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FINANCIAL SECTOR ASSESSMENT PROGRAM

June 2021

TECHNICAL NOTE—STRESS TESTING THE BANKING SECTOR AND SYSTEMIC RISK ANALYSIS

This Technical Note on Stress Testing the Banking Sector and Systemic Risk Analysis for the People's Republic of China–Hong Kong Special Administrative Region FSAP was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in June 2021.

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June 7, 2021

TECHNICAL NOTE

STRESS TESTING THE BANKING SECTOR AND SYSTEMIC RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in People's Republic of China - Hong Kong Special Administrative Region, led by Ananthakrishnan Prasad. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at: http://www.imf.org/external/np/fsap/fssa.aspx

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AFC	Asian Financial Crisis
BELR	Banking (Exposure Limits) Rules
BIS	Bank for International Settlements
CRE	Commercial Real Estate
D-SIB	Domestic Systemically Important Bank
DSR	Debt service ratio
ELA	Emergency Liquidity Assistance
FSAP	Financial Sector Assessment Program
FSI	Financial Soundness Indicators
FSSA	Financial Sector Stability Assessment
FX	Foreign Exchange
GDP	Gross Domestic Product
GFC	Global Financial Crisis
G-SIB	Global Systemically Important Bank
HIBOR	Hong Kong Interbank Offered Rate
HKD	Hong Kong dollar
HKMA	Hong Kong Monetary Authority
IRB	Internal ratings-based
LCR	Liquidity Coverage Ratio
LIBOR	London Interbank Offered Rate
LTV	Loan-to-Value
MaPP	Macroprudential Policies
MC	Mainland China
MPMs	Macroprudential Policy Measures
NPL	Non-performing Loan
NSFR	Net Stable Funding Ratio
RAM	Risk Assessment Matrix
RMB	Renminbi
STA	Standardized Approach (for calculating capital requirements for credit risk)
STeM	Stress Testing Matrix
USD	US dollar

EXECUTIVE SUMMARY[1]

Hong Kong SAR (HKSAR) is a small and open economy, and a major international financial center with extensive linkages to Mainland China. Over the past two years, Hong Kong SAR's economy and financial sector were adversely impacted by domestic social unrest, US-China tensions, and the global COVID-19 pandemic, resulting in an unprecedented two consecutive years of negative economic growth.

Sound macroeconomic and prudential policies have provided HKSAR with important buffers to cope with the unprecedented COVID-19 shock and future shocks. The banking sector remained well capitalized, profitable, and nonperforming loan ratios remained low during the COVID-19 shock period. HKSAR's exchange rate mechanism, the Linked Exchange Rate System (LERS), remains well-anchored and resilient to shocks, underpinned by large foreign exchange reserves.

The main macro-financial vulnerabilities facing HKSAR's banking system relate to HKSAR's extensive linkages to Mainland China, stretched real estate valuations, and exposure to shifts in global market and domestic risk sentiment. Risks to the financial system can manifest from a prolonged COVID-19 pandemic, a further slowdown in Mainland China economy, a sharp rise in global risk-premia compounded by escalating US-China tensions, and a sharp housing market correction. In a severe scenario, the four risks described above could materialize at the same time and amplify each other's effects.

Stress tests, carried out with pre-COVID-19 data, indicate that bank solvency is resilient to severe macrofinancial shocks, thanks to the initial high capital buffers and high pre-shock profitability. Even under a severely adverse stress scenario, banks' average CET 1 ratio decreases by about 4.5 percentage point to 11.5 percent in 2022—remaining well above regulatory requirements for all banks in the sample. That said, HKSAR banks have sizeable concentrated credit exposures. Assuming the default of the five largest non-financial corporate (NFC) exposures in each bank, the average CET1 ratio would decline by more than 6 percentage points, which warrants analysis and stress testing of banks' large exposures separately from their total loan books by HKMA. Non-financial corporate debt-at-risk and default risk could increase significantly under an adverse scenario, particularly in the Mainland China real estate sector.

The liquidity stress tests revealed overall high-stress resilience and a comprehensive reporting framework in HKSAR. In particular, the local banking system has sufficient liquidity buffers to cover the outflows in the scenarios, although the contractual maturity of the deposit base is short. However, liquidity stress-tests have revealed that some of the foreign branches are more vulnerable to liquidity stress. This is largely due to their higher reliance on unsecured interbank funding and their inability to tap the local deposits base. The Covid-19 pandemic did not lead to elevated liquidity risk of the banking system. This was partly due to a sufficient pre-crisis liquidity risk bearing

[1] This technical note was prepared by Tumer Kapan, Frank Hespeler, Romain Lafarguette, Elizabeth Mahoney, Alla Myrvoda, Stephanie Ng, Nico Valckx (IMF-MCM), Fei Han (IMF-APD), and Stefan W. Schmitz (external expert).

capacity and partly due to measures taken by the HKMA. The latter enhanced the provision of systemic liquidity and pro-actively communicated the usability of the LCR as buffer to absorb potential COVID-19 related liquidity shocks. The HKMA approach to liquidity stress testing is well advanced and comprehensive, aligned with international standard.

The interconnectedness patterns suggest that foreign branches could be a source of spillovers to other financial sectors both at home and abroad. The cross-border and domestic intra-financial system lending data suggest that foreign branches in HKSAR source funding from local banks and extend significant amounts of lending to other financial entities: NBFIs in HKSAR and other banking systems abroad.

To further enhance banking system stability, FSAP recommends enhanced oversight over banking groups that have both foreign branches and local subsidiaries in HKSAR; heightened monitoring of liquidity risk at the group and entity level for banks that operate with multiple group entities, and stress testing banks' large exposures separately from their total loan books; and ensure that internal risk models used to determine the capital charge for Mainland China real estate borrowers with low credit ratings are sufficiently forward looking.

Table 1. Hong Kong SAR: Recommendations on Financial Stability and Stress Testing

Recommendations and Authority Responsible for Implementation	Time[1]	Responsibility
Integrate all bank liquidity stress tests, streamline reporting, and enhance monitoring of liquidity position of foreign branches that appear more vulnerable.	MT	HKMA
Analyze the early redemption risk for time deposits and banks measures to address such early redemption risk in the form of a thematic review.	ST	HKMA
Take measures to incentivize banks to diversify funding sources, lengthen and stagger funding tenors.	MT	HKMA
Support the development of funding sources that are more likely to be available also under stress, such as broad and deep repo markets.	MT	HKMA
Support the development of safe assets to reduce the shortage of high-quality liquid assets in HK (e.g. a covered bond regime).	MT	HKMA
Continue to closely monitor the credit risks facing MC borrowers and to ensure that the internal risk models used to determine the capital charge for potential high-risk MC borrowers are sufficiently forward-looking.	ST	HKMA
Consider incorporating non-financial corporates in the stress testing framework and communicating key findings in the HKMA's Monetary and Financial Stability Report on a regular basis.	MT	HKMA
Enhance authorities' data collection of intersectoral claims across major sectors of the economy (banking, NBFIs, non-financial corporates, households, government, and the rest of the world) with a focus on claims of the NBFI, to better gauge the importance of intersectoral linkages and develop an aggregate balance sheet approach in systemic risk assessment.	ST	FSTB/HKMA/SFC/IA
Enhance oversight over banking groups that have both foreign branches and local subsidiaries in HKSAR would further improve the authorities' ability to monitor and mitigate risks, given their potential for contagion.	ST	HKMA
Enhance monitoring of liquidity risk both at the group and entity level for banks that operate with multiple group entities in HKSAR to ensure that banks adhere to internal risk management practices.	ST	HKMA
Periodically stress tests banks' large exposures separately from their total loan books, considering potential cash flows from collateral in case of default of large borrowers.	ST	HKMA

[1] I Immediate (within 1 year); ST Short term (within 1-3 years); MT Medium Term (within 3-5 years).

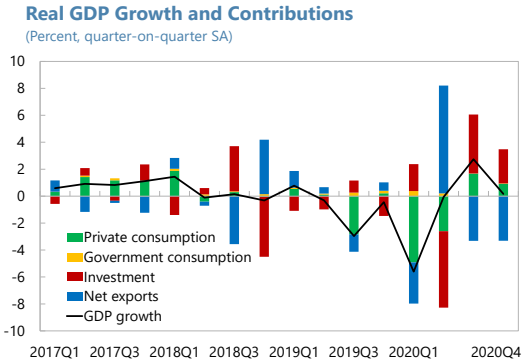
INTRODUCTION

A. Recent Developments

1. The economic slowdown that started in the second half of 2019 accelerated with the onset of the COVID-19 pandemic in early 2020. Following a GDP decline of 1.2 percent in 2019, with the onset of the pandemic in early 2020 the GDP declined by 8.9 percent in 2020 Q1 compared to a year earlier, driven by a fall in private consumption and investment. For the full year 2020, GDP declined by 6.1 percent, with the pandemic forcing occasional shutdowns of non-essential businesses, border closures to foreign visitors, and lost demand from abroad as other countries also faced the pandemic. HKSAR's unemployment rate rose from 3.3 percent at end-2019 to 6.6 percent at end-2020, with retail and hospitality being the most affected sectors. However, growth has started to recover since the second half of 2020 and an economic rebound in 2021 and 2022 is projected as the authorities took measures to support the economy and external demand started recovering.

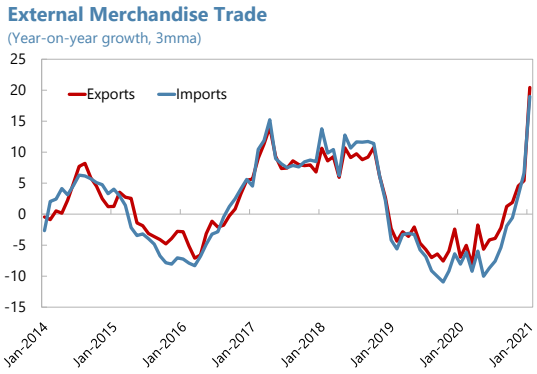
Figure 1. Hong Kong SAR: Macroeconomic Developments During the Pandemic

The economic recession deepened amid the pandemic, although growth started to recover in 2020Q3



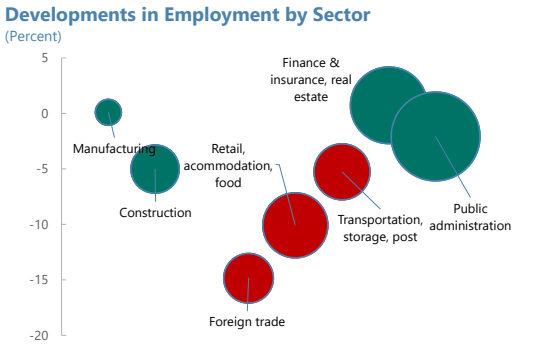
Sources: C&SD, and IMF staff calculations.

Trade flows remained weak for most of 2020 but recovered quickly in recent months.



Sources: CEIC; and IMF staff calculations.

Layoffs have intensified amid the pandemic, particularly in trade-related and retail sectors.



Value on Y axis depicts growth rate between 2019Q4 and 2020Q4. Size of the bubble depicts share in employment in 2019. Red bubbles indicate trade-related and retail sectors.
Sources: CEIC; and IMF staff calculations.

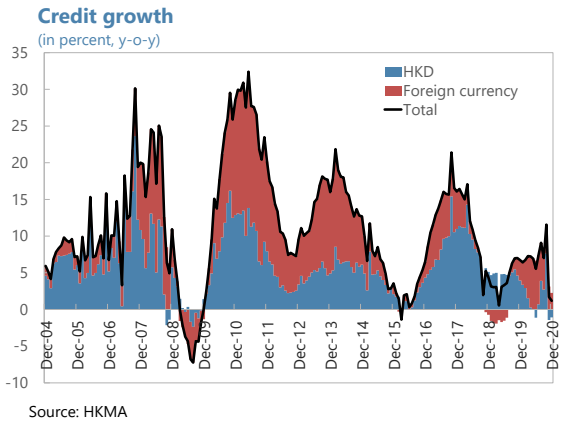
Nearly 100-percent decline in visitor arrivals exacerbated the decline in retail sales, despite the recent recovery.

1/ Tourism-related retail sales are defined as sales of jewelry, watches and clocks; Chinese drugs and herbs; medicines and cosmetics; and sales in optical shops.
Sources: CEIC; and IMF staff calculations.

2. Despite the economic contraction, total bank lending increased by 6.7 percent in 2019, which was followed by an increase of 1.2 percent in 2020. The slowdown in bank credit growth in 2020 was largely driven by the moderation in trade finance credit. This recent modest growth was preceded by strong growth in previous years, reaching a recent peak of 16 percent in 2017. In line with the strong bank credit growth, total NFC debt increased significantly from 202 percent of GDP in 2014 to 257 percent in 2020Q3, and household debt increased from 65 percent to 88 percent over the same period. This increase led to a widening of the credit-to-GDP gaps in 2020, although the recent increase was mostly driven by the significant decline in GDP. On the bank liability side, customer deposits continued to be the primary source of funding, and they grew at a moderate pace in 2020, with greater contributions from KSD deposits. As a result of balanced growth of deposits and loans, the average loan-to-deposit ratio, has been stable around 75 percent since 2018.

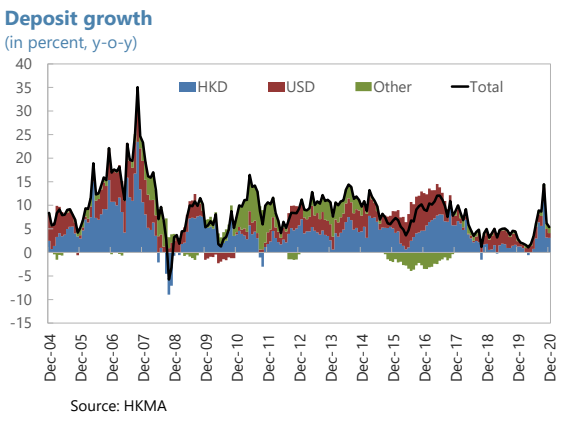
Figure 2. Hong Kong SAR: Recent Bank Credit and Sectoral Debt Developments

Total Credit Growth, All Authorized Institutions (AIs)



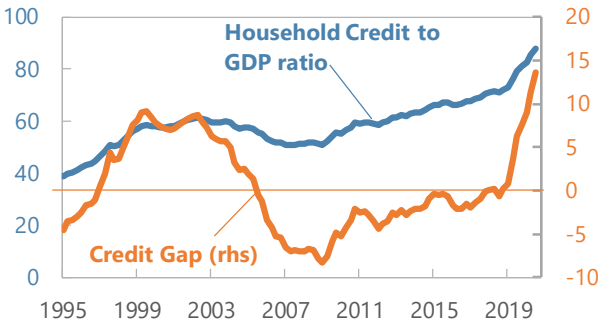
Source: HKMA

Customer Deposits Growth

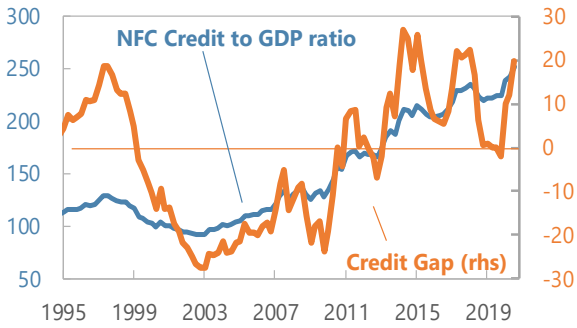


Source: HKMA

Household debt-to-GDP ratio and gap (in percent)]



NFC debt-to-GDP ratio and gap (in percent)]



Source: BIS; IMF Staff Computations.
Note: Data refers to credit to households and NPISHs from all sectors and to credit to non-financial corporations from all sectors, respectively. Data are at market value and adjusted for breaks. Credit gaps (right-hand scale) are estimated using data from 1988Q4-2020Q3 with a Hodrick-Prescott filter (lambda=400,000).

Policy Measures in the Context of COVID-19

3. With the first case of the coronavirus confirmed in early 2020, the authorities started adopting policy measures in February to support the economy and maintain financial stability. The authorities' measures covered a wide range including increasing market liquidity, supporting businesses and households to ease cash-flow pressures created by the pandemic, and releasing buffers in the banking system.

4. In early April 2020 HKMA announced its plan to reduce the issuance size of Exchange Fund Bills to increase the overall HKD liquidity in the interbank market. The reduction in the Exchange Fund Bill issuance increases the Aggregate Balance and adds liquidity to the interbank market. Following the 50-basis points rate cut by the Federal Reserve on March 4, HKMA adjusted the Base Rate from 2.0 to 1.5 percent. After a further reduction of the Fed Funds rate by 100 basis points, HKMA adjusted the Base Rate[2] to 0.86 percent. After the elevated HKD interbank rates gradually declined, the Base Rate reached 0.5 percent (50 bps above lower end of Fed Funds target range) around mid-May.

5. To improve USD liquidity conditions, HKMA announced in April the introduction of the temporary "US Dollar Liquidity Facility". This facility is directly related to the US Federal Reserve's establishment of a temporary repurchase agreement facility for foreign and international monetary authorities ("FIMA Repo Facility"), which is meant to support USD liquidity in financial markets. Under the FIMA Repo Facility HKMA has the option to enter into repurchase agreements with the Federal Reserve and exchange the US Treasuries it holds for US dollars. Following this development, HKMA introduced[3] its US Dollar Liquidity Facility which offered USD liquidity to HKSAR banks via 7-day repos for a total volume of US$10 billion. Take-up of the USD repos by banks has been limited, indicating that the funding strains have eased after the initial financial market stress in early 2020, and since July 2020 the facility has not been used.

