo and securities lending transactions) [20], (iii) expected and potential net cash flows related to derivatives (excl. credit derivatives) – net contractual cash flows [20], and (iv) potential inflows from committed/uncommitted credit lines to related and third parties [5/3].	cumulative cash outflows: (i) maturing and non-maturity funding without liquid financial assets as collateral [**discount factor**: 5 percent per day] (i.e., all deposits and funding from financial and non-financial corporates as well as private households and SME clients) with the exception of sovereign and other public sector and central bank clients [0], (ii) expected outflows of cash and liquid assets related to transactions with liquid securities and bank loans (e.g., reverse repo and securities borrowing transactions) [20], (iii) maturing outflows to related parties [20], and (iv) committed/uncommitted contingent claims to related and third parties [5].	A ratio lower than 100 percent implies a liquidity shortage if the stress scenario would materialize at the reporting date (i.e., potentially required liquidity > potentially available liquidity); only *unencumbered* liquid assets (generating cash inflows), i.e., assets used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope"); new unsecured financing and securitization impossible within the time horizon; no offsetting cash inflows from new or renewed (secured/unsecured) wholesale lending (at contractual maturities) but full renewal of secured retail lending (e.g., secured lending with illiquid collateral (residential mortgages)); central bank eligible collateral can be monetized at appropriate haircuts; repo markets are open at appropriate haircuts; fire-sale of assets possible at appropriate haircuts; no consideration of funding via potentially re-usable securities received as collateral ("rehypothecation"); limited potential unsecured support in convertible currencies from related and third parties (e.g., in the form of committed lines); no renewal of term retail and wholesale deposits; and full convertibility between currencies (within one week).
	30-day implied cash flow (ICF) test	non-cumulative	liquid financial assets: (i) cash and cash balances with central banks [0], (ii) securities and bank loans eligible at major central banks/HKMA [0-20], (iii) securities and bank loans which can be mobilized in repo transactions (or another type of lending against financial collateral) [10-60], and (iv) marketable securities [20-70]; non-cumulative cash inflows: (i) expected cash inflows related to credit extension without liquid financial assets as collateral [100], (ii) expected inflows of cash and liquid assets related to maturing transactions with liquid securities and bank loans (e.g., repo and securities lending transactions) [100], (iii) expected and potential net cash flows related to derivatives (excl. credit derivatives) – net contractual cash flows [100], and (iv) potential inflows from committed/uncommitted credit lines to related and third parties [23/12].	non-cumulative cash outflows: (i) maturing and non-maturity funding without liquid financial assets as collateral [10-75] (i.e., all deposits and funding from financial and non-financial corporates as well as private households and SME clients) with the exception of sovereign and other public sector and central bank clients [0], (ii) expected outflows of cash and liquid assets related to transactions with liquid securities and bank loans (e.g., reverse repo and securities borrowing transactions) [100], (iii) maturing outflows to related parties [100], and (iv) committed/uncommitted contingent claims to related and third parties [23].	
HKMA	**7-day deposit run-off and LOLR analysis**	non-cumulative	liquid financial assets: (i) Exchange Fund bill and notes (EFBNs) [**haircut:** 5 percent], (ii) negotiable certificates of deposit (NCDs) and negotiable debt instruments (NDIs) (excl. EFBNs as well as acceptance and bills of exchange) [40], (iii) banker's acceptance and bills of exchange accepted/payable by other banks [40], and (iv) HKMC-conforming mortgages [20]; non-cumulative cash inflows: (i) net due from unconnected banks within one month [**call-back rate:** 40 percent], (ii) loans and advances due within one month [15], and (iii) revocable/irrevocable standby facilities [50/100]; other assets eligible for obtaining LOLR facilities: (i) interbank placements longer than one month [5-15 by currency], (ii) not HKMC-conforming but LOLR-compliant mortgages [5-20 by type].	non-cumulative outflows: (i) retail deposits [**discount factor**: 2 percent per day] and (ii) wholesale deposits [3], which results in an average overall (non-cumulative) deposit outflow of 17 percent in 7 days.	A ratio lower than 100 percent implies a liquidity shortage if the stress scenario would materialize at the reporting date (i.e., potentially required liquidity > potentially available liquidity); only unencumbered liquid assets (generating cash inflows), i.e., assets used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope"); the analysis is largely based on supervisory data collected from the regulatory return on assets and liabilities, and a template for collecting information on banks' assets available to support LOLR facility; deposit outflow assumption reflects actual bank-run experience in times of stress; does not take into account non-deposit wholesale funding run-off;-net cash shortfall would be covered by the liquidity buffer via LOLR-eligible assets after application of assigned
	Enhanced liquidity stress test (ELST)	non-cumulative	liquid financial assets: (i) negotiable certificates of deposit (NCDs) and negotiable debt instruments (NDIs) held [20], and (ii) banker's acceptance and bills of exchange accepted/payable by other banks [40]; non-cumulative cash inflows: (i) due from connected/unconnected banks within three months [80], (ii) loans and advances due within one month [20], and (iii) revocable/irrevocable standby facilities [50/100].*	non-cumulative outflows: (i) LCR QIS-consistent deposit run-off for retail/other banks [floor at 20/30], (ii) NCDs and NDIs outstanding and due within three months [50], and (iii) due to connected/unconnected banks within three months [50].*	A ratio lower than 100 percent implies a liquidity shortage if the stress scenario would materialize at the reporting date (i.e., potentially required liquidity > potentially available liquidity); only unencumbered liquid assets (generating cash inflows), i.e., assets used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope"); the analysis is based on supervisory data collected from the regulatory return on assets and liabilities; uses LCR QIS deposit run-off assumptions + floor; takes into account non-deposit wholesale funding, including related party funding (but without differentiating treatment).
	Liquidity stress test with shocks to market and credit risk	cumulative inflow and outflow over a one-year horizon	Liquid financial assets: MtM losses of financial assets are simulated statistically based on assumed distributions of relevant risk factors, which erode banks' ability to generate liquidity by selling financial assets over a one-year stress horizon. At the 90th percentile, the credit spreads of corporate bonds with credit ratings of 'AA' or higher, 'A' and 'BBB' rise by around 0.4 percent, 1.7 percent and 1.74 percent, respectively. Those corporate bonds with speculative grade ratings or unrated rise by around 10.5 percent. The market value of equities and that of structured financial assets decline by 27 percent and 32 percent, respectively. The scenario assumes an interest rate hike by around 125 basis points. cash inflows: cash inflows from income reduce by 10 percent.	cash outflows: both retail and wholesale deposit outflow rates are determined by the endogenously determined default risk of banks. The maximum monthly run-off rate for retail deposits is 42 percent, while that for wholesale deposits is 100 percent. 15 percent of committed credit lines are assumed to grant to SIVs, and the drawdown rate is assumed to be negatively correlated with asset prices. Cash outflows from other liabilities are assumed to follow their contractual maturities.	The classified loan ratio of banks increases by 200 basis points. The framework assumes no risk mitigation measure by parent banks and the central bank in the stress horizon. Banks are counterfactually assumed to manage their investment portfolios passively amid the shocks. The retail deposit runoff rate does not take into account the potential benefits from Hong Kong's enhanced deposit protection 2011. The correlations between the risk-free interest rate and credit spreads are assumed to be zero.

Notes: HKMC=The Hong Kong Mortgage Corporation Limited; (*) when the ELST is completed for each currency separately, the HKMA applies a call-back/run-off rate of 80/50 percent to cash in-/outflows due to funding swaps (if net liabilities/net assets).

Table 12. Hong Kong SAR: Basel III Liquidity Risk Framework: Standard Measures (LCR and NSFR)

Test	Definition	Proposed Basel III Standard Measures		Other Assumptions
		Asset Side (cash inflows)	Liabilities (cash outflows)	
Liquidity Coverage Ratio (LCR): short-term resilience to potential liquidity disruptions [revised version, Jan. 2013] — *adapted to liquidity reporting by banks to HKMA (based on current consultation paper issued in July 2013) (HKMA, 2013)*	Stock of high-quality liquid assets that would need to cover 30-day net cash outflows	assets that remain liquid under stress: (i) cash and central bank reserves [**haircut**: 0]; (ii) sovereign, central bank, public sector entities (PSE), multilateral development banks (MDB) and other institutions debt securities qualifying for 0 percent risk-weighting [haircut: 0]; (ii) high-quality corporate bonds and covered bonds (rated 'AA-' and higher) [15]; (iii) corporate bonds (rated 'A+' to 'BBB-') [50]; (iv) sovereign, central bank, PSE and MDB debt securities qualifying for 20 percent risk-weighting [15]; (v) high-quality RMBS (rated AA or higher) [25]; and (vi) common equity shares [50]. non-cumulative cash inflows: (i) secured lending back by Level 1, Level 2A, Level 2B RMBS, level 2B non-RMBS or other assets [**call-back rate**: 0/15/25/50/100]; (ii) unsecured contractual inflows based on given maturities from financials/other counterparties [100/50]; (iii) operational deposits held at other financial institutions [0]; (iv) other contractual cash inflows [100].	non-cumulative cash outflows: (i) term deposits from retail and small business customers with residual maturity > 1 month [5]; (ii) stable deposits from retail and small business customers [5]; (iii) less stable deposits from retail and small business customers [10]; (iv) unsecured insured/uninsured wholesale funding from financial and non-financial institutions with operational relationships [5/25]; (v) unsecured insured/uninsured non-operational funding from non-financial institutions [20/40]; (vi) unsecured non-operational funding from financial institutions [100]; (vii) secured funding back by level 1 assets or conducted with central bank [0]; (viii) other secured funding backed by Level 2A, Level 2B RMBS, level 2B non-RMBS or other assets [15/25/50/100]; (ix) market value change of non-level 1 assets posted for derivative transactions [20]; (x) other collateral-related liquidity needs [100]; (xi) other derivative-related liquidity needs [100]; (xii) committed credit and liquidity facilities to retail and small business customers [5]; (xiii) committed credit facilities to non-financial institutions [10]; (xiv) committed liquidity facilities to non-financial institutions [30]; (xv) credit/liquidity facilities to banks [40]; (xvi) credit facilities to non-bank financial institutions [40]; (xvii) liquidity facilities to non-bank financial institutions [100], (xviii) non-contractual obligations from customer short position [50]; (xix) other contractual cash outflows [100]	No consideration of access to HKMA liquidity via the LOLR facility on the basis of non-LCR asset buffer eligible high-quality liquid assets (HQLAs); in line with the general requirements of the LCR, cash inflows are capped at 75 percent of cash outflows; Level 2A and Level 2B liquid assets are limited to 40 percent and 15 percent of the total HQLA stock, respectively; draw-down rate for interbank credit and liquidity facilities strictly follow BCBS parameters. The HKMA interpretation of the LCR ratio for elements within national discretion/restrictions beyond the minimum requirements set forth by BCBS: (i) standard assumption of 5 percent run-off rate for retail stable deposits under the LCR (no application of decreased 3 percent run-off rate for retail deposits in the presence of a robust deposit protection scheme); (ii) 5 percent run-off rate for retail term deposits > 30 days (instead of 0 percent); (iii) no inflow from new or the renewal of interbank lending in times of stress; and (iv) no reinvestment assumption for assets (not required by BCBS), except for inflow rates for retail, SME and non-financial corporate loans [50].
Net Stable Funding Ratio (NSFR)—long-term structural ratio to address liquidity mismatches	Amount of available stable funding to exceed the level of required stable funding	required stable funding (RSF): (i) cash, unencumbered or encumbered for < 1 year, short-term unsecured instruments and transactions with remaining maturity < 1 year: securities with offsetting reverse repo, non-renewable loans to financials with maturity < 1 year, and securities with maturity < 1 year and items deducted from Tier 1 and Tier 2 capital [0]; (ii) unencumbered or encumbered for < 1 year: Level 1 assets with maturity > 1 year [5]; (iii) unencumbered or encumbered for < 1 year: Level 2A assets with maturity > 1 year [20]; (iv) unencumbered or encumbered for < 1 year: corporate bonds and covered bonds, rated 'A+' to 'A-' and maturity > 1 year [50]; (v) unencumbered or encumbered for < 1 year: loans to non-financial sector with maturity < 1 year [50]; (vi) unencumbered or encumbered for < 1 year: listed equities and gold [50]; (vii) unencumbered or encumbered for < 1 year: residential mortgages of any maturities and other loans with maturity > 1 year that would qualify for 35 percent risk weight or lower [65]; (viii) unencumbered or encumbered for < 1 year: other loans to retail clients and small business customers with maturity < 1 year [85]; (ix) net derivative receivables and all other assets [100]; (x) conditionally revocable and irrevocable credit and liquidity facilities [5]; and (xi) other off-balance sheet items [0].	available stable funding (ASF): (i) capital and long-term debt (> 1 year) [100], (ii) 'stable deposits' of retail and small business customers (< 1 year) [90], (iii) 'less stable' deposits of retail and small business customers (< 1 year) [80], (iv) unsecured wholesale funding provided by non-financials (< 1 year) and secured borrowings and liabilities from central banks, sovereigns, PSEs or MDBs [50], and (v) all other liabilities [0].	No inflows of interbank lending in times of stress; no consideration of access to HKMA liquidity on the basis of non-eligible assets. HKMA strictly follows the BCBS (2010) version to calculate banks' NSFR.

Note: 1/ This defintion does not consider the latest consultation round of the Basel Committee on the NSFR (BCBS, 2014).

Table 13. Hong Kong SAR: Summary of Satellite Model Estimation (IMF TD Solvency Approach)

Dependent Variable	**Lagged Term**	**Total assets** (logarithm of total assets)	**Equity to total assets** ("leverage ratio")	**Total customer loans** to total assets in %	**Funding gap** (customer loans and eposits / total assets)	**Real GDP growth (y-o-y)**	**Nominal GDP growth (y-o-y)**	**3-month interest rate**	**12-month interest rate**	**Best Lending Rate**	**Time deposit rate**	**Equity price index**	**Commercial property prices**	**Constant**
Change (Δ) in interest Income to total assets in %	-***	+***	-***	-***			+(-1)***	+*** +(-1)***	+(-1)** +(-2)***	+***				-***
Δinterest expenses to total assets in %	-**	+***	-***		+***		+(-1)***	+***			+(-1)***			-***
Δnet fee and commission income to total assets in %	-***						+***					+***		-
Δoperating expenses to total assets in %	-***													-***
Δstock of loan loss provisions to customer loans in %	+*					- (-1) ***							-*** -(G)**	+***
Δflow of loan loss provisions to customer loans in %	-***					-*** -(G)*							-***	+**
Δnon-performing loans to customer loans in %	+***					-*** +(G)*		+(-1)***					- (-1)***	+**
Δtotal customer loans to total assets in %	+					+(-1)*** - (G)(-1)***							+*** -(G)***	-***

Sources: HKMA, and IMF staff estimates.
Notes: "+" and "-" indicate the sign of coefficients. ***, **, and * denote significance at 1, 5 and 10 percent levels respectively. (-1) and (-2) indicate that explanatory variables are lagged by one quarter and two quarters, respectively. (G) indicates that the explanatory variable interacts with a dummy variable (0, 1) for the four largest (local) banks in the sample.

Table 14. Hong Kong SAR: IMF Top-down Solvency Test: Descriptive Statistics/FSIs

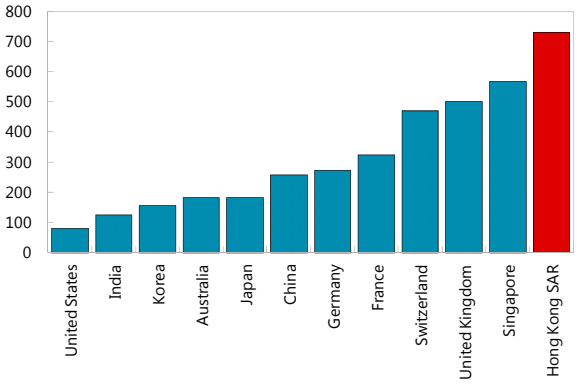
(In percent, unless otherwise noted)

	Total 1/
Total assets (In billions of HKD)	11,699.4
Total capital (In billions of HKD)	991.3
Capital Adequacy	
Regulatory capital to risk-weighted assets (average)	16.5
Tier 1 capital to risk-weighted assets (average)	13.3
CET 1 capital to risk-weighted assets (average)	13.2
Risk-weighting (In percent)	97.2
Asset Quality	
Loss rate (average)	0.5
Non-performing loan ratio (average)	0.2
Earnings/Profitability	
Return on assets (average)	1.2
Return on equity (average)	12.6
Liquidity	
Loan-to-deposit ratio 2/	62.2

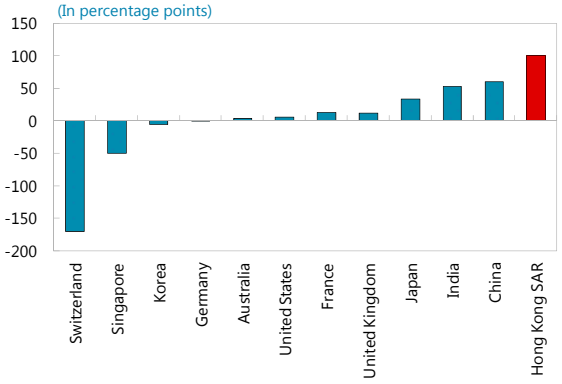
Source: institutions' own granular data.
Notes: 1/ 16 locally incorporated banks covered in the IMF TD Solvency Test on consolidated basis.
2/ If loans to banks are included, the ratio increases to 74.5 percent.

Figure 2. Hong Kong SAR: Structural Features of Hong Kong Financial Sector

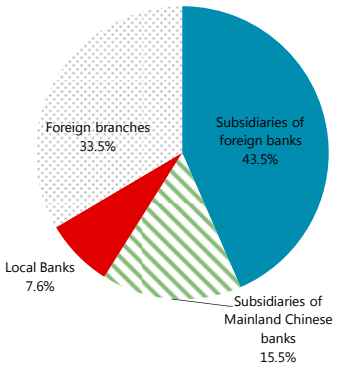
Total Banking Sector Assets in Selected Countries 1/
(In percent of 2012 GDP)



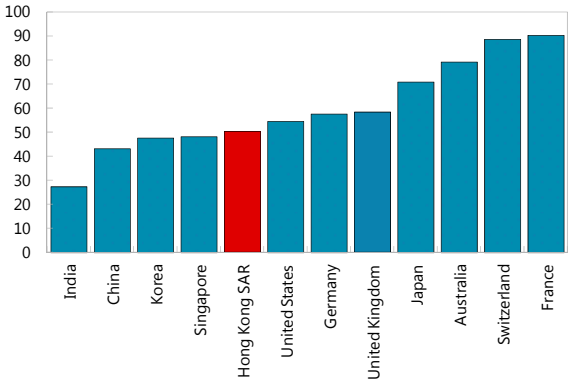
Changes in Total Banking Sector Assets in Selected Countries as Percent of GDP from 2007—2012
(In percentage points)



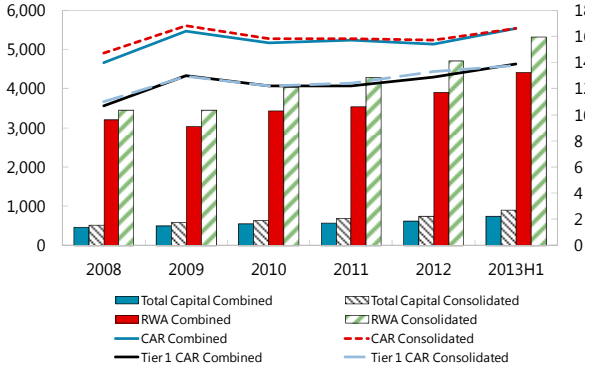
Structure of Banking Sector
(In percent of total banking sector assets at end-2012)



Assets of Four Largest Banks 2/
(In percent of total banking sector assets)



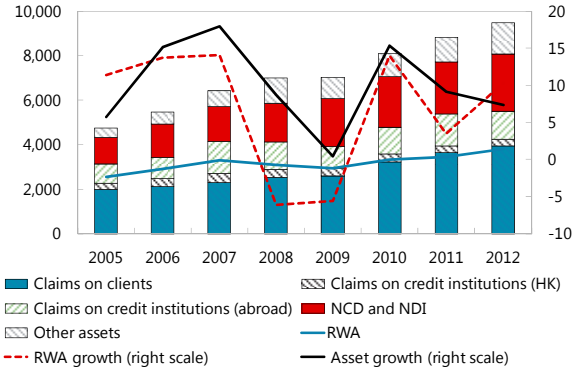
Comparison by Reporting Basis 3/
(In billions of HKD and in percent)



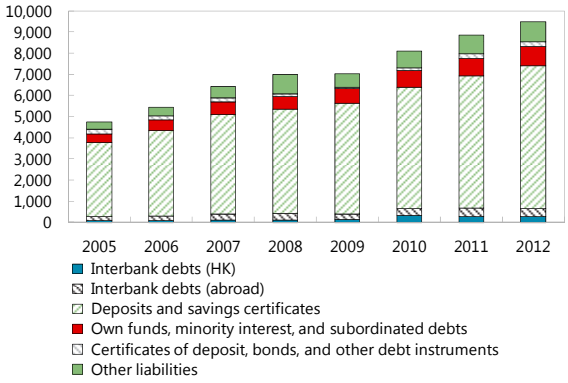
Sources: Bankscope, HKMA, Australian Prudential Regulation Authority, Bank of England, China Banking Regulatory Commission, European Central Bank, Financial Supervisory Service of Korea, Japanese Bankers Association, Monetary Authority of Singapore, Reserve Bank of India, United States Federal Reserve Board, and IMF staff calculations.
Notes: 1/ The number for Hong Kong includes all authorized institutions on the Hong Kong office basis.
2/ The assets of the four largest banks in Hong Kong account for around half of the industry total on consolidated basis.
3/ The "combined basis" of a bank means the position of the bank's Hong Kong office plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries.

Figure 3. Hong Kong SAR: Banking Sector Developments

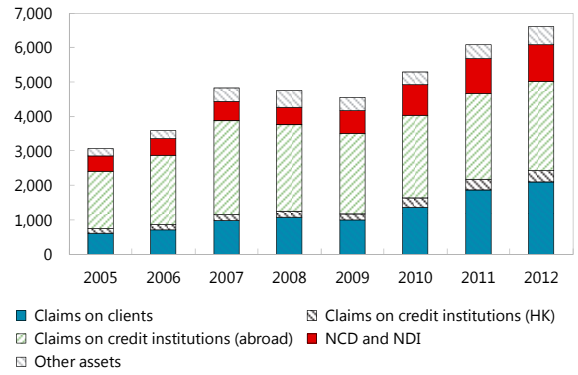
Assets of locally incorporated banks 1/
(In billions of HKD and in percent)



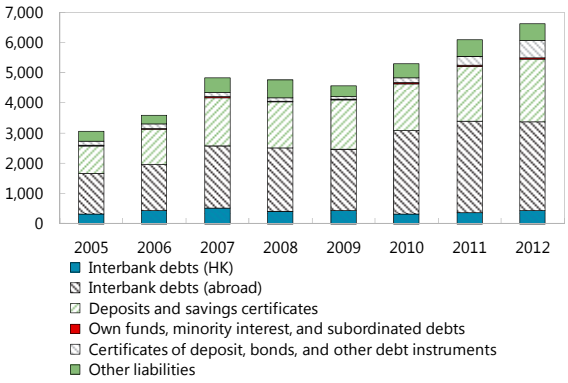
Liabilities of locally incorporated banks 1/
(In billions of HKD)



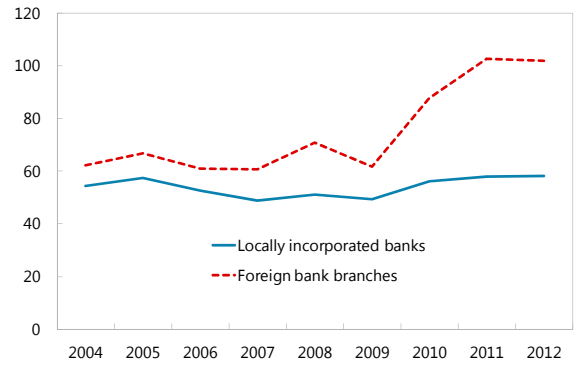
Assets of Foreign Branches 2/
(In billions of HKD)



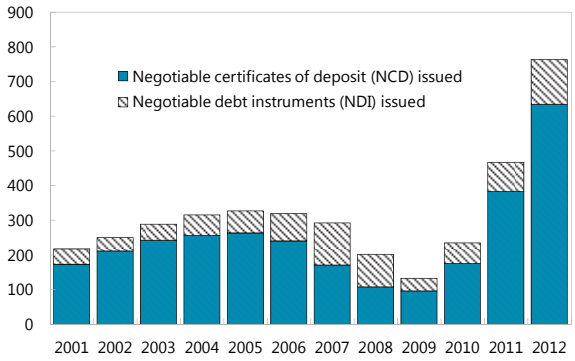
Liabilities of Foreign Branches 2/
(In billions of HKD)



Loan-to-deposit ratio, by institution type 3/
(In percent)



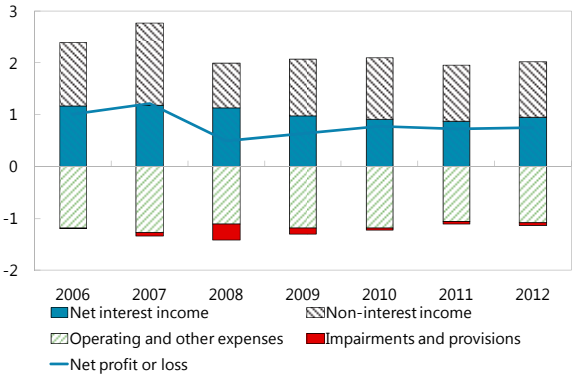
Debt Issuance of Banks 2/
(In billions of HKD; all authorized institutions)



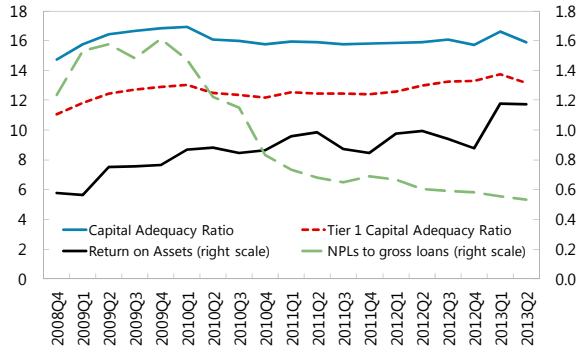
Sources: HKMA and IMF staff calculations.
Notes: 1/ Data for locally incorporated banks is on combined basis. The "combined basis" means the position of the bank's Hong Kong office plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries.
2/ Hong Kong office basis.
3/ Loans exclude non-bank loans; deposits include deposits and saving certificates; data for locally incorporated banks is on combined basis and on Hong Kong office basis for foreign bank branches.

Figure 4. Hong Kong SAR: Banking Sector Soundness

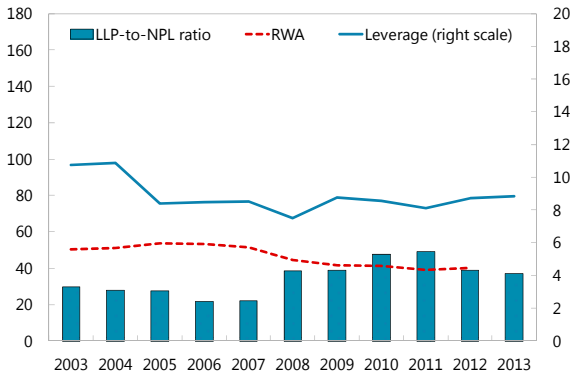
Income and Expenses 1/
(In percent of average assets; all authorized institutions)



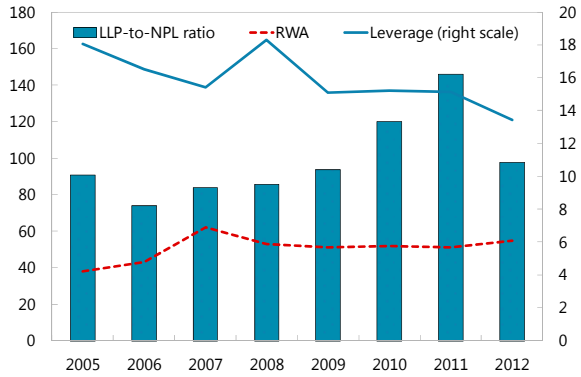
Banking Sector Soundness 2/
(In percent)



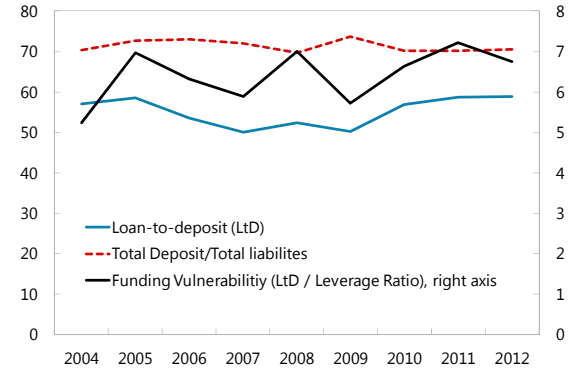
LLP/NPL ratio, RWAs and Leverage 3/
(In percent)



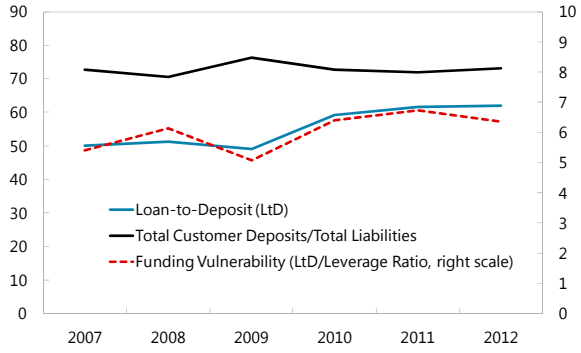
Top 4 banks: LLP/NPL ratio, RWAs and Leverage 4/
(In percent)



Structural Funding Conditions 5/
(In percent)



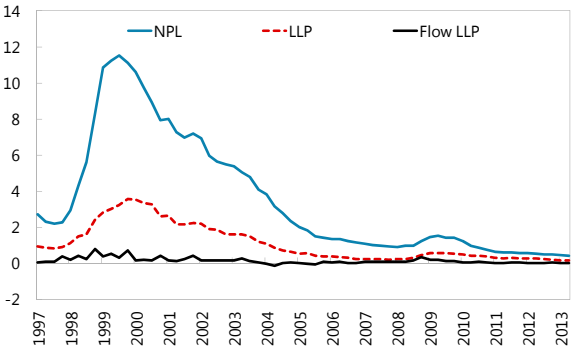
Top 4 banks: Structural Funding Conditions 4/
(In percent)



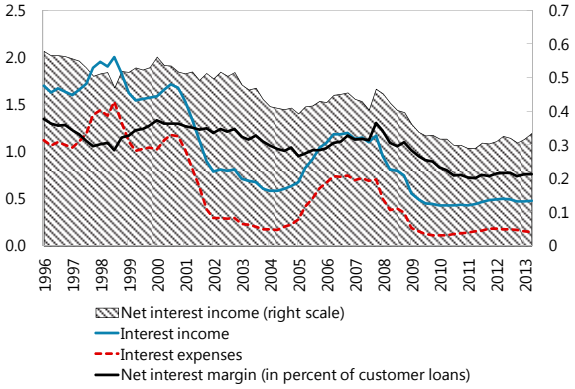
Sources: HKMA, IMF FSI database, and IMF staff calculations.
Notes: 1/ All authorized institutions on Hong Kong office basis.
2/ Capital adequacy ratio and Tier 1 capital adequacy ratio for locally incorporated authorized institutions (AIs) on consolidated basis; return on assets for all AIs on Hong Kong office basis; NPLs to gross loans for all AIs on combined basis.
3/ Locally incorporated licensed banks on combined basis; leverage refers to capital divided by total assets.
4/ Asset-weighted average for the four largest banks on consolidated basis.
5/ All locally incorporated authorized institutions on combined basis; the "combined basis" of a bank means the position of the bank's Hong Kong office (solo basis) plus its overseas branches.

Figure 5. Hong Kong SAR: Banking Sector Performance

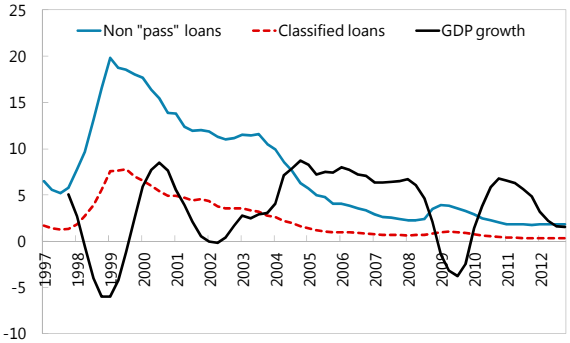
NPL and LLP 1/
(In percent of customer loans)



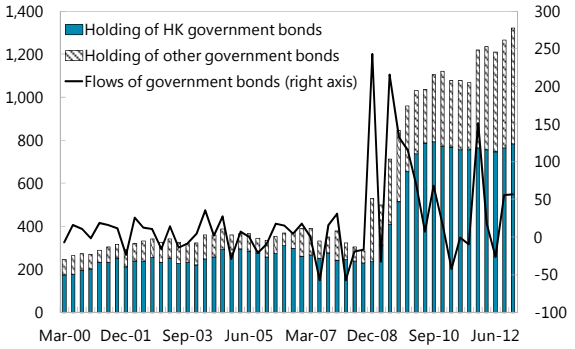
Interest margin 2/
(In percent of total assets unless otherwise indicated)



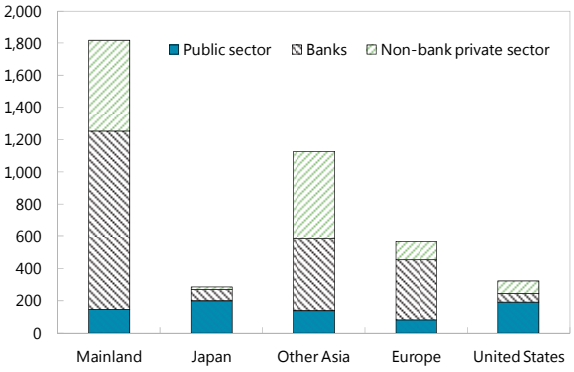
Asset Quality Indicators 3/
(In percent of total loans; retail banks)



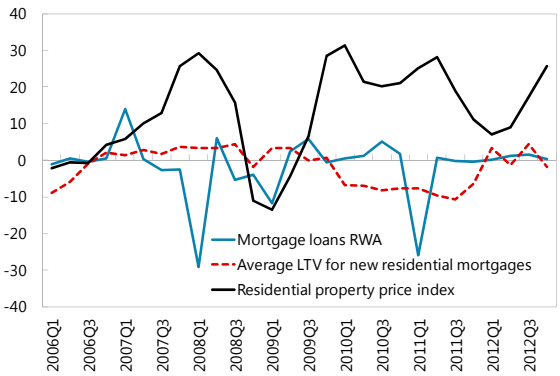
Holdings of Government Bonds 4/
(In billions of HKD; all authorized institutions)



Cross-border Claims 5/
(In billions of HKD; locally incorporated, authorized institutions)



Mortgage loans 6/
(Year-on-year percent change)



Sources: HKMA and IMF staff calculations.

Notes: 1/ Asset-weighted averages of 19 Group 1 banks on a combined basis; the "combined basis" of a bank means the position of the bank's Hong Kong office (solo basis) plus its overseas branches.

2/ Asset-weighted averages of 19 Group 1 banks on a combined basis; interest income and expenses are expressed in percent of total assets; net interest margin is scaled to total customer loans.

3/ Combined basis. Retail banks comprise all the locally incorporated, licensed banks plus foreign bank branches that engage in material retail banking business; classified loans are net of specific provisions/individual impairment allowances.

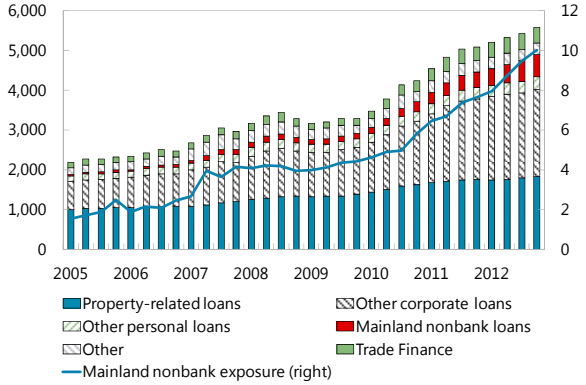
4/ All authorized institutions on Hong Kong office basis.

5/ Consolidated basis; the "combined basis" of a bank means the position of the bank's Hong Kong office plus its overseas branches, while the "consolidated basis" covers the combined basis plus the bank's subsidiaries. Position as of December 2012.

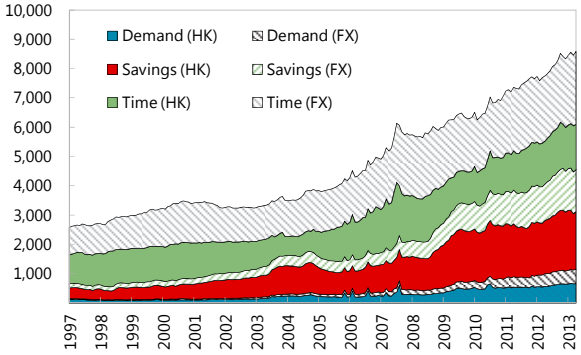
6/ Locally incorporated, licensed banks on a combined basis.

Figure 6. Hong Kong SAR: Banking Sector—Lending and Deposit Composition

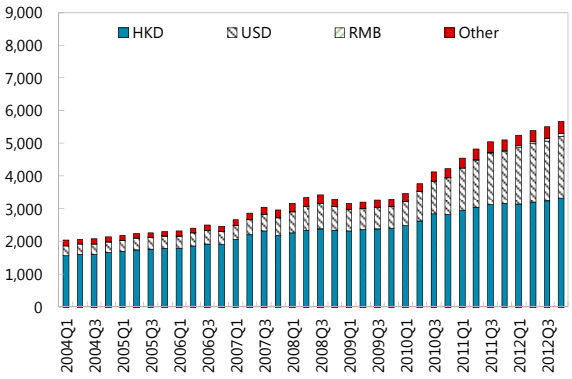
Loan compositions 1/
(In billions of HKD and percent of total)



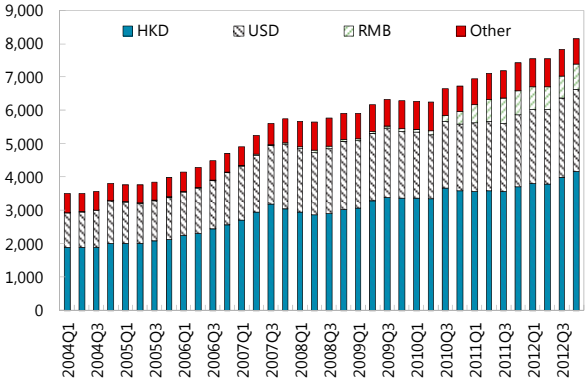
Customer deposits by type 2/
(In billions of HKD)



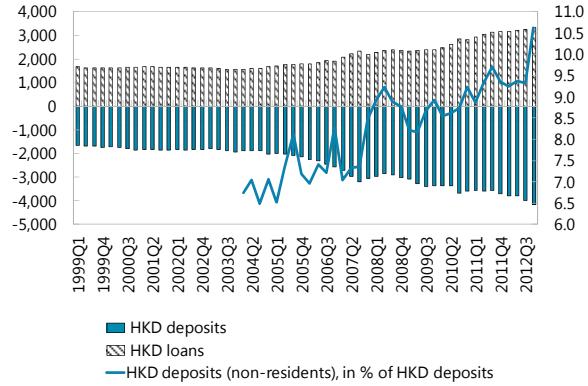
Loans by currency 3/
(In billions of HKD; all authorized institutions)



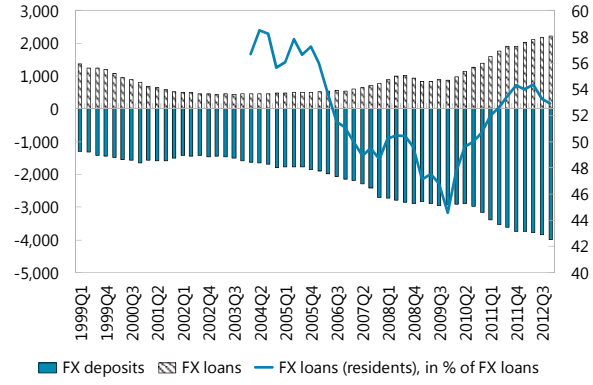
Deposits by currency 3/
(In billions of HKD, all authorized institutions)



HKD loans and deposits 3/
(In billions of HKD and in percent)



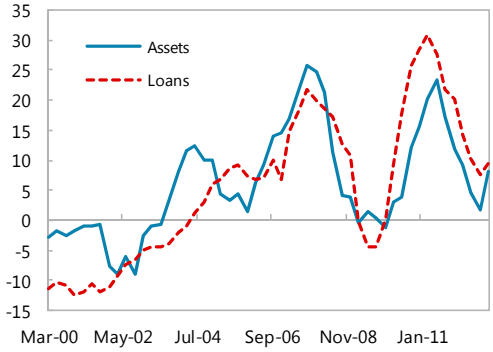
FX loans and deposits 3/
(In billions of HKD and in percent)



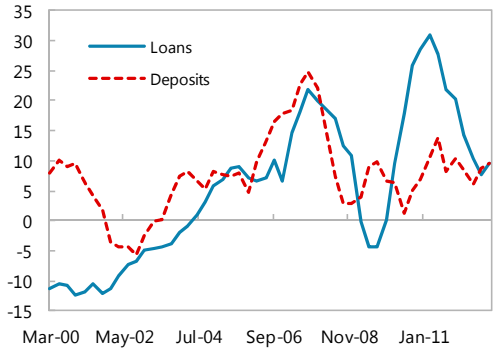
Sources: HKMA and IMF staff calculations.
Notes: 1/ All authorized institutions on a Hong Kong office basis. Mainland nonbank loans refer to external claims on non-bank customers in Mainland China.
2/ Deposits at licensed banks on a Hong Kong office basis; unadjusted for foreign currency swap deposits.
3/ All authorized institutions on a Hong Kong office basis.

Figure 7. Hong Kong SAR: Banking Sector—Lending and Deposit Trends

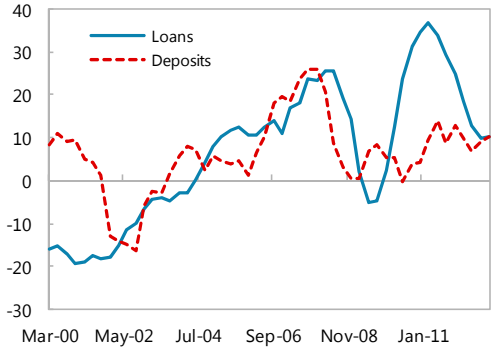
Total Assets and Loans 1/
(Year-on-year percent change)



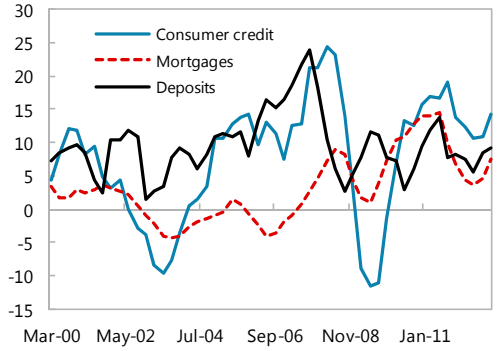
Total Loans and Deposits 1/
(Year-on-year percent change)



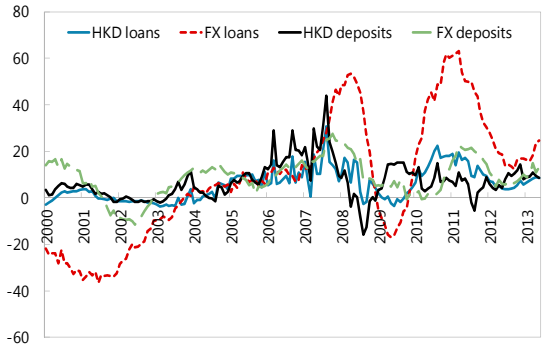
Non-Financial Corporates Loans and Deposits 2/
(Year-on-year percent change)



Households Loans and Deposits 2/
(Year-on-year percent change)

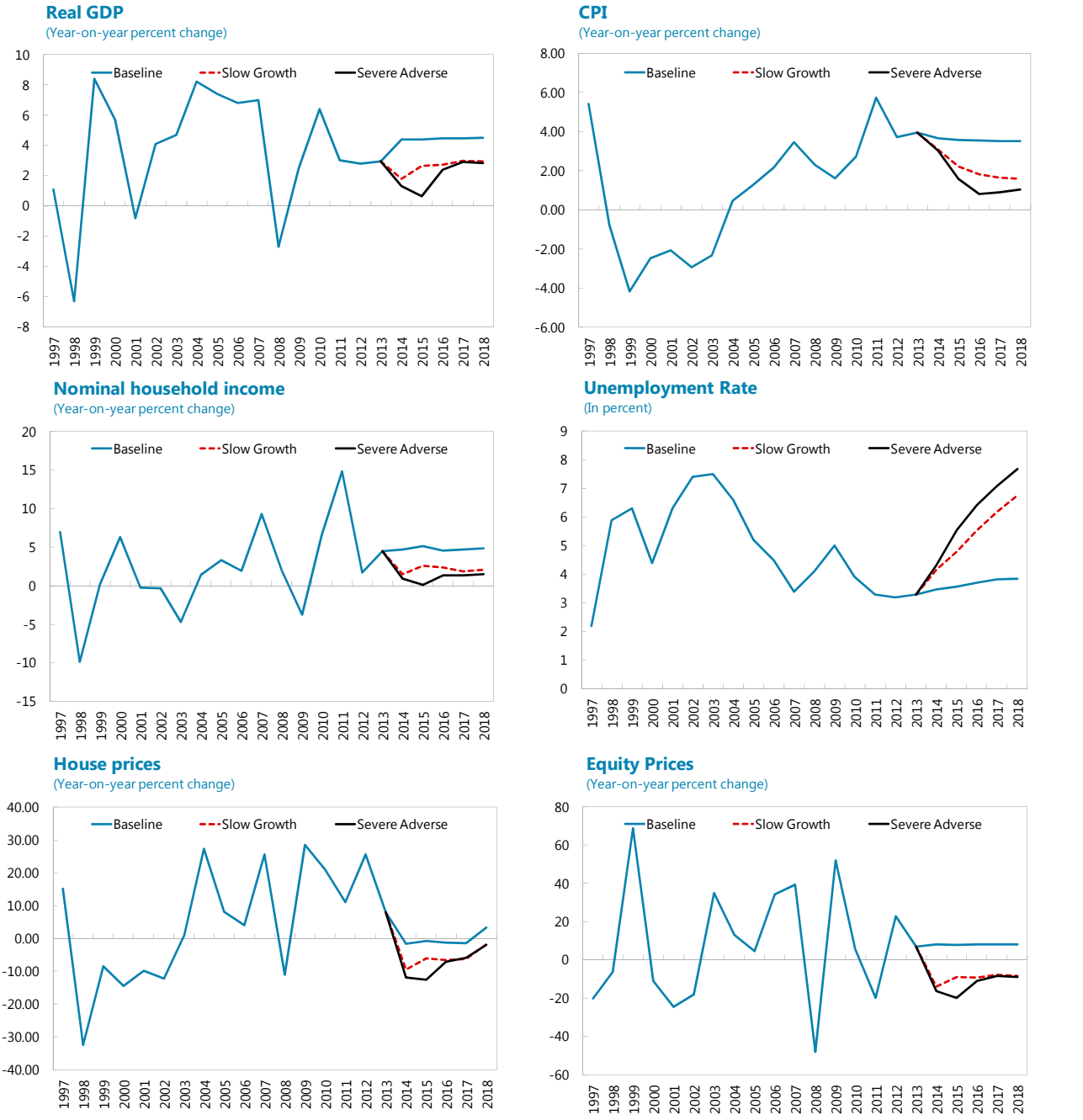


Loans and Deposits by Currency 3/
(Year-to-year percentage growth; all authorized institutions)



Sources: HKMA and IMF staff calculations.
Notes: 1/ All authorized institutions. Hong Kong office basis.
2/ All authorized institutions on a Hong Kong office basis. Non-financial corporate deposits and household deposits are estimated from the results of LCR QIS for December 2012 by the HKMA.
3/ Deposits with all authorized institutions on a Hong Kong office basis, adjusted for foreign currency swap deposits.

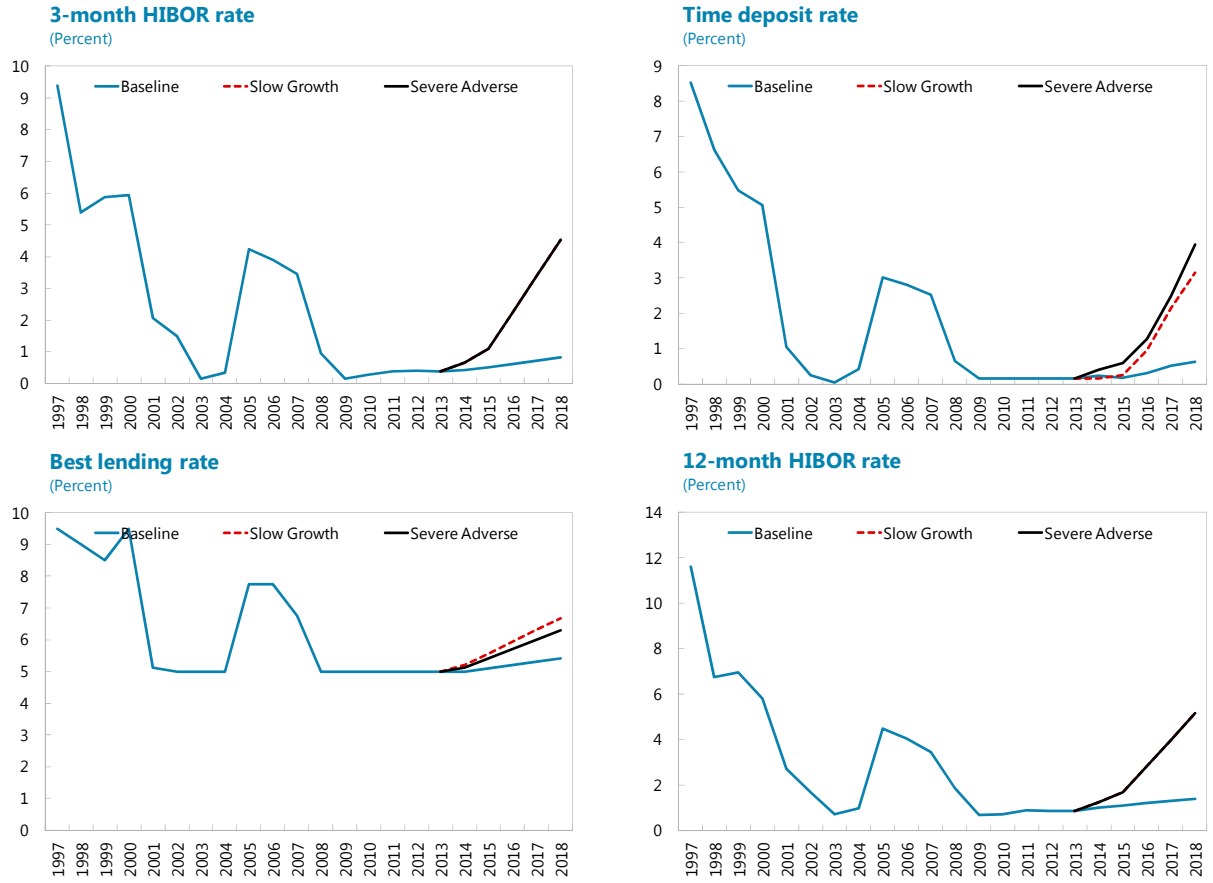
Figure 8. Hong Kong SAR: Macroeconomic Assumptions under Different Stress Test Scenarios (1)



Sources: HKMA and IMF staff estimates and calculations.