6. The authorities introduced various relief measures to ease the cash flow pressures of firms and households caused by the COVID-19 pandemic. First, in coordination with the banks, authorities implemented the Pre-approved Principal Payment Holiday Scheme, under which banks offered a six-months' moratorium on principal repayments for qualifying SMEs[4]. Up to end-March 2021, more than 62,000 requests were made for moratoria and other relief measures involving loans totaling HK$ 770 billion (total domestic non-financial corporate debt HKD 3 trillion). In addition, the authorities introduced the Special 100% Loan Guarantee scheme for SMEs that have experienced a material decline in sales related to the COVID-19 pandemic. Loans are distributed via private banks and guaranteed by a subsidiary of the government-owned Hong Kong Mortgage Corporation.

[2] The Base Rate is set at either 50 basis points above the lower end of the prevailing target range for the US Fed Funds rate or the average of the five-day moving averages of the overnight and one-month HIBOR, whichever is higher.

[3] The facility became operational on May 6 and following the Fed's extension of the FIMA Repo Facility beyond the initial six months' period, HKMA extended the US Dollar Liquidity Facility until 30 September 2021.

[4] Those with less than HKD800 million annual turnover.

Against the total commitment of HK$ 50 billion through March 31, 2021, around 30,000 applications were made for loans totaling around HK$ 48 billion. The government also provided wage subsidies for employers to retain their workforce during a period of low demand (Employment Support Scheme, HK$ 80 billion or 2.8 percent of GDP) and set up various subsidy schemes to support sectors affected by the pandemic, e.g., transportation, tourism, and cinemas.

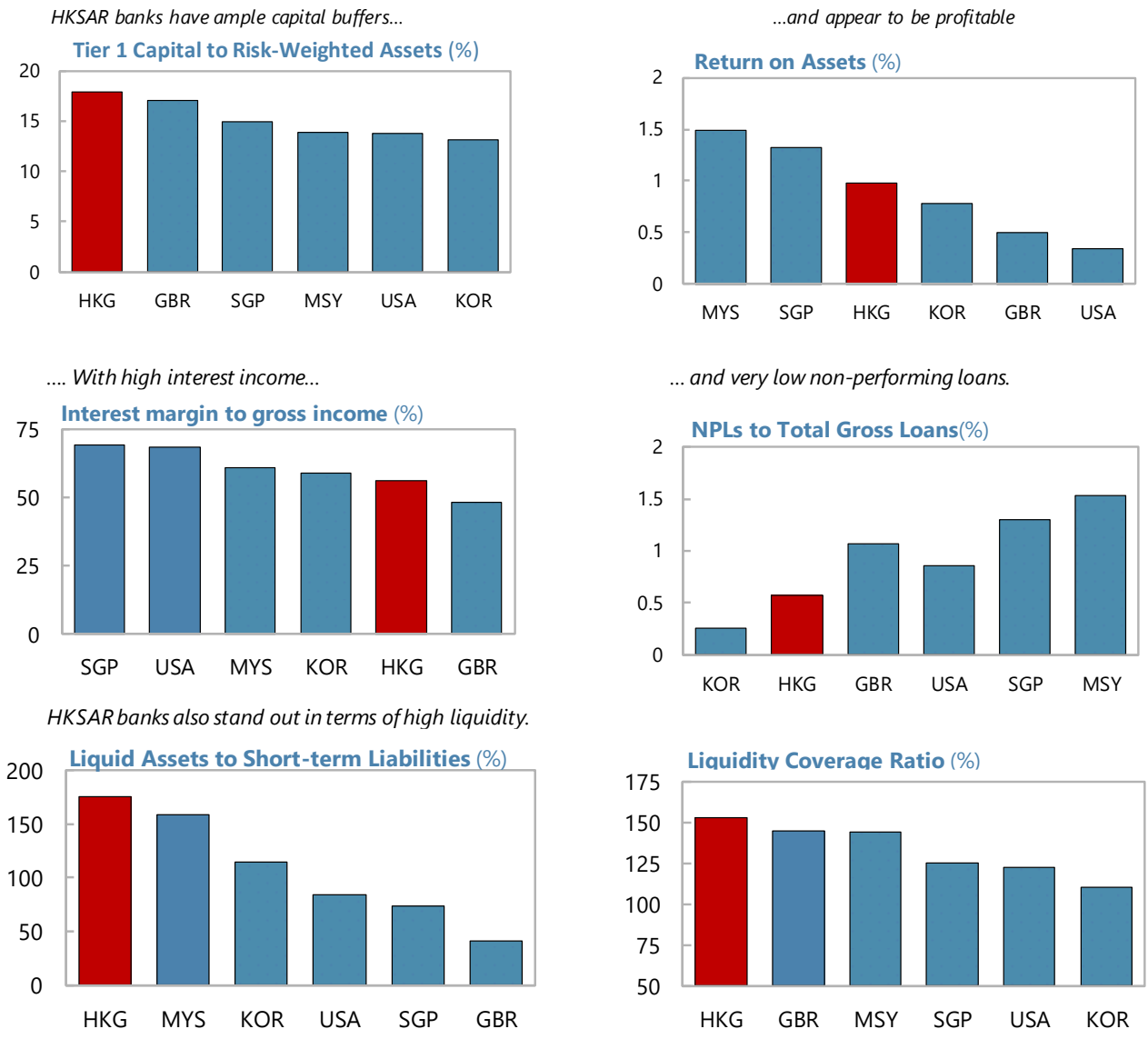
7. Similarly, to support the households, authorities introduced direct cash transfers and loan relief measures. To stimulate consumption and alleviate liquidity strains of households, the authorities announced in February 2020 a plan to give cash payouts of 10,000HKD to permanent residents aged 18 or above, estimated to cost HKD 71 billion or 2.5 percent of GDP. Additionally, several banks have offered residential mortgage loan customers an option for postponement of principal payments or extensions of loan tenors for personal lending. According to HKMA, through September 15, 2020 more than 19,000 customers benefited from such relief involving total credit of HK$ 35 billion (total outstanding residential mortgages 1.4 trillion, outstanding credit card debt HK$ 130 billion).

8. The countercyclical capital buffer (CCyB) was lowered from 2 percent to 1 percent in March 2020. This reduction was intended to provide banks with more flexibility in supporting the financing needs of the economy, and it was preceded by a reduction of the buffer from 2.5 to 2 percent in October 2019, implemented against the backdrop of the slowdown in 2019. In April 2020, the HKMA lowered the regulatory reserve (which is a requirement on top of the accounting provisions) by 50%. The HKMA noted that locally incorporated banks had made good progress in increasing their expected loss provisioning models under IFRS9 in late 2019 during the slowdown, and hence the need for maintaining reserve in excess of accounting provisions had diminished. Similarly, the HKMA encouraged banks to make use the liquidity buffers they have in excess of LCR and liquidity maintenance ratio (LMR) requirements.

Banking Sector's Recent Performance

9. As the substantial COVID-19 shock in 2020 exacerbated the economic contraction that started in late 2019, HKSAR banks' profitability declined. Despite this decline, banking system remained profitable in the aggregate with ample capital and liquidity buffers. Strong initial capital and liquidity positions of HKSAR banks prior to the start of the pandemic (Figure 3) helped them weather the shock, along with the relief measures implemented by the authorities that helped ease the cash flow pressures of households and corporates.

Figure 3. Hong Kong SAR and Peer Countries: Financial Soundness Indicators (FSIs)
(In percent, 2019)



Sources: IMF Financial Soundness Indicators; national authorities' websites; and Haver Analytics.

10. The decline in profitability during 2020 was largely driven by the decline in net interest income of banks. During Q1-Q3 2020, the aggregate pre-tax operating profit-to-asset ratio for all locally incorporated banks fell by about 29 percent from its 2019 level to 0.84 percent (annualized), driven by a comparable decline in banks' net interest income and with a minor impact from higher loan losses (Figure 4). HIBOR rates declined significantly from their 2019YE levels[5], which led to some compression of interest margins on banks' HIBOR-based loan books. Overall net

[5] For example, 3-month HIBOR declined by about 180 basis points from 2019YE to September-end 2020.

interest margin (NIM) stayed at just under 1.3% at the end of Q3, a 23 percent decline from its 2019YE level.[6]

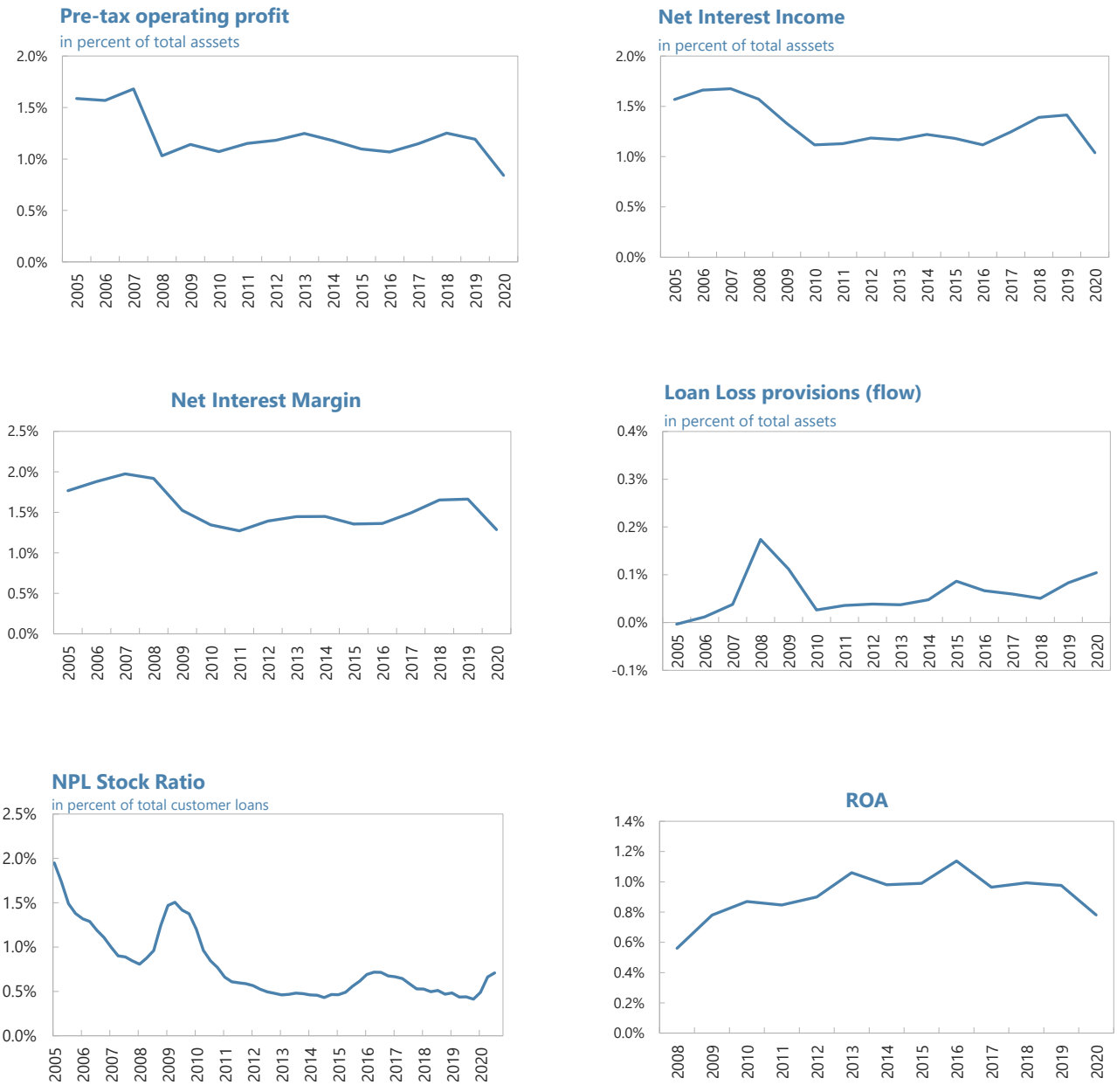
11. Despite significant increases in 2019 and 2020, loan losses remained at minimal levels. In 2020, flow of loan loss provisions for locally incorporated banks almost doubled compared to their average level in the preceding decade, however, they still stood at only 0.1% of total assets as of 2020Q3 (annualized). The subdued level of loan losses is due to the limited deterioration that HKSAR banks saw in their loan book performance during 2020. Despite the significant increase in unemployment and the overall economic downturn during the pandemic, the non-performing loan (NPL) stock ratio saw a limited increase, from just over 0.4 percent of total loans at 2019YE to 0.8 percent at 2020YE for all retail banks.[7] Measures such as temporary loan principal payment holidays of SMEs, direct cash transfers to households, and mortgage principal payment holidays offered by some banks are likely to have limited the deterioration observed in loan performance in the context of significant economic downturn.

12. Banks' total costs also remained relatively low, which contributed to continued overall profitability in 2020, despite the significant contraction in the economy. The cost-to-income ratio for locally incorporated banks increased from just under 40 percent as of 2019YE to 42 percent as of Q2 2020. As a result, banking system continued being profitable, achieving a 0.8 percent return on assets (ROA) during Q1-Q3 2020 (annualized), down by about 20 basis points from its 2019 level.

[6] HKMA reports that some retail banks raised mortgage rates and reduced cash rebates to customers which limited the compression of banks' NIMs.

[7] Retail banks consist of all locally incorporated banks plus a number of foreign branches that are active in retail lending. The non-performing loan stock ratio for the larger group of all authorized institutions was 0.9 percent at 2020YE.

Figure 4. Hong Kong SAR: Banking Sector Performance 1/



Sources: HKMA, Haver Analytics.
1/ 2020 numbers are as of 2020Q3.

13. With continued profitability, bank capital buffers were largely unchanged during 2020. Tier 1 capital ratio stood at 18.3 percent as of Q3 2020, slightly lower from its 2019YE level of 18.5 percent, which continues to provide significant buffers for any further potential deterioration in the economic environment.

14. Banks also continued to hold ample liquidity buffers during 2020. The average LCR ratio for Category 1 institutions[8] stood at just under 157 percent as of 2020Q3, slightly lower than the 160 percent as of 2019YE, yet well above the 100 percent requirement. The average Liquidity Maintenance Ratio (LMR) of Category 2 institutions was about 56 percent, mostly unchanged from 2019YE, and well above the regulatory minimum of 25 percent. The NSFR ratio slightly increased to around 134 percent from around 132 percent at 2019YE, again comfortably above the regulatory minimum of 100 percent. Customer deposits remained stable during 2020 and grew roughly in line with the overall asset growth. They continued to be the primary source of funding for banks at 57 percent of total liabilities as of 2020Q3 (72 percent for locally incorporated banks and 33 percent for foreign branches).

B. Financial System Landscape

15. HKSAR is a major international financial center with extensive linkages to Mainland China. The banking system holds assets equivalent to around 950 percent of GDP. HKSAR hosts local subsidiaries and foreign branches of many international banking groups and contributes materially to the profitability and total assets of several Global Systemically Important Banks (G-SIBs) (Table 2). The life insurance sector is amongst the world's largest, particularly by penetration (with insurance premiums-to-GDP ratio of about 18 percent in 2019) and in per capita terms (with life premiums of around US$9,000 in 2019). HKSAR hosts the world's fifth largest stock exchange by market capitalization (US$ 6.1 trillion). Mainland China-related companies account for around half of the listed companies in HKSAR, representing 81 percent of total capitalization. Total assets under management (AUM) of asset and wealth management companies amounted to 1,000 percent of GDP in 2019. Investors outside of HKSAR own a majority of the managed assets (64 percent of AUM in 2019), reflecting the important role of HKSAR as a global wealth management center. A growing share of these companies is also Mainland China-related, with 387 licensed corporations and registered institutions established by Mainland China-related groups active in HKSAR. The overall structure of the financial system remained largely stable in recent years, while the importance of Mainland China increased (see also paragraph 17).

[8] For liquidity supervision purposes, the HKMA differentiates between "Category 1" and "Category 2" authorized institutions (AIs). "Category 1" institutions are either having significant international exposures or being significant to the general stability of the local banking sector having regard to their size or complexity of business operations. Most major banks including all D-SIBs are Category 1. These institutions are required to comply with the requirements relating to the LCR and NSFR. Other authorized institutions are regarded as "category 2 institutions", which must comply with the requirements relating to the local Liquidity Maintenance Ratio (LMR) and the local Core Funding Ratio (CFR).

Table 2. Hong Kong SAR: Financial Sector Structure
(2020Q3 or latest available data)

	Number of institutions	Total assets (HK$bn)	Multiples of GDP
Banks	193	26,080	9.5
by place of incorporation:			
Local banks - domestic	10	7,037	2.6
Local banks - subsidiaries of foreign banks	46	8,990	3.3
Foreign bank branches	137	10,053	3.7
by business nature:			
Retail banks	34	17,012	6.2
Non-retail banks	159	9,068	3.3
Authorized Insurance Companies (2019)	163	3,872	1.4
Life	49	3,562	1.2
Non-Life	84	166	0.06
Reinsurance	17	144	0.05
Composite	13	(N.A.)	(N.A.)
		AUM (HK$bn)	
Asset and wealth management business (2019)	-	28,769	10.0
by type of business activities:			
Asset management business	-	17,898	6.2
Fund advisory business	-	1,853	0.6
Private banking and private wealth management business	-	7,774	2.7
SFC-authorized Real Estate Investment Trusts (REITs)	-	289	0.1
Assets held under trusts attributable to non-licensed corporations and non-registered institutions	-	955	0.3

Source: HKMA.