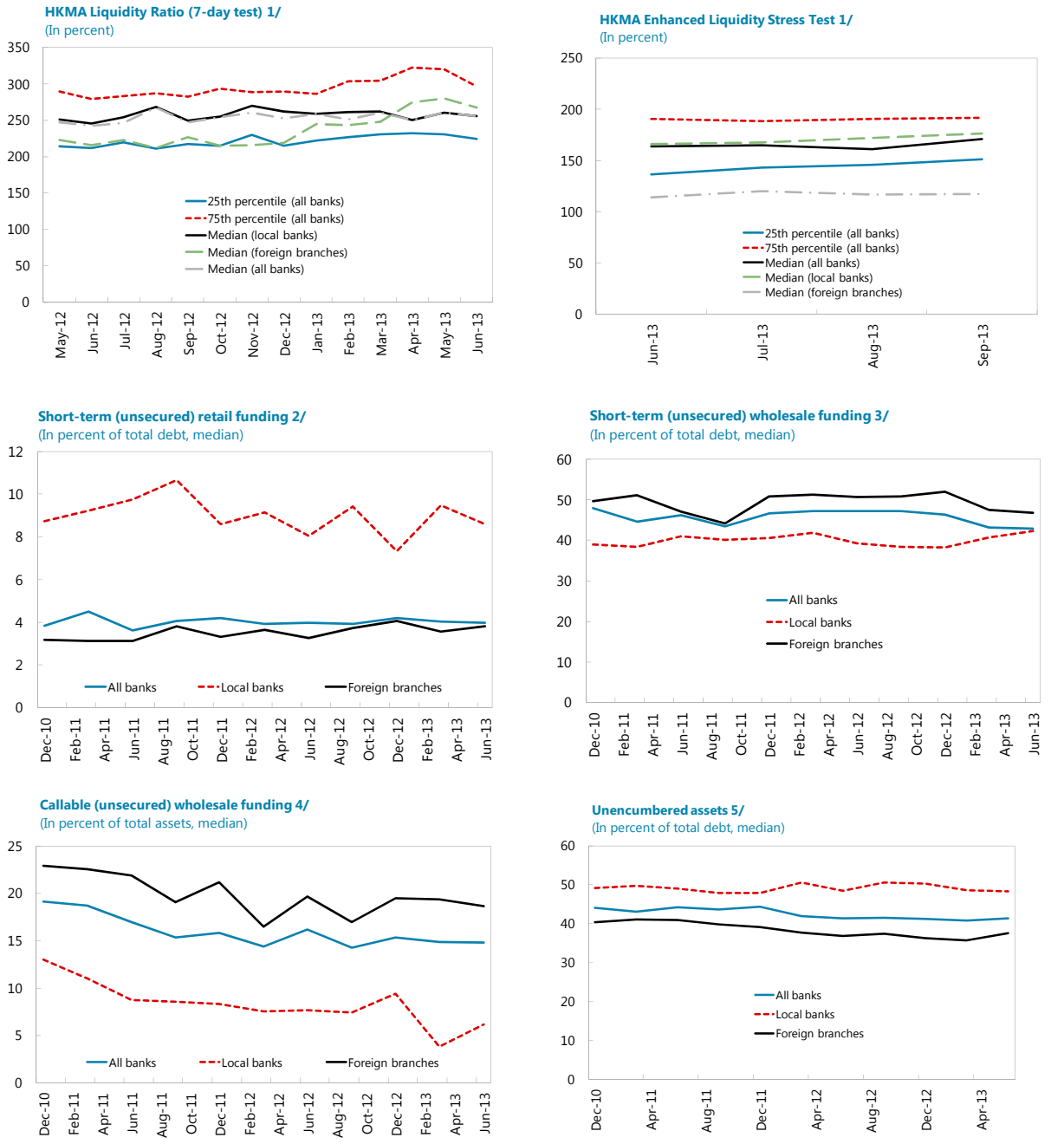
Notes: For the BU solvency stress test, the commercial real estate prices and residential house price are used. The chart above refers to residential house prices only (which form the basis for the modelling of commercial property prices.

Figure 9. Hong Kong SAR: Macroeconomic Assumptions under Different Stress Test Scenarios (2)



Sources: HKMA and IMF staff estimates and calculations.
Notes: Best lending rate refers to the rate quoted by HSBC. Interest rates for 2013 above are recorded as of end-June 2013.

Figure 10. Hong Kong SAR: Liquidity and Short-term Funding



Sources: HKMA and IMF staff calculations.

Notes: 1/ For the HKMA Liquidity Ratio (7-day test) and HKMA Enhanced Liquidity Test, 19 local banks and 8 foreign branches are included. The ratios are specified as total inflows (including liquid financial assets and non-cumulative cash inflows) as a percentage of total outflows.

2/ Sum of unsecured open maturity retail deposits as well as similar liabilities with a remaining maturity of less than 1 year. Secured and long-term (> 1 year) financing are not included. Total debt includes all unsecured/secured retail and wholesale financing.

3/ Sum of unsecured open maturity wholesale (i.e., non-retail) deposits and unsecured bonds as well as similar liabilities with a remaining maturity of less than 1 year. Intra-group, secured, long-term (> 1 year) and retail financing are not included. Total debt includes all unsecured/secured retail and wholesale financing.

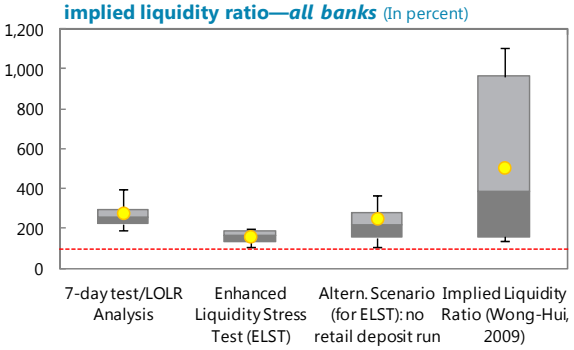
4/ Callable (unsecured) wholesale funding includes all unsecured wholesale deposits and bonds with an open maturity or maturing within one week. Intra-group, secured, medium-term (> 1 week) and retail financing are not included. Total debt includes all unsecured/secured retail and wholesale financing.

5/ Unencumbered assets include all unencumbered cash and unencumbered central bank/HKMA-LOLR eligible, repoable, marketable and re-usable financial assets, measured at market value and before prudential haircuts.

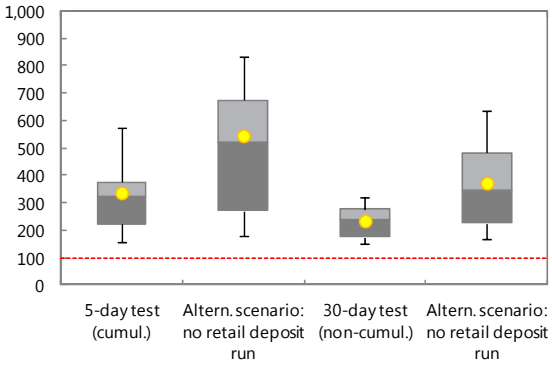
Figure 11. Hong Kong SAR: Top-down Liquidity Stress Test Results—Implied Cash Flow Analysis

(solo basis* with the exception of the implied liquidity measure)

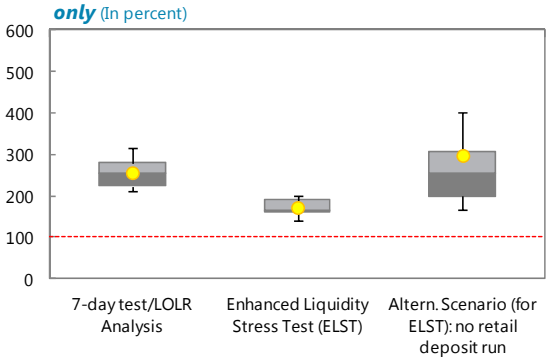
Top-Down Test (HKMA): 7-day Test/LOLR Analysis, Enhanced Liquidity Stress Test, and Wong-Hui (2009) implied liquidity ratio—*all banks* (In percent)



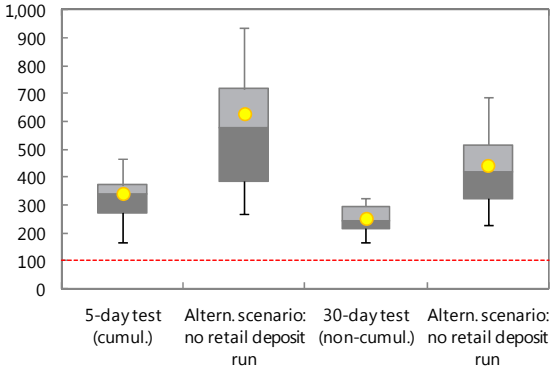
Top-Down Test (IMF): Implied Cash Flow Tests (In percent)



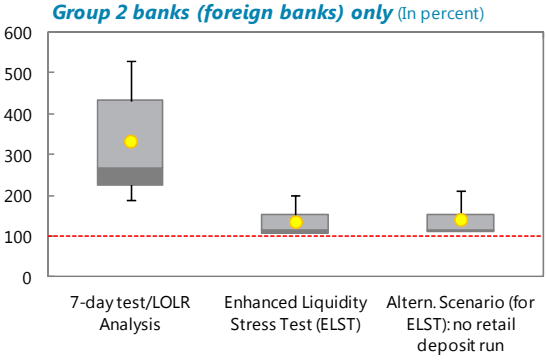
Top-Down Test (HKMA): 7-day Test/LOLR Analysis and Enhanced Liquidity Stress Test—*Group 1 banks only* (In percent)



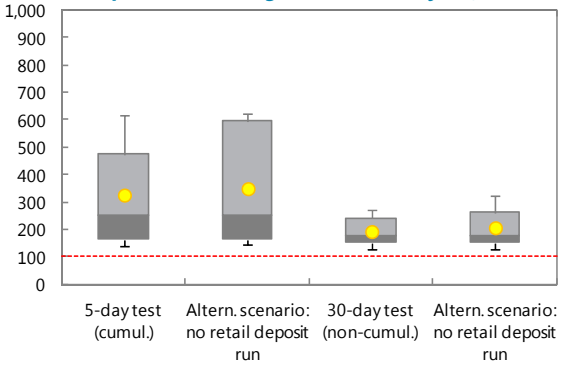
Top-Down Test (IMF): Implied Cash Flow Tests—*Group 1 banks only* (In percent)



Top-Down Test (HKMA): 7-day Test/LOLR Analysis and Enhanced Liquidity Stress Test—*Group 2 banks (foreign banks) only* (In percent)



Top-Down Test (IMF): Implied Cash Flow Tests—*Group 2 banks (foreign branches) only* (In percent)



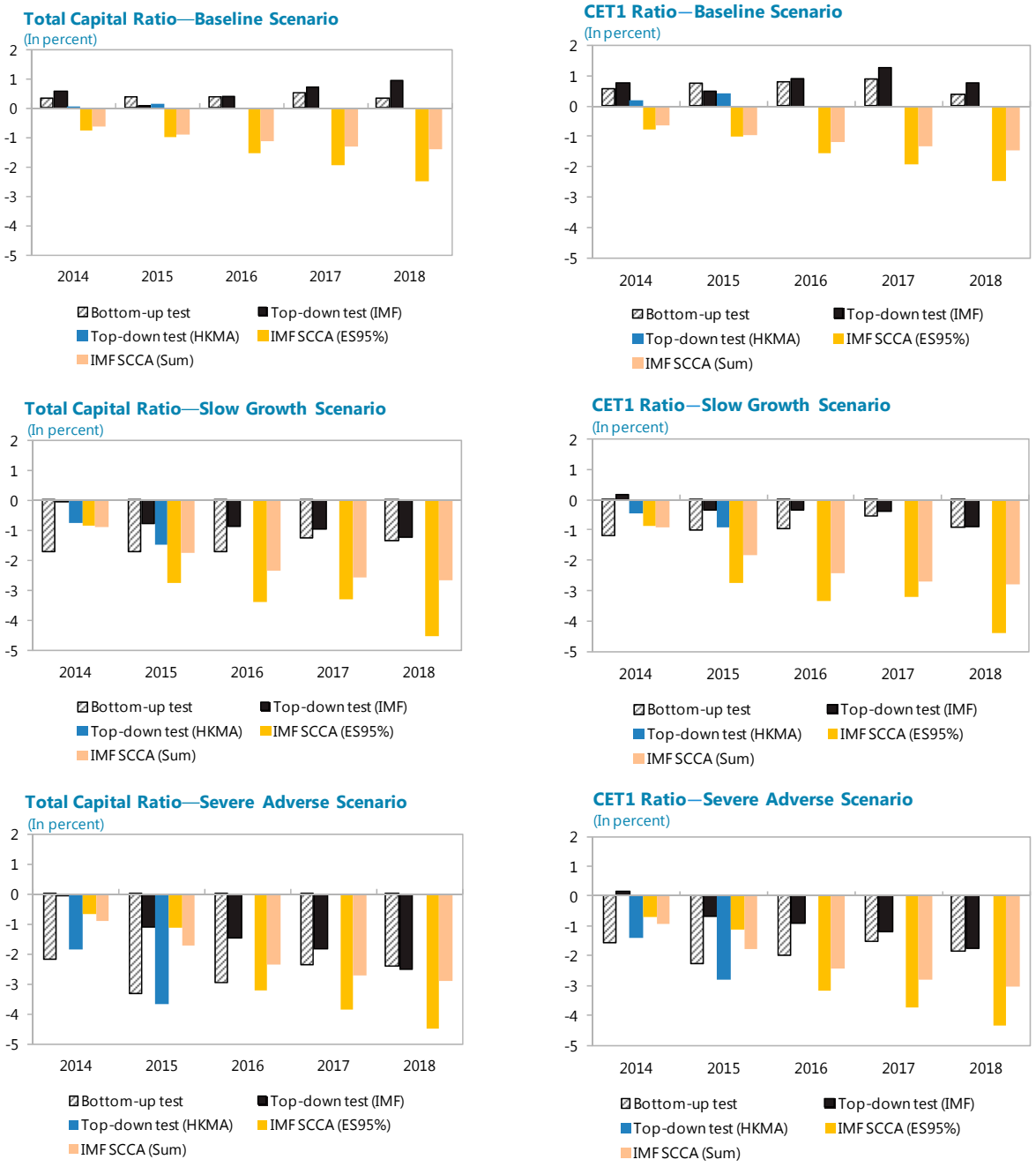
Sources: HKMA and IMF staff estimates. Notes: The sample of banks included in both HKMA [left column] and IMF [right column] TD liquidity ratios and ICF (ICF) stress tests comprising all 19 banks in Group 1 (fully licensed, locally incorporated banks) and all 8 banks in Group 2 (foreign branches) on a HK office basis ((*) except for the Wong-Hui (2009) analysis , which was completed in a consolidated basis), representing 70.9 percent of the banking sector's total assets. For the HKMA 7-day test/LOLR analysis, the existing 7-day test was augmented with the LOLR analysis, which examines the liquid asset buffers of authorized institutions with access to HKMA liquidity. While cash inflow that banks could obtain under stress by seeking LOLR funding increases the liquidity ratio, none of the sample banks would fail the test (i.e., <100 percent) if potential cash inflow from LOLR measures were ignored. It covers 17 out of the 19 licensed banks in Group 1 or 63 percent of the banking sector's total consolidated assets. Bank of China's consolidated reporting includes its two subsidiaries, Nanyang Commercial Bank Ltd. and Chiyu Banking Corporation Ltd., while HSBC's consolidated reporting excludes Hang Seng Bank, which has been tested separately in order to avoid double counting of results. The methodology by Wong and Hui (2009) analyses banks' liquidity risk arising from interactions between market, solvency and liquidity risks. The implicit liquidity ratio generated by their methodology compares the cumulative cash inflow to the cumulative cash outflow at the end of the stress horizon (in percent). The framework aims to capture how MtM losses on banks' holding of risky assets due to a prolonged period of negative asset price shocks would increase banks' solvency risk and reduce the ability to generate liquidity from asset sales. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers). The red dotted line indicates the lowest acceptable ratio value (threshold) of 100 percent.

Figure 12. Hong Kong SAR: Evolution of Aggregate Capital Ratios in Solvency Stress Tests (1)

Sources: HKMA and IMF staff estimates. Notes: Only the total capital ratio and the common equity Tier 1 (CET1) ratios are shown given the small portion of non-CET1 capital in Tier 2 capital reported by banks. The sample of banks included in the stress test differs among the various approaches. The balance sheet-based, top-down (TD) exercises include all Group 1 (fully licensed local) banks on a *consolidated* (IMF) and *combined* (HKMA) basis, representing 63.0 and 58.0 percent of the banking sector's total assets, respectively, whereas the bottom-up (BU) exercise covers selected local banks, which together represent about 50 percent of total consolidated assets in the banking sector. The Systemic CCA analysis considers only the HK activities of 9 publicly listed local banks, covering 53.8 percent of the sector (on a consolidated basis). The results of the HKMA TD solvency stress test reflect two adverse scenarios, namely "severe" and "more severe" scenarios (Table 6), which differ slightly from the "slow growth (SG)" and "severe adverse (SA)" scenarios adopted in the BU and IMF TD tests. The capital ratios prior to the forecast horizon are based on reported prudential data. For the balance sheet-based TD tests of the HKMA and IMF, the end-2012 CET1 capital ratio is set equal to the Tier 1 capital ratio as a proxy (both on a combined (HKMA) and consolidated (IMF) basis).

Figure 13. Hong Kong SAR: Evolution of Aggregate Capital Ratios in Solvency Stress Tests (2)

(Difference Relative to Starting Period (2013))



Sources: HKMA and IMF staff estimates.

Notes: The sample of banks included in the stress test differs among the approaches. The balance sheet-based, top-down (TD) exercises include all Group 1 (fully licensed local) banks on a *consolidated* (IMF) and *combined* (HKMA) basis, representing 63.0 and 58.0 percent of the banking sector total assets, respectively, whereas the bottom-up (BU) exercise covers selected local banks, which together represent about 50 percent of total consolidated assets in the banking sector. The Systemic CCA analysis considers only the HK activities of 9 publicly listed local banks, covering 53.8 percent of the sector (on a consolidated basis). The results of the HKMA TD solvency stress test reflect two adverse scenarios, namely "severe" and "more severe" scenarios (Table 6), which differ slightly from the "slow growth (SG)" and "severe adverse (SA)" scenarios adopted in the BU and IMF TD tests. The capital ratios prior to the forecast horizon are based on reported prudential data. For the balance sheet-based TD tests of the HKMA and IMF, the end-2012 CET1 capital ratio is set equal to the Tier 1 capital ratio as a proxy (both on a combined (HKMA) and consolidated (IMF) basis). The Systemic CCA analysis results in a significant decline of the capital ratios even under the baseline scenario due to the high statistical confidence level of joint expected losses affecting capital levels over the forecast horizon.

Figure 14. Hong Kong SAR: Comparison of IMF Top-Down Solvency Stress Test Results—Baseline and Severe Adverse Scenario, Capital Adequacy Ratio (Total Capital)
(locally incorporated, fully licensed banks only)

Sources: HKMA and IMF staff estimates.

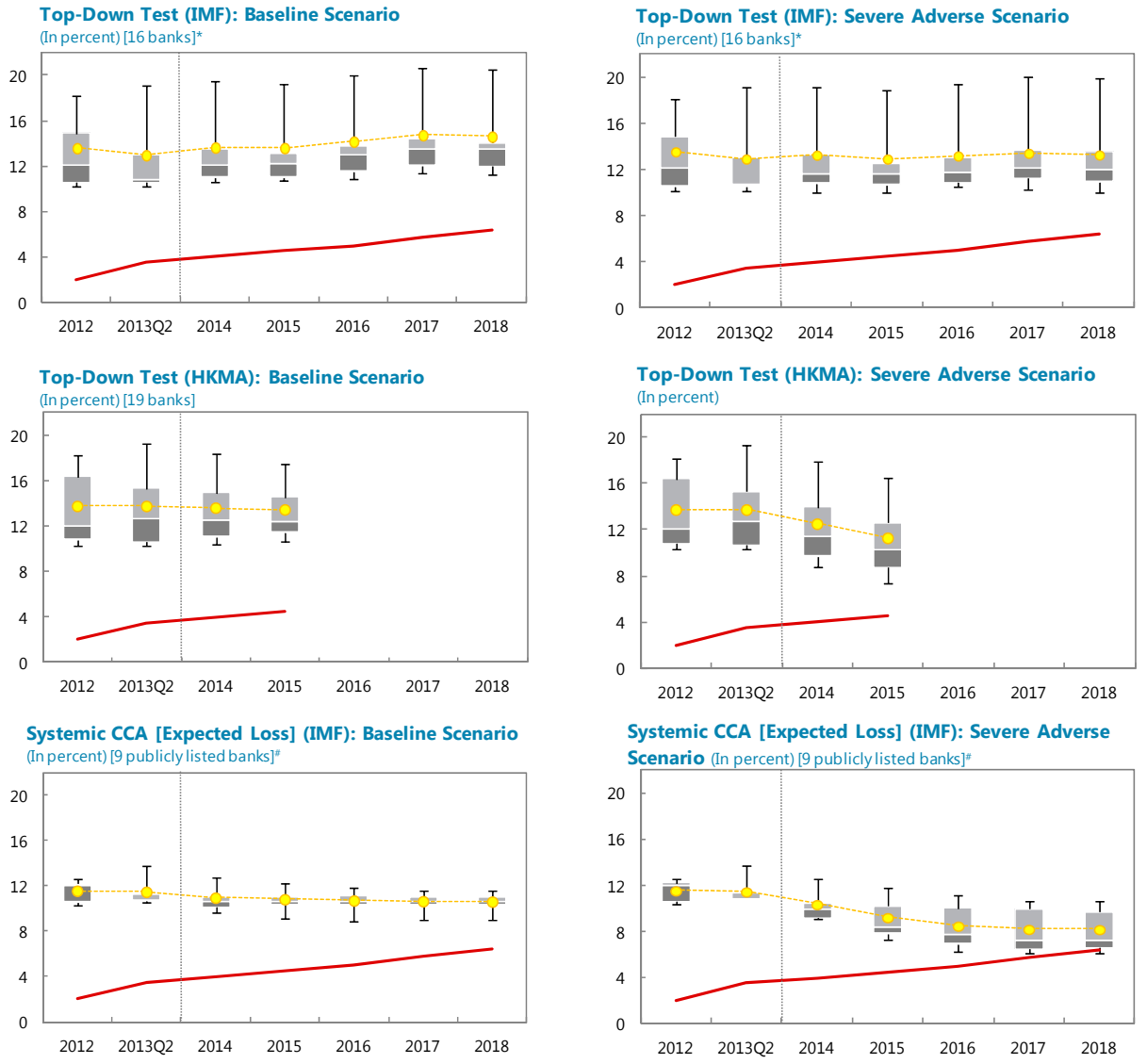
Notes: The sample of banks included in the stress test differs among the approaches. The balance sheet-based, top-down (TD) exercises include all Group 1 (fully licensed local) banks on a consolidated (IMF) and combined (HKMA) basis, representing 63.0 and 58.0 percent of the banking sector's total assets, respectively, whereas the bottom-up (BU) exercise covers selected local banks, which together represent about 50 percent of total consolidated assets in the banking sector. The Systemic CCA analysis considers only the HK activities of 9 publicly listed local banks, covering 53.8 percent of the sector (on a consolidated basis). The results of the HKMA TD solvency stress test reflect two adverse scenarios, namely "severe" and "more severe" scenarios (Table 6), which differ slightly from the "slow growth (SG)" and "severe adverse (SA)" scenarios adopted in the BU and IMF TD tests. The capital ratios prior to the forecast horizon are based on reported prudential data. For the balance sheet-based TD tests of the HKMA and IMF, the end-2012 CET1 capital ratio is set equal to the Tier 1 capital ratio as a proxy (both on a combined (HKMA) and consolidated (IMF) basis).

Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers). The red line indicates the Basel III hurdle rate.