Notes: "*Banks*" refers to "authorized institutions (AIs)" authorized under the Banking Ordinance to carry on the business of taking deposits. Total assets of life insurance companies, non-life insurance companies and reinsurance companies also comprise those of the composite insurance companies. "*Private banking and private wealth management business*" excludes asset management business provided to private banking and private wealth management clients.

16. The banking system comprises locally incorporated banks ("local banks") and many smaller foreign branches. These two groups have different business models both on the asset and liability sides. Local banks have a strong local deposit funding base and engage in financial intermediation mostly in HKSAR, but with a significant portion of Mainland China-related loans (about one-third of their loans). They invest largely in loans to non-banks (46 percent of total assets, Table 3). Approximately 30 percent of their non-bank lending are to households (mortgages and consumer loans), with the rest to corporates (Figure 4). Foreign branches, on the other hand, rely more on the interbank borrowing from local banks and on corporate deposits. On the asset side, interbank lending constitutes a much higher share of foreign branches' assets compared to local banks (34 vs. 16 percent), and their non-bank loan books consist almost entirely of loans to corporate borrowers many of which are located outside of HKSAR. Branches are allowed to conduct

only limited retail business in principle, and if local retail lending of a branch grows beyond a certain level, HKMA requires the branch to subsidiarize in HKSAR which, would bring the bank within the framework of local capital regulations.

Table 3. Hong Kong SAR: The Balance Sheet Structure of Local Banks and Foreign Branches
(In % of total assets/liabilities, September 2020)

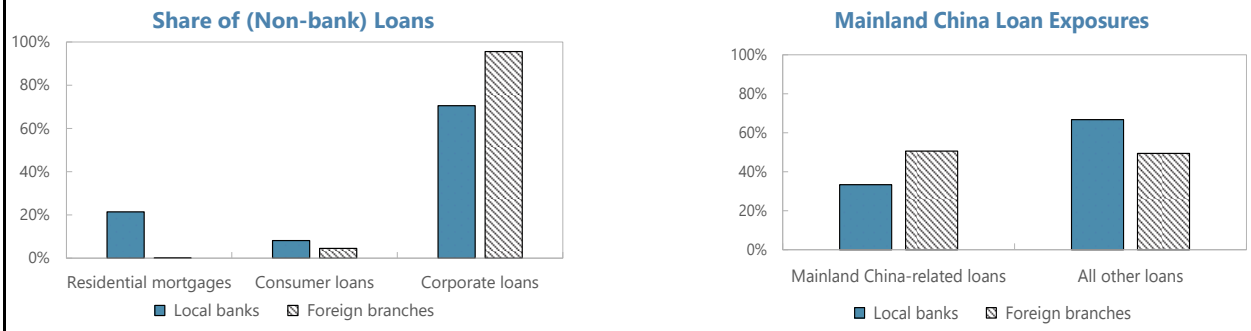
	Local Banks		Foreign Branches		
Asset Category	Asset Share	Liability Share	Asset Share	Liability Share	**Liability Category**
Total Loans to Non-anks	46%	72%	37%	33%	Customer Deposits
Cash and Due from anks	16%	7%	34%	44%	Due to banks
Securities Holdings	23%	1%	20%	13%	Debt Securities Outstanding
Fixed Assets	1%	20%	0%	10%	Equity and Other Liabilities
Other Assets	15%		8%		
Total Assets	100%	100%	100%	100%	Total Liabilities

Source: HKMA data, IMF staff calculations.

17. The banking system has significant loan exposures to Mainland China. Although only 8 percent of loans are to borrowers located in Mainland China, close to 39 percent of loans are Mainland China-related loans[9]. Mainland China-related lending accounts for a much larger portion of foreign branches' loan books compared to local banks: close to 51 percent of foreign branches' loan books, compared to about one third for local banks (Figure 5). A similar differentiation between local banks and foreign branches exists in terms of location of their borrowers. 84 percent of loans of local banks are to borrowers located in HKSAR, with five percent of borrowers in Mainland China, while 62 percent of loans of foreign branches are to borrowers located in HKSAR.

[9] Mainland China-related loans cover a broader group of borrowers which derive a majority of their revenues from Mainland China-related activities.

Figure 5. Hong Kong SAR: Banks' Loan Categories
(In percent, September 2020)



Sources: HKMA data, IMF staff calculations.

18. The funding structure of overall HKSAR banking system is deposit focused. Customer deposits account for 57 percent of total funding and funds from banks for another 21 percent (Table 4). Debt securities[10] account for 6 percent and equity and other liabilities (including reserves) for 16 percent. Loans to non-banks (42 percent) dominate the asset side, with loans to banks accounting for 23 percent. Holdings of debt securities amount to 22 percent of assets; the rest consists of fixed assets (1 percent) and other assets (12 percent). The balance sheet structure has remained relatively stable from 2019YE to 2020Q3.

Table 4. Hong Kong SAR: The Balance Sheet Structure of the HKSAR Banking System
(In % of total assets/liabilities, September 2020)

	All Banks		
Asset Category	**Asset Share**	**Liability Share**	**Liability Category**
Total Loans to Non-banks	42	57	Customer Deposits
Cash and Due from Banks	23	21	Due to banks
Securities Holdings	22	6	Debt Securities Outstanding
Fixed Assets	1	16	Equity and Other Liabilities
Other Assets	12		
Total Assets	100	100	Total Liabilities

Source: HKMA data, IMF staff calculations.

19. Similar to the asset side, there are significant differences between local banks and foreign branches in their funding models. Interbank funding plays a small role for local banks, but a significant one for foreign branches. Local banks fund 72 percent of their balance sheet by deposits from non-banks compared to just under 33 percent for foreign branches (Table 3). For the former, interbank funding accounts for 7 percent while for the latter it stands at 44 percent. Debt securities issuance plays a minor role for local banks (1 percent), and a much higher one for foreign

[10] Debt securities consist of negotiable debt instruments (NDI) and negotiable certificates of deposit (NCD).

branches (close to 13 percent). Equity and other liabilities (including reserves) amount to 20 percent for the former and 10 percent for the latter. From 2019YE to 2020Q3, the funding structure of banks were mostly stable with the share of interbank funding declining by about one percentage point for foreign branches and increasing by a similar amount for local banks. To sum up, local banks are largely locally funded and redistribute excess funding to the foreign branches via unsecured interbank loans. The latter also receive unsecured funding from overseas.

20. Local banks are largely funded in HKD, while foreign branches feature a larger share of USD funding. HKD funding accounts for 56 percent of all liabilities for the local banks and for 21 percent for foreign branches (Table 5). Foreign branches fund more than sixty percent of their balance sheet in USD while the share is much lower, at 31, percent for local banks. The Renminbi (RMB) plays a small role for both groups. During 2020, the funding currency mix stayed mostly stable for both groups of banks.

Table 5. Hong Kong SAR: The Denomination Structures of Liabilities of HKSAR Banks

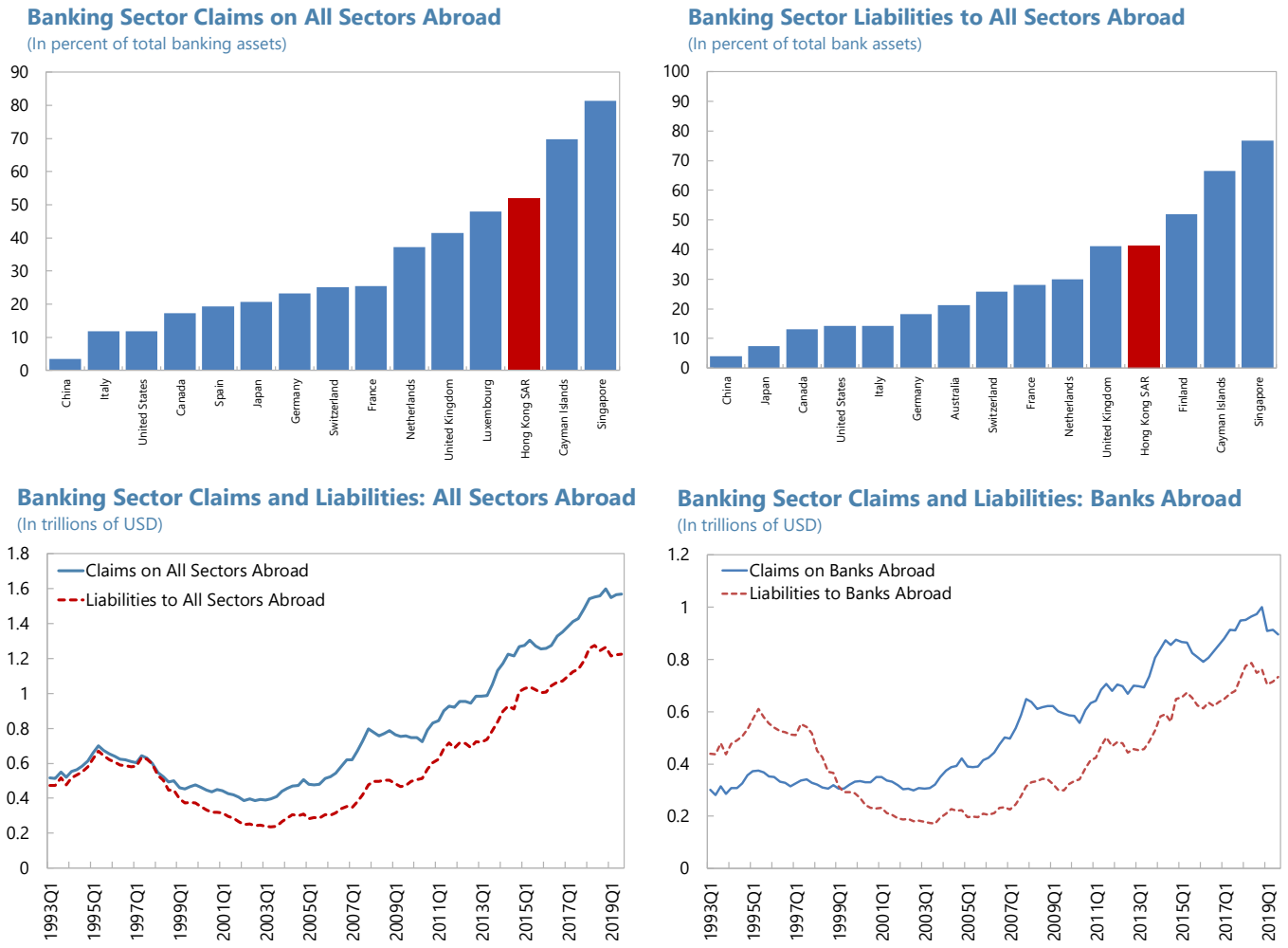
(In % of total liabilities, September 2020)

	Local Banks	Foreign Banks
in HKD	56	21
in USD	31	61
in RMB	5	7
in other foreign currency	7	11
Total	100	100

Source: HKMA data, IMF staff calculations.

21. HKSAR's banking sector has one of the highest levels of cross-border exposures in the world and Mainland China's banking sector receives the largest share of HKSAR's cross-border lending by far. BIS locational banking statistics indicate that HKSAR banks' cross-border exposures to counterparties are significantly higher on the asset side, with total cross-border claims exceeding liabilities by close to 30 percent in 2019. Since the Asian Financial Crisis (AFC), HKSAR banks have been a net lender to other banking sectors abroad since late 1999, which increases the banking system's exposure to potential shocks from abroad. On the domestic front, financial connectedness is also high, with large fund flows from local banks to foreign branches and from foreign branches to nonbank financial institutions (NBFIs). These patterns of interconnectedness will be discussed in detail in the interconnectedness and contagion analysis below.

Figure 6. Hong Kong SAR: Banking Sector Cross-border Claims and Liabilities



Source: BIS Locational Banking Statistics.

C. Scope of the Financial Stability Analyses

22. The financial stability analyses described in this technical note primarily focuses on assessing the resilience of the banking system.[11] The FSAP analysis focused on identifying the vulnerabilities in the banking system and financial stability risks related to banks' solvency and liquidity, as well as domestic and cross-border interconnectedness. Additionally, a corporate sector vulnerability analysis was carried out to complement the banking vulnerability analysis. The analyses consisted of the below-listed modules.

23. The FSAP examined the solvency and liquidity resilience of banks from a systemic risk perspective and it was complemented by a series of sensitivity exercises (see STeM in

[11] The FSAP also carried out and analysis of the resilience of the investment fund sector. For the details, see the Technical Note on investment Fund Sector Liquidity Stress Testing.

Appendix II)[12]. The exercise covered 12 local banks (including all six D-SIBs) and 11 foreign branches. The solvency stress test (ST) analysis focused only on the subset of local banks which account for about 93 percent of total consolidated assets of all local banks in HKSAR that are subject to capital regulation by the HKMA. The solvency ST utilized a baseline scenario and an adverse scenario. The analysis generated three-year estimates for profit and losses, and the evolution of risk-weighted assets and capital. To assess the liquidity risks, the FSAP carried out an analysis of banks' regulatory liquidity ratios and complemented it with a variety of liquidity stress tests. The liquidity ratios consist of LCR and NSFR, as well as their equivalents for Category 2 banks in HKSAR: the Liquidity Monitoring Ratio (LMR) and the Core Funding Ratio (CFR). For liquidity stress testing, the FSAP Team ran cash flow-based tests using supervisory data on contractual cash flows and security flows for employing multiple scenarios of increasing severity and covering several time horizons.

24. The interconnectedness and contagion analysis mapped out the major patterns of interconnectedness from both cross-border and domestic intra-financial system perspectives. It first mapped intra-financial sector linkages between banks and major nonbank financial sectors, based on exposure data provided by the largest 20 banks in HKSAR ranked according to their HKSAR office basis assets.[13] Additionally, using BIS locational banking statistics data, the FSAP carried a cross-border interbank credit shock simulation whereby a counterparty default induces losses and a funding shock simulation whereby the withdrawal of a funding counterparty induces a funding shortfall. A potential fire sale of assets in a stressed market is also utilized to simulate an extreme funding shock. In addition to these balance sheet-based analyses, the FSAP also carried a market-based contagion analysis. This approach assessed the potential for contagion through equity valuations of major banks. The sample for the analysis included the sample of global systemically important banks (G-SIBs)[14], many of which have substantial presence in HKSAR, and five publicly traded HKSAR banks. The analysis is based on the Diebold-Yilmaz (2014)[15] methodology and uses daily equity return data from through December 2020.

25. Finally, The FSAP carried out a corporate sector vulnerability analysis to complement the banking vulnerability analysis. The FSAP assessed the vulnerabilities of HKSAR's non-financial corporate sector and its resilience to adverse shocks using scenario-based firm-level analyses. Using the firm-level data, the FSAP carried out two scenario-based analyses: i) debt-at-risk to assess the overall corporate sector vulnerabilities, and ii) bottom-up default analysis (BuDA), which uses both market-based information and balance sheet indicators to assess the sensitivity of corporate defaults to shocks in an adverse macroeconomic scenario.

[12] The details of liquidity stress testing are presented in separate background note.

[13] 9 local banks and 11 foreign branches.

[14] As identified by the FSB as of November 2020.

[15] Diebold, Francis, and Kamil Yilmaz, 2014, "On the network topology of variance decompositions: Measuring the connectedness of financial firms," Journal of Econometrics, 182, 119–134.

BANK SOLVENCY STRESS TESTS

A. Key Vulnerabilities and Risks

The main macro-financial vulnerabilities of the banking system relate to HKSAR's extensive linkages to Mainland China, stretched real estate valuations, and exposure to shifts in global market and domestic risk sentiment.

26. Interconnectedness with Mainland China is high and rising, through real sector ties, credit exposures of the HKSAR banking sector and fundraising by Mainland China firms through other financial intermediaries.

- *Real sector Mainland China ties, mostly through trade and tourism.* Historically, Mainland China visitors account for over three quarters of tourism spending in HKSAR, accounting for about 30 percent of total retail sale, and a slowdown in Mainland China would adversely affect trade, logistics, tourism, and retail sectors[16] in HKSAR.
- *Direct Mainland China credit exposures of the banking system,* with close to 40 percent of banks' total loan books comprising Mainland China-related lending (33 percent for local banks and 51 percent for foreign branches).
- *Linkages through the financial services hub for Mainland China*, providing the main fundraising platform for Chinese firms and offering a range of asset management services. Most listed firms and bond issuers in HKSAR are from Mainland China. Annual issuance of offshore non-bank Mainland China bonds increased to US$190billion in 2019 — more than 10 times the total issuance of US$18billion in 2014. Non-bank Mainland China corporate bond outstanding totals US$662billion: most of them are short-term (2-3 years) and only one-third have investment-grade ratings.

Given the high level of interconnectedness, shocks to Mainland China could have significant spillovers to HKSAR. For example, a significant slowdown in China could reduce trade flows through HKSAR and lead to a sharp decline in economic activity there. Lower trade volumes would reduce corporate profits and investment, raise unemployment, and weaken consumption. Similarly, a slowdown in Mainland China would reduce tourism flows which would have direct adverse effects on tourism and retail sectors. Banks would likely face higher losses on their loans to Mainland China-related and other corporate borrowers, as well as on their broader credit portfolio due to the overall decline in economic activity. Additionally, a slowdown in Mainland China would lead to higher defaults among corporate bond issuers and increase credit risk of bondholders in HKSAR.