* In order to avoid double counting, the following subsidiaries of local banks were excluded (since they are included in the consolidated reporting used for the IMF TD solvency stress test): Hang Seng Bank Ltd. (HSBC), Nanyang Commercial Bank Ltd. (Bank of China (Hong Kong)), and Chiyu Banking Corporation Ltd. (Bank of China (Hong Kong)).

Figure 15. Hong Kong SAR: Comparison of IMF Top-Down Solvency Stress Test Results—Baseline and Severe Adverse Scenario, CET1 Ratio

(locally incorporated, fully licensed banks only)



Sources: HKMA and IMF staff estimates.

Notes: The sample of banks included in the stress test differs among the approaches. The balance sheet-based, top-down (TD) exercises include all Group 1 (fully licensed local) banks on a consolidated (IMF) and combined (HKMA) basis, representing 63.0 and 58.0 percent of the banking sector's total assets, respectively, whereas the bottom-up (BU) exercise covers selected local banks, which together represent about 50 percent of total consolidated assets in the banking sector. The Systemic CCA analysis considers only the HK activities of 9 publicly listed local banks, covering 53.8 percent of the sector (on a consolidated basis). The results of the HKMA TD solvency stress test reflect two adverse scenarios, namely "severe" and "more severe" scenarios (Table 6), which differ slightly from the "slow growth (SG)" and "severe adverse (SA)" scenarios adopted in the BU and IMF TD tests. The capital ratios prior to the forecast horizon are based on reported prudential data. For the balance sheet-based TD tests of the HKMA and IMF, the end-2012 CET1 capital ratio is set equal to the Tier 1 capital ratio as a proxy (both on a combined (HKMA) and consolidated (IMF) basis). Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers). The red line indicates the Basel III hurdle rate.

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Figure 16. Hong Kong SAR: Solvency Stress Test (IMF Top-down Approach)—Risk Drivers

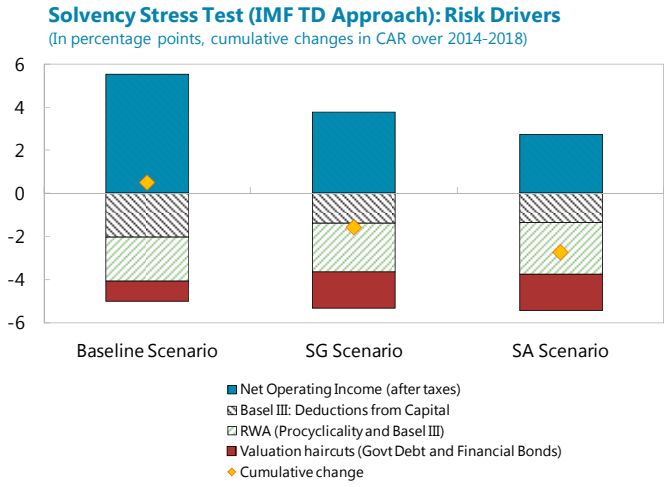
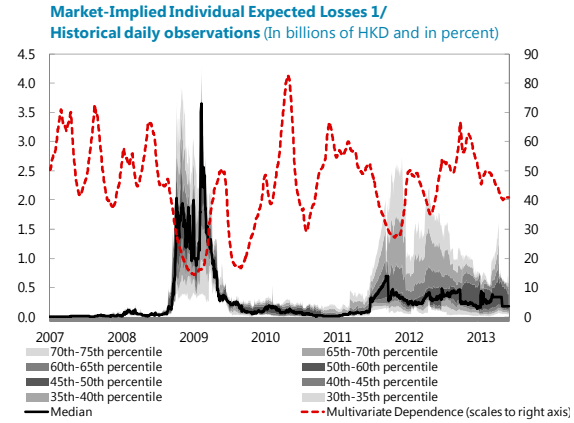
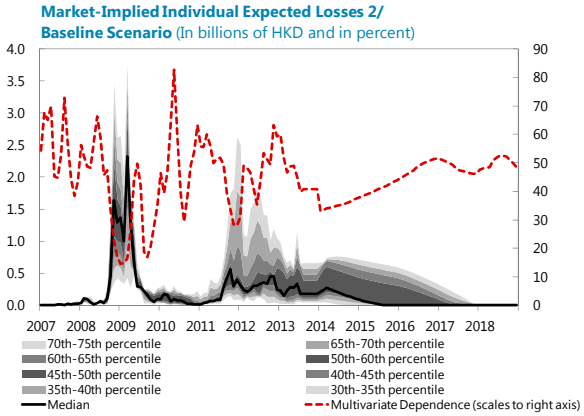
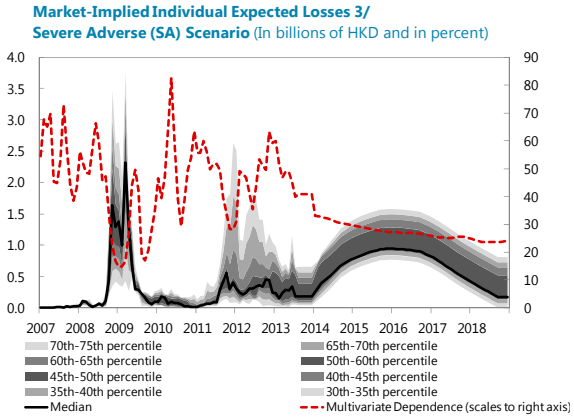
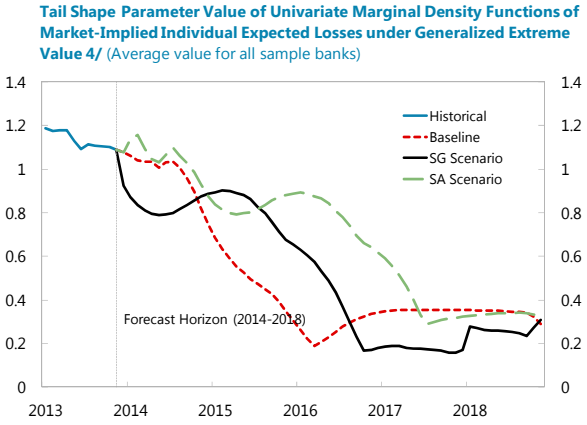


Figure 17. Hong Kong SAR: Systemic Contingent Claims Approach—Distribution of Market-Implied Individual Expected Losses (Historical and Forecasted)









Sources: IMF staff estimates.

Notes:
1/ Consolidated reporting basis, scaled to reported amount of Hong Kong activities (solo basis); historical daily observations of expected losses.
2/ Consolidated reporting basis, scaled to reported amount of Hong Kong activities (solo basis); historical and stress horizon (2014-2018), monthly observations of expected losses.
3/ Consolidated reporting basis, scaled to reported amount of Hong Kong activities (solo basis); historical and stress horizon (2014-2018), monthly observations of expected losses.
4/ Shows the change in the tail shape parameter under all scenarios, based on the convergence of each series of expected losses to General Extreme Value (GEV).

Annex. Guidelines for the Bottom-Up Solvency Stress Test—Banking[1]

INTRODUCTION

A. Background

1. The stress testing exercise of the FSAP Update for HKSAR comprises a comprehensive analysis of solvency and liquidity risks of the banking sector. Solvency tests consist of a BU stress test by selected local banks in HKSAR and a cross-validation through several TD tests, undertaken jointly by staff of the HKMA and the FSAP team. These TD tests cover about 70 percent of the banking sector. Solvency tests are complemented by TD liquidity stress tests using supervisory data and parameters specified by both the HKMA and the FSAP team. These tests cover both the local banks and foreign branches in the system.

2. The solvency tests are based on three macroeconomic scenarios, determined in collaboration with the HKMA. The objective of these tests is to determine the capacity of the banking sector—using mid-2013 unaudited financial results—to absorb any realization of key macro-financial risks. The scenarios comprise a baseline scenario and two adverse scenarios, specified contingent on the projected growth path of HKSAR, Mainland China, and the United States. These have been identified as the core economies influencing the macro-financial linkages affecting the performance of the banking sector. Hurdle rates are applied according to the Basel III implementation schedule.

3. Liquidity tests focus on the sudden, sizeable withdrawal of funding (liabilities) and the sufficiency of existing assets to withstand those shocks under stressed conditions. The standard liquidity measures under Basel III, the LCR and NSFR, and various ICF tests (over one-week and one-month periods) are applied to determine the short- and medium-term resilience of individual banks and the overall system, independent of access to central bank liquidity.

B. Objective

4. This note summarizes key assumptions related to the calibration and estimation of the BU solvency stress testing component of the FSAP. The exercise forms part of a wider stability analysis that comprises several tests aimed at assessing the capital adequacy of the banking sector based on end-2013: Q2 financial results. It contains specific instructions regarding the implementation of the stress test that should help determine the capacity of the banking sector to absorb the realization of key macro-financial risks, which would result in downside deviations from a defined baseline scenario.

[1] These guidelines have been developed in Jobst (2013).

5. The objective of this stress test—as part of the FSAP mission's analysis of financial stability—is to assess system-wide vulnerabilities of the selected local banks under different adverse macroeconomic scenarios and capital market conditions.[2] The assessment is completed by considering three key channels of stress affecting bank balance sheets from a creditor perspective: (i) impairment charges (credit losses, other losses from held-to-maturity assets) and MtM valuation changes of fixed income securities (financial and government bonds) in both the trading and banking book; (ii) changes in pre-impairment income, including changes in funding costs; and (iii) changes in RWAs. Key risks over both the short- and medium-term are incorporated into the design of the stress test. The stress test also incorporates specific risk factors, including cross-border developments (such as sovereign risk) and foreign currency risk, as well as the impact of current regulatory reforms and behavioral assumptions, in order to determine the capacity of banks to absorb the manifestation of macro-financial stress, without identifying individual institutions.[3]

6. The purpose of the stress test differs from that of supervisory stress testing exercises. The multi-period FSAP stress test is for surveillance purposes, with a medium-term focus. The exercise typically involves very severe stress scenarios to assess the overall resilience of the financial system. The results of this BU stress test have no immediate supervisory implications but provide input into a broader analysis undertaken by the FSAP, forming the basis for policy discussions with the authorities. This is different to the routine capital assessments undertaken by the HKMA, which are aimed at identifying potential capital needs from risks in the near term, for which management actions may be required. No management action would be expected as a result of the FSAP stress tests (IMF, 2011a and 2011c; Jobst and others, 2013).

7. The sample of firms involved in this BU stress test exercise includes the selected local banks, which together represent about 50 percent of the banking sector. For these banks, the assessment of vulnerabilities is not straightforward given the diversity of their business models and global activities. The key limitations are acknowledged and reflected appropriately as caveats in the interpretation of the final results. Sample banks with other significant businesses (e.g., insurance and/or non-financial commercial operations) that are separate companies (subject to separate regulations) and effectively ring-fenced may exclude those businesses from the stress test.

8. The following macroeconomic projections and guidelines on selected risk parameters are consistently applied:

[2] It should be emphasized that the stress tests are necessarily based on economic and market conditions as of end-2013: Q2, the cut-off date of the exercise, and do not take into account the most recent developments.

[3] Most stress tests are built on a modular design, based on risk management techniques similar to the ones applied by commercial banks for their internal stress tests. This stress test, however, is focused more on capital adequacy of the banking sector under different macroeconomic scenarios (rather than portfolio stresses of individual firms and/or reverse stress tests) using the historical macro-financial linkages affecting parameter sensitivities.

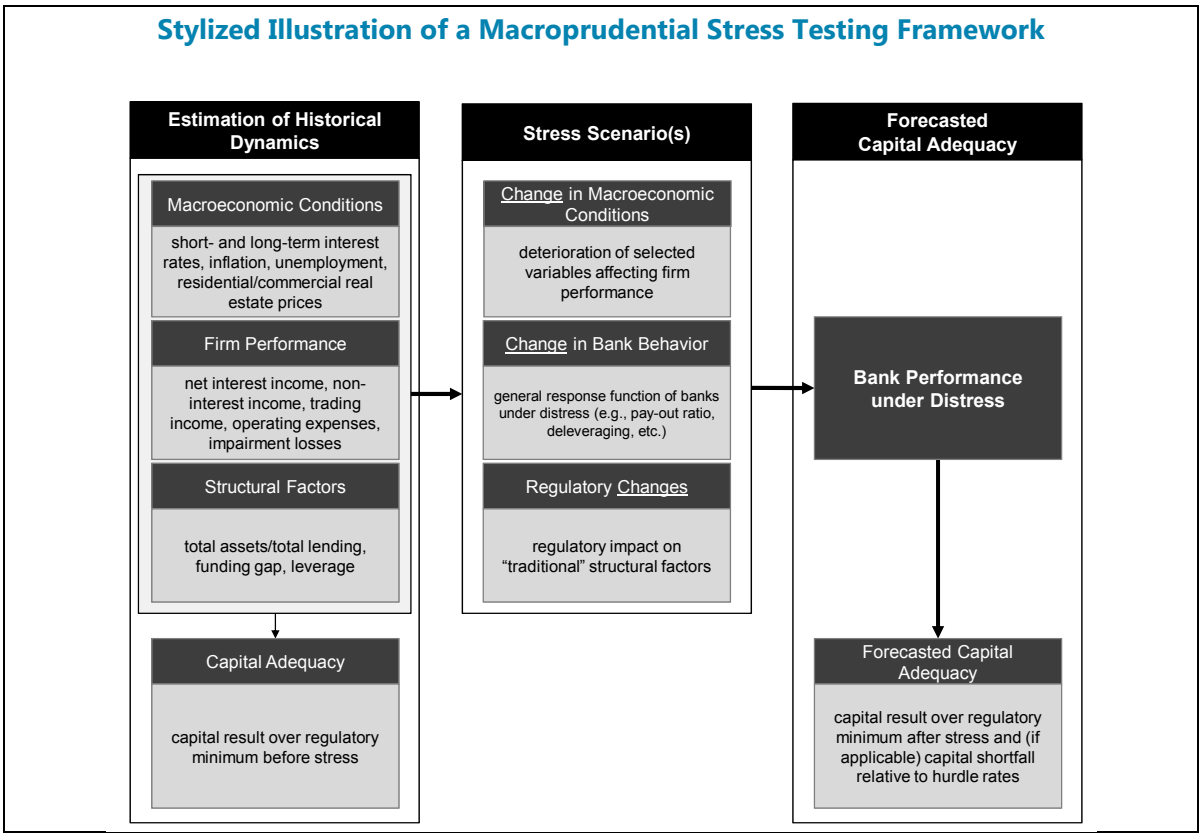
- Based on the given scenarios, related key macroeconomic and financial variables have been projected, using the HKMA's and the IMF's macro models and IMF staff estimates, for input into the solvency stress tests, namely, inflation, unemployment, housing prices, commercial property prices, interest rates (short-term interest rates and asset swap rate curve (up to 10 years)), net household income, and equity prices (Appendices III and IV). An illustrative specification of macro-financial linkages affecting firm performance can be found in Appendix V.

- Prescriptive assumptions covering areas such as (i) risk factors (loss rates, market risk impact on fixed income holdings due to credit risk/FX risk, taxes, and funding costs), (ii) behavioral adjustments (balance sheet and credit growth, dividend pay-out, asset disposal, and capital raising), and (iii) regulatory changes (capital requirements, RWAs, and the definition of capital) are provided.

- Some elements, which do not represent a continuation of existing policies and require managerial intervention, should be excluded from consideration, including on-going de-risking/de-leveraging of balance sheets through restructuring, run-offs and divestments that have been announced/implemented after the cut-off date (i.e., end-June 2013).[4] Potential mitigating factors, such as managerial actions and strategic decisions as well as contingent capital arrangements and bail-in provisions that could become effective during times of stress, are not considered. This assumption is essential to the comparability of stress test results, which should be viewed as the most conservative lower bound to possibly more positive outcomes under the same magnitude of stress. However, firms are encouraged to provide alternative stress test results that include the impact of mitigating factors, which would allow for a suitable qualification of findings without compromising the consistent application of stresses to sample banks.

9. A summary of the macro scenarios, key assumptions, and hurdle rates is presented in Appendix II. Firms are requested to conduct their BU stress tests, using end-2013: Q2 data, and (on a "best endeavors" basis) to report their final results to the HKMA by November 11, 2013. The HKMA will perform due diligence analysis and report aggregate findings to the FSAP team.

[4] This would otherwise distort results due to a gradual decrease of RWAs and potential risks from restructured loans that no longer meet contractual covenants (and the scope for regulatory forbearance).



MACRO SCENARIOS

10. The stress testing exercise analyses three scenarios—one baseline scenario and two adverse scenarios—as the macroeconomic context. The baseline scenario is in line with the projections outlined in the IMF's World Economic Outlook as of April 2013, whereas the adverse scenarios are based on a negative deviation of economic activity (i.e., real GDP) from the central growth forecast. In portraying the adverse scenarios as a "mark-up" over the most likely outcome (i.e., WEO baseline), the adversity of the negative deviation from the expected growth path takes into account perceived risk (i.e., the potential for central expectations to vary due to future uncertainties and revisions in light of new information). For all scenarios, the following variables are provided: real GDP, household income, unemployment rate, price and cost developments (including consumption prices, residential house prices, commercial real estate prices, equity market index), and interest rates (short-term interest rates and asset swap rate curve (up to 10 years)) (Appendices III and IV).

11. The two adverse scenarios comprise a prolonged period of slow growth, and a severe slowdown followed by a partial recovery over a forecast period of five years. The formulation of the adverse scenarios is motivated by a broad-based change in global macroeconomic

conditions—for example, in line with the adverse emerging market scenario[5] presented in the April 2013 WEO. The overall impact on economic growth in HKSAR reflects the historic transmission effects of economic growth in both Mainland China and the United States.

- *"SG" scenario (long-term)*— this scenario is underpinned by a broad-based slowdown in global growth driven by an increase in the cost of capital given markets' accelerated view on the pace of tightening in U.S. monetary policy. A global investment shock results in a moderate slowdown in activity in the Mainland China and the United States, with growth of 6.6 and 3.0 percent on average, respectively. As a consequence of spillovers, growth in HKSAR deteriorates by an average of 1.8 percent a year (to 2.6 percent) relative to baseline expectations of average annual growth of 4.4 percent (which is slightly above the long-term (30-year) annual growth rate of 4.1 percent); given the negative impact on productivity, the impact persists throughout the forecast horizon. The overall magnitude of the shock, with a cumulative negative deviation of about 9.1 percentage points in real GDP over a five-year period, equates to more than one and a half standard deviations of the long-term (30-year average) two-year cumulative growth rate (5.6 percent), which has been used as unit of measure in other FSAPs.[6]

- *"SA" scenario (short-term)*—in this scenario, the investment shock is aggravated further by a severe intensification of capital outflows in emerging market countries impacting all of Hong Kong's major trading partners. This results in a more pronounced "hard landing" for economic growth. However, the sharp contraction of output over the first two years is partially offset by positive adjustment dynamics during the subsequent three years of the forecast horizon. This scenario results in average growth of about 2 percent a year (or 2.4 percent on average lower than the baseline), broadly in line with the experience during the Asian financial crisis. This amounts to a cumulative negative deviation of about 12.1 percentage points in real GDP over a five-year horizon. The overall magnitude of shock equates to more than two standard deviations of the two-year cumulative growth rate (5.6 percent)—or more than three quarters of one standard deviation of the five-year cumulative growth rate over the last 30 years. In line with this, growth in key trading partners of Mainland China and the United States comes in at an average of 6.0 and 2.8 percent, respectively.

12. The severity and dynamics of the macro scenarios are in line with the spectrum of economic shocks considered in the context of other macroprudential and supervisory stress testing exercises. The annual supervisory stress test by the HKMA includes a sharp contraction of economic growth over a short forecast horizon of up to two years, which is broadly in line with the cumulative deviation from the expected growth path projected in the SG scenario above. The stress tests completed as part of recent FSAPs for relevant other countries, such as the United States (IMF, 2010), but also various large European countries within the S-25 Group, such as France (IMF, 2012b),

[5] See http://www.imf.org/external/pubs/ft/weo/2013/01/c1/fig1_17.pdf.

[6] The severity of GDP shock would be almost two thirds of one standard deviation of the five-year cumulative growth rate over the last 30 years (15 percent).

Germany (IMF, 2011c), and the United Kingdom (IMF, 2011a), have included a sharp contraction of economic growth over an initial period of one or two years prior to a dynamic recovery over a total forecasting horizon of five years—like the SA adverse scenario applied in the case of HKSAR.[7] The prolonged slow growth scenario remains unique to FSAP stress testing exercises, and is considered the "tail shock" scenario (albeit slightly less severe than in the case of the FSAP for the United Kingdom (IMF, 2011a)).

13. Cross-border effects are considered in all macro scenarios. Assumptions about the type of shocks (temporary or permanent) affecting the domestic economy—and the degree to which they also affect countries in which banks operate outside HKSAR (i.e., mainly Mainland China, Japan, the United Kingdom, and the United States)—have been aligned by allowing for time-varying patterns consistent with the forecasts for HKSAR under both baseline and adverse scenarios.

14. In addition, projections of short-term interest rates have been supplemented by estimates of key maturity tenors of the asset swap rate curve in order to isolate the impact of credit spreads on the projection of interest rates over the forecast horizon (Appendix IV). The estimation follows a three-step process, which builds on a conventional term structure model of government bond yields and incorporates the dynamics of the historical swap spread curve in order to generate a discrete interest rate path for the three major currencies of the aggregate sector balance sheet:[8]

- Determining the asset swap rate curve at maturities between three months and 10 years based on the median of observations from January 1, 2013 to September 6, 2013 ("historical term structure of interest rate swaps");[9]

- Fitting the sovereign yield curve at maturities between three months and 10 years by using the arbitrage–free generalized Nelson-Siegel-Svensson term structure model (Nelson and Siegel, 1987; Svensson, 1994),[10] with discrete and continuously compounded spot rates obtained for the most liquid bonds of each sample country ("benchmark bonds"); and

[7] Also note that the negative cumulative deviation from the expected growth path by slightly more than two standard deviations of the two-year cumulative real GDP growth rate in the SA scenario is consistent with severity of the most adverse scenario of the stress tests conducted in these other FSAPs and the system-wide banking stress test conducted by EBA in 2011 (EBA, 2011). In addition, while the stress test in the FSAP for Mainland China (IMF, 2011b) was a more static one-period shock, the scale of the "extreme" scenario (of 2.7 standard deviations of one-year growth) was similar in intention as that of the SA scenario for HKSAR.

[8] Note that firms should apply the relevant interest rates shocks gradually over each forecasted year. Rate movements in other currency areas need to be in line with presented interest rate dynamics and can be deduced using this methodology.

[9] Missing observations can be interpolated as the weighted average of the interest rate swap rates at four lower maturity terms closest to the maturity term of interest or via cubic splines (Nowak and others, 2011).

[10] See also Bliss (1997) and Anderson and others (1996).

- Re-calibrating the historical term structure to the asset swap rates based on the variation of the difference between the interest rate path and swap rates across the entire maturity.

SATELLITE MODELS

15. Satellite models should be used to specify the macro-financial linkages of firm performance over the forecast horizon. Firms are required to determine credit losses and various elements of profit, including funding costs in response to changing capitalization via so-called "satellite models" or expert judgment. When expert-judgment is used, it should be closely aligned with the output of satellite models.[11] Satellite models should at least cover the last five years and include a lagged term, GDP growth, interest rates, other macroeconomic variables, and firm-specific variables, such as leverage, loan-to-asset ratio and the funding gap (i.e., loans less deposits divided by total earning assets). Appendix V provides an overview of possible satellite specifications for the various profit elements and credit impairment.

- *Credit losses* in the banking book are forecasted based on separate models for write-downs (and write-ups) derived from the estimated PD and LGD specific to each sector (i.e., corporate, retail, public sector, and other financial institutions).

- *Lending* is assumed to grow broadly in line with nominal GDP (or forecasted based on a suitable satellite model specification comprising changes in real GDP, short-term interest rates, headline inflation, and other significant and relevant macro variables, such as industrial production, real estate prices, household income, and unemployment).[12]

- *Operating profits* are estimated using separate models for interest income, interest expenses, net fee and commission income, and operational expenses. The net interest margin across all portfolios should broadly follow the term spread between the short-term interest rate (which determines the amount of interest expenses) and the lending rate. The latter is allowed to increase (decrease) in excess of the overall change in the lending rate due to higher (lower) credit risk of certain exposures as long as the results of such detailed portfolio-based assessment preserves the overall narrowing (widening) of net interest margins from banking business. Estimated changes in lending rates during times of stress should be reasonable by supervisory judgment. Projected net interest income should also consider foregone interest from impaired assets but ignore potential pass-through effects of higher lending rates to borrowers that experience deterioration of credit quality over the stress period. Income and capital gains

[11] Benchmarks for the sensitivity of credit losses to macroeconomic variables are the stress tests conducted by the HKMA, the European authorities (CEBS in 2010 and EBA in 2011), and recent IMF FSAP stress testing exercises (IMF, 2010, 2011, and 2012).

[12] Nominal GDP (and the GDP deflator) are not included the set of forecasted macro-financial variables under the relevant stress test scenarios (Appendix III). For simplicity (and given the high contribution of consumption to GDP in HKSAR), the GDP deflator is assumed to be equivalent to headline inflation, so that the change in nominal GDP would be the same as the sum of the changes in real GDP and headline inflation (as projected).

taxes are assumed to be 16.5 percent for firms recording a profit, and zero otherwise. Tax credit that has been accumulated over the forecast period only can be applied during profitable years (before dividend payout).