27. Real estate valuations are stretched. House prices appear overvalued relative to income and rent, based on both historical norms and in international comparisons. Housing affordability deteriorated as nominal wages grew by only about 23 percent between early 2014 and September

[16] Retail sales accounted for about 20 percent of HKSAR's GDP during 2011-19, on average.

2020. On the supply side, housing production has fallen significantly short of the supply target outlined in the Long-Term Housing Strategy document, originally issued in 2014, by around 30 percent on average since 2015. Real house prices exceeded fundamental-based valuations by about 33 percent in 2020Q2, following a prolonged state of overvaluation and stagnated between March and December 2020 (up 0.2 percent in nominal terms).[17] Together with rising unemployment and falling income, a continued overvaluation of HKSAR house prices may eventually result in a sharp downside correction (Figure 7). Similarly, a sharp increase in interest rates would result in significantly higher mortgage payments and may result in a large decline in prices. Hence, careful monitoring of house price risks is warranted to prevent negative feedback effects from large downside risk to house prices under stressed conditions on households' and banks' balance sheets, which would adversely affect financial stability and the HKSAR economy.

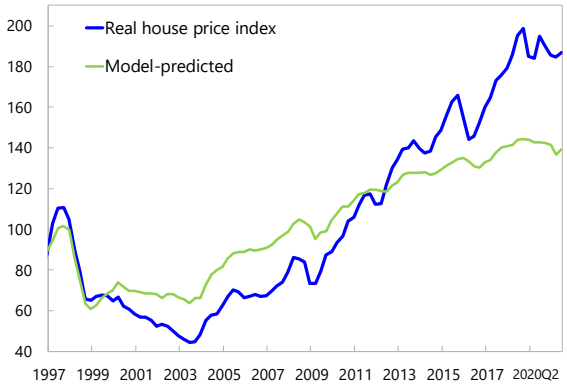
28. As a global financial center with an open economy, HKSAR is vulnerable to shifts in global risk sentiment. Tighter global liquidity conditions and US-China tensions could have a broad-based impact on both the financial system and the real economy.

29. Finally, the discontinuation of LIBOR as a reference rate by end-2021 implies transition risk for the HKSAR banking sector, although the risk appears to be well-managed (Box 1)**.** To preempt any adverse effects from the transition of LIBOR-referenced products to alternative rates, HKMA advised banks to address the related legal, operational and market risks early, and to cease the further use of LIBOR as a benchmark starting from June 2021.

[17] Housing price misalignment is calculated as deviation of the market residential property price from the value estimated using a first-order autoregressive model AR(1).

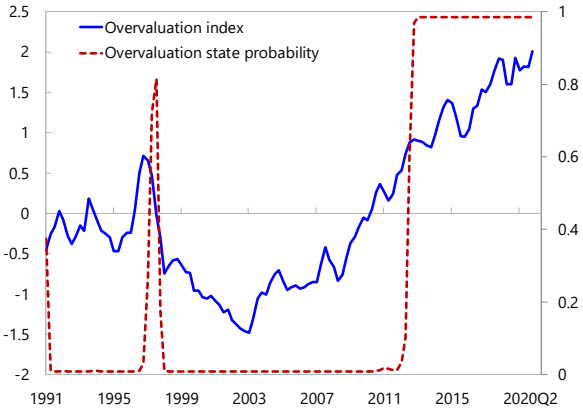
Figure 7. Hong Kong SAR: House Price Overvaluation Indicators

1. Comparison of real and model implied value of house prices (index)



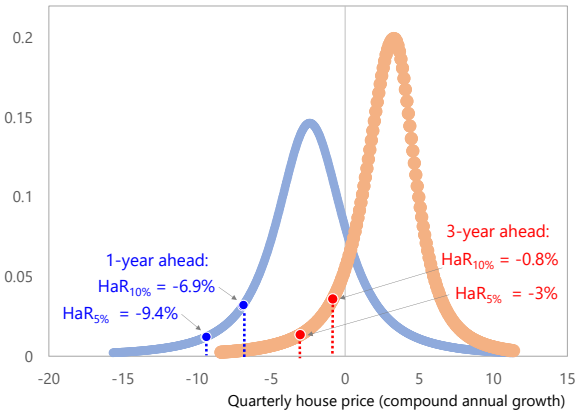
Sources: IMF staff estimates and calculations.

2. Bubble index and overvaluation state probability (z-score, primary axis; probability, secondary axis)

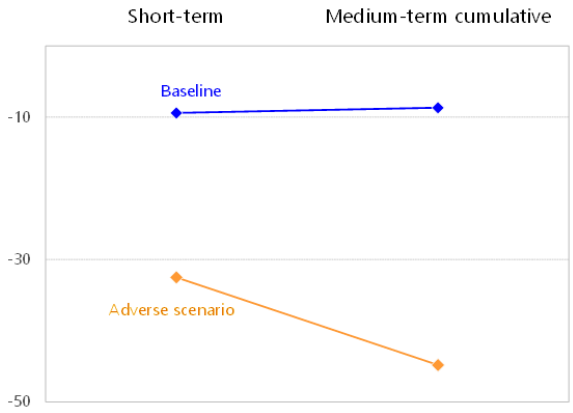


Sources: IMF staff estimates and calculations.

3. Baseline One- and Three-Year-Ahead T-Skew Density Forecasts, 2020Q2
(Probability Density Function, PDF)



4. One-Year and Three-Year-Ahead HaR Baseline and Adverse Scenarios (percentage change, 5th percentile, 1 standard deviation shock)



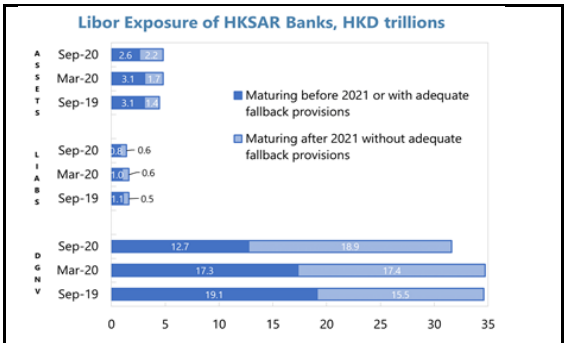
Sources: Haver and IMF Staff Calculations.

Note: HaR = house price at risk. Panel 1 compares real house prices to the value estimated using an AR(1) model. The model captures demand and supply side factors, including land supply, building works tender price index, housing vacancy rate, private construction-to-GDP, residential unit completions, population growth, housing affordability, lending rate, private sector credit growth. Panel 2 shows an overvaluation indicator constructed using factor analysis to extract common overvaluation information from the following fundamental factors: price-to-GDP per capita ratio, price-to-rent ratio, changes in real house prices, changes in household debt-to-GDP ratio, changes in construction-to-GDP ratio and changes in the best-lending rate. The red line refers to the probability of changing from a normal regime to an overevaluation state as measured by a dynamic Markov-switching model applied to the overvaluation indicator. Panel 3 shows the conditional probability distributions of one (blue line) and three-year-ahead (orange) house price growth based on a parametric, t-skew density, fitted over quantile regression estimates in the period 2020:Q2. Figures are annualized growth rates. Panel 4 shows the point estimates of predicted HaR for 2020:Q2 in the short-term (one-year-ahead) and the medium-term (three-years-ahead) projections at the 5th percentile (at compounded growth rates). The counterfactual ("adverse scenario") scenario is calibrated as a simultaneous one standard deviation shock to the house-prices-to-GDP per capita ratio (misalignment), financial conditions index and credit to household-to-GDP ratio.

Box 1. LIBOR Transition Risks for the Hong Kong SAR Financial Sector

The London Interbank Offered Rate (LIBOR) will be discontinued as a benchmark interest rate for adjustable-rate financial products. In the past, several large international banks were fined for LIBOR market manipulation and as a result, LIBOR is being discontinued since it is now based on too few transactions. USD LIBOR rates will cease publication mid-2023, while USD one- and two-week tenors and all non-USD LIBOR rates will cease at end-2021. For banks with LIBOR-referenced lending and securities that mature beyond the termination of LIBOR, this may pose some transition risk and legal uncertainty.

HKSAR banks have considerable LIBOR and HIBOR exposures,[1] while funds and insurers have negligible exposures. As of September 2020, almost 40 percent of their assets and 5 percent of their liabilities (mostly LIBOR) are referenced to LIBOR or HIBOR. Off-balance sheet derivative exposures referenced to LIBOR (mostly interest and cross-currency swaps) amount to additional 120 percent of HKSAR banking assets. Two-thirds of those exposures mature after end-2021, with 93 percent not yet covered by adequate fallback provisions in underlying contracts. While these exposures are expected to decline rapidly over 2021, residual positions would entail legal uncertainties and could become less liquid or experience volatile changes in their value once the cessation dates approach.



Sources: HKMA and IMF Staff Calculations. LIABS = Liabilities; DGNV = Derivative Gross Notional Value. Figures are notional amounts at quarter-end.

The HKMA advised banks to address legal, operational and market risks early and appropriately and is currently reviewing banks' LIBOR transition plans. In 2019, the Treasury Markets Association identified the HKD Overnight Index Average (HONIA) as the alternative reference rate (ARR) to the HIBOR. With no panel instabilities or conduct problems observed in the HIBOR benchmark, however, HIBOR and HONIA are expected to coexist in HKSAR markets under a multiple rate approach, where market participants can choose their benchmarks freely. Hence, currently, no change in the computation of the HKMA's base rate for monetary policy is required. The HKMA has encouraged banks to no longer issue LIBOR-linked products after June 2021. Market participants are also urged to be prepared to provide products linked to ARR and to start including fallback provisions for new contracts. If needed, the HKMA has the tools to discourage a continued use of LIBOR, such as larger collateral haircuts on LIBOR-referencing products in its liquidity facility framework or higher haircuts in the LCR framework. Issues around a lack of derivative markets for ARRs may be of less concern for HKSAR as HIBOR provides a full-term curve. The only remaining concern would be the compliance of HIBOR with relevant EU law, to ensure that HIBOR can continue to serve as a benchmark for EU banks (as the transition period for third-country benchmarks expire by end-2023 under current EU law).

LIBOR volatility during the transition period may feed into HIBOR volatility, but related risks appear manageable for local banks in HKSAR. Under a scenario of increased interest rate volatility, amounting to a 200bps shock to HKD and USD interest rates, local banks would experience a 1.4 percent decline in their total capital ratio, which is easily absorbed by existing capital buffers. In addition, the HKMA's standby liquidity facility and its contingent term facility could provide additional protection, if needed. Moreover, broad international efforts, including the FSB's coordination role through its OSSG group, and ISDA's new fallbacks for IBOR derivatives, in effect since early 2021 are supporting a smooth transition. Nevertheless, while overall benchmark transition risk is assessed to be limited, HKSAR authorities should continue to monitor the situation vigilantly.

[1] In this discussion exposure refers to the notional of instruments that use these benchmarks as reference rates, not to market value sensitivity to fluctuations in these rates.

30. Based on the vulnerabilities discussed above, the FSAP identifies the following key macro-financial risks for the banking sector (see Risk Assessment Matrix [RAM], Appendix III). The sources of risks and transmission channels are highlighted below:

a. *Prolonged COVID-19 pandemic*. The disease proves harder to eradicate, requiring prolonged containment efforts both in HKSAR and abroad. Costly containment efforts and uncertainties about the intensity and the duration of the outbreak could reduce both domestic and external economic activity and prevent a speedy recovery.

b. *Accelerating de-globalization and heightened protectionism accompanied by a further slowdown in China*. Geopolitical competition could lead to further fragmentation and trade tensions could escalate. Uncertainty due to trade tensions could weigh on economic activity with businesses postponing their investment and hiring decisions. A further slowdown in China would reduce trade flows through HKSAR and lead to a sharp decline in economic activity there. Lower trade volumes would reduce corporate profits and investment, raise unemployment, and weaken consumption. Trade, logistics, tourism, and retail sectors would be affected most adversely. Banks would likely face higher losses on their loans to Mainland China-related and other corporate borrowers, as well as on their broader credit portfolio due to the overall decline in economic activity.

c. *A sharp rise in global risk premia compounded by escalating US-China tensions*. A reassessment of market fundamentals, e.g., in response to adverse COVID-19 developments, could trigger a widespread risk-off event. A spike in risk premia and more volatile global financial conditions would lead to a tightening of liquidity in global money markets. An escalation of US-China tensions could lead to a further repricing of HKSAR-specific risk. Any resulting capital outflows would increase funding cost for banks and corporates and push down asset values, including property prices. The heightened uncertainty could further weaken economic sentiment, leading to larger-than-expected housing market correction. Higher uncertainty could also lead to deposit outflows and, along with capital outflows, could also have FX implications via pressure on the LERS.

d. *A sharp housing market correction and decline in demand*. A sharp decline in house prices would lower confidence, weaken housing demand, lower residential investment, and constrain new bank lending as many loans are secured by property, leading to a larger downturn. A house price-at-risk model indicates that prices could fall by about 45 percent over 3 years under an adverse scenario (Figure 7).[18]

31. In a severe scenario, the four risks described above could materialize at the same time and amplify each other's effects. For example, further slowdown in China could coincide with renewed US-China tensions and impose significant growth pressures on HKSAR. Looking ahead, renewed social incidents, global economic uncertainties, and US-China tensions could continue to

[18] House price-at-risk analysis as of 2020Q2 indicate that, under the adverse scenario real house prices in Hong Kong SAR could fall by 45 percent (at compounded growth rates) over the next 3 years with a 5 percent likelihood. The adverse scenario is calibrated as a simultaneous standard deviation shock to the house-prices-to-GDP per capita ratio (misalignment), financial conditions index and credit to household-to-GDP ratio.

pose challenges to HKSAR's standing as an international financial center. These developments could also trigger a house price correction in HKSAR, amplifying the downturn through a feedback loop of falling house prices, weaker consumption, higher NPLs, and tightening of banks' lending standards.

B. Scenarios Utilized in the Solvency Analysis

32. The FSAP assessed the banking system's solvency resilience against two macroeconomic scenarios over a three-year horizon: adverse and baseline. The starting point of the stress test was 2019, the latest date for which confidential bank-level supervisory data was available under the extraordinary COVID-19 pandemic circumstances. The data precedes the start of the COVID-19 shock and the solvency stress testing (ST) exercise does not incorporate the impact of temporary policies aimed at supporting borrowers (e.g., income support to households and SMEs, loan principal payment deferrals), which is conservative, since the support policies are likely to prevent NPLs from increasing to the levels suggested by estimates from historical data up to 2019YE. While the support policies are likely to have helped with attenuating the downturn in 2020; several measures help households and businesses beyond their direct effect on GDP or unemployment. For example, loan principal payment deferrals and direct cash payouts help borrowers stay current on their loans despite the historically high unemployment rate and GDP contraction. By continuing to use predictions implied by the historical relationship and ignoring realized NPLs observed during 2020, the ST takes a conservative approach. This conservatism is warranted given the uncertainties around loan performance once the temporary support measures are lifted.

33. The two scenarios assume different degrees of risks. The GDP path of the adverse scenario corresponds to a significant shock as it is more severe than the AFC throughout the three-year simulation period (2020-2022). Unlike the AFC, policy interest rates are assumed to remain accommodative. However, financial conditions tighten significantly in the adverse scenario as corporate credit spreads rise and asset prices fall, which amplify the effect of the economic slowdown on the banking system.

- ***Baseline scenario*** reflects the developments in early 2020 whereby pandemic and the containment measures in place led to a significant decline in private consumption and investment, and a virtual stop in tourist arrivals in 2020. The baseline scenario is based on the October 2020 WEO forecast[19], and it envisions a GDP contraction of 7.5 percent in 2020 in HKSAR, which will turn to a growth of 3.7 percent in 2021[20]. GDP growth in Mainland China is simulated to slow down to 1.9 percent in 2020, before bouncing back at a fast pace of 8.2 percent in 2021.

- ***Adverse scenario*** assumes the joint realization of the four macro-financial risks discussed above. First, it assumes a prolonged outbreak with prolonged containment measures. Additionally, heightened protectionism coupled with a further slowdown in Mainland China further reduces trade flows and leads to a sharper decline in economic activity in HKSAR. The scenario also

[19] October 2020 WEO forecast was the latest available WEO forecast at the time of the FSAP's bank solvency analysis.

[20] The WEO growth forecasts were revised upwards since the October WEO. The 2020 realized growth was -6.1 percent, with the 2021 and 2022 forecasts being updated to 4.3 and 3.8 percent, respectively.

envisions a sharp rise risk in global risk premia compounded by escalation of tensions between the US and China leading to higher HKSAR-specific risk premia and tightening financial conditions. Finally, the scenario simulates a sharp correction in the housing market. As a result, following the sharp contraction in 2020, the economy continues to contract significantly in 2021 and starts recovering only in 2022, leading to a GDP path that is well below the AFC experience. The adequacy of the stress scenario for GDP is corroborated by the Growth-at-Risk (GaR) model (Figure 8).

34. The Adverse scenario simulates HKSAR GDP growth rates of -8.5 and -4.9 percent in the first two years, respectively. Under this path, the first 2-years' cumulative growth would reach -13 percent, which corresponds to a shock of 1.5 times the standard deviation of two-year cumulative GDP growth rates[21] applied to the October 2020 WEO forecast, which itself features a significant negative shock. The economy would start recovering in the third year with GDP growth turning positive at 2.5 percent. The full set of macrofinancial variables are generated by the Flexible System of Global Models developed by the IMF Research Department[22] and benchmarked to past experiences of economic shocks in HKSAR with expert judgment. Given HKSAR's extensive linkages with Mainland China, the Adverse scenario assumes a slowdown there as well, with GDP growth rates of 1 percent, 3 percent, and 4 percent during 2020-2022, respectively. with the AUD losing 25 percent of its value against the USD in the first year. The adverse scenario assumes a depreciation of RMB against the USD by 2.4 percent in the first year followed by a further depreciation of 5 percent in the second year. This depreciation partially reverses in the third year of the scenario resulting in cumulative depreciation 3.8 percent by the end of the third year.

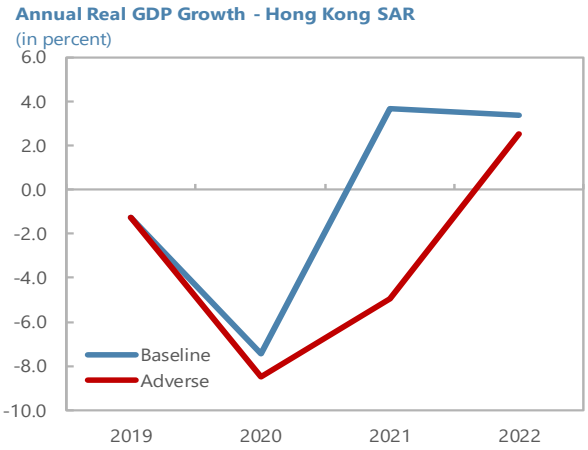
35. The simulated economic downturn in the adverse scenario for HKSAR leads to a significant increase in unemployment. The unemployment rate increases from its 2019Q4 level of 3.3 percent to a peak of 8.5 percent in the second half of 2021 and starts declining in 2022. Additionally, reflecting the sharp correction in housing markets envisioned in the scenario, house prices decline by 25 percent, 12 percent, and 9 percent in the three years of the adverse scenario respectively, with cumulative decline approaching 40 percent at the end of the three-year period.

[21] Standard deviation of GDP growth series is calculated with the period starting in 1984, the first full year with the Linked Exchange Rate System in place.

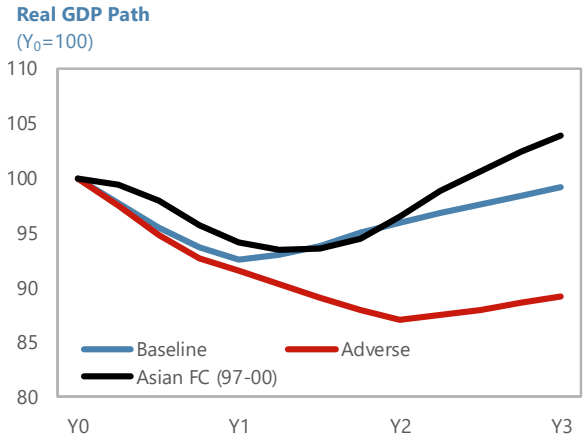
[22] See the IMF working paper The Flexible System of Global Models – FSGM (2015).

Figure 8. Hong Kong SAR: HKSAR GDP Growth Scenarios in the Solvency Stress Test

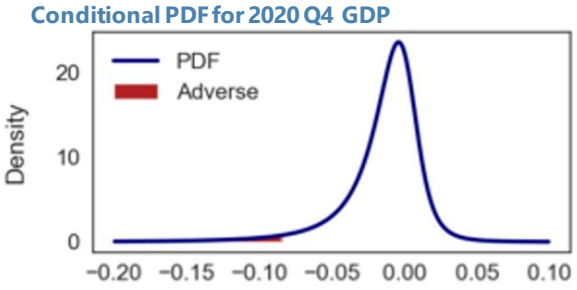
HKSAR GDP growth in baseline and adverse scenarios



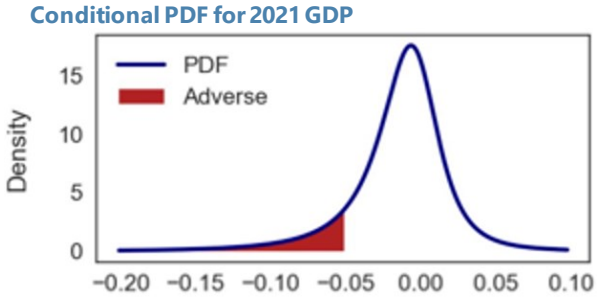
Real GDP Paths under the two scenarios and during the Asian financial crisis (normalized)



The adverse scenario GDP growth assumption for 2020 has a 3.8 percent probability in the growth-at-risk model…



… and the assumed adverse GDP growth for 2021 is a 11.4-percentile tail event based on the model.

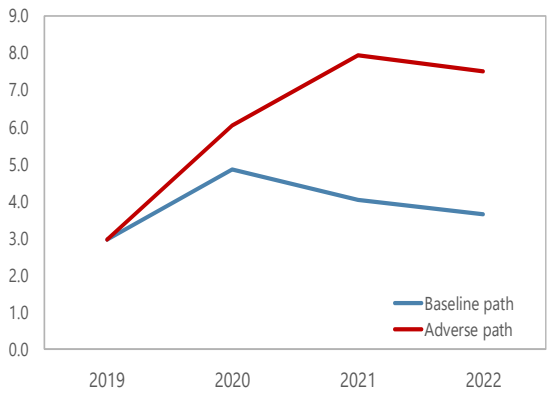


Source: IMF Staff Computations.

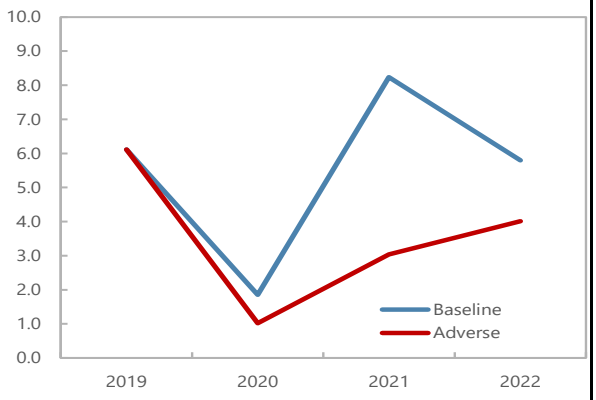
36. The simulated sharp rise risk in global risk premia compounded by higher HKSAR-specific risk premia leads to significant tightening in financial conditions. First, in line with stress in the HKSAR interbank market, the 3-month HIBOR/LIBOR spread widens from its 2019Q4 average level of 37 basis points to 160 basis points at the end of 2020, well exceeding the levels seen during the Global Financial Crisis (GFC). The spread starts declining meaningfully only in the second half of 2021 (Figure 9). The interbank market spreads affect broader bank borrowing costs significantly as discussed later in the note. Similarly, the investment-grade corporate bond spread widens from its starting level by 400 basis points at the peak and starts declining meaningfully only towards the end of 2021. In line with the rise in global risk premia, the LIBOR spreads to US Federal Funds rate also increase in 2020, reflecting stress in the USD interbank borrowing market. At the same time, the US monetary policy rate is reduced to near-zero, which limits the increase in the overall level of interest rates.

Figure 9. Hong Kong SAR: Solvency Stress Test Scenarios Additional Variables

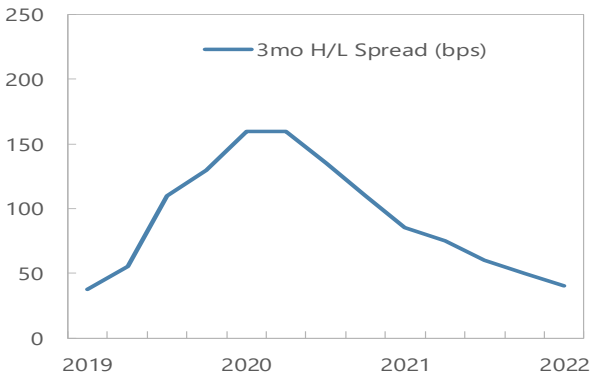
HKSAR unemployment increases and remains elevated.



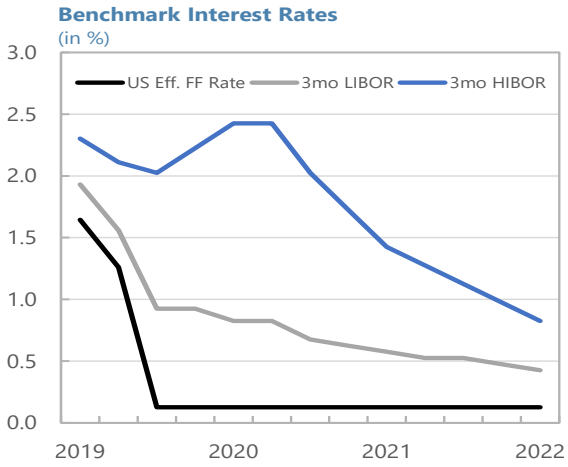
China GDP growth slows down in the adverse scenario



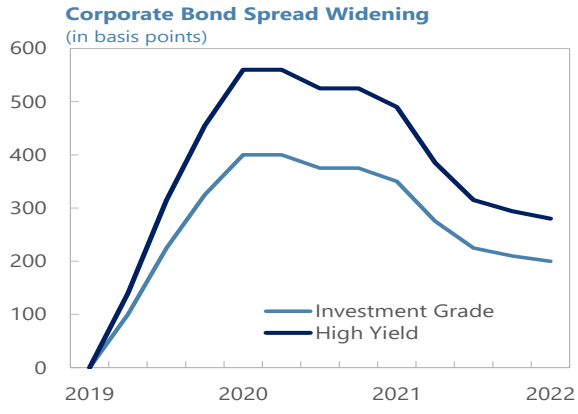
The HIBOR/LIBOR spread widens significantly in the adverse scenario as risk aversion increases.



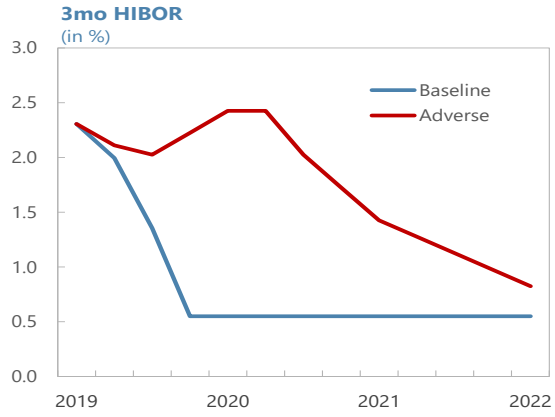
Spread widening in the adverse scenario pushes HIBOR up in the first year and it starts declining in the second year.



Risk aversion pushes corporate bond spreads up significantly from initial levels in the adverse scenario.



HIBOR declines significantly in the baseline scenario after the initial market turmoil.



Sources: IMF Staff.

C. Solvency Stress Test Methodology

37. The solvency stress testing assessment utilized macrofinancial scenario analysis and sensitivity tests. The scenario analysis assesses banks' solvency over a period of three years (2020–2022), while the sensitivity tests are static; that is, they assess the instantaneous impact of single risk factors on banks' balance sheets. For the scenario analysis, the FSAP carried out a top-down exercise based on the methodology described below.

38. The solvency stress tests followed a balance sheet-based approach. Six banks in the ST sample follow the Internal Ratings-Based approach (IRB)[23] for calculating capital requirements for credit risk while the five banks followed the Standardized Approach (STA). Banks' performance under the simulation was assessed based on common equity tier 1 (CET 1) capital ratio. The hurdle rate used was 4.5 percent CET 1 ratio. In addition to this minimum capital requirement, the FSAP also considered the capital conservation buffer of 2.5 percent of CET 1 capital as an additional benchmark.

39. The balance sheet-based approach projects key items in banks' balance sheets and income statements based on the evolution of macrofinancial variables in the scenarios. Funding shocks and bank credit losses are projected with quarterly frequency using satellite models. Based on the outputs of the satellite models, changes in the projected balance sheets and income statements determine changes in the regulatory capital of banks. These items are projected with an annual frequency in the simulation. The analysis is carried out with a passive balance sheet assumption. Under this assumption, banks do not strategically change the composition of their assets or liabilities throughout the simulation period. Additionally, growth of gross exposures, such as total gross loans and gross holding of debt securities, is assumed to follow nominal GDP growth with a zero-growth floor. Thus, the size of the banking system assets remains roughly stable relative to the size of the economy. This assumption aims to ensure that banks continue to maintain their fundamental function of financial intermediation even during a crisis and do not attempt to meet capital requirements simply by shrinking their balance sheets. In addition, it is assumed that banks would be able to build capital buffers only through retained earnings; no other capital is raised during the scenario period. Banks satisfying capital requirements during the stress test simulation are assumed to distribute 50 percent of after-tax profits. Given the evolution of total assets and equity, total liabilities adjust accordingly, with banks expected to raise additional funding, as needed.

40. Changes in net income during the scenario are an important driver of changes in the capital levels. Net income has three major components: i) net interest income, ii) net non-interest income, and iii) credit loss provisions. The estimation of net interest income accounts for changes in balance sheet size, net interest margins including the effect of funding shocks (discussed below), and non-performing loans (NPLs). It is assumed that banks would not receive interest income from NPLs. Non-interest income items were based on simple assumptions following the overall economic growth instead of models. Under the adverse scenario, net fee and commission income and other non-interest income were assumed to decline by 30 percent from its initial level in the first year of

[23] One of the IRB banks changed to the Standardized Approach during the course of the FSAP. For consistency with the initial data collection, the FSAP maintained the IRB approach throughout the simulation period.

the scenario, to account for the overall economic contraction, and recover by 15 percent in the third year as the economy turns to positive growth. In the baseline scenario these non-interest income items are assumed to decline by 25 percent in the first year, start recovering in the second year as the economy starts recovering and reach 90 percent of their initial level in the third year. Non-interest income items, such as operational and administrative expenses, were assumed to grow in line with the overall size of banks' balance sheets, carrying over the zero-growth floor assumption. Finally, the loss provisions are estimated separately for standardized and IRB banks using estimates NPL and probability of default (PD) estimates. The two approaches are discussed in more detail below.

Calculation of Loss Provisions for Standardized Banks

41. The two main components of credit loss projection for standardized banks are the projection of new flow of NPLs and the projection of loan provisioning rates. The FSAP estimated satellite credit risk models to project the ratio of stock of NPLs (see below discussion) during the scenario period for each major loan category (corporate loans, mortgages, retail loans, and bank loans) and converted the NPL stock ratios to flows. The estimated NPL flows times the provisioning rates gives the loss provision estimate for each loan category and bank. As for the provisioning rates, banks' historical realized loss-given-default (LGD) rates were used as proxies for provisioning rates. The FSAP calculated 4-quarter moving averages of quarterly realized LGDs to smooth out volatility and outliers in the quarterly data and used the peak of the moving average series to calibrate the stressed provisioning rates for the adverse scenario. These stressed provisioning rates are meant to reflect the higher losses that are likely to be experienced in the simulated significant economic downturn. The average provisioning rates for corporate loans was 58 percent in the sample. For retail loans, which are mostly uncollateralized, the average provisioning rate was higher at 76 percent.

42. For mortgage loans, the provisioning rates were modest. For mortgages, in addition to historical LGDs, the FSAP team constructed loss rates from the ground up, using the loan-to-value (LTV) distribution of banks' mortgage portfolios and the simulated house price declines in the scenario. The HKMA tightened macroprudential policy measures (MPMs) related to LTV ratios several times in the past years, which helps limit banks' exposure to significant house price declines. The average LTV ratio for the banks in the solvency ST sample stood at around 39 percent at the end of 2019 with the share of high-LTV[24] mortgages at less than two percent of the total mortgage books[25]. Given that banks' mortgage portfolios have low average LTVs and a low share of high-LTV loans, even with substantial declines in house prices, the average provisioning rate for STA banks was 10 percent in the adverse scenario. For the baseline scenario, more recent LGD rates were utilized with elevated LGDs in the first year and reverting to longer-term median values as the economy recovers quickly in the second and third years. The average provisioning rates in the

[24] Defined as those with LTV ratio greater than or equal to 80 percent.

[25] These numbers take into account the portion of mortgage exposures covered by the Mortgage Insurance Programme. Without netting of the portion covered by the Mortgage Insurance Programme, the average LTV ratio would increase to just under 42 percent and the share of high-LTV mortgages would increase to just under five percent of total mortgage book.

sample for the baseline scenario was just over 35 percent for corporate loans and 67 percent for retail loans. For mortgages, the average provisioning rates were minimal. The baseline scenario simulates a flat residential property prices in the first year, followed by growth rates of 11.7 percent and 8.2 percent in the second and third years. Stable and increasing house prices, combined with the low starting LTV profile of mortgage portfolios, limits the potential losses on the baseline scenario, which is in line with banks' recent experience of realized LGDs.

Calculation of Loss Provisions for IRB Banks

43. Loss provisions for IRB banks are based on the Expected Loss (EL) approach, calculated separately for each exposure class. The EL calculation, based on the formula EL=PDxLGDxEAD, requires point-in-time (PiT) PDs and LGDs which would reflect the current risk profiles of banks' portfolios and would increase in response to a deterioration in the economic environment. The FSAP estimated satellite credit risk models to project PiT PDs (see below discussion) during the scenario period for each major IRB exposure category: corporate, mortgages, individual retail[26], and bank. For LGDs, banks' historical realized LGD rates were used. The FSAP calculated 4-quarter moving averages of quarterly realized LGDs and used the peak of the moving average series to calibrate the stressed LGDs for the adverse scenario. Additionally, the through-the-cycle (TTC) LGDs were used as floors for stressed LGDs for the adverse scenario. The average LGD for corporate exposures 48 percent in the sample. For individual retail exposures, the average LGD was close to 82 percent.