- *Funding costs* should be estimated as a separate component of general changes in interest expenses. The specification of changes in interest rate expenses should include the nonlinear sensitivity of funding costs to changes in solvency conditions (Section D).

- *Trading income* under stress should be aligned with changes in nominal GDP, based on historical data.[13] To this end, economic growth under each scenario and year can be matched to the corresponding GDP growth rate during the last 15 years (i.e., the growth rate closest to the simulated one). However, firms that experienced exceptionally high trading losses during the recent financial crisis (relative to the historical experience) may wish to model the probability distribution of trading income and match the point estimates to the percentile level of projected GDP growth under different scenarios, all relative to past volatility of growth. A high-dimensional parametric fit function can be used to enhance the alignment of GDP with trading income.

16. As a general rule, satellite models need to be clearly documented and back-tested in order to demonstrate proper identification and sufficient robustness. Since firms themselves specify the macro-financial linkages affecting their forecasted performance, the HKMA, together with the FSAP team, will require full disclosure of the various satellite models and expert judgments on earnings capacity, market and credit losses as well as the change in funding conditions under the various scenarios.

KEY ASSUMPTIONS

17. This section describes the various assumptions that should be applied to the BU solvency stress test. These assumptions are aimed at establishing a consistent implementation of key risk drivers in order to ensure that stress test results can be compared across all banks within the sample. In this regard, institutions are expected to demonstrate a clear link between their risk appetite, business strategy, and capital planning relative to the outcome of different macro scenarios. Institutions should assess their ability to remain above regulatory minimum capital requirements through the period stress, consistent with their stated risk appetite.

- Firms are also encouraged to conduct additional solvency stress tests without these restrictions so that the aggregate impact of business strategies, behavioral adjustments under stress, and other idiosyncratic assumptions can be compared and assessed.

[13] While empirical evidence suggests that there is a very weak relation between trading results and macroeconomic conditions, it is assumed that unfavorable trading results coincide with macroeconomic shocks.

- The stress test results would ideally be augmented (if applicable) by an explanation of how firms that report a significant deterioration of their capital position can adopt mitigating actions (through credible management action, including undertaking changes in business strategy, reinforcing the capital base and/or putting in place other contingency plans).

A. Balance Sheet Growth

18. Firms' balance sheets are assumed to be generally static with the exception of credit growth, which increases in line with nominal GDP.[14] The credit balance evolves in accordance with general credit growth experienced during the business cycle, with overall lending (without considering contemporaneous asset impairments)—and commensurate funding—increasing with a (positive) change in nominal GDP in each year of the forecast horizon. For a detailed specification, growth rates can vary across portfolios within the loan book (in light of different historical elasticities to changes in the business cycle) as long as the overall growth of credit balances remains consistent with the nominal GDP assumption. The growth rate of lending is matched by a proportionate increase in liabilities supporting the loan book without changes in the funding mix (i.e., the leverage ratio remains unchanged all else equal); this also impacts the forecast for profit and loss under various satellite models, which should be demonstrated. This assumption is consistent with the EBA stress test, which assumed a static balance sheet (except for pre-agreed disposals).[15]

- Loan assets are expected to increase only if GDP growth in the current period is positive; otherwise, there is no new lending.
- Exposures going into default are *not* replaced in the performing portfolio and generate *no* interest income in the period they become impaired (which also means that foregone interest of defaulted loans has to be taken into account when assessing net interest income under stress).
- The rate of increase of both lending and funding is applied to the values reported at the end of the previous period, without considering the impact of defaulted exposures on the stock of outstanding loans at the start of the current period.

19. Firms affected by stress are assumed to reduce credit growth through deleveraging (Appendix II). Based on empirical evidence and expert judgment, it is assumed that credit growth starts declining once a firm's capital adequacy falls below a threshold of 2.5 percentage points above the minimum Tier 1 capital ratio applicable over the forecast horizon (e.g., 5.5 percent in 2014 (Y1) in the transition to Basel III). If a firm falls below the threshold, credit growth declines by twice the capital shortfall in percentage points. For instance, for a Tier 1 capital ratio of half a percentage

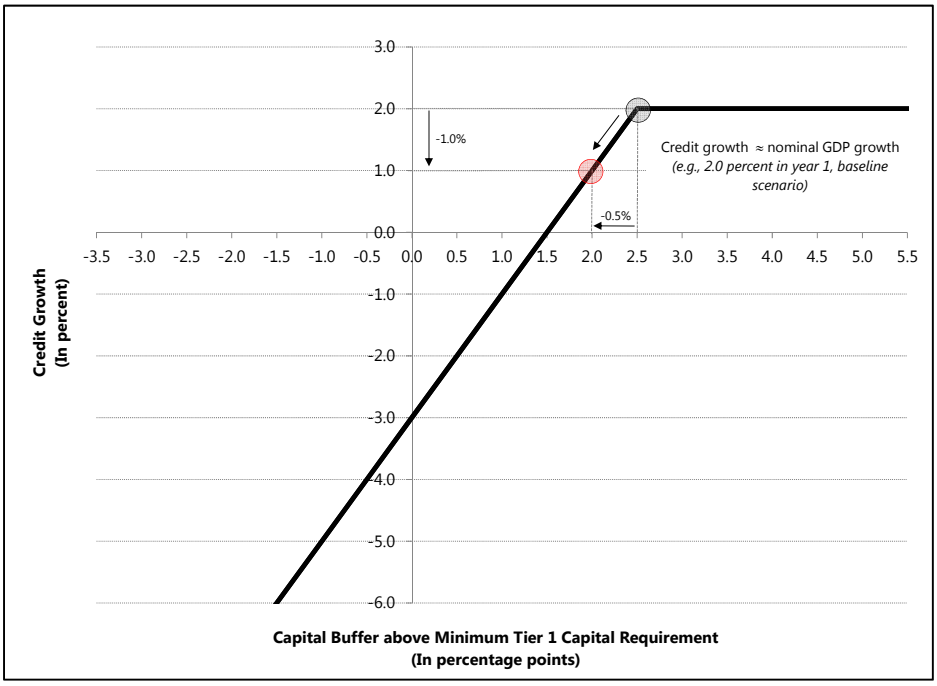
[14] This assumption represents a hybrid approach, which reconciles two different assumptions about the evolution of bank balance sheets under stress in (prescriptive) multi-period, top-down models: (i) a *static* balance sheet (i.e., no economic changes of assets and liabilities due to factors other than asset impairments and higher funding costs), and (ii) a *constant* balance sheet (i.e., all assets change in line with the business cycle based on pre-defined macro-financial linkages, supervisory/expert judgment, or a combination of both).

[15] Credit growth does not affect the funding structure. As a general rule, all funding needs to be replaced/added in a way that does not materially alter the existing funding structure during each period of the forecast horizon.

point below the regulatory minimum (and capital buffer), credit growth declines by one percentage point.

- Each adjustment is made immediately *after* the period during which the potential for deleveraging is assessed, and should shed light on the ability of firms to cope with the capital shortfall, albeit with the simplification of a sequential rather than contemporaneous reaction function.
- Since defaulted loans are not replaced they impact the portfolio growth calculation after the period during which they are realized.[16]

Credit Growth Conditional on Tier 1 Ratio *(Example: baseline scenario, year 1)*



20. The impact of additional factors influencing asset growth should be minimized. Asset disposals are generally disallowed, and maturing exposures are assumed to be replaced:

- Asset disposals (such as putting assets in run-off or the sale of non-core businesses) and acquisitions over time should not be considered, except where agreed with legally binding commitments prior to the cut-off data of the exercise (end-June 2013).
- Any interim (and approved) capital increase until end-2013 can be considered in calculations.

[16] Note, however, that prepaid mortgages are assumed to be refinanced (i.e., they trigger no change in credit volumes and RWAs and only impact interest rate income).

B. Risk Measurement and Riskiness of Assets

21. In order to measure the impact of stress in economic terms, internal capital adequacy models should be used. Since all sample banks have adopted advanced Basel II standards, their economic (risk) profile (and attendant capital adequacy) is assessed by calculating IRB capital requirements as a result of an economic capital model. As such, it is also important to account for the "point-in-time" (PIT) level of RWAs, as well as changes in RWAs under stress in economic terms.

22. The test includes, as a minimum, credit risk and market risk. Ideally, the tests are based on the credit-specific PD and LGD on a firm and/or portfolio level. In case this information is not available, other proxies such as provisions, NPLs in lieu of PDs, and country-level LGDs may be referenced. Market risk is assessed via changes in the interest and credit risks impacting the valuation of investments.

- For the estimation of credit losses, the LGD under stress should increase according to the following empirical specification: LGD(under stress)=0.3502+2.3408*PD (Moody's, 2009) or, if the down-cycle LGDs actually represent long-term averages, LGD(under stress)=0.4022+2.1535*PD. In case of overcollateralization (or supervisory LGDs below the intercept value), the increase of LGDs is limited to the trend coefficient (beta) of the LGD elasticity to PDs.

- For the estimation of valuation changes due to market risk, the investment and banking books are assessed with regard to changes in FX rates as well as short-term interest rates and credit spreads implied by the proposed valuation haircut for fixed income securities issued by sovereigns and financial institutions; in addition, these exposures are included in the assessment of credit risk of assets held in the banking book.

23. Higher RWAs due to regulatory changes and deteriorating credit quality should be taken into account using economic capital models and/or some form of expert judgment. If changes in risk weights cannot be derived from internal models prescriptive standards should be applied. If internal models fall below the defined minimum levels (see below) based on spot-checks for the material exposures, underlying assumptions need to be documented and approved by the HKMA in the review process.

- RWAs for operational risk remain constant throughout the forecast period.

- RWAs for credit risk and market risk are subject to the Basel I floor and sensitive to the regulatory impact due to Basel 2.5 and Basel III (as reported in several QIS and monitoring exercises (BCBS, 2010a, 2012b, 2012c, and 2013b)). Firms are encouraged to estimate the regulatory impact on these risk weights using available internal models (as of end-June 2013) or select minimum increases in risk weights based on the general QIS results published by the Basel Committee (BCBS, 2010a and 2013a) risk weights should increase by at least 5.13 percent [credit risk] and 0.47 percent [market risk] (independent of asset growth) in 2014 and 2015, respectively (assuming that 1/3 of the change in RWAs has already been absorbed during the

implementation of Basel 2.5 and III in 2013). As an alternative, where the calculation of Basel III risk weights for some exposure types (e.g., counterparty credit risk) are difficult to estimate, firms can select greater of the minimum increase in risk weights for certain sub-categories due to Basel 2.5 and Basel III, such as securitization in the trading and/or banking book (in the case of market risk RWAs), and double the original Basel II weights for these sub-categories. Lower values for the changes in risk weights for credit and market risk based on internal models would need to be documented and approved by the HKMA in the review process.

- Firms should also incorporate the sensitivity of credit RWAs to changes in PDs and portfolio concentration in order to account for the increase of unexpected losses during stress periods. Firms are encouraged to estimate the economic impact of stress conditions on risk weights using available internal models (as of end-June 2013) in addition to the increase of credit RWAs owed to regulatory changes. Alternatively, the following (additive) increase of risk weights should be considered using general assumptions about the sensitivity of RWAs under stress conditions:[17]

  — *nonlinear effect of changes in PDs on RWAs* is determined by fixing the asset correlations to the lowest level of the PDs (i.e., a level corresponding to an "Aaa"-rating) and the LGD to 45 percent[18] (Note: since the impact of LGDs on RWAs is linear, the elasticity of unexpected losses leading to changes in RWAs can be extracted from the Basel II IRB formula for corporate loans after fixing the asset correlations to the lowest level of the PDs (a level corresponding to a "Aaa"-rating) and the LGD to 45 percent). Thus, the marginal increase of RWAs for an increase of PDs (in percent) can be calculated for each portfolio as: delta_RWA(in percent)=0.12*delta_PD^2-0.049*delta_PD+0.006;

  — *impact of concentration risk on RWAs* is calculated as the percentage increase of RWAs based on delta_RWA(in percent)=100*(0.02+12.6*HHI Parameter) at portfolio level in the banking book (HHI=Herfindahl-Hirschman concentration measure) for PD=0.4 percent; delta_RWA increases the formula above by 1+(PD of bank portfolio/0.4%-1)*0.1 for PDs>0.4 percent for each 0.4 percentage point increase of the PD if PD>0.4 (Appendix VI);[19] for instance, a very large portfolio with a low degree of concentration (HHI ≤0.0006) and an EAD-weighed PD of 0.8 percent would be expected to experience an increase of RWAs by 3.0 percent due to the impact of concentration risk on unexpected losses; and

[17] Banks that apply the standardized approach and do not have an economic capital model to generate estimates of portfolio-based PDs should assume constant credit RWAs. This applies equally to immaterial portfolios if they represent less than one percent of the loan book in aggregate.

[18] Firms that estimate the sensitivity of RWAs to changes in PDs under stress using internal models with a flexible (or different) LGD value do not need to apply the stressed LGD used for the estimation of credit losses.

[19] If the estimated economic capital model accounts for unexpected loss through stress-sensitive RWAs (at sufficient capital levels), the concentration-based adjustment of RWAs can be ignored.

— *impact of defaults on RWAs* is taken into account by reducing total credit risk RWAs by the RWAs of defaulted exposures, which should be approximated by taking 2.5 times the average RWAs for non-defaulted exposures (accounting for the fact that risk-weights for defaulted exposures were higher prior to default).

24. Firms are expected to closely follow existing reporting standards, such that:

- In order to allow for meaningful results, granular data should be used. Besides data on credit and market risk parameters, data should include sectoral credit information, information on securities in the trading and banking book, and regulatory data on capital and capital adequacy.
- PDs and LGDs are assumed to be "through-the-cycle" (TTC), but an appropriate way may be found to run relevant tests based on " PIT risk parameters (by means of calibrating parameters to accommodate the severity of the chosen scenario);
- no feedback effect of firms' lending on macro variables is assumed; and
- there are no changes to either the portfolio allocation to reduce RWAs or to firms' lending standards beyond the change in the credit balance according to the constant loan book assumption (Section A).

C. Dividend Payout Rule/Retained Income

25. The assessment of potential capital shortfall is made conditional on assumptions regarding the payout of dividends, after considering any repayment of public sector support (if applicable):

- Dividend payouts are payable out of the previous year's operating profit and, thus, cannot result in an *ex post* drop below any of the minimum capital requirements.
- Only well-capitalized firms (i.e., firms that meet the minimum capital requirement) that generate positive earnings after taxes are assumed to pay out dividends.
- Dividends are paid only by firms that satisfy all three measures of capital adequacy (total capital, Tier 1, and CET1 capital ratios) and exhibit a leverage ratio of no less than three percent in a given year (after having created adequate provisions for impairment of assets and transfer of profits to staff benefits and statutory reserves).

26. The dividend pay-out rule is consistent with the maximum pay-out ratios defined under Basel III but established a floor to minimum payouts depending on the level of total capital:[20]

[20] Under Basel III, the maximum pay-out rules are defined based on CET1 capitalization rather than based on total capitalization.

- The dividend payout ratio is defined as the percentage of "dividend payable in a year" to "net profit during the year".
- The minimum payout of profitable firms is set to 40 percent of profits, in line with empirical evidence.
- If the firm meets the minimum total CAR of 8.0 percent (after the envisaged dividend payout and, at the same time, exhibits sufficient Tier 1 and CET1 capitalization) but falls below the 10.5 percent threshold during the previous period, it is considered capital-constrained and follows a schedule of fixed dividend payouts during the *same* period (Appendix XI).

D. Additional Elements Impacting Profits and Losses

Funding Risk

27. The treatment of stress-induced funding costs is explicit (in the form of an *additional* interest expenses) but applies to undercapitalized firms) only. The preferably non-linear increase of funding costs of firms that experience high degrees of stress over the short-term should be based on the proposed approaches below or a reasonable internal model approach, calibrated on a best effort basis (based on historical and/or theoretically derived data points). These funding costs (in addition to the long-term sensitivity of interest expenses) apply only if the Tier 1 capital ratio (after stress) falls below the applicable hurdle rate (including a historical capital buffer of 2.5 percent).

28. The estimation of the annual increase of funding costs is unaffected by possible balance sheet deleveraging and assumes a constant funding structure:

- In each year, the estimated impact of shocks to the firm's balance sheet on the cost of funding ("funding rates") during the *previous* year is applied (without taking into account the fact that some losses during the current year are attributable to higher funding costs).[21] This approach avoids the simultaneity problem between contemporaneous losses and higher costs of capital.
- The funding structure is fixed due to the constant balance sheet assumption unless there are well-specified funding plans that have been discussed and agreed at board level before end-2013: Q2.[22]

[21] The macro scenarios affect any liquidity stress test only insofar as any changes in funding costs will be consistent with assumptions applied to the solvency test.

[22] The constant funding structure facilitates the modeling of funding costs under stress based on changes in prices (while controlling for the likely change in quantities). Moreover, it is consistent with the overall assumption of conducting both TD and BU stress tests based on the assumption of a static balance sheet. The constant funding mix should not be viewed as an ex ante assumption but rather as the consequence of facilitating the modeling of a disproportionate rise in funding cost during times of stress. Conversely, it would be very difficult to design a rule-based mechanism that would create additional funding costs if the degrees of freedom to seek alternative funding sources during times of stress were not restricted.

- The change in overall funding costs for all liabilities with residual maturity of up to one year is calculated each year. All short-term debt (excluding deposits) is funded at the new funding rate, but only the long-term debt due in each year is re-priced at the new rate.

- Against the background of rising competition for stable funding under adverse scenarios, the deposit rate moves in proportion to the change of overall funding costs, weighted by the levels of liabilities with residual maturity of up to one year and all other (longer term) debt.

29. An empirical approach can be used to estimate the annual increase of funding costs over the forecast horizon based on the average historical sensitivity of interest expenses to changes in capitalization. A satellite model could help link short-term funding costs to one-period lagged risk-weighted capital ratios (and/or leverage)—possibly conditional on changes in loan loss provisions and the funding gap—to simulate a nonlinear effect with respect to default risk. The marginal change in funding costs should then be added to the estimated (general) interest rate expense.[23]

30. If the firm's existing approach does not meet this precondition, a generic (linear) formula for the calculation of an "add-on factor" to interest expenses is proposed to approximate the macro-financial linkages of short-term funding costs in stress situations. This adjustment is shown in the stylized specification of the satellite model for interest expenses (Appendix V). This approach is also applied in the parallel TD solvency stress test of the FSAP. More specifically, the following additional costs (in basis points or bps) are applied to the following renewable funding sources each year of the forecast horizon for each percentage point of the forecasted capital ratio below the Tier 1 hurdle rate (+2.5 percentage point buffer):

- retail deposits (all maturities) [5 basis points],

- interbank deposits with a contractual maturity of less than one year or without maturity [20 basis points],

- short-term wholesale funding (i.e., wholesale deposits and debt securities) [10 basis points], and

- long-term wholesale funding [50 basis points, multiplied by the share of short-term liabilities in total liabilities].[24]

31. Alternatively, firms can directly apply the results from an aggregate funding risk model based on the generic historical relation between Moody's KMV Expected Default Frequencies (EDFs) and (weighted-average) funding costs of banks—also taking into account

[23] Banks can distinguish between different funding instruments in their estimation of short-term funding costs under stress. The lack of bank-specific historical observations during stress as a result of a shift in the funding structure during the recent crisis (e.g., changing collateral, the migration to central bank borrowing from private repo, and the shortening of the maturity term) could be addressed by applying data from peers with a suitable degree of severity.

[24] Only a fraction of the long-term liabilities will need to be renewed over the short term.

variations of relative importance of different funding sources for specific countries. In this general specification of the funding cost elasticity, the implicit sensitivity of the economic capital ratio to the observed (average) funding costs determines an "add-on" to be applied to estimates of expected interest expenses (Appendix VII).[25] The risk-based capital ratios for a series of rating grades are inferred from the Basel II capital model by using the confidence level corresponding to the EDFs of banks. The method is heavily based on empirical data and determines changes in the cost of debt for the average banking sector.

Valuation Changes to Fixed Income Holdings

32. The stress test must include a comprehensive assessment of sovereign risk, which covers the impact of adverse price movements on exposures in *both* the trading and banking books in order to cover all material market risk affecting exposures in economic terms, irrespective of their accounting treatment. The MtM test of exposures focuses on the projection of valuation haircuts for fixed income holdings (and long derivative positions) of sovereign debt and financial bonds. Firms are asked to adopt IMF estimates of valuation haircuts (Appendix VIII), which are based on an assumed increase of sovereign credit spreads consistent with market expectations (and a constant common shock to interest rates at all maturities of 50 basis points in the adverse scenarios), and then estimate the effects on income and expenses. Firms can also apply the implied change in credit spreads (rather than the valuation haircuts) as input for internal models. Firms can also apply the implied change in credit spreads (rather than the valuation haircuts) together with the interest rate term structure to fully reevaluate their holdings of sovereign debt and financial bonds as well as their derivatives positions (both trading book and banking book).[26]

33. The calculation of valuation haircuts under different adverse scenarios is based on the valuation of government bonds using forward-looking information from credit default swap (CDS) markets (Jobst and others, *forthcoming*) (Appendix IX). Sovereign bond prices for each year under each scenario are calculated within a model-based specification contingent on market expectations of default risk as reflected in the past dynamics of CDS spreads. More specifically, for all (liquid) bonds of sample country, the future prices over a forecast horizon are calculated by using the end-year risk-free rate and applying a density forecast of expected default risk, which is derived from the historical variation of forward rates on sovereign CDS contracts at different maturities. These price changes result in valuation haircuts, whose underlying severity assumptions are contingent on the chosen scenario—current market expectations (baseline scenario) and a high-

[25] The general elasticity of funding costs is based on the historical relation between Moody's KMV EDFs and (weighted-average) funding costs of a selected sample of European banks. This sensitivity has been derived from a panel estimation, which defined by how much funding costs should increase (decrease) as the EDF (increases) decreases. In order to utilize the estimates to motivate funding costs in addition to the long-term elasticity of interest expenses, the EDFs have been transposed into risk-based capital ratios under the IRB formula using the Basel II specification. Thus, the economic capital ratio can be considered equivalent to the CAR.

[26] Note that FX derivatives can be included in this part of the exercise or treated separately in the assessment of the FX shocks to net open positions.

percentile density forecast of the historical variation of forward contracts on sovereign CDS (adverse scenario).

34. For the purposes of the FSAP, valuation haircuts are based on current and forecasted market expectations of idiosyncratic credit risk and a general increase of interest rate. The most liquid government bonds at maturities of one, three, five, seven, and ten years have been considered for this estimation. The estimation results over the forecast horizon of five years (2014 to 2018) are shown in Appendix VIII (for end-June 2013 values) for both the baseline scenario (based on "current expectations") and the two adverse scenarios (based on the 75 percent confidence level of the density forecast, including a common interest rate shock of 50 basis points).

- For instance, in the case of HKSAR government bonds with an average maturity of five years, the appropriate haircuts for each year of the forecast time horizon are as follows:[27]

  - *baseline scenario:* **–1.67%** (2014), –2.64%+1.67%=**-0.97%** (2015), –3.60%+2.64%=**-0.96%** (2016), –4.33%+3.60%=**-0.73%** (2017) , –4.81%+4.33%=**-0.48%** (2018);

    and

  - *adverse scenario(s):* **–5.60%** (2014) and –6.53%+5.60%=**-0.93%** (2015), –7.43%+6.53%=**-0.90%** (2016), –8.05%+7.43%=**-0.62%** (2017) , –8.56%+8.05%=**-0.51%** (2018).

35. These haircuts should be applied each year of the forecast horizon to all relevant sovereign and financial sector debt exposures in the investment book (HtM) as well as AfS and trading accounts, covering all significant countries, including the local government. On aggregate, the largest foreign exposures of the local banking sector are to (in alphabetical order) Australia, Mainland China (including Chinese Taipei), France, Germany, India, Japan, Singapore, South Korea, the United Kingdom, and the United States.[28] It is assumed that sovereign risk evolves over time, and consequently rising haircuts will be applied to all years of the forecast horizon.

- *The exposures to be stressed should include all direct and indirect sovereign exposures to all significant countries, including bonds issued by financial institutions in those countries.* The net exposure comprises gross (long) exposures net of cash (short) positions (without derivative hedges such as CDS), including both on- and off-balance sheet assets and claims. Cash at central banks as well as repos or asset swaps where there is no economic interest in the

[27] Each additional year beyond the first period of the forecast horizon implies a marginal increase in valuation haircuts (especially due to a negative sovereign risk dynamics implied by forward CDS prices).

[28] As a simplification firms can combined exposures into buckets (and apply valuation haircuts on weighted-average basis using relative orders of magnitude as scaling factor): "Domestic" (Mainland China, Chinese Taipei, and HKSAR), "Developed Asia" (Australia, Japan, Singapore, and South Korea), "Emerging Asia" (all other countries in Asia-Pacific), "Core Europe" (France, Germany), "Peripheral Europe" (Greece, Italy, Ireland, Portugal, and Spain), the United States, and "Other countries".

security—e.g., instruments held against assets pledged to the HKMA or the People's Bank of China—are excluded.

- *Direct derivatives positions should be subject to fair value adjustments based on the relevant shock* (e.g., for interest rate derivatives, the implied shock to interest rates is used, and for credit-sensitive derivatives, the relevant credit value adjustment).

- *Indirect derivatives positions* (with counterparties other than the sovereign itself, such as CDSs) should be treated in a similar way as direct derivatives positions, subject to fair value adjustments of the relevant shock and the credit value adjustment.