44. Similar to STA banks, LGDs for mortgages were modest for IRB banks. In addition to historical LGDs, the FSAP team used ground-up loss rates (using portfolio LTV distributions and simulated house prices), and the TTC (downturn) LGDs provided by the banks. Again, with the low average LTVs and low share of high-LTV mortgages in IRB banks' portfolios, the average LGD for credit loss calculation was 12 percent in the adverse scenario. For the baseline scenario, more recent LGD rates were utilized with elevated LGDs in the first year and reverting to longer-term values as the economy recovers quickly in the second and third years. The average LGD rates in the sample was around 31 percent for corporate exposures and 70 percent for retail loans. For mortgages, again increasing house prices combined with the low starting LTV profile of mortgage portfolios, leads to minimal potential losses on the baseline scenario, which is in line with banks' recent experience of realized LGDs.

Changes in Risk-Weighted Assets (RWA)

45. The stress test accounted for changes in RWA under the scenarios. The increase in risk weights is meant to reflect the increase in credit risk going forward, due to a deteriorating economic environment, and could contribute materially to changes in RWA-based capital ratios. For IRB banks, the RWA formula uses the through-the-cycle (TTC) PDs and downturn LGDs. The changes in TTC PDs for exposure categories were derived from the PiT PDs used for EL calculation using the formula:

Δ TTC PD=λ * Δ PiT PD (with $0<\lambda<1$).

[26] Individual retail exposures consist of qualifying revolving retail exposures and other retail exposures to individuals.

That is, the increase in TTC PDs were assumed to be a fraction of the increase in PiT PDs. For corporate exposures λ was chosen to be 0.4[27] and for the other exposures λ was chosen to be 0.2. With this approach, higher PDs under the scenario simulations also lead to higher RWAs. As for the downturn LGDs, the FSAP used the downturn LGDs reported by the banks in their RWA calculation, with no additional increases.

46. For the STA banks, the risk weights are determined by the risk ratings of loans. HKSAR's Banking (Capital) Rules (BCR) specifies the risk weights corresponding to loans with each rating category and to unrated loans. If corporate and bank loans migrate to lower risk ratings under adverse economic conditions, risk weights assigned to those loans would increase. The FSAP considered the potential shifts in ratings of corporate and bank loans, under both baseline and adverse scenarios. However, standardized banks have conservative starting risk weights. For example, with many corporate loans being unrated, receiving 100 percent risk weight, the average risk weights for corporate loan exposures is already above 90 percent. For this reason, there is more limited room for increases in RWAs due to risk weight shifting of STA banks, compared to IRB banks.

D. Long-term View of Credit Risk in HKSAR

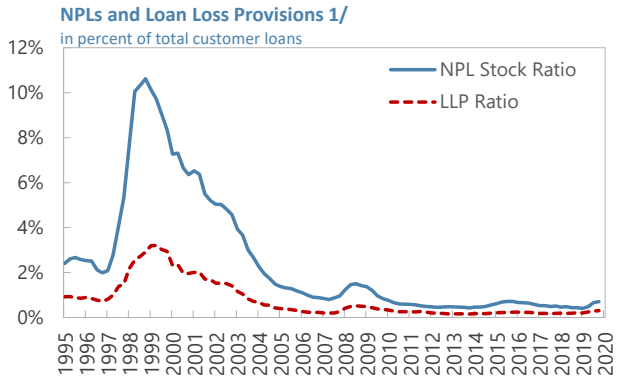
47. After increasing substantially during the AFC, aggregate non-performing loan stock ratio in HKSAR has been consistently low and stable since mid-2000s. Low frequency of loan delinquencies has persistent during the GFC, when HKSAR GDP growth declined sharply from 6.5 percent in 2007 to 2.1 percent and -2.5 percent in 2008 and 2009, respectively. Even during the contraction in 2009, the aggregate NPL stock ratio of retail banks peaked at just 1.5 percent in 2009Q2, increasing by only about 0.6 percentage points from its 2007 levels (Figure 10). Since 2010, the ratio has been consistently below 1 percent. During the growth slowdown in late 2015-2016, in parallel with the slowdown in Mainland China, the NPL ratio increased by less than 0.3 percentage points and peaked at 0.7 percent. [28] More recently, NPL ratios remained at around 0.5 percent in 2019 even as the GDP contracted by 1.2 percent in that year. Looking at the aggregate borrower profiles since the AFC provides some insights into this history of consistently low NPL ratios since the AFC shock.

[27] Historical TTC PD series for corporate exposures displayed higher correlation with macrofinancial variables compared to other exposure types.

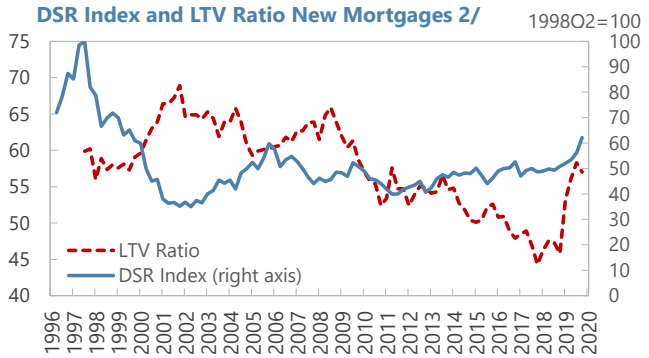
[28] NPL stock ratios are based on a combined basis, that is, including all Hong Kong office and overseas branches.

Figure 10. Hong Kong SAR: Loan Performance and Borrower Risk

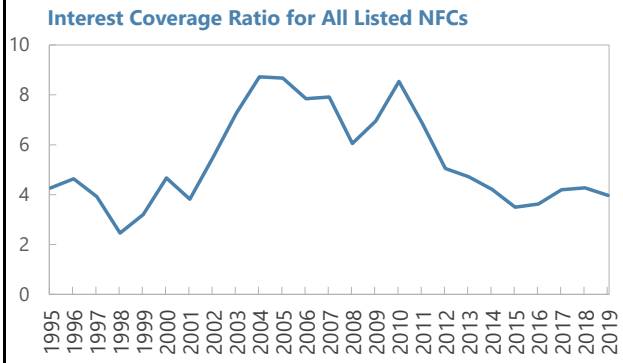
NPLs have been consistently low and stable since mid-2000s.



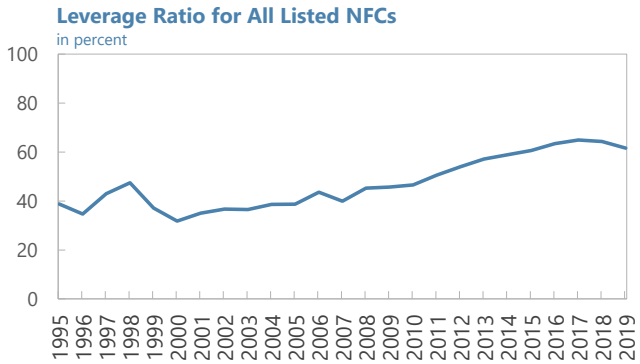
Mortgage loan risks declined significantly since the AFC.



Corporate debt servicing ability consistently stayed above the AFC trough levels…



… while corporate leverage increased since early 2000s.



Source: HKMA, HKMA Staff Computations based on data from Bloomberg.
1/ 2020 data are as of Q3-end 2020.

2/ 2020 data are as of Q3-end 2020. The DSR index in this figure is compiled based on various aggregate data including average household income, average amount of mortgage loans and mortgage rates. Therefore, by constructio n, the level of the DSR index may not be strictly comparable with that of the average DSR of new mortgages approved , which is directly surveyed from AIs.

48. Mortgage underwriting standards have been tightened significantly in recent years. Thanks to the consecutive tightening of macroprudential policies by HKMA, credit profile of residential mortgage loans remains sound on average. For example, the average LTV ratio of new mortgages have been on a downward trend since 2010 after the HKMA started the macroprudential tightening of LTV limits in 2009Q4. LTV ratios on newly approved mortgages declined from their peak of 69 percent in 2002 to 46 percent in 2019Q3. Since then, the LTV ratios on new mortgages increased to 57 percent (2020Q3), which was partly driven by the fact that a higher share of new mortgages were extended under the Mortgage Insurance Programme starting in 2019Q4, when the eligibility of the mortgage insurance was expanded. Despite this recent increase in the LTV of new mortgages, the average LTV of banks' stock of mortgage loans remained very low, at around 42 percent at 2020 year-end. Similarly, the HKMA introduced a debt servicing ratio (DSR) cap in 2010, to

limit household leverage and reduce total debt servicing burden of loans on households.[29] In addition to base DSR limits, the HKMA also applies "stressed DSR" limits. The stressed DSR assumes a 300-basis point increase in interest rates, which would increase the borrowers' monthly loan payments, and the HKMA requires the effect of that increase not to increase the stressed DSR beyond 10 percentage points above the base DSR limit. The stressed DSR is aimed at ensuring that households can cope with monthly payments of their loans even under significant rate shocks.

49. Additionally, the high saving rate and large household assets of HKSAR residents are likely to mitigate the risks from rising household leverage. The average household net worth-to-liabilities-ratio was 11.2 in 2019 and safe assets-to-liabilities ratio was 2.88. At the same time, the wealth distribution is likely skewed towards higher-income households. Lower and medium-income households have higher DSRs and they could experience significant payment hardship under severe stress of higher rates and lower income shocks.

50. Corporate leverage has been on an upward trend since early 2000s although debt servicing ability of the corporate sector has remained at healthy levels. After a period of deleveraging following the AFC shock, listed corporates in HKSAR have been increasing their leverage since early 2000s (Figure 10)[30]. The increase in leverage has accelerated after the GFC with the persistent low interest rate environment. As a global financial center with free capital movement, HKSAR also experienced a prolonged corporate credit cycle as it provides a fund-raising platform for both local firms and firms from Mainland China (MC). At the same time, the average debt servicing ability of the corporate sector remained at healthy levels. Following the AFC shock, the average interest coverage ratio (ICR)[31] of all listed NFCs in HKSAR dipped below 2.50 at its trough in 1998. With the deleveraging following the AFC and the strong growth in mid-2000s, ICR increased sharply. With the accelerated leveraging after the GFC, the average ICR of the sector declined in 2010s, while it remained at around 4 at the end of 2019. This level still provides the sector, on average, a meaningful buffer against shocks as ICR levels below 1 are generally considered as higher risk. Nevertheless, the high level of leverage makes the corporate sector vulnerable to shocks, particularly to a potential sudden increase in interest rates. More recent developments in corporate balance sheets during the COVID-19 pandemic and the sensitivity of corporates to various shocks are discussed in detail in the Corporate Sector Vulnerability Analysis section below.

E. PD and NPL Projections for Credit Loss Simulations

51. Unlike the longer-term aggregate NPL series, the granular bank-level data for PDs and NPLs start in 2013. During this period, HKSAR did not experience any significant economic downturn, and hence delinquencies have been muted across all major exposure types. In addition to

[29] As of 2020 year-end, the base DSR limit stands at 50 percent and stressed DSR limit stands at 60 percent for first time borrowers whose income is mainly derived in HKSAR (40 percent and 50, respectively, for non-first time borrowers).

[30] Leverage ratio in the figure is defined as the weighted average ratio of firm's debt to equity.

[31] The ICR in the figure is calculated as the weighted average ratio of firm's earnings before interest and tax (EBIT) to the total interest expenses.

the granular bank-level data for PDs and NPLs, the FSAP utilized the longer-term aggregate NPL series to benchmark the PD/NPL predictions.

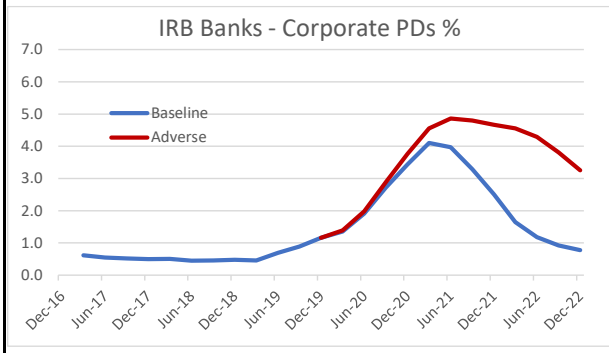
PD Projections for IRB Banks

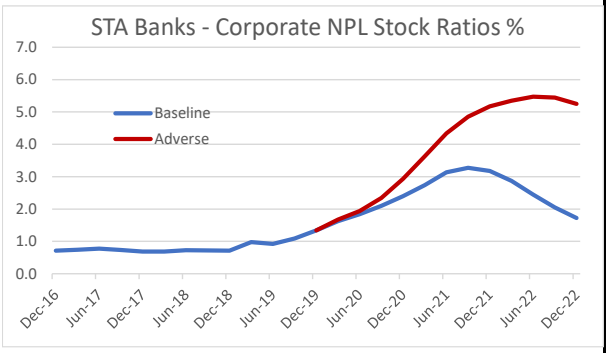
52. The FSAP estimated models using the bank-level PiT PD history for each exposure category and benchmarked the predictions against the aggregate NPL series. Although PDs for all exposure categories have been muted during recent years, as discussed above the corporate sector is likely to experience higher delinquencies in an adverse scenario due to the high leverage observed in the sector. Econometric analysis indicated the GDP growth was the most significant driver of corporate delinquencies. Given the high exposure of HKSAR banks to Mainland China-related loans, the FSAP utilized a weighted average of the HKSAR GDP growth and Mainland China GDP growth series. The weights for the two series were chosen for each bank based on their relative share of Mainland China-related loans in their portfolios.[32] With the significant contraction in the HKSAR GDP and the slowdown in the Mainland China GDP growth simulated under the adverse scenario, the corporate PD predictions increase significantly (Figure 11). The predicted PDs approach five percent in the second year of the adverse scenario and decline only slowly in the third year as the economy starts recovering. The predicted mortgage PDs peak at just over 2 percent in the second year of the adverse scenario and decline in the third year. Although these predictions are significantly higher than the observed PDs in recent years, they are still muted. This result is not surprising given the strict underwriting standards for mortgage loans and the minimal variation displayed by the mortgage PDs in recent years. Retails loans display higher sensitivity to the economic cycle with the predicted PDs peaking at around 3.5 percent in the second year of the adverse scenario. Based on these estimates, banks that have relatively higher exposures to corporates and lower exposures to mortgages, all else equal, would experience higher credit losses and larger declines in their capital under an adverse economic environment.

[32] At the system level, close to 40 percent of banks' customer (non-bank) loans are Mainland China-related. A vast majority of these are corporate loans with a minimal amount in the retail category.

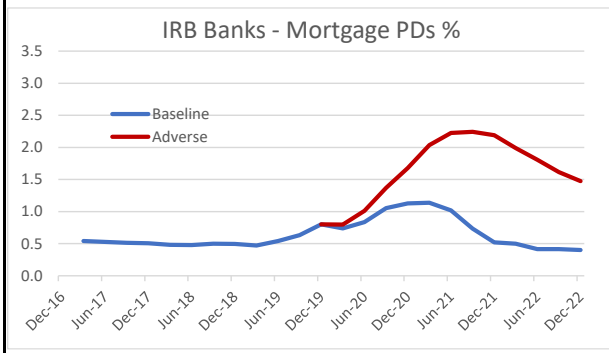
Figure 11. Hong Kong SAR: Credit Loss Input Projections

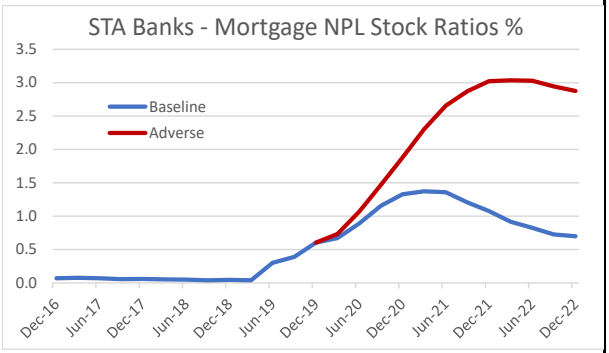
Corporate delinquencies increase substantially both for IRB and STA banks….





…while the increase in mortgage delinquencies is more muted.





Sources: HKMA, IMF Staff Computations.

53. The FSAP took a ratings-based approach to simulating PDs for bank exposures. The bank-level data show that the IRB banks in the sample experienced zero PDs in their bank exposures during the limited sample period covered by the granular data, which does not allow for econometric modeling. As a proxy, the FSAP utilized PDs based on simulated ratings of average banking sector exposures. The Moody's banks rating methodology establishes a relationship between a bank's initial rating, financial performance, and the macro profile of the country.[33] In the adverse scenario, the average banking exposures were simulated to be downgraded from Aa in 2019 to Baa in 2020, and then to Ba in 2021 and 2022. These letter ratings were then mapped to the annual default rate[34] observed in 2008 during the GFC, given the similar stressed conditions observed at the time. The mapping led to adverse scenario PDs of 0.5 percent in 2020 and 2021 and just over 1 percent in 2022. In the baseline scenario, the average banking exposures were simulated to be downgraded from Aa in 2019 to A in 2020 and 2021, and to be upgraded to Aa in 2022 as the economic recovery continues in the third year of the baseline scenario. For 2020, the letter rating was mapped to the annual default rate observed in 2008, which then reverted to the longer-term average default rate in 2021 and 2022 as the economy recovers in the baseline scenario starting in

[33] See Moody's Investor Service, *Banks Methodology*, November 2019, Exhibit 22.

[34] See Moody's Investor Service, *Corporate Default and Recovery Rates, 1920-2008*, February 2009, Exhibit 36.

2021. The mapping led to baseline scenario PDs of 0.5 percent in 2020 and 0.1 percent in 2021 and 2022.

NPL Projections for STA Banks

54. The FSAP estimated an NPL model using the aggregate NPL stock ratio series and projected STA banks' NPL ratios based on that model. Similar to the PDs of IRB banks, the observed NPL stock ratios of STA have been muted during recent years. As with the IRB banks, the increase in NPL ratios for corporate loans of STA banks is higher than the increase estimated for other loan categories. The predicted corporate NPL stock ratio peaks at around 5.5 percent and decline slowly (Figure 11). The predicted mortgage NPL stock ratio peaks at around 3, showing the lowest increase among the major loan categories. Retails loans display higher sensitivity to the economic cycle with the predicted NPL stock ratio peaking at around 4.5 percent in the second year of the adverse scenario. After the NPL stock ratios are estimated for the scenarios, they need to be converted to NPL flows for every period. However, NPL flows are not directly observed in the input bank dataset and the conversion requires assumptions on how quickly remove NPLs from their balance sheets.

55. Recent NPL data suggest that HKSAR banks have been removing NPLs from their balance sheet rather quickly in recent years. As the economy started contracting in the second half of 2019 loan provision flows started increasing slowly, however, the aggregate NPL stock ratio stayed stable at just under 0.5 percent, with a small decline at the end of the year. If banks move the inflow of elevated new NPLs off their balance sheets at the same pace as they become non-performing, the NPL stock ratio would be roughly stable, masking the increase in the inflows. At the same time, historical US experience during the housing crisis[35] and anecdotal evidence from the AFC period in HKSAR suggest that the speed at which banks deal with NPLs reduce during periods of stress, especially via reduced speed of foreclosures of collateral properties. To account for this effect, the FSAP assumed that banks would reduce the speed and remove only two thirds of the stock of NPLs from their balance sheets each year. Once the projections of NPL stock ratios are converted to projections of NPL flows, the average annual inflow of projected delinquencies are at roughly similar levels between the IRB and STA banks.

56. For STA banks' loans to other banks, the FSAP took the same ratings-based approach that was adopted for the IRB banks. The projected flow of NPL levels were matched to the flows implied by the PDs reported for the IRB banks above, under both the adverse and the baseline scenarios. Finally, in addition to the provisions for projected NPLs/PDs, the FSAP also applied general provisions to capture the general deterioration in the credit quality of banks' loan portfolios for all banks the ST sample. The average adverse scenario general provisions were 0.4 percent and 0.3 percent of the loans in the first and second years of the scenario, respectively. As the economy turns to recovery and the credit outlook improves, the banks reduce general provisions by 0.1 percent in the third year of the scenario.

[35] See, for example, *Foreclosure Timelines and House Prices*, Fout, H. et al (2019).

F. Simulation of Funding Cost Shocks and Interest Rate Risk

57. In addition to the simulated sharp rise risk in global and HKSAR-specific risk premia, the FSAP simulated the impact of higher risk premiums shocks on the full set of bank funding sources. Faced with adverse economic developments, banks might need to increase interest rates to retain wholesale deposits, while tighter global financial conditions will imply higher borrowing costs for funds from abroad. For the calibration of the funding shocks, the FSAP team analyzed the historical bank-level data for major categories of interest-bearing funding sources. The input dataset consisted of bank-level quarterly funding composition and average funding cost data starting from early 2010s. In this dataset interest-bearing funding sources were grouped based on their time to repricing and their currency, providing highly granular average funding cost information. The major categories analyzed were: i) overnight (repricing) deposits, ii) term deposits repricing in one year or less, iii) non-deposit funding repricing in one year or less, iv) all funding repricing with maturities in more than one years. All funding categories are provided with a breakdown including several currencies, however, HKD, USD, and RMB jointly account for about 90 percent of all interest-bearing liabilities, hence the FSAP team focused the modeling on these three currencies (Table 6).

Table 6. Hong Kong SAR: The Denomination Structures of Interest-bearing Assets and Liabilities
(In % of total interest-bearing assets/liabilities)

	Interest-bearing Assets	Interest-bearing Liabilities
in HKD	44	45
in USD	31	33
in RMB	12	12
in other significant foreign currencies	14	10
Total	100	100

Source: HKMA data, IMF staff calculations.

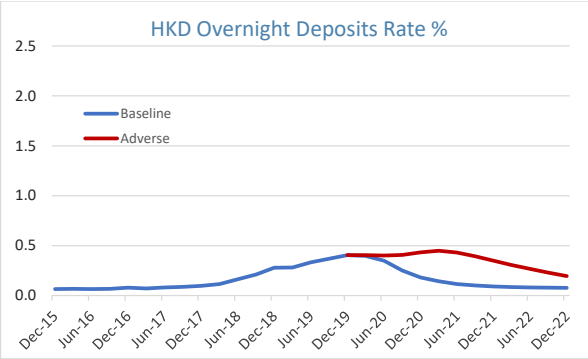
58. For the calibration of systemic funding shocks regression analyses were carried out. The FSAP regressed quarterly average funding cost data on benchmark interest rates and included bank capital ratios to allow for potential effects of shocks to banks' capital on their funding costs. The benchmark interest rates variables used were 3-month HIBOR, 12-month HIBOR, 3-month USD LIBOR, 3-month HIBOR/LIBOR spread, and 12-month USD LIBOR. Across all funding categories, 3-month HIBOR, capturing the stress in the HKSAR interbank market, was the most stable explanatory variable across various funding categories in the regression analysis. The resulting shocks for the funding sources under the baseline and adverse scenarios are presented in Figure 12.

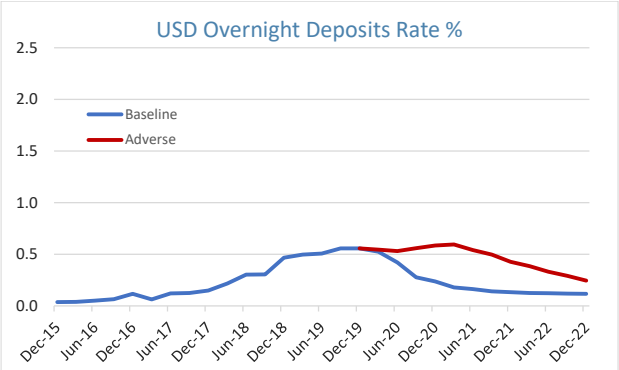
59. Funding cost curves broadly follow a similar pattern, but with various degrees of sensitivity to benchmark interest rates. For example, overnight HKD deposits roughly follow the path of the 3-month HIBOR, but they display low sensitivity to it. Overnight deposits historically have the lowest average funding costs. As the 3-month HIBOR increases somewhat in the first year of the Adverse scenario, overnight deposit costs increase slightly and decline gradually as the 3-month HIBOR/LIBOR spread and 3-month HIBOR rate decline in the second half of the second year. On the

baseline scenario, overnight HKD deposit costs start declining slightly in the second half of the first year following the marked decline in the interest rates. This largely stable behavior is intuitive as overnight deposits are commonly operational deposits with very low average interest rates, and they are less sensitive to changes in market rates.

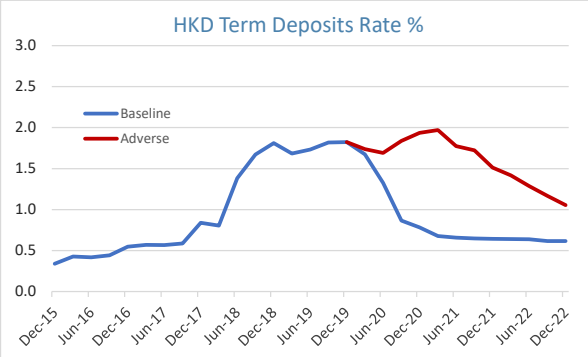
Figure 12. Hong Kong SAR: Funding Cost Projections

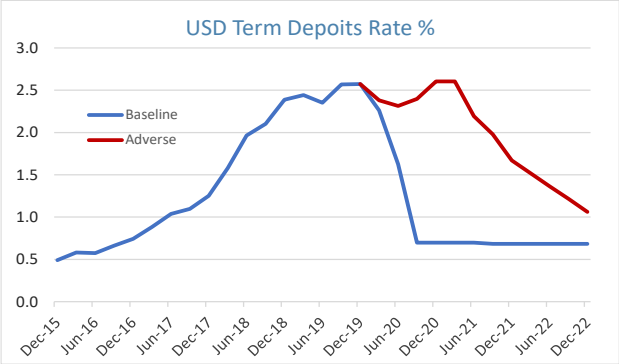
Overnight deposits are more stable…

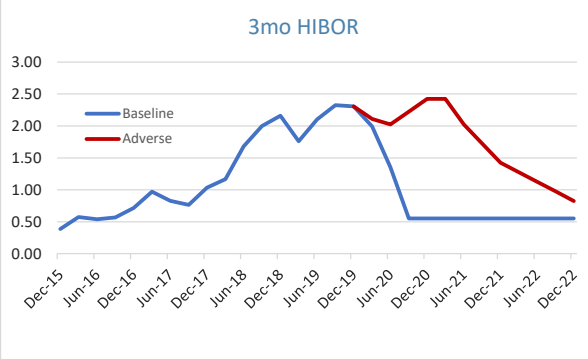


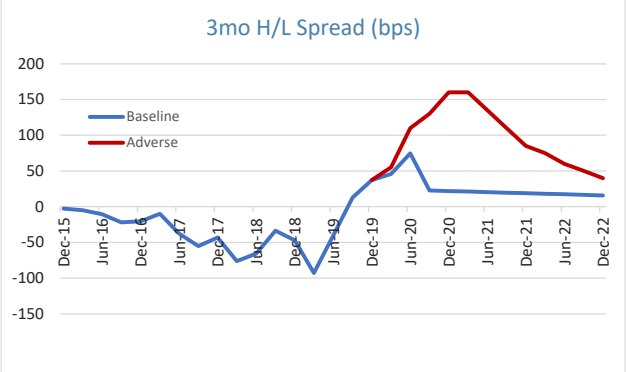


…while term deposits follow the interbank market conditions more closely.









Sources: HKMA, IMF Staff Computations.

60. Term deposits display larger sensitivity to changes in benchmark interest rates. They increase by approximately 25 basis points in the first year, stay elevated, and start declining towards the second half of the second year. Those banks that rely more on term deposits and less on overnight deposits will see higher increases in funding costs initially, but also larger declines starting

from the end of second year of the adverse scenario as the term deposit rates decline more in line with the benchmark interest rates compared to overnight deposits.

61. The simulated funding shocks lead to a direct compression of banks' net interest margins. While their funding costs increase during the adverse scenario, changes on banks' interest-bearing assets also affect their interest margins. At the system level, a vast majority of banks' corporate loans are contractually tied to HIBOR or LIBOR rates, however the FSAP team did not have asset side interest yield data to model those directly. The FSAP team assumed that 80 percent of the changes in the 3-month HIBOR and LIBOR rates will be passed on to their interest-bearing assets. Initially, as the benchmark rates increase, the interest flows on the asset side will also somewhat increase. However, as the benchmark rates start declining later in the simulation period, the asset cash flows will also decline accordingly, leading to declining overall interest margins and profitability pressures for banks. Once the full set of asset and liability side shocks are estimated, the impact on cash flows are calculated using bank-level interest rate risk exposures.[36] Similarly, the impact of the changes in benchmark interest rates on the cash-flows of banks' interest rate sensitive off-balance sheet positions are captured via banks' interest rate risk exposures.

62. Under the baseline scenario, the benchmark interest rates decline significantly after the initial period of market turmoil in early 2020. These significant declines in benchmark rates could start putting pressure on banks' interest margins more rapidly compared to the gradual declines under the adverse scenario. However, after the contraction in 2020, the baseline scenario simulates a rapid economic recovery with credit demand likely following this broad economic recovery. In that environment banks are more likely to have some pricing power to increase their spreads and reduce the negative effect of declining benchmark rates on their asset yields. To reflect the improved economic environment under the baseline scenario, the FSAP team assumed a lower pass-through, 60 percent, from benchmark interest rates to interest-bearing assets. As the benchmark rates start declining significantly in 2020 under the baseline scenario, the asset cash flows will also follow this decline, however with a lower sensitivity which will limit the interest margins pressures for banks.

G. Stress Test Results

63. Under the baseline scenario, banks experience mild capital declines. The average decline is about one percentage point reduction in CET1 ratio during Year1. With the quick return to positive growth in Year2, capital levels stabilize but high NPL levels still weigh on balance sheets. Banks start building up capital buffers in Year3 with the continued recovery in the economy. It is important to highlight that the realized average capital levels in the system were mostly unchanged in 2020 from their 2019 levels, which is better than the decline simulated under the baseline scenario. The realized 2020 GDP growth (-6.1 percent) turned out to be significantly better than the October WEO-based baseline GDP number utilized in the baseline scenario (-7.5 percent). Additionally, the FSAP took a conservative approach to loss estimation by not incorporating the positive impact of temporary policies aimed at supporting borrowers (e.g., income support to households and SMEs, loan principal payment deferrals). These measures are likely to have prevented NPLs from increasing to the levels

[36] HKMA's MA(BS)12 returns.

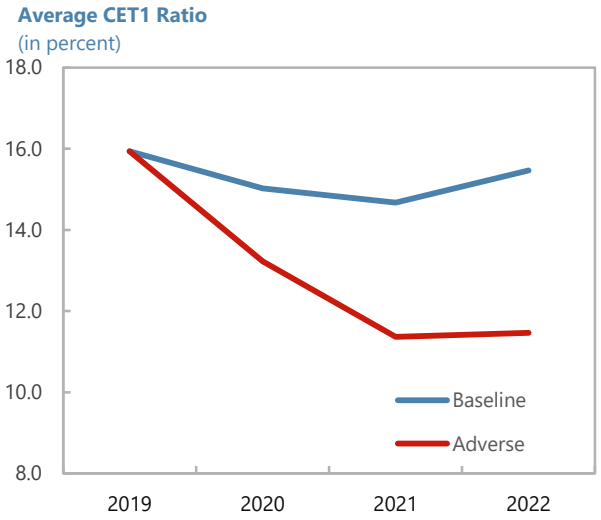
suggested by estimates from historical data up to 2019 which were the estimates used by the FSAP. Finally, the FSAP took an overall conservative approach to NPL and RWA modeling under the baseline scenario shocks.

64. ST results indicate that even under the adverse scenario, HKSAR's banking system appears to be broadly resilient to the severe macro-financial shocks, thanks to the initial high capital buffers and pre-shock profitability. In the simulation, banks experience significant credit losses and their profitability declines substantially, resulting in significant reductions in their capital levels. Even with those significant declines in capital, all banks remain above the regulatory minimum of 4.5 percent CET1 ratio plus the capital conservation buffer of 2.5 percent (Figure 13). Banks' high initial capital buffers and profitability allow them to withstand significant amount of losses in the adverse scenario. The average CET 1 ratio of banks in the sample decreases from 15.9 percent in 2019 to 11.5 percent in 2022. For the IRB banks in the sample, the CET 1 ratio decreases by 4.6 percentage points, from 16.4 percent in 2019 to 11.7 percent in 2022, while the banks using standardized credit risk modeling experience smaller declines in their average CET 1 ratio, which decreases from 14.4 percent in 2019 to 10.8 percent in 2022. The credit losses are slightly smaller for standardized banks and they experience a significantly smaller increase in their risk-weighted assets (RWA), which contributes to the smaller declines in their capital ratios. The average leverage ratio[37] of the sample declines from 7.8 percent in 2019 to 6.7 percent in 2022. As the leverage ratio computation does not utilize risk weighted assets, the ratio's decline is much milder compared to the decline in the CET 1 ratio, which factors in changes in risk weights.

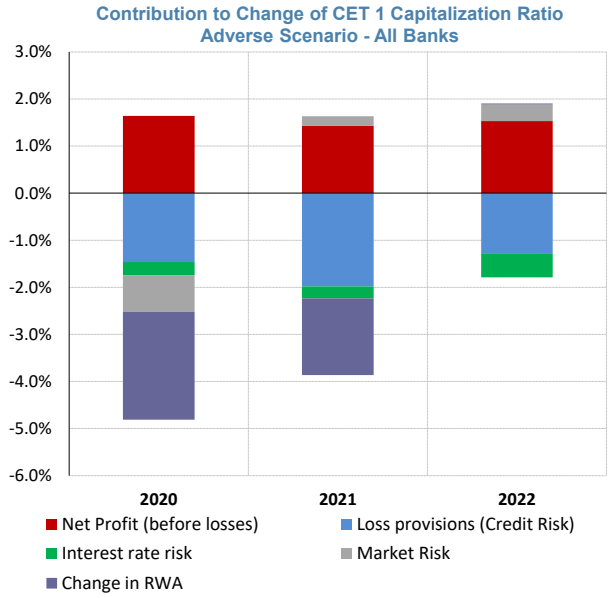
[37] Defined here as Tier 1 capital/total assets. Note that HKSAR uses the standard Basel III definition of leverage ratio, viz. Tier 1 capital/total exposure measure.