- *Haircuts are applied to adjusted (MtM) balance sheet values.* For exposures in the investment book, the *additional* market value adjustment to historical cost until end-2013: Q2 should be added to the theoretical valuation losses attributable to changes in sovereign risk. Haircut loss amounts for AfS and HtM exposures should be fully reflected in the income statement (instead of passing them through the revaluation reserve in the case of AfS book).

- The size-weighted maturity profile of *direct and indirect sovereign exposures* determines the choice of valuation haircut for the relevant maturity term specified in Appendix VIII.

Valuation changes to foreign exchange positions

36. Firms are asked to report the aggregate impact of FX shocks on net open positions and FX assets (both through the P&L and on RWAs) in terms of an appreciation of the reminbi, euro, Japanese yen, pound sterling, Singapore dollar, and other material currencies for the firm vis-à-vis the U.S. dollar:

- The shock for each currency should be four times the maximum deviation of the annualized FX volatility during the 2008–11 period from the long-term FX volatility and impact both the P&L and the RWAs of the trading book in 2014 (at 100 percent of the calibrated shock) and 2015 (at 50 percent of the calibrated shock) only (Appendix X). For instance, net open FX positions denominated in Japanese yen should increase by 14.6 percent in Y1 (2014) and 7.3 percent in Y2 (2015).

- The Hong Kong dollar-U.S. dollar exchange rate moves within the peg range (HK$7.75 to HK$7.85).

- The impact of such unexpected revaluation of FX positions applies only to the adverse scenarios (not baseline) and should not generate any knock-on effects on other elements of the stress test.

CAPITAL ASSESSMENT

37. Solvency is assessed in accordance with changes in regulations published by the BCBS in September and December 2010 ("Basel III"). Thus, the hurdle rates applied in the FSAP stress tests follow the graduated schedule of Basel III (Appendix XII). The changes under Basel III include:

- higher in minimum capital requirement ratios, i.e., Tier 1 and CET1;
- a more restrictive definition of eligible capital ("capital deductions");
- higher asset risk-weightings; and
- the restriction on financial leverage by means of a minimum leverage ratio.[29]

38. The forecasting period of the stress test covers a large part of the Basel III transition schedule. As of January 1, 2014, firms will need to meet the following minimum capital requirements in relation to RWAs: 4.0 percent common equity/RWAs (up from 2.0 percent prior to Basel III) and 5.5 percent Tier 1 capital/RWAs (up from 3.0 percent), in addition to the existing CAR of 8.0 percent total capital/RWAs. These capital requirements are supplemented by a minimum Tier 1 leverage ratio of 3.0 percent.[30] The graduated regulatory adjustments of CET1 (i.e., deductions and prudential filters), including amounts above the aggregate 10/15 percent limit for investments in financial institutions, mortgage servicing rights, and deferred tax assets from timing differences, are scheduled to begin on January 1, 2014.[31]

39. The definition of capital at end-2013: Q2 should be consistent with the guidelines for the graduated implementation of Basel III, subject to phase-in, phase-out and grandfathering considerations affecting available capital each period over the forecast horizon (Appendices XII and XIII):

- The starting point for CET1 and Tier 1 should be the official definitions as laid out by the HKMA.
- For the *phase-in of total regulatory adjustments to CET1 capital*, 20.1 percent (per annum) of CET1 capital (e.g., goodwill, deferred tax assets and minority interests that exceed the permissible limit) are deducted between 2014 and 2018; firms must document deductions if the amount is less than 20.1 percent (~4.0 percent p.a.) (Note: 20.1 percent is the average value for Group 2 (small banks) according to the results from results from the latest Basel III monitoring exercise as of 30 June 2012 (BCBS, 2013a)).

[29] See http://www.bis.org/press/p100912.htm.

[30] The changes in minimum capital requirements also have to be taken into account for counterparty risk and market risk considerations.

[31] In particular, the regulatory adjustments will begin at 20 percent of the required deductions from common equity on January 1, 2014 over a five-year period (until end-2018). During this transition period, the remainder not deducted from common equity will continue to be subject to existing national treatments.

- For the *phase-out of non-Tier 1 and Tier 2 capital elements*, it is the higher of either 10 percent (per annum) of the amount of capital to be phased-out based on QIS results (BCBS, 2010a) for Group 2 (small banks) at 16.6 percent (~1.7 percent p.a.) or the amount of capital maturing each year of the stress test horizon between 2014 and 2018.

- Existing capital instruments are *not* grandfathered until they mature for the tier in which they currently belong.[32]

OUTPUT

40. Firms assess capital adequacy under stress on consolidated basis by reporting to the HKMA all capital measures for each year over the forecast horizon using the output template presented in Appendix XIII (and attached to this guidance note in electronic form). These metrics comprise (i) total capital, (ii) Tier 1 capital, and (iii) CET1 capital, and are reported for each year of the forecast time horizon. Firms should disclose the composition of capital in each period and show the calculated recapitalization needs (if they would experience a capital shortfall).

41. Firms should also report the major risk drivers (profitability, credit/trading losses). They should show the marginal impact of including haircuts on sovereign exposures. In addition, firms may report alternative stress test results without considering the restrictions on the behavioral adjustment of banks as separate output.

42. Firms should document their estimation of important stress testing elements, such as funding costs, supervisory standards (risk-weights), and macro-financial linkages ("satellite models" and/or expert judgment), and demonstrate their compliance with the IMF-provided minimum standards:

- Results should show RWAs for credit, market and operational risk, and the specifications of macro-financial linkages ("satellite models" and/or expert judgment) affecting the forecast of profitability and credit losses.

- HKMA staff will engage, on an ongoing basis, with the stress testing efforts of firms to help ensure consistency of underpinning assumptions, supervisory appropriateness of interpretation and implementation, and suitability of models prior to the final submission of the stress test results. Banks are encouraged to involve line supervisors at the HKMA early on so that preliminary results can be assessed prior to final submission. These efforts could also include the "pre-approval" of internal model-generated estimates, which will help reduce the time required for HKMA staff to review the final stress test results.

- The results will also be checked by HKMA staff against historical experience, other stress testing work by the firms under the supervisory stress test conducted by the HKMA, as well as general

[32] Firms should exclude the Tier 1 share of a material holdings deduction for securitization at the consolidated level.

plausibility by using results from a TD version of the stress test exercise by IMF staff (jointly with HKMA staff), using satellite models estimated based on aggregate data.

43. The IMF will only publish results related to the stress test after consulting with the HKMA—and subject to the existing confidentiality agreement between the HKMA and firms as well as IMF statutes that govern data confidentiality with national authorities. The focus will be on the identification of system-wide vulnerabilities and the evolution of overall capital adequacy. Information about the impact of changes in hurdle rates and the modification of capital treatment under Basel III, as well as the risk drivers, will be used to support the interpretation of results only.

44. The proposed timeline for the completion of the BU stress tests is presented in Appendix I.

Appendix I. Timeline for Completion of Solvency BU Stress Test

September 16, 2013	Firms receive stress testing guidelines from HKMA
September 3-17, 2013	Technical follow-up with participating banks during first IMF FSAP mission
November 11, 2013	Firms report final results and HKMA prepares output for IMF FSAP team
November 18, 2013	HKMA communicates results to IMF FSAP team
November 14-26, 2013	Discussion of results by HKMA staff and IMF FSAP team during second IMF FSAP mission

Appendix II. Key Bottom-up Solvency Stress Test Parameters

Domain	Element	Specific Rules/Assumptions
Scenarios	(i) Baseline (ii) "Slow Growth" (SG) (iii) "Severe Adverse" (SA)	• Macroeconomic scenarios over five years (forecast horizon). • Macroeconomic/financial variables (GDP (nominal and real), household income, unemployment, inflation, interest rates/asset swap rates (short-term and long-term), equity prices, commercial property price index, real estate price index, and credit growth) conditional on specific scenario; macroeconomic models run by HKMA and IMF staff for all variables with the exception of credit growth. • Cross-border effects are considered in all macro scenarios. IMF staff provided estimates for real GDP growth consistent with the macroeconomic forecast for HKSAR and Mainland China under both baseline and adverse scenarios for all relevant countries affecting bank performance abroad. • Aim to ensure consistency with HKMA stress test and other FSAPs.
Risk factors assessed	Credit risk (loss rates) Market risk Profitability FX shock Taxes	• ***Credit losses*** are based on satellite models depending on the selected scenario; since all sample banks report under IRB, own internal estimates rather than the prescribed PDs/LGDs according to Basel II should be used; estimates should be specific to each material loan category and include an increase of LGDs under stress according to the following specification: LGD(under stress)=0.3502+2.3408*PD (Moody's, 2009) or LGD(under stress)=0.4022+2.1535*PD (if the down-cycle LGDs are based on a long-term average, i.e., "through the cycle"). In case of overcollateralization (or supervisory LGDs below the intercept value), the increase of LGDs is limited to the trend coefficient (beta) of the LGD elasticity to PDs. • ***Market risk***: (a) FX shock to U.S. dollar (vis-à-vis most important currencies) and (b) haircuts on holdings of both sovereign and all financial sector debt securities in both trading and investment books based on market expectations over five years after controlling for changes of market valuation using density forecasts of forward contracts on sovereign CDS spread over an estimation using the methodology developed by IMF staff. • ***Profit*** (interest income, interest expenses, net fee and commission income, and operating expenses) should be based on IMF/firm's own satellite models (or expert judgment). Reported net profit before tax at sample cut-off (end-June 2013) should be adjusted for extraordinary income/losses in order to avoid misleading results when extrapolating operational performance until year-end. "Other income" changes with nominal GDP. • ***Trading income*** based on satellite model or statistical matching of both trading income and GDP growth using a parametric fit of their historical distribution (i.e., a decline in GDP growth is assumed to result in lower trading income).

Domain	Element	Specific Rules/Assumptions
		• ***Funding costs*** based on IMF/firm's own satellite model for additional interest expenses under stress, including (preferably) a nonlinear effect (with the IMF-suggested funding cost increase establishing an absolute minimum). Changes in funding costs are unaffected by possible balance sheet deleveraging. • ***Sovereign risk:*** Haircut on direct and indirect sovereign exposures, including financial bonds, in the banking and trading books based on market expectations over five years after controlling for changes of market valuation between January 2009 and June 2013 as developed by IMF staff. Cash at central banks as well as repos or asset swaps where there is no economic interest in the security (for instance, instruments held against assets pledged to the HKMA or the People's Bank of China) are excluded. • ***FX shock:*** Firms are asked to report the aggregate impact of the following FX shock of the following currencies on FX net open positions (both through the P&L and on RWAs): Chinese Reminbi, Euro, Japanese yen, Pound sterling, Singapore dollar, and other material currencies for the firm vis-à-vis the U.S. dollar. The shock for each currency should be four times the maximum deviation of the annualized FX volatility during the 2008-11 period from the long-term FX volatility (>10 years) for the adverse scenarios (not baseline) and impact the trading book in 2014 (100 percent) and 2015 (50 percent) only. • ***Tax assumption:*** 16.5 percent in case of net operating profits, zero otherwise. Tax credit after the first year of the stress period is taken into account.
Behavioral adjustment of banks	Dividend pay-out rules (similar to Basel III minima) Credit growth Asset disposal Capital raising	• ***Balance sheets*** are assumed to be static but credit growth is constant (i.e., lending and commensurate funding requirements increase in line with nominal GDP (if positive)), subject to a "deleveraging rule"; defaulted loans are not replenished. • ***Dividend payout*** depends on capitalization under stress. There is a minimum dividend pay-out, which occurs only if the firm reported profits during the previous period; if the total capital ratio is above 8.0 percent (after the envisaged dividend payout) but below 10.5 percent (which reflects the magnitude of the CAR and "capital conservation buffer" under Basel III), the firm is considered capital-constrained and needs to follow a payout schedule as displayed in Appendix XI; however, firms that are not capital constrained will have to pay out at least 40 percent of earnings after tax each year.

Domain	Element	Specific Rules/Assumptions
		• ***Credit growth*** in line with nominal GDP for banks with a Tier 1 capital buffer of 2.5 percentage points above the regulatory minimum (for Tier 1); credit growth decreases by 2 percentage points for each decrease in Tier 1 capital by 1 percentage point once the buffer is less than 2.5 percentage points. Hence, growth becomes negative when capitalization is at minimum capital ratio. • ***Other business strategy considerations:*** asset disposals or acquisitions over time should not be considered, except where legally binding commitments existed prior to the end-date of data input (end-June 2013). Maturing exposures are assumed to be replaced. Any interim capital-raising until end-2013 can be considered in calculations.
Regulatory standards	Capital requirements ('hurdle rates') Changes in risk-weighted assets (RWAs) Capital phase-out/-in	• ***Hurdle rates*** for CET1, Tier 1 capital (T1), and total capital (CAR) according to the Basel III schedule (i.e., increasing from 2013 onwards with application to the five-year stress testing horizon from 2014 to 2018). • ***Changes in RWAs:*** RWAs for operational risk remain constant throughout the forecast period; RWAs for credit risk and market risk are subject to the Basel I floor and sensitive to the regulatory impact due to Basel 2.5 and Basel III (as reported in several QIS and monitoring exercises (BCBS, 2010a and 2013a)), which should increase by at least 5.13 percent [credit risk] and 0.47 percent [market risk] (independent of asset growth) in 2014 and 2015, respectively (assuming that 1/3 of the change in RWAs has already been absorbed during the implementation of Basel 2.5 and III in 2013); in addition, credit RWAs are sensitive both changes in PDs and portfolio concentrations: ➢ calculate the nonlinear effect of changes in PDs on RWAs: since the impact of LGDs on RWAs is linear, the elasticity of unexpected losses leading to changes in RWAs can be extracted from the Basel II IRB formula for corporate loans after fixing the asset correlations to the lowest level of the PDs (a level corresponding to a "Aaa"-rating) and the LGD to 45 percent; thus, the marginal increase of RWAs(in percent) for an increase

Domain	Element	Specific Rules/Assumptions
		➢ of RWAs(in percent) for an increase of PDs (in percent) can be calculated as: delta_RWA(in percent)=0.12*delta_PD^2-0.049*delta_PD+0.006 (which assumes an initial elasticity of 0.6 of RWAs to PDs at the lowest level of PD); ➢ control for concentration risk impact on RWAs: delta_RWA(in percent)=100*(0.02+12.6*HHI Parameter) at portfolio level in the banking book, with an increase of delta_RWA by 1+(PD of bank portfolio/0.4%-1)*0.1 for PDs>0.4 percent, where HHI is the Herfindahl-Hirschman concentration measure (Appendix VI). Firms may apply lower values for the initial increase of RWAs for credit risk if documented. Where the calculation of Basel III risk weights for some exposure types (e.g., counterparty credit risk) are difficult to estimate, risk weights are double those of the Basel II weights. • ***RWA impact of defaulted loans:*** The risk-weights for credit risk are reduced by the RWAs of defaulted exposures, which should be approximated by taking 2.5 times the average RWAs for non-defaulted exposures (accounting for the fact that risk-weights for defaulted exposures were higher prior to default). • **Capital definition** according to the Basel III framework. During the forecast horizon it has to comply with the envisaged phase-in of capital deductions and the phase-out of non-eligible forms of capital elements without consideration of grandfathering. ➢ ***Phase-in of total regulatory adjustments to CET1 capital:*** 20.1 percent of CET1 capital (e.g., goodwill, deferred tax assets and minority interests that exceed the permissible limit) is to be deducted between 2014 and 2018; firms must document deductions if the amount is less than 4.0 percent p.a. (Note: 20.1 percent is the average value for Group 2 (small banks) according to the results from results from the latest Basel III monitoring exercise as of 30 June 2012 (BCBS, 2013a)).

Domain	Element	Specific Rules/Assumptions
		➢ ***Phase-out of non-Tier 1 and Tier 2 capital elements:*** the higher of either (i) 10 percent (per annum) of the amount of capital to be phased-out based on QIS results (BCBS, 2010a) for Group 2 (large banks) at 16.6 percent (≈ 1.7 percent p.a.) or (ii) the amount of capital maturing each year of the stress test horizon between 2014 and 2018.
Outcome	Reporting of results and additional outputs	• ***Output template:*** Firms report capital adequacy under stress based on the common capital measures (total capital, Tier 1 capital and CET1) for each year over the forecast horizon using the suggested output template. In case of a capital shortfall, recapitalization needs are calculated. Firms should report the major risk drivers (profitability, credit/trading losses, risk-weights) and show the marginal impact of including (i) haircuts on sovereign debt holdings; (ii) capital phase-in/phase-out according to Basel III; and (iii) FX shocks. In addition, firms may report alternative stress test results without considering the restrictions on the behavioral adjustment of banks as separate output.

Table A3.1. Macroeconomic Projections for HKSAR under Different Scenarios

(annual percentage change, unless otherwise indicated)

		Baseline Scenario					Slow Growth (SG) Scenario					Severe Adverse (SA) Scenario				
	2013 (est.)	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
Economic activity and labor market																
Real GDP	2.96	4.39	4.37	4.46	4.46	4.51	1.78	2.66	2.70	2.99	2.95	1.32	0.63	2.38	2.91	2.84
Nominal household income	4.49	4.67	5.13	4.56	4.69	4.82	1.53	2.62	2.33	1.82	2.06	0.88	0.14	1.38	1.33	1.48
Unemployment rate (% of labor force)	3.30	3.46	3.57	3.70	3.82	3.84	4.15	4.78	5.54	6.18	6.75	4.32	5.54	6.43	7.09	7.69
Price and cost developments																
Consumption prices (average CPI)	3.95	3.67	3.57	3.54	3.53	3.53	3.09	2.21	1.81	1.65	1.58	3.04	1.59	0.82	0.91	1.05
Residential house prices	7.97	-1.68	-0.70	-1.20	-1.49	3.28	-9.54	-6.10	-6.51	-6.24	-1.84	-11.97	-12.58	-7.06	-5.98	-1.97
Commercial real estate prices	-1.15	-9.35	-0.26	2.03	1.98	7.95	-17.05	-7.19	-4.99	-3.69	1.20	-19.26	-14.47	-6.96	-3.47	1.02
Equity market index (Hang Seng index)	7.00	8.06	7.94	8.00	8.00	8.04	-13.95	-9.13	-9.39	-7.89	-8.32	-16.42	-20.00	-11.13	-8.28	-8.89
Interest rates																
3-month U.S. Treasury rate	0.10	0.17	0.13	0.26	0.46	0.57	0.10	0.20	0.90	2.10	3.10	0.35	0.53	1.23	2.43	3.90
Time deposit rate (%)	0.15	0.22	0.18	0.31	0.51	0.62	0.15	0.25	0.95	2.15	3.15	0.40	0.58	1.28	2.48	3.95
3-month HIBOR rate (%)	0.38	0.41	0.51	0.62	0.72	0.82	0.66	1.10	2.24	3.39	4.53	0.66	1.10	2.24	3.39	4.53
12-month HIBOR rate (%)	0.87	1.00	1.10	1.20	1.30	1.40	1.25	1.68	2.84	3.99	5.15	1.25	1.68	2.84	3.99	5.15
Best lending rate (%)	5.00	5.00	5.10	5.20	5.30	5.40	5.20	5.57	5.94	6.31	6.68	5.12	5.41	5.71	6.00	6.30
Memo item																
Real GDP (P.R. China)	7.80	7.70	7.60	7.50	7.50	7.50	5.60	5.52	6.96	7.50	7.44	5.23	3.73	6.32	7.32	7.27

Source: HKMA and IMF staff estimates and calculations. Note: Interest rates shown for 2013 above are recorded as of end-June 2013.

Table A3.2. Projected Real GDP for Other Countries under Different Scenarios

Real GDP growth, year-on-year

(In percent)

			Baseline		Deviation from Baseline: Slow Growth		Deviation from Baseline: Severe Adverse	
	2012	2013	2014	2015	2014	2015	2014	2015
HKSAR	1.4	3.0	4.4	4.4	-2.6	-1.7	-3.1	-3.7
China	7.8	7.8	7.7	7.6	-2.1	-2.1	-2.5	-3.9
Australia	3.6	3.0	3.3	3.1	-0.8	-0.4	-0.9	-0.9
France	0.0	-0.1	0.9	1.5	-0.4	-0.2	-0.5	-0.5
Germany	0.9	0.6	1.5	1.3	-0.8	-0.5	-3.1	-3.7
India	4.0	5.7	6.2	6.6	-2.0	-1.7	-2.4	-3.2
Japan	2.0	1.6	1.4	1.1	-1.5	-1.5	-1.8	-2.8
South Korea	2.0	2.8	3.9	4.0	-1.3	-0.9	-1.6	-1.8
Singapore	1.3	2.0	5.1	4.2	-0.5	-0.5	-0.6	-0.9
United Kingdom	0.2	0.7	1.5	1.8	-0.7	-0.4	-0.9	-0.9
United States	2.2	1.7	2.7	3.5	-0.9	-0.8	-1.0	-1.5

Appendix IV. Estimated Asset Swap Rate Curve

Table A4.1. Estimated Asset Swap Rate Curve (U.S. dollar, Renminbi and H.K. dollar) under Different Scenarios

Estimated Asset Swap Rates—United States, P.R. China, and Hong Kong SAR

(In percent, end of period)

Baseline

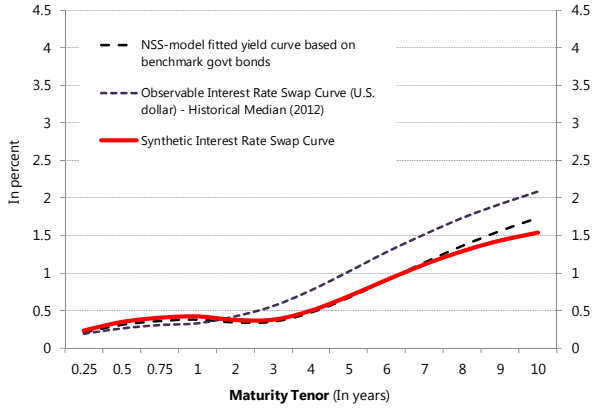
Maturity Term	2014			2015			2016			2017			2018		
	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD
3M	0.23	1.69	0.03	0.33	1.79	0.13	0.43	1.89	0.24	0.53	1.99	0.34	0.63	2.09	0.44
6M	0.35	2.30	0.05	0.45	2.40	0.15	0.55	2.50	0.25	0.65	2.60	0.35	0.75	2.70	0.45
9M	0.40	2.76	0.08	0.50	2.86	0.18	0.60	2.96	0.28	0.70	3.06	0.38	0.80	3.17	0.48
1Y	0.42	3.11	0.13	0.52	3.21	0.23	0.62	3.31	0.33	0.72	3.42	0.43	0.82	3.52	0.53
2Y	0.37	3.72	0.39	0.47	3.82	0.49	0.57	3.92	0.59	0.68	4.02	0.69	0.78	4.12	0.79
3Y	0.38	3.72	0.65	0.48	3.82	0.75	0.58	3.92	0.85	0.68	4.02	0.95	0.78	4.12	1.05
4Y	0.50	3.63	0.87	0.60	3.73	0.98	0.70	3.83	1.08	0.80	3.93	1.18	0.90	4.03	1.28
5Y	0.69	3.62	1.07	0.79	3.72	1.17	0.89	3.82	1.27	0.99	3.92	1.38	1.09	4.02	1.48
6Y	0.91	3.69	1.26	1.01	3.79	1.36	1.11	3.89	1.47	1.21	3.99	1.57	1.31	4.10	1.67
7Y	1.11	3.80	1.46	1.21	3.90	1.56	1.31	4.00	1.66	1.42	4.10	1.76	1.52	4.20	1.86
8Y	1.29	3.89	1.67	1.39	3.99	1.77	1.49	4.09	1.87	1.59	4.19	1.97	1.69	4.29	2.07
9Y	1.43	3.90	1.89	1.53	4.00	1.99	1.63	4.10	2.09	1.73	4.20	2.19	1.84	4.30	2.30
10Y	1.54	3.80	2.14	1.64	3.90	2.24	1.74	4.00	2.34	1.84	4.10	2.44	1.94	4.20	2.54

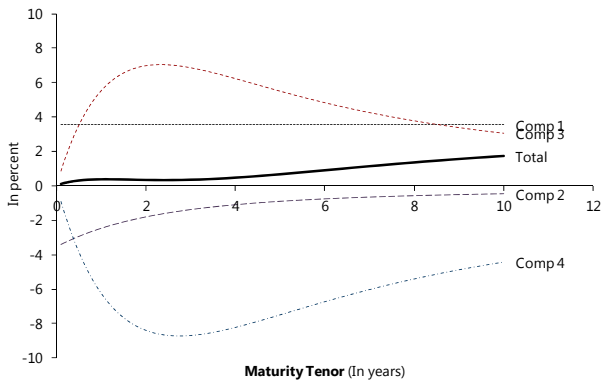
Slow Growth (SG)/Severe Adverse (SA)

Maturity Term	2014			2015			2016			2017			2018		
	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD	USD	CNY	HKD
3M	0.48	1.94	0.28	0.91	2.37	0.72	2.06	3.52	1.86	3.21	4.66	3.01	4.35	5.81	4.15
6M	0.60	2.54	0.29	1.03	2.98	0.73	2.18	4.13	1.88	3.33	5.28	3.02	4.48	6.43	4.17
9M	0.65	3.01	0.33	1.08	3.45	0.76	2.24	4.60	1.91	3.39	5.75	3.07	4.54	6.90	4.22
1Y	0.67	3.36	0.38	1.10	3.80	0.81	2.26	4.95	1.97	3.42	6.11	3.12	4.57	7.26	4.28
2Y	0.62	3.97	0.64	1.06	4.40	1.08	2.23	5.57	2.24	3.40	6.74	3.41	4.57	7.91	4.58
3Y	0.63	3.97	0.90	1.07	4.41	1.34	2.25	5.59	2.52	3.43	6.77	3.70	4.61	7.95	4.88
4Y	0.75	3.88	1.13	1.19	4.32	1.56	2.38	5.51	2.76	3.58	6.71	3.96	4.77	7.90	5.15
5Y	0.94	3.87	1.32	1.38	4.31	1.77	2.59	5.52	2.97	3.80	6.73	4.18	5.01	7.94	5.39
6Y	1.16	3.94	1.52	1.60	4.39	1.96	2.83	5.61	3.18	4.05	6.83	4.40	5.27	8.05	5.63
7Y	1.37	4.05	1.71	1.81	4.50	2.16	3.05	5.74	3.39	4.28	6.97	4.63	5.52	8.21	5.86
8Y	1.54	4.14	1.92	1.99	4.59	2.37	3.24	5.84	3.62	4.49	7.09	4.87	5.74	8.34	6.12
9Y	1.69	4.15	2.15	2.13	4.60	2.59	3.40	5.86	3.86	4.66	7.13	5.12	5.93	8.39	6.39
10Y	1.79	4.05	2.39	2.24	4.50	2.84	3.52	5.78	4.12	4.80	7.06	5.40	6.08	8.34	6.68

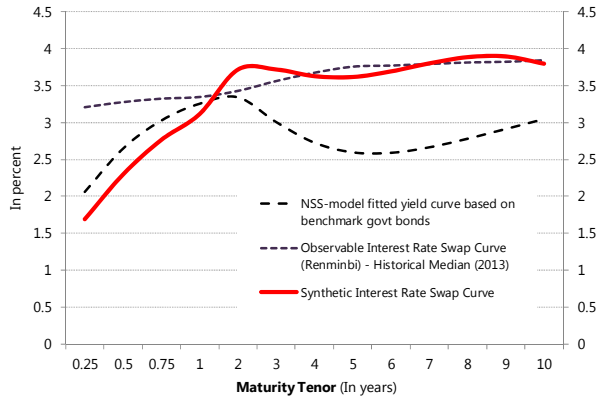
Table A4.2. Estimated Asset Swap Rate: Fitted Risk-free Term Structure and Observed Interest Rate Swap Curve.

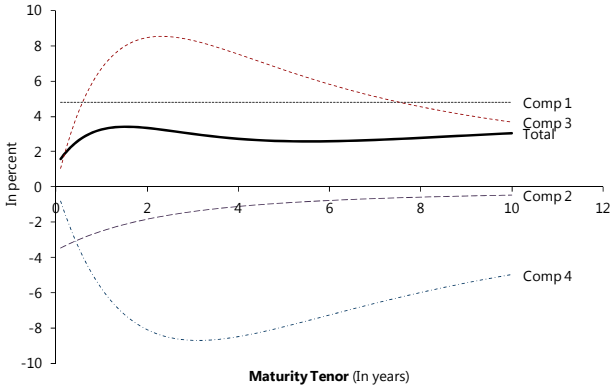
United States (U.S. dollar)



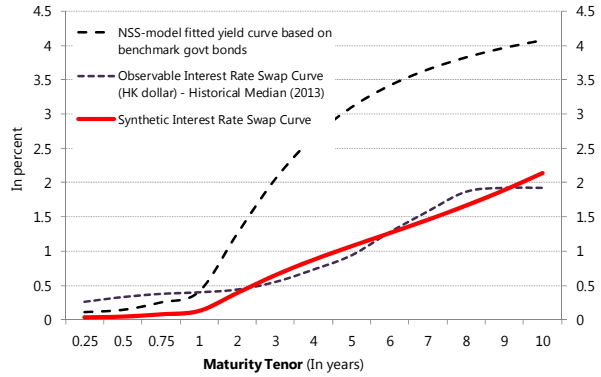


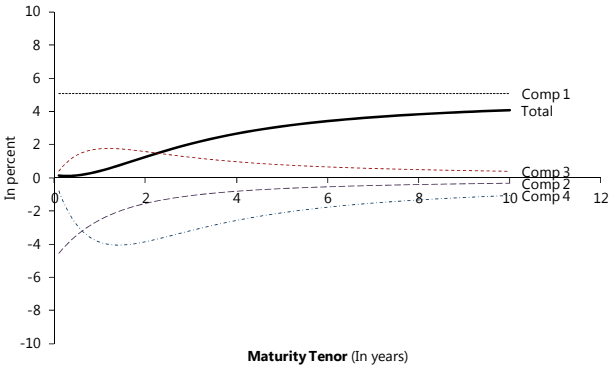
P.R. China (Renminbi)





Hong Kong SAR (HK dollar)





Source: Bloomberg LP and staff calculations. *Note:* This methodology represents a hybrid approach for the calibration of a swap spread curve based observable interest rates under different macro scenarios of the stress test. The estimation follows a three-step process, which builds on a conventional term structure model of government bond yields (Nelson-Siegel-Svensson, 1994) and incorporates the dynamics of the historical interest rate swap spread curve in order to generate a discrete interest rate path for the three major currencies of the aggregate sector balance sheet.

Appendix V. Possible Satellite Model Specification

Dependent Variable	**Lagged Term**	**Total customer loans** to total assets in %	**10-year sov. yield**	**3-month interest rate** (effective)	**Real GDP growth (y-o-y)**	**Total assets** (logarithm of total assets, lagged)	**Leverage ratio** (equity to total assets) in %, lagged	**Nonperforming loans to customer loans** in %, lagged	**Funding gap** (difference between customer loans and deposits in % of total assets, lagged)	**Other macro variables:** headline inflation, unemployment, and asset prices (real estate/equity markets)	Constant	R^2
Change (Δ) in interest Income to total assets in %	x	-	x	x	x	x	-	x	-	x	x	
Δinterest expenses to total assets in %	x	x	x	x	x	x	X	-	x	x	x	
	+ funding cost add-on per one percentage point (pcp) of capital (in percent)*([x]-Tier 1 capital ratio (after stress) in percent)*defined liabilities$_t$ (see above)), where [x] represents the hurdle rate (e.g., 6%) for Tier 1 in each forecast period and a 2.5pcp capital buffer) 1/											
Δnet fee and commission income to total assets in %	x	-	-	-	x	x	X	-	-	x	x	
Δoperating expenses to total assets in %	x	-	-	-	x	x	-	-	-	x	x	
Δloan loss provisions (LLP) (write downs in lending business in % of customer loans)	x	x	x	x	x	x	-	-	-	x	x	

Note: 1/ This term represents an adjustment of interest expenses by additional funding costs (in basis points) at a level of capitalization consistent with the applicable hurdle rate Tier 1 capital in the stress test and the economic capital ratio approximation in Appendix VII.

Appendix VI. Concentration Impact on RWAs under Stress

		Increase in RWAs *(In percent)*												
		Portfolio PD *(In percent)*												
		0.4	0.5	0.6	0.7	**0.8**	0.9	1	1.1	**1.2**	1.3	1.4	1.5	**1.6**
		Multiple												
		1	1.025	1.05	1.075	**1.1**	1.125	1.15	1.175	1.2	1.225	1.25	1.275	1.3
Portfolio Size	HHI													
large portfolio	0.0006	**2.8**	2.8	2.9	3.0	**3.0**	3.1	3.2	3.2	**3.3**	3.4	3.4	3.5	**3.6**
medium-sized portfolio, low concentration	0.0010	**3.3**	3.3	3.4	3.5	**3.6**	3.7	3.7	3.8	**3.9**	4.0	4.1	4.2	**4.2**
small portfolio, low concentration	0.0040	**7.0**	7.2	7.4	7.6	**7.7**	7.9	8.1	8.3	**8.4**	8.6	8.8	9.0	**9.2**
small portfolio, concentrated	0.0110	**15.9**	16.3	16.7	17.0	**17.4**	17.8	18.2	18.6	**19.0**	19.4	19.8	20.2	**20.6**
very small portfolio	0.0310	**41.1**	42.1	43.1	44.1	**45.2**	46.2	47.2	48.2	**49.3**	50.3	51.3	52.3	**53.4**

Appendix VII. Minimum Funding Cost: Empirical Estimation of Nonlinear Change

Rating scale (S&P, Fitch)	**EDF or PD** (one-year, in percent)	**Funding costs** (spread above T-bills, bps)	**Economic capital ratio** (Basel II (quasi-IRB))	**Change of funding spread** (CAR elasticity)
AAA	0.00004	8.7	28.1	n.a.
AA+	0.00006	8.7	27.3	0.0000
AA	0.0001	8.7	26.2	0.0000
AA-	0.001	8.9	21.2	0.0002
A+	0.002	9.0	19.7	0.0008
A	0.026	11.9	14.3	0.0055
A-	0.032	12.7	13.9	0.0180
BBB+	0.1	21.0	11.7	0.0386
BBB	0.139	25.9	11.1	0.0806
BBB-	0.291	44.6	9.9	0.1464
BB+	0.682	92.7	8.5	0.3541
BB	0.728	98.4	8.4	0.5738
BB-	1.791	229.4	7.1	1.0269
B+	2.45	310.5	6.7	2.0109
B	3.827	480.2	6.2	3.1611

Note: Funding cost exclude the cost of equity. The economic capital ratio includes a capital buffer above the hurdle rate of 2.5 percentage points.

Appendix VIII. Valuation Haircuts and Implied Credit Spread Shock for Relevant Country Exposures

Table A8.1. Estimated Valuation Haircuts

Valuation Haircut for Sovereign Exposures (relative to end-June 2013), *In percent*

(country-specific shock without (with) constant common shock (50bps) to interest rate level in the baseline (adverse) scenario)

	Baseline Scenario *current expectations 1/*					Adverse Scenarios *75th percentile value 2/*					Baseline Scenario *current expectations 1/*					Adverse Scenarios *75th percentile value 2/*				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
	Hong Kong SAR										**United States**									
1 Year	0.25	0.38	0.69	0.98	1.37	0.88	1.00	1.40	1.76	2.14	0.04	0.10	0.22	0.51	0.63	0.71	0.78	0.96	1.31	1.56
3 Years	0.75	1.36	2.25	2.91	3.36	2.68	3.54	4.50	5.05	5.52	0.10	0.56	1.04	1.42	1.55	2.15	2.76	3.45	3.90	4.24
5 Years	1.67	2.64	3.60	4.33	4.81	5.60	6.53	7.43	8.05	8.56	0.62	1.18	1.69	2.10	2.25	4.60	5.19	5.90	6.40	6.80
7 Years	2.60	3.68	4.74	5.54	6.07	8.67	9.52	10.37	10.96	11.50	1.21	1.83	2.41	2.88	3.04	7.38	7.98	8.79	9.30	9.82
10 Years	3.58	4.78	5.95	6.86	7.46	12.84	13.51	14.26	14.77	15.34	0.81	1.59	2.32	2.92	3.14	11.41	12.05	13.06	13.62	14.36
	P.R. China										**United Kingdom**									
1 Year	0.25	0.55	1.07	1.36	1.59	1.01	1.40	2.03	2.44	2.72	0.21	0.35	0.51	0.60	0.94	0.85	1.01	1.22	1.26	1.56
3 Years	1.04	2.09	3.09	3.64	3.96	3.81	5.06	6.26	6.91	7.26	0.76	1.16	1.75	2.27	2.73	3.25	3.66	4.29	4.62	4.82
5 Years	1.83	3.25	4.45	5.12	5.49	7.45	8.92	10.20	10.94	11.30	1.24	2.11	2.81	3.45	3.87	6.22	6.93	7.50	7.65	7.64
7 Years	2.64	4.18	5.45	6.17	6.56	10.67	12.06	13.40	14.15	14.55	1.74	2.75	3.54	4.20	4.61	9.44	9.86	10.31	10.30	10.13
10 Years	4.96	7.02	8.73	9.70	10.23	18.99	20.52	22.21	23.11	23.65	1.82	2.83	3.69	4.24	4.67	12.58	12.59	12.81	12.58	12.20
	Chinese Taipei										**Germany**									
1 Year	0.27	0.60	1.18	1.49	1.74	1.11	1.53	2.23	2.67	2.99	0.06	0.19	0.26	0.56	0.92	0.78	0.99	1.07	1.46	1.91
3 Years	1.06	2.14	3.17	3.74	4.06	3.91	5.19	6.42	7.09	7.45	0.31	0.83	1.55	2.23	2.72	2.83	3.65	4.69	5.30	5.68
5 Years	1.69	3.00	4.11	4.73	5.07	6.89	8.25	9.44	10.14	10.47	1.03	1.97	2.87	3.73	4.31	6.99	8.17	9.08	9.45	9.65
7 Years	2.53	4.00	5.21	5.91	6.29	10.23	11.57	12.85	13.57	13.96	1.95	2.96	3.88	4.76	5.35	10.46	11.29	12.07	12.28	12.37
10 Years	3.90	5.53	6.89	7.67	8.10	15.18	16.44	17.83	18.58	19.03	1.78	3.20	4.49	5.74	6.58	17.48	18.19	19.01	19.01	18.92
	Japan										**France**									
1 Year	0.20	0.49	0.96	1.05	1.78	0.92	1.24	1.82	1.87	2.65	0.30	0.66	1.00	1.43	2.05	1.24	1.74	2.14	2.54	3.17
3 Years	1.03	1.79	3.02	3.91	4.42	3.40	4.25	5.64	6.52	6.99	1.07	2.13	3.45	4.51	5.03	4.61	5.87	7.30	8.05	8.37
5 Years	2.15	3.79	4.93	5.50	5.91	6.85	8.46	9.56	10.15	10.52	2.16	4.02	5.56	6.81	7.20	10.31	11.96	12.99	13.29	13.29
7 Years	3.46	4.75	5.78	6.37	6.80	9.98	10.91	12.00	12.57	12.92	2.32	4.14	5.68	6.78	7.12	13.17	14.30	14.99	15.08	14.95
10 Years	4.81	6.18	7.34	8.00	8.48	14.36	15.14	16.26	16.85	17.18	3.37	5.76	7.80	8.93	9.37	21.66	22.42	22.80	22.58	22.24
	Australia										**Italy**									
1 Year	0.00	0.26	0.62	0.83	1.00	0.67	0.98	1.40	1.59	1.79	0.68	1.39	1.94	2.30	2.32	2.31	2.99	3.51	3.96	4.02
3 Years	0.66	1.35	1.98	2.32	2.46	2.73	3.45	4.10	4.39	4.55	2.28	4.02	5.06	5.30	4.80	8.14	9.36	9.99	10.28	9.75
5 Years	1.77	2.70	3.46	3.89	4.06	6.10	6.89	7.58	7.90	8.02	3.86	5.85	6.41	6.13	5.54	14.78	15.31	14.98	14.50	13.92
7 Years	2.85	3.94	4.84	5.35	5.55	9.87	10.56	11.24	11.55	11.66	5.68	7.44	8.00	7.67	6.97	21.32	20.82	20.26	19.66	19.03
10 Years	2.00	3.25	4.30	4.88	5.12	12.95	13.41	14.01	14.25	14.34	6.03	8.38	8.99	8.55	7.61	30.32	29.12	28.19	27.36	26.63
	South Korea										**Ireland**									
1 Year	0.26	0.51	0.90	1.19	1.35	1.10	1.38	1.99	2.53	2.79	0.05	0.29	0.59	0.93	1.05	1.75	1.70	1.80	2.15	2.30
3 Years	0.85	1.85	2.74	3.25	3.32	4.44	5.91	7.10	7.74	7.88	0.57	2.05	3.27	4.06	4.08	11.51	10.80	10.12	10.20	10.03
5 Years	1.73	2.88	3.67	4.06	4.14	9.19	10.02	10.76	11.12	11.27	2.73	4.60	5.84	6.56	6.58	25.82	21.57	18.35	17.35	17.06
7 Years	2.67	3.82	4.72	5.19	5.27	14.34	14.25	14.91	15.26	15.55	4.66	6.36	7.67	8.43	8.45	34.53	28.09	23.79	22.45	22.14
10 Years	4.93	6.47	7.69	8.31	8.42	24.67	23.80	24.38	24.70	25.25	4.04	6.20	7.86	8.83	8.86	47.17	38.13	31.88	29.90	29.51
	India										**Portugal**									
1 Year	0.80	1.73	2.65	3.21	2.88	1.87	2.77	3.88	4.92	4.52	0.40	1.45	1.95	2.78	2.41	4.48	3.44	3.02	3.93	3.99
3 Years	3.61	6.13	7.31	7.53	7.15	7.57	10.98	12.43	12.67	12.25	2.37	4.97	6.09	5.93	5.40	15.21	10.90	10.12	10.24	9.67
5 Years	6.37	8.75	10.19	10.53	10.08	15.05	17.35	18.87	19.19	18.75	6.44	8.33	8.78	8.49	7.84	29.98	20.29	16.57	15.84	15.19
7 Years	9.97	12.84	14.56	14.95	14.41	22.92	25.03	26.67	26.97	26.69	11.71	12.85	13.45	13.07	12.20	45.70	31.42	25.43	24.07	23.16
10 Years	19.08	23.15	25.55	26.10	25.35	40.31	42.60	44.49	44.75	44.74	17.87	19.85	20.92	20.26	18.75	73.19	53.68	43.38	40.65	39.15
	Singapore										**Spain**									
1 Year	0.25	0.38	0.68	0.97	1.36	0.87	1.00	1.39	1.75	2.12	0.50	1.21	1.76	2.27	2.18	2.48	3.08	3.51	4.04	3.87
3 Years	0.72	1.32	2.18	2.83	3.26	2.60	3.44	4.37	4.90	5.36	1.77	3.52	4.54	4.76	4.34	8.26	9.30	9.65	9.62	8.95
5 Years	1.89	2.99	4.08	4.90	5.44	6.33	7.38	8.39	9.08	9.65	4.11	6.09	6.87	6.69	6.16	16.60	16.64	15.92	15.19	14.31
7 Years	2.67	3.78	4.86	5.69	6.23	8.90	9.77	10.64	11.24	11.79	5.61	7.30	8.17	8.03	7.45	22.20	21.40	20.37	19.36	18.37
10 Years	3.47	4.63	5.78	6.66	7.24	12.47	13.12	13.86	14.36	14.92	6.79	9.22	10.46	10.34	9.52	34.00	32.39	30.69	29.05	27.69

Sources: Bloomberg, IMF (2013), and Jobst and others *(forthcoming)*. *Notes:* Exposures to Greece (if applicable) receive a valuation haircut of 100 percent. 1/ "Current expectations" reflect market expectations (and their implications for valuation haircuts) implied by forward contracts (with maturity terms between 1 and 5 years) on 1-, 3-, 5-, 7-, and 10-year credit default swaps (CDS) at end-June 2013 (without considering past CDS dynamics); 2/ The adverse scenarios was generated from the historically derived density forecast at the 75th percentile of variations in the forward CDS spreads between 2009 and 2013. The CDS-based changes in credit risk for current expectations and the historical severity are applied to liquid government bonds at prices as of end-June 2013.

Table A8.2. Estimated Credit Spread Shock

Implied Credit Spread Increase of Direct and Indirect Sovereign Exposures (relative to end-June 2013), *In percent*
(country-specific shock with common shock (50bps) to interest rate level in the adverse scenarios)

	Baseline Scenario *current expectations 1/*					Adverse Scenarios *75th percentile value 2/*					Baseline Scenario *current expectations 1/*					Adverse Scenarios *75th percentile value 2/*				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
	Hong Kong SAR										**United States**									
1 Year	38.4	49.3	76.2	102.0	136.3	93.2	104.0	139.3	171.4	204.5	16.1	21.5	32.4	58.4	69.2	76.3	32.8	49.2	80.5	103.4
3 Years	57.3	76.8	105.6	127.1	141.7	119.5	147.7	179.4	197.6	213.2	23.8	38.5	53.5	65.6	70.0	89.0	58.8	81.1	95.7	106.9
5 Years	81.9	100.8	119.6	134.0	143.5	159.5	178.2	196.6	209.4	219.9	39.7	50.0	59.6	67.4	70.2	115.0	76.4	90.4	100.1	108.1
7 Years	97.6	112.0	126.2	137.1	144.3	180.4	192.5	204.6	213.0	220.9	47.5	55.1	62.3	68.2	70.3	125.8	83.8	94.5	101.3	108.3
10 Years	109.6	120.3	131.1	139.4	144.9	196.4	203.1	210.6	215.7	221.6	53.4	59.0	64.4	68.8	70.3	134.1	89.3	97.6	102.2	108.4
	P.R. China										**United Kingdom**									
1 Year	49.0	77.6	127.2	154.4	176.5	121.4	157.9	218.9	257.5	285.4	33.2	48.4	64.8	74.3	109.6	100.9	117.7	139.0	143.2	175.4
3 Years	86.4	120.1	152.5	170.4	180.7	175.8	217.0	257.1	279.0	290.9	53.0	65.4	83.9	100.4	115.3	131.7	145.0	165.4	176.0	182.7
5 Years	116.2	141.7	163.3	175.8	182.6	219.1	247.0	271.7	286.3	293.4	68.7	84.0	96.6	108.1	115.7	158.8	172.1	182.8	185.7	185.4
7 Years	132.5	152.2	168.7	178.2	183.4	238.9	258.4	277.3	288.1	293.9	81.2	93.2	102.8	110.8	115.8	176.7	182.1	187.9	187.8	185.6
10 Years	145.1	160.1	172.7	180.0	184.0	253.9	266.8	281.5	289.4	294.3	91.0	99.8	107.3	112.2	116.0	189.4	189.6	191.6	189.5	185.7
	Chinese Taipei										**Germany**									
1 Year	49.0	77.6	127.2	154.4	176.5	121.4	157.9	218.9	257.5	285.4	17.4	29.9	37.3	66.5	102.2	88.3	109.4	117.5	156.2	201.0
3 Years	86.4	120.1	152.5	170.4	180.7	175.8	217.0	257.1	279.0	290.9	28.4	45.5	69.6	92.2	108.7	112.7	140.5	176.0	197.1	210.6
5 Years	116.2	141.7	163.3	175.8	182.6	219.1	247.0	271.7	286.3	293.4	51.0	68.2	84.8	100.7	111.5	162.6	185.6	203.5	210.7	214.8
7 Years	132.5	152.2	168.7	178.2	183.4	238.9	258.4	277.3	288.1	293.9	66.1	79.8	92.4	104.5	112.7	185.9	198.2	209.9	213.0	214.2
10 Years	145.1	160.1	172.7	180.0	184.0	253.9	266.8	281.5	289.4	294.3	78.2	88.5	98.0	107.3	113.7	201.4	207.6	214.7	214.7	213.9
	Japan										**France**									
1 Year	48.3	75.2	119.2	127.0	195.3	115.5	145.0	199.2	204.2	277.8	43.8	77.3	109.9	149.6	208.2	131.9	179.1	216.9	255.6	315.7
3 Years	83.5	108.2	148.7	178.0	195.1	161.0	189.3	236.0	266.2	282.2	77.9	112.9	156.8	192.2	210.0	195.7	238.5	288.3	314.3	325.7
5 Years	113.7	144.7	166.8	177.9	185.9	204.3	236.4	258.7	270.6	278.2	117.1	150.6	178.9	202.2	209.5	268.9	301.4	321.8	328.0	328.0
7 Years	134.4	152.5	167.2	175.7	181.8	228.6	242.6	259.1	267.8	273.2	141.6	166.8	188.6	204.4	209.3	299.9	317.4	328.3	329.7	327.7
10 Years	143.1	156.2	167.5	174.0	178.7	239.0	247.3	259.4	265.7	269.4	159.5	178.9	195.8	205.4	209.1	321.8	329.3	333.1	331.0	327.5
	Australia										**Italy**									
1 Year	26.4	49.2	81.6	99.7	115.4	85.9	113.3	151.3	167.8	185.6	238.3	309.2	364.8	401.3	402.5	402.1	471.2	523.9	570.0	575.8
3 Years	55.5	79.0	100.3	112.0	116.7	126.2	151.2	173.7	183.9	189.3	303.1	359.6	393.8	401.7	385.2	497.8	539.9	561.6	572.0	553.3
5 Years	76.3	92.7	106.4	114.1	117.1	154.6	169.2	182.0	188.2	190.5	339.8	376.6	387.0	381.8	370.6	552.0	563.1	556.1	546.2	534.2
7 Years	86.6	98.9	109.2	115.0	117.4	168.7	177.2	185.5	189.3	190.8	348.3	370.1	377.2	373.0	364.2	558.8	551.3	543.2	534.5	525.4
10 Years	94.3	103.5	111.3	115.7	117.5	179.4	183.2	188.1	190.2	190.9	347.7	365.2	369.8	366.5	359.4	554.4	542.6	533.6	525.7	518.7
	South Korea										**Ireland**									
1 Year	51.9	77.7	118.0	148.3	165.0	138.8	168.3	231.7	288.4	316.4	124.4	167.8	221.9	284.6	306.7	436.5	427.4	444.9	509.7	537.8
3 Years	84.0	115.2	143.5	160.0	162.2	198.1	246.2	285.6	307.3	311.8	172.2	225.2	269.5	298.8	299.3	584.8	556.5	529.7	532.6	526.2
5 Years	111.5	133.9	149.4	157.3	158.7	262.1	279.5	295.2	302.9	306.3	216.8	253.2	277.6	291.9	292.3	723.5	619.4	544.0	521.4	514.9
7 Years	123.4	138.2	150.1	156.1	157.2	282.7	281.4	291.2	296.2	300.5	234.0	258.5	277.6	288.8	289.2	744.1	616.8	538.0	514.4	508.9
10 Years	130.3	141.6	150.6	155.2	156.1	290.8	282.8	288.1	291.1	296.1	243.2	262.5	277.6	286.6	286.8	748.7	614.9	533.4	509.1	504.4
	India										**Portugal**									
1 Year	171.3	263.8	356.4	413.4	379.8	278.5	369.4	482.6	590.4	548.2	352.3	443.8	487.0	560.9	528.3	712.8	619.9	582.5	663.6	668.8
3 Years	264.5	342.6	380.0	387.2	375.0	388.6	499.4	548.3	556.2	542.0	424.9	506.3	541.9	536.7	519.8	849.3	700.2	674.0	677.8	659.0
5 Years	308.7	351.0	377.3	383.4	375.1	468.8	514.1	544.7	551.2	542.2	490.5	524.3	532.7	527.3	515.5	972.9	757.2	681.2	666.8	653.9
7 Years	322.3	356.2	376.9	381.8	375.2	484.6	513.5	536.6	540.8	536.9	508.1	520.6	527.3	523.0	513.5	974.9	750.7	670.4	652.9	641.5
10 Years	333.0	360.0	376.7	380.6	375.3	492.5	513.1	530.6	533.1	533.0	507.5	517.7	523.2	519.8	511.9	973.8	746.0	662.4	642.8	632.4
	Singapore										**Spain**									
1 Year	38.4	49.3	76.2	102.0	136.3	93.2	104.0	139.3	171.4	204.5	240.9	304.0	353.6	399.1	391.3	418.5	472.8	511.4	560.0	544.9
3 Years	57.3	76.8	105.6	127.1	141.7	119.5	147.7	179.4	197.6	213.2	298.6	353.4	385.7	392.9	379.3	506.9	541.6	553.3	552.3	529.8
5 Years	81.9	100.8	119.6	134.0	143.5	159.5	178.2	196.6	209.4	219.9	334.9	368.9	382.5	379.4	370.2	562.5	563.1	549.2	535.0	518.2
7 Years	97.6	112.0	126.2	137.1	144.3	180.4	192.5	204.6	213.0	220.9	343.5	364.4	375.3	373.4	366.2	566.5	554.7	539.7	525.1	511.1
10 Years	109.6	120.3	131.1	139.4	144.9	196.4	203.1	210.6	215.7	221.6	344.3	361.1	369.9	369.0	363.2	563.8	548.4	532.6	517.8	505.7

Sources: Bloomberg, IMF (2013), and Jobst and others *(forthcoming)*. *Notes:* 1/ "Current expectations" reflect market expectations implied by forward contracts (with maturity terms between 1 and 5 years) on 1-, 3-, 5-, 7-, and 10-year credit default swaps (CDS) at end-June 2013 (without considering past CDS dynamics); 2/ The adverse scenarios was generated from the historically derived density forecast at the 75th percentile of variations in the forward CDS spreads between 2009 and 2013.