Figure 13. Hong Kong SAR: Bank Solvency ST Results

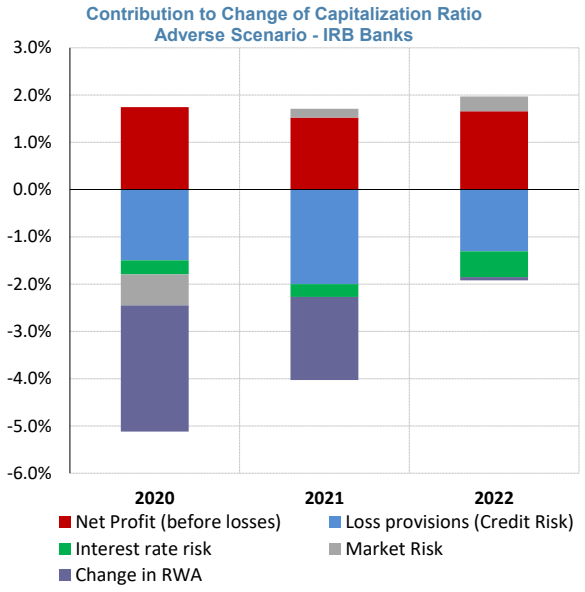
CET1 ratio declines by about 4.5 percentage points in the adverse scenario….



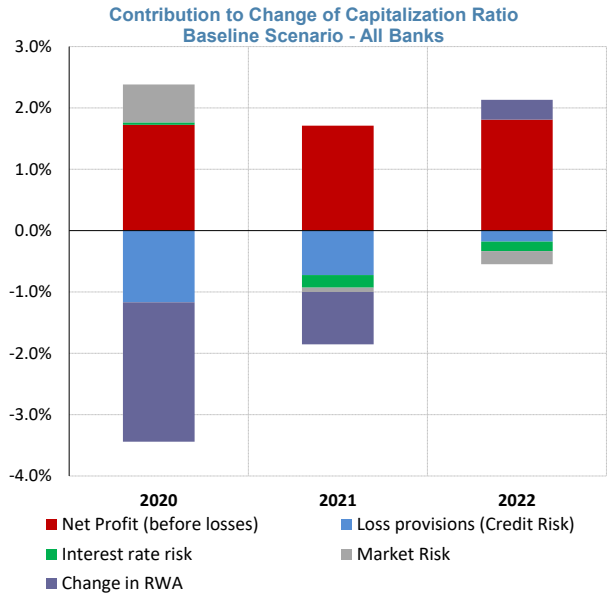
…with credit losses followed by the increase in RWA being the largest drivers of capital declines in the adverse scenario.



IRB banks experience larger increases in their RWAs reducing their capital ratios more than the STA banks.



Increase in RWAs is the largest driver of the declines in the baseline scenario with limited credit losses after the first year.



Source: IMF staff computations.

65. The largest drivers of the change in capital ratios in the adverse scenario are loan loss provisions, increases in RWA, and to a lesser extent, declines in net interest margins (interest rate risk). In line with the simulated deterioration in the economic environment, loan defaults increase substantially, which leads to large loan loss provisions. At the same time, the secured nature of large portions of banks' exposures, with average LTV ratios of mortgages at just under 40 per cent in 2019, moderates the estimated loan losses, even with significant property price declines in the scenario. The increase in risk weights, which reflects the increase in credit risk going forward, also

contributes to the decline in the capital ratios, especially for IRB banks. Standardized banks have more conservative starting risk weights; for example, with the average risk weights for corporate loan exposures already above 90 percent, which leads to high initial RWA density. For this reason, the risk weight shifting does not lead to major changes in RWAs in the scenarios for standardized banks, limiting the estimated decline in capital ratios.

66. The losses from market risk, from mark-to-market (MTM) decline in the price of securities holdings of banks, leads to more modest declines in capital ratios. In the first year, the spread widening, especially for corporate bonds, leads to a decline of about 0.8 percentage points of CET1 capital ratio. The generally higher quality composition of securities portfolios, with significant portion in short-term Exchange Fund Bills and Notes (EFBNs) and investment grade securities, moderates the losses despite significant spread widening for corporate bonds. With the base interest rates remaining low and spread widening starting to reverse towards the end of the second year, the losses from market risk are partially reversed in second and third year of the scenario. On the interest risk side, higher funding costs leads to compression of net interest margins, but HKSAR banks generally have balanced interest rate sensitivities on the asset and liability sides, which limits the overall losses from interest rate shocks.

H. Spread Sensitivity Analysis

67. The FSAP team also assessed the impact of an increase in interest spreads of banks' securities portfolios. Under the adverse scenario where multiple shocks are applied concurrently. The spreads on securities increase significantly, however, the USD benchmark interest start declining in the first year of the simulation, followed by the HKD benchmark rates starting to decline towards the end of the second year of the simulation, which reduces the negative price effect of the spread widening, especially for banks with large USD securities portfolios. This sensitivity analysis assumes a stand-alone shock of 300 basis points increase in the spread on banks' all non-sovereign securities portfolios[38]. Then, all non-sovereign securities in banks' portfolios designated as held-for-trading (HFT) or fair value through other comprehensive income (FVTOCI) are marked to market (MTM) under the assumed spread widening. The MTM effect of the widening for the full sample of banks is a decline of 1.9 percentage points in the average CET 1 ratio. Without the buffering effect of declining benchmark interest rates, the estimated MTM losses increase compared to those estimated under the solvency scenario, especially for banks with larger USD securities portfolios. However, the total losses are modest compared to banks existing capital buffers.

I. Concentration Risk

68. The FSAP also tested concentration risk in banks credit exposures by assessing the impact of the default of banks' largest non-financial corporate exposures. This sensitivity analysis assessed both single-name concentration and sectoral concentration. For the single-name concentration, the FSAP assessed the impact of the hypothetical default of the five largest NFC exposures by calculating implied losses from these exposures. In this analysis, the FSAP team

[38] Largely, corporate and bank debt securities.

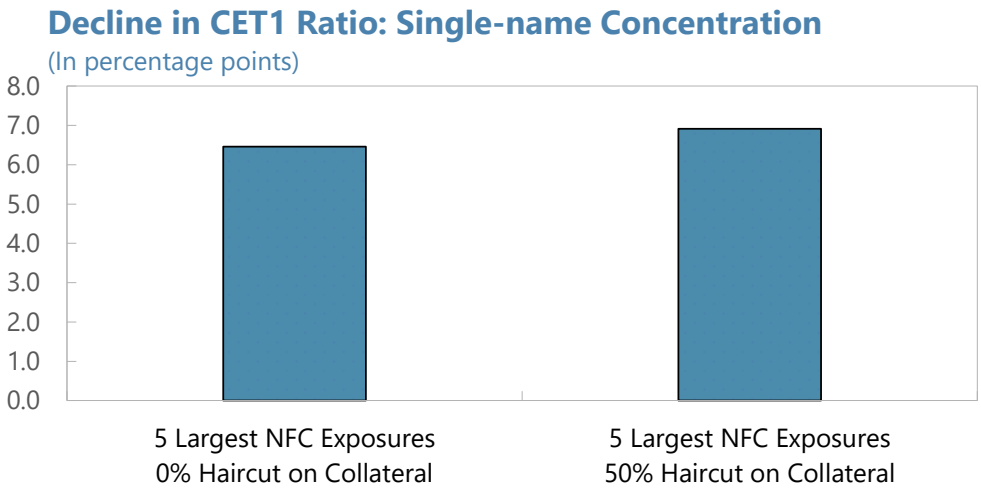
assumed a scenario of zero recovery on the unsecured part of the exposure and full recovery of the value of any available collateral. Assuming the default of the five largest NFC exposures in each bank, the average CET1 ratio decline would be sizeable, at close to 6.5 percentage points of CET 1 capital ratio. Under a more severe scenario of zero recovery on the unsecured part of the exposure and a 50 percent haircut on the value of any collateral, the losses would increase modestly, by 0.5 percentage points. This low sensitivity to the assumption on collateral recovery is due to many large exposures' being backed by minimal level of collateral.

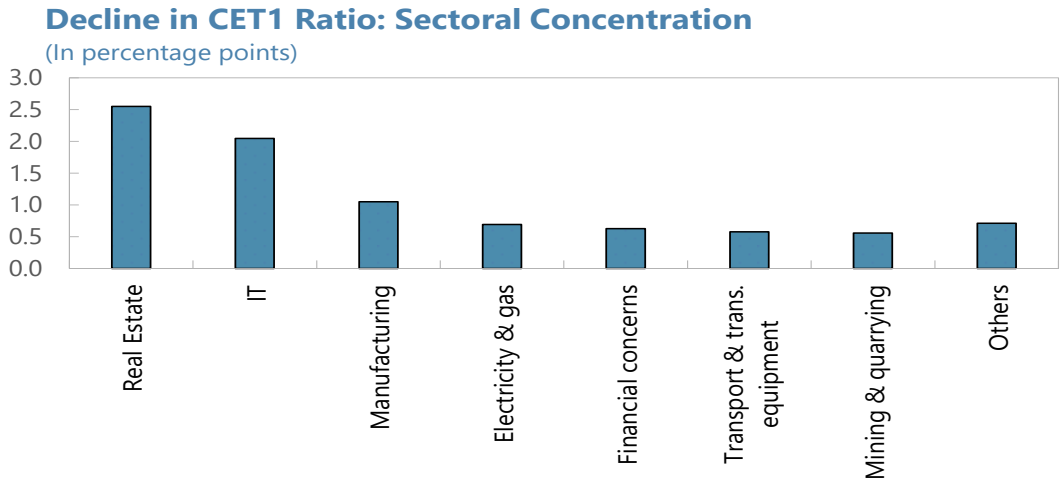
69. Sectoral concentration analysis indicated that the largest exposures of the banking system are to the real estate sector followed by the IT sector. Under an assumption of default of all real estate-related borrowers[39] that are among the top ten large exposures of each bank, the average CET1 ratio would decline by about 2.5 percentage points. The data indicate that large exposures to sectors that are likely to suffer more from the COVID-19 pandemic (transportation, hotels, recreational activities) correspond to a much smaller amount and their defaults would pose minimal losses for banks in the sample. Nevertheless, deterioration in household's balance sheet driven by the pandemic and the recent softening in house prices may pose risks for some borrowers operating in the real estate sector. HKSAR adopted Basel Committee's large exposure framework in 2019,[40] which went effectively into effect on July 1, 2019 with a six months' implementation grace period for compliance with the single counterparty (or group of linked counterparties) and connected party exposures limits. This new framework strengthened the requirements on banks' management of large exposures and enhanced HKMA's monitoring of these exposures. The FSAP recommends that the HKMA periodically stress tests banks' large exposures separately from their total loan books, considering potential cash flows from collateral in case of default of large borrowers. While the borrowers of the large exposures might have high credit quality, the potential for large losses in a rare default event highlights the importance of monitoring these exposures closely.

[39] Real estate-related borrowers include borrowers involved in property development, property development and operation, property investment and management, and conglomerates with a focus on property sector.

[40] HKMA Banking (Exposure Limits) Rules (BELR). See https://www.elegislation.gov.hk/hk/cap155S.

Figure 14. Hong Kong SAR: Credit Concentration Analysis





Source: IMF staff calculations.

BANK LIQUIDITY RISK ANALYSIS AND STRESS TESTS

A. Overview

70. To assess current banking system liquidity risks, the FSAP carried out a comprehensive analysis of banks' short-term and structural liquidity ratios and complemented it with a variety of liquidity stress tests. The former considers the Basel III liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR) (as well as their equivalents for category 2 banks in Hong Kong, the Liquidity Maintenance Ratio (LMR) and the Core Funding Ratio (CFR)). While the LCR/LMR measure short-term liquidity risks, the NSFR/CFR gauge more structural longer-term refinancing and funding risks. Also, the FSAP Team ran cash flow-based liquidity stress tests using supervisory data on contractual cash flows, and security flows for different maturity buckets. This approach employs multiple scenarios of increasing severity covering several horizons (7 days, 1 month, and 3 months) with varying assumptions regarding shocks to cash inflows and outflows and haircuts on liquidity buffers. The calibration of shock scenarios is based on historical evidence. Also, HKMA needs to ensure that the provision of liquidity support for banks is done in accordance with the currency board arrangements. Hence, it is very important to clearly understand banks' liquidity risk so that policymakers can mitigate them or explore credible backstop options.

71. To deal with stress-test scenario parameters uncertainty, the cash flow tests were conducted over a wide range of scenarios featuring different degrees of severity and central bank support. This approach allows for shifting the focus from parameter calibration to liquidity risk tolerance. In the same way that the Value-at-Risk approach informs about potential losses at a given probability, the range of scenarios conducted in the liquidity stress-tests provides a wide range of liquidity strain under many combinations of run-offs and haircuts, including banks' idiosyncratic factors.

72. The sample of banks for the quantitative analysis consists of 23 banks with total assets of 24,000 bn HKD.[41] This corresponds to 96 percent of the total assets of banks in HK (about 24,900 bn HKD under a simplified consolidation approach as of June 2020). There are 13 category 1 banks in the sample (including the 6 D-SIBs) and 10 category 2 banks. Of the former, 11 are locally incorporated banks. There are 11 foreign branches in the sample. All but one locally incorporated bank are category 1 banks; all but two foreign branches are category 2 banks.

73. The quantitative liquidity risk analysis comprises analysis of the composition of regulatory ratios and cash-flow based liquidity stress-tests. The FSAP team first studied the evolution and composition of the regulatory liquidity ratios, then carried out a comprehensive cash-flow based liquidity stress tests were carried.

[41] The aggregate assets of the sample are calculated as the sum across individual bank's total assets according to MA(BS)23.

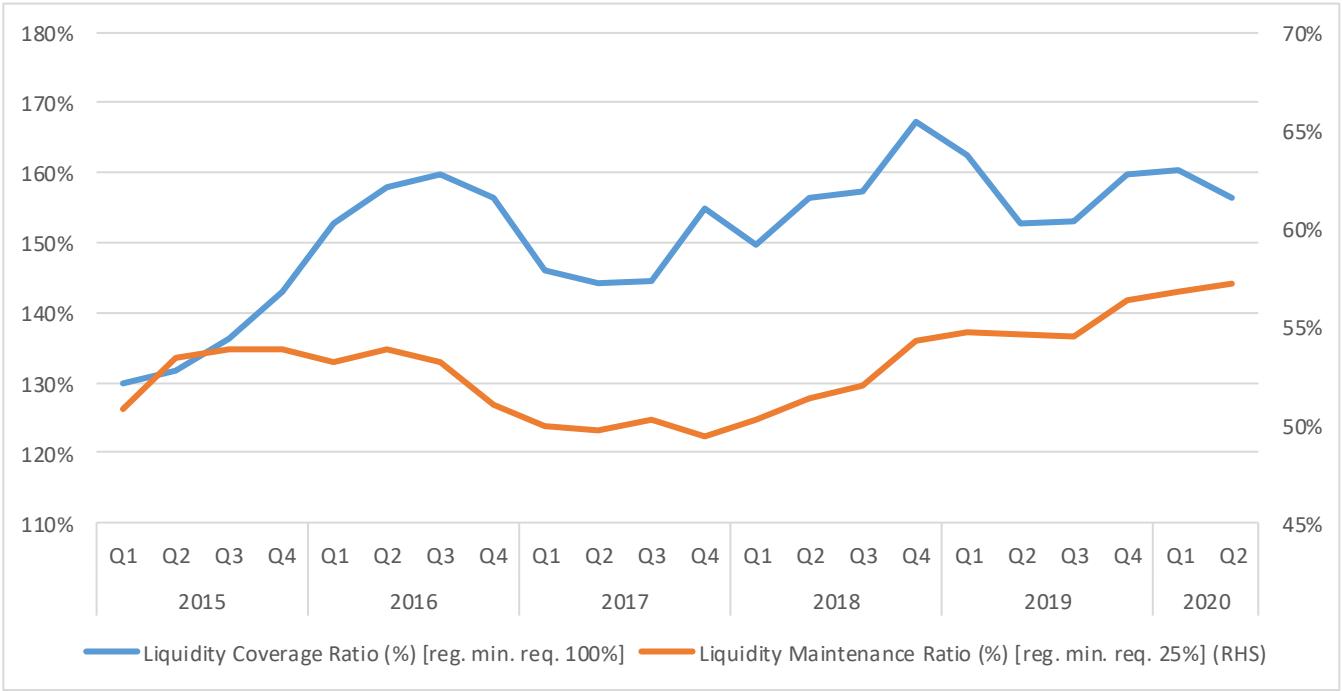
B. Regulatory Liquidity Ratios

Liquidity Coverage Ratio (LCR) and Liquidity Maintenance Ratio (LMR)

74. Hong Kong has implemented the LCR for category 1 banks in 2015 with a phase-in period until 2019 when the minimum requirement reached 100 percent. Smaller category 2 banks are subject to the LMR with a minimum requirement of 25 percent. "The LMR is a ratio, expressed as a percentage, of the amount of a category 2 institution's "liquefiable assets" to the amount of the institution's "qualifying liabilities" (after deductions) over a calendar month."

75. Both, category 1 and 2 banks feature aggregate LCRs and LMRs, respectively, well above the regulatory minimum requirements. For the LCR it is 100 percent; for