Appendix IX. Estimation Methodology for Sovereign Risk Valuation Haircuts

The calculation of haircuts on sovereign debt exposures under different adverse macro scenarios is based on the valuation of government bonds in response to rising credit spreads using forward-looking information from CDS markets. Sovereign bond prices for each year under each scenario are calculated contingent on changes in the term structure of the applicable risk-free rate and market expectations of default risk as reflected in the past dynamics of CDS spreads. More specifically, for a selection of bonds of a sample country, the future prices over the entire interest rate term structure (1, 3, 5, 7, and 10 years) are calculated by using the end-year risk-free rate and applying a density forecast of expected default risk based on the empirically derived probability distribution of the forward rates on sovereign CDS contracts at different maturities. For each country, the most liquid bonds in maturity buckets of one, three, five, seven and ten years (±0.5 years) are assumed to be representative of the maturities of banks' bond holdings.[1]

First, the standard pricing formula for a coupon-bearing bond *(b_1)* is reconciled with the zero-coupon bond pricing formula (assuming equivalence of economic value) in order to project future bond prices contingent on changes in idiosyncratic risk. This is done for several bonds of each sample country (with a specified residual maturity tenor). Since the sample bonds carry regular coupon payments, the discounted cash flow pricing formula

$$P_{b_1,t} = \prod_{m=1}^{T-t} \frac{c}{(1+r_t)^{m/n}} + \frac{p}{(1+r_t)^{T-t}}, \qquad \text{(A9.1)}$$

of fixed-rate bond *(b_2)* with yield-to-maturity (YTM) r_t in year *t*, principal value *p*, and time-to-maturity *T-t* is stripped of coupon payments *c* (with payout frequency *n*)[2] and set equal to the quasi-zero coupon price

$$P_{b_2,t} = \exp\left(-r_{f_t}\left(T-t\right)\right)\left(1-LGD\times PD\left(T-t\right)\right), \qquad \text{(A9.2)}$$

with the cumulative probability of default (PD) at the last observable sample date until maturity date *T*, constant loss-given-default (LGD), and risk-free rate r_{f_t} in year *t*, so that

$$P_{b_2,j,t} = \exp\left(-\left(r_{f_t} + s_{CDS_{k,j,t}}/10{,}000\right)\left(T-t\right)\right), \qquad \text{(A9.3)}$$

where

[1] For simplicity of notation, the designation of maturity has been ignored in the remainder of the text.

[2] This step ignores the second order effect (i.e., convexity) of interest rate changes on the future bond price in the determination of haircuts.

$$s_{CDS_{k,j,t}} = -\ln\left(1 - LGD \times PD\left(T-t\right)\right)/\left(T-t\right), \tag{A9.4}$$

is the cash *k*-year credit default swap (CDS) spread (in basis points) of country *j* at time *t* with

$$PD\left(T-t\right) = \left(1-\left(1-PD\left(t\right)\right)^{T-t}\right), \tag{A9.5}$$

which represents the idiosyncratic risk of the reference entity. In cases when the calculations are performed before year-end, controlling for the change in market valuation due to the change in yield between the end-point of the estimation window *t* and starting point of the forecasting period $t+\tau$ we can write[3]

$$\frac{p}{\left(1+r_t^*\right)^{T-t+\tau}} = \exp\left(-\left(\hat{r}_{f_t} + \left(r_t^* - r_t\right) + \overline{s}_{CDS_{k,j,t}}/10{,}000\right)\left(T-t+\tau\right)\right), \tag{A9.6}$$

where r_t^* is the extrapolated yield at year-end to reflect the valuation effect on the discounted cash flow formula

$$P_{b_1,j,t+\tau} = \prod_{m=1}^{T-t} \frac{c}{\left(1+r_t^*\right)^{(m+\tau)/n}} + \frac{p}{\left(1+r_t^*\right)^{T-t+\tau}} > P_{b_1,j,t}, \tag{A9.7}$$

for a coupon-bond issued by country *j* at the start of time period τ prior to the end of the base year *t*, and $\overline{s}_{CDS_{k,j,t}}$ is the average cash CDS spread over the last year prior to the starting point of the forecasting period. Equation (A8.6) above is then solved for the risk-free rate

$$\hat{r}_{f_t} = -\ln\left(\frac{p}{\left(1+r_t^*\right)^{T-t+\tau}}\right)\frac{1}{\left(T-t+\tau\right)} - \left(r_t^* - r_t\right) - \frac{\overline{s}_{CDS_{k,j,t}}}{10{,}000}. \tag{A9.8}$$

Second, the future price $P_{b_2,t+i,j}$ of each outstanding bond of country *j* is then calculated up to a forecast horizon of *T*-*t* years, with and without a common shock to the interest rate term structure. It is derived from using the estimated risk-free rate and applying the *i*-period forward sovereign CDS spread $f_{CDS_{k,j,t+i}}$ with a maturity of *k* years to the standard zero-coupon pricing formula so that

$$P_{b_2,t+i,j} = \exp\left(-\left(\left(\hat{r}_{f_t} + \Delta r_i\right) + f_{CDS_{k,j,t+i}}/10{,}000\right)\left(T-t\right)\right) \tag{A9.9}$$

[3] See CEBS (2010) and EBA (2011) for similar approaches.

in order to inform haircuts relative to the valuation $P_{B,t,j}$ at time *t*, where the implied periodic default risk for each year of the forecast horizon is given by $PD(t) = f_{CDS_{k,j,t+i}} / LGD \times 10,000$, and $\Delta r_i > 0$ denotes a positive (common) shock to the risk-free rate for all or a particular year during the forecast horizon. This is done for several bonds of each sample country (with similar residual maturity). The same approach can also be applied to the discounted cash flow pricing formula in line with the estimation of market risk parameters in the European stress test (EBA, 2011; ECB, 2011) for comparative purposes, so that

$$P_{b_1,t+i,j} = \prod_{m=1}^{T-t} \frac{c}{\left(1+r_t+\theta\right)^{m/n}} + \frac{p}{\left(1+r_t+\theta\right)^{T-t}}, \tag{A9.10}$$

where

$$\theta = \Delta r + \left(r_t^* - r_t\right) + \left(f_{CDS_{k,j,t+i}} - \overline{s}_{CDS_{k,j,t}}\right) / 10,000. \tag{A9.11}$$

More specifically, the *i*-period forward rate $f_{CDS_{k,j,t+i}}$ on the CDS spread is derived as a density forecast at time *t* from the past dynamics of expected default risk. The historical series $\mathbf{X}_{CDS_{k,j,t+i}} = f^1_{CDS_{k,j,t+i}}, \ldots, f^{\tilde{x}}_{CDS_{k,j,t+i}}$ of *z*-number i.i.d. random observations over a given estimation period is parametrically fitted to the *generalized extreme value* (GEV) distribution in order to account for large (nonlinear) fluctuations in sovereign CDS spreads. The cumulative distribution function is defined accordingly as

$$G_{CDS_{k,j}}(x) = \exp\left(-\left(1+\frac{\hat{\xi}_{k,j}\left(x-\hat{\mu}_{k,j}\right)}{\hat{\sigma}_{k,j}}\right)^{-1/\hat{\xi}_{k,j}}\right), \tag{A9.12}$$

where $1+\hat{\xi}_{k,j}\left(x-\hat{\mu}_{k,j}\right)/\hat{\sigma}_{k,j} > 0$, scale parameter $\hat{\sigma}_{k,j} > 0$, location parameter $\hat{\mu}_{k,j} > 0$ and shape parameter $\hat{\xi}_{k,j}$. The higher the absolute value of shape parameter, the larger the weight of the tail and the slower the speed at which the tail approaches its limit.[4] Thus, the quantile value

$$\sup\left\{G^{-1}_{CDS_{k,j}}(\square) \middle| \Pr\left[X_{CDS_{k,j,t+i}} > G^{-1}_{CDS_{k,j}}(\square)\right] \geq a = 0.95\right\} \tag{A9.13}$$

and the density forecast at a certain statistical confidence level *a*

[4] The moments of the corresponding density function are estimated via the *linear combinations of ratios of spacings* (LRS) method, which identifies possible limiting laws of asymptotic tail behavior of normalized extremes (Jobst, 2007).

$$G^{-1}_{CDS_{k,j}}(a) = \hat{\mu}_{k,j} + \hat{\sigma}_{k,j} \Big/ \hat{\xi}_{k,j} \left(\left(-\ln(a) \right)^{-\hat{\xi}_{k,j}} - 1 \right), \tag{A9.14}$$

with corresponding probability density function

$$g_{CDS_{k,j}}(x) = \hat{\sigma}^{-1}_{k,j} \left(1 + \frac{\hat{\xi}_{k,j}\left(x - \hat{\mu}_{k,j}\right)}{\hat{\sigma}_{k,j}} \right)^{-1/\hat{\xi}_{k,j}-1} \exp\left\{ -\left(1 + \frac{\hat{\xi}_{k,j}\left(x - \hat{\mu}_{k,j}\right)}{\hat{\sigma}_{k,j}} \right)^{-1/\hat{\xi}_{k,j}} \right\} \tag{A9.15}$$

can be determined. Thus, the specification of the future price of each outstanding bond of country with and without a common shock to the interest rate term structure under both pricing approaches equations (A8.9) and (A8.10) can be revised to

$$\hat{P}(a)_{b_2,t+i,j} = \exp\left(-\left(\left(\hat{r}_{f_t} + \Delta r_i \right) + G^{-1}_{CDS_{k,j}}(a) \Big/ 10{,}000 \right)(T-t) \right), \tag{A9.16}$$

and

$$\hat{P}(a)_{b_1,t+i,j} = \prod_{m=1}^{T-t} \frac{c}{\left(1 + r_t + \hat{\theta}\right)^{m/n}} + \frac{p}{\left(1 + r_t + \hat{\theta}\right)^{T-t}}, \tag{A9.17}$$

respectively, where

$$\hat{\theta} = \Delta r + \left(r^*_t - r_t \right) + \left(G^{-1}_{CDS_{k,j}}(a) - \bar{s}_{CDS_{k,j,t}} \right) \Big/ 10{,}000. \tag{A9.18}$$

The valuation haircuts are derived from changes in prices of selected bonds in response to changes in individual sovereign spreads (and common interest rate shocks) based on (i) current market expectations and (ii) different adverse scenarios defined by the historical changes of expected default risk. For current market expectations, the forward CDS spread $f_{CDS_{k,j,t+i}}$ observed at the end of the estimation period at time *t* is used to project future bond prices over *i*-periods in the future based on the pricing formulas in equations (A8.9) and (A8.10) above.

In contrast, for the adverse scenarios, point estimates of expected changes in default risk based on the historical distribution of forward spreads on CDS are chosen. Since haircuts under the adverse scenario should reflect the volatility of market expectations, the density forecasts at the 75th percentile of the cumulative probability distribution is used as country-specific shock to $f_{CDS_{k,j,t+i}}$ (for both adverse scenarios). Thus, for each year over the forecast horizon of $i \in n$-years, there are two bond prices

$$P_{b_1,t+i,j} \in \mathbf{P}_{b_1,t+i,j} = \left\{ P_{b_1,t+i,j_{current}}; \hat{P}(a)_{b_1,t+i,j_{adverse}} \right\} \tag{A9.19}$$

and

$$P_{b_2,t+i,j} \in \mathbf{P}_{b_2,t+i,j} = \left\{ P_{b_2,t+i,j_{current}}; \hat{P}(a)_{b_2,t+i,j_{adverse}} \right\} \tag{A9.20}$$

for each pricing method, based on current market expectations and a density forecast of default risk at statistical confidence level $a = 0.75$. The corresponding haircuts are calculated for each bond from changes in bond prices in each year *i* over the forecast horizon, relative to the base year *t*, using the following specification

$$\Delta P_{b_1,i,j} = \left(P_{b_1,t+i,j} / P_{b_1,t,j} - 1\right) \times 100 \tag{A9.21}$$

and

$$\Delta P_{b_2,i,j} = \left(P_{b_2,t+i,j} / P_{b_2,t,j} - 1\right) \times 100, \tag{A9.22}$$

where $\hat{P}_{b_1,t+i,j}$ and $\hat{P}_{b_2,t+i,j}$ are the bond prices under each pricing method, respectively.[5] The general haircut *h* for each sovereign is then derived as an issuance size-weighted average of individual projected haircuts applied to a *q*-number of bonds outstanding,[6] so that

$$\begin{Bmatrix} h_{b_1,t,j} \\ h_{b_2,t,j} \end{Bmatrix} = \max\left(\begin{Bmatrix} \sum_{b=1}^{q} \Delta P_{b_1,i,j} \\ \sum_{b=1}^{q} \Delta P_{b_2,i,j} \end{Bmatrix} \times \frac{Amt_{b,j}}{\sum_{b=1}^{q} Amt_{b,j}}, 0 \right), \tag{A9.23}$$

where $\Delta P_{b_1,i,j}$ and $\Delta P_{b_2,i,j}$ are the haircuts under each pricing method over forecast period *i*, and Amt_b is the outstanding amount of bond *b* issued by country *j*.[7] As a final step, these haircuts would then be applied to the amount of relevant direct and indirect sovereign exposures to countries $j \in J$ held in both the banking and trading books at time *t*. The corresponding trading losses or changes in valuation in each year *t* over the forecast horizon are calculated as

$$\sum_{j}^{J} \begin{Bmatrix} h_{b_1,t,j} \\ h_{b_2,t,j} \end{Bmatrix} \times \text{exposure}_{t,j} \tag{A9.24}$$

based on a firm's total exposure to country *j*.

[5] Note that the haircut estimation is not fully accurate, because in each year over the projected time horizon, the projected yield to maturity is imposed on an unchanged set of bonds. This implies no new government issuance (and time-invariant coupon), which overstates the actual haircut (unlike in cases when the sample of bonds changes and the remaining maturity is kept constant over the projected time period).

[6] Haircuts cannot take negative values when price appreciation occurs between years (e.g., in response to "safe haven flows").

[7] Sovereign exposure gains, should they materialize, are ignored, i.e., there are no negative haircuts that enter the calculation.

Appendix X. Foreign Currency Shock

Negative Shock to Net Open Foreign Currency Positions

(In percent)

	CNY	EUR	JPY	GBP	CHF	SGD	AUD	*Avg.*
Maximum (2008-11)	*8.0*	*14.6*	*14.7*	*15.2*	*13.6*	*9.4*	*18.4*	*13.4*
Long-term average	*4.6*	*11.0*	*11.0*	*10.3*	*11.0*	*6.6*	*12.8*	*9.6*
Multiple (4x)	**13.4**	**14.1**	**14.6**	**19.7**	**10.4**	**10.9**	**22.5**	*15.1*

Sources: Bloomberg LP and staff calculations. *Note:* "Maximum (2008-11)" show the highest implied annualized volatility of the respective currency pair with the U.S. dollar as reference currency); the long-term average was determined over an estimation period from Jan. 1, 2005 to Sept. 6, 2013; banks should apply 100% and 50% of the percentage shock to net open FX positions in Year 1 and Year 2 of the stress test horizon, respectively. For net open FX position to currencies other than those shown above, the simple average (rightmost column) should be applied.

Appendix XI. Pay-out Ratio and Hurdle Rates

Table A11.1. Pay-out ratio Conditional on Capitalization under Stress

In percent

Capital buffer *(In percent)*	FSAP (minimum dividend pay-out ratio based on total capital ratio)	Basel III (maximum pay-out ratio based on CET 1 ratio)
0-0.5	5	0
0.5-1	10	20
1-1.5	15	20
1.5-2	20	40
2-2.5	30	40
>2.5	40	40 to 100

Table A11.2. Hurdle Rates (2014-2018)

In percent

Forecast Year	Y1 (2014)	Y2 (2015)	Y3 (2016)	Y4 (2017)	Y5 (2018)
	Hurdle Rates (under Basel III definition of capital)				
(1) Reg. Minimum Total Capital	**8.0**	**8.0**	**8.625**	**9.25**	**9.875**
(2) Reg. Minimum Tier 1 Capital*	**5.5**	**6.0**	**6.625**	**7.25**	**7.875**
(3) Reg. Minimum Common Equity Tier 1	**4.0**	**4.5**	**5.125**	**5.75**	**6.375**
Memo item					
Conservation Buffer	0.0	0.0	0.625	1.25	1.875

* Assumption of conservation buffer applying to Tier 1 capital in order to ensure continuity of hurdle rates for stress testing purposes.

Appendix XII. Basel III Transition Schedule Possible Satellite Model Specification

Year	2011	2012	2013	2014	2015	2016	2017	2018	2
Leverage Ratio	Supervisory monitoring		Parallel run January 2012 - January 2017; disclosure starts in January 2015					Migration to Pillar I	
Minimum Common Equity Capital Ratio			3.50	4.00	4.50	4.50	4.50	4.50	
Capital Conservation Buffer						0.625	1.25	1.875	
Minimum Common Equity + Capital Conservation Buffer			3.50	4.00	4.50	5.125	5.75	6.375	
Phase-In (incl. amnts. > CET1 limit for DTAs, MSRs & financials)				*20*	*40*	*60*	*80*	*100*	
Minimum Tier 1 Capital			4.50	5.50	6.00	6.00	6.00	6.00	
Minimum Total Capital			8.00	8.00	8.00	8.00	8.00	8.00	
Minimum Total Capital + Capital Conservation Buffer			8.00	8.00	8.00	8.625	9.25	9.875	1
Phase-out of instruments that no longer qualify as non-core Tier 1 or 2 capital			Phased out over a 10-year horizon beginning 2013						

Liquidity Coverage Ratio (LCR)	Obs. period begins				Introduce min. standard				
					60	*70*	*80*	*90*	
Net Stable Funding Ratio (NSFR)		Obs. period begins						Introduce min. standard	

Source: Basel Committee for Banking Supervision (BCBS), http://www.bis.org/press/p100912b.pdf. *Note:* see also BCBS (2010b and 2010c). According to recent revisions to the l risk framework under Basel III (BCBS, 2013a) the introduction of the LCR will be now be graduated. Specifically, the LCR will be introduced as planned on 1 January 2015, but th minimum requirement will begin at 60 percent, rising in equal annual steps of 10 percentage points to reach 100 percent on 1 January 2019.

Appendix XIII. Output Format for Reporting Firms to Hong Kong Monetary Authority

Outcome of Solvency Stress Test

				[Bank Name]	(end-June 2013)	Y1 (2014)	Y2 (2015)	Y3 (2016)	Y4 (2017)	Y5 (2018)
Reporting basis				solo / combined / consolidated						
Macro scenario [select]				baseline / slow growth / severe adverse						
reported as distribution for all firms by IMF	**Main Results**	Failed stress test? (1 = yes, 0 = no)	Total Capital							
			Tier 1							
			Common Equity Tier 1							
		Capital needs to recapitalize bank *(In HKD millions)*	Total Capital							
			Tier 1							
			Common Equity Tier 1							
		Capital needs to recapitalize bank (relative to total assets) *In percent*	Total Capital							
			Tier 1							
			Common Equity Tier 1							
	Hurdle Rate Assumption	Hurdle Rate Total Capital (with conservation buffer)				8.0%	8.0%	8.6%	9.250%	9.875%
		Hurdle Rate Tier 1 Capital (with conservation buffer)				5.5%	6.0%	6.6%	7.250%	7.875%
		Hurdle Rate Common Equity Tier 1 Capital (with conservation buffer)				4.0%	4.5%	5.125%	5.750%	6.375%
reported as distribution for all firms by IMF	**Sensitivity Check:** like "Main Results" above but without valuation haircuts	Failed stress test? (1 = yes, 0 = no)	Total Capital							
			Tier 1							
			Common Equity Tier 1							
		Capital needs to recapitalize bank *(In HKD millions)*	Total Capital							
			Tier 1							
			Common Equity Tier 1							
		Capital needs to recapitalize bank (relative to total assets) *In percent*	Total Capital							
			Tier 1							
			Common Equity Tier 1							
	Hurdle Rate Assumption	Hurdle Rate Total Capital (with conservation buffer)				8.0%	8.0%	8.6%	9.250%	9.875%
		Hurdle Rate Tier 1 Capital (with conservation buffer)				5.5%	6.0%	6.6%	7.250%	7.875%
		Hurdle Rate Common Equity Tier 1 Capital (with conservation buffer)				4.0%	4.5%	5.125%	5.750%	6.375%
reported as distribution for all firms by IMF	**Risk Drivers**	Operating profit (before losses and impairments but after taxes)								
		of which: change in interest income (incl. foregone interest)								
		of which: change in interest expenses								
		of which: change in fee income								
		of which: change in trading income								
		of which: change in operating expenses								
		Credit losses/net impairments from lending								
		Losses/gains from trading and investment activities (incl. impact of valuation haircut								
		of which: valuation haircuts of investments								
		of which: FX shock								
		Net profit (after dividends paid and tax, if applicable) 1/								
		Risk-weighted assets (RWAs)								
	Risk Drivers *(In percent of RWAs)*	Net profit (before losses): after tax profit for the period				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: change in interest income				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: change in interest expenses				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: change in fee income				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: change in trading income				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: change in operating expenses				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		Credit losses/net impairments from lending (incl. foregone interest)				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		Losses/gains from trading and investment activities (incl. impact of valuation haircut				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: valuation haircuts of investments				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		of which: FX shock				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		Net profit (after dividends paid and tax, if applicable)				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		Change in risk-weighted assets (RWAs), *In percent*				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
reported as distribution for all firms by IMF	**Background**	Total capital adequacy ratio (In percent)			12.1%					
		Tier 1 capital ratio (In percent)			8.6%					
		Common/core Tier 1 ratio (In percent)			6.1%					
		Total capital (in '000)			23,565,678					
		Tier 1 capital (in '000)			16,957,185					
		Common/core capital (in '000)			13,508,413					
		Leverage (capital/assets)			3.3%					
		Return on total regulatory capital			6.3%					
		Dividend yield (dividend paid/equity)			7.2%					
reported as distribution for all firms by IMF	**Stress test parameters** *(In percent)*	Percentage of profits retained			40.0%					
		Basel III: Phase-in of capital deductions								
		Basel III: Phase-out of non-Tier 1 and Tier 2 capital								
		Credit risk								
		PD/NPL ratio (EAD-weighed average)			0.50%					
		LGD (EAD-weighed average)			25.0%					
		Asset correlation (EAD-weighed average)			30.0%					
		Credit growth				2.0%				
		Risk-weighted Assets (RWAs)								
		Change of Credit Risk RWAs				2.0%				
		of which: Basel III-related								
		Change of Market Risk RWAs				2.0%				
		of which: Basel 2.5-related								
		Change of Operational Risk RWAs				2.0%				

Source: IMF staff. *Note:* values in the pre-populated cell are for illustration purposes and define the cell formatting. 1/ minus credit losses/net impairments (including haircuts) and overall trading losses for the period.

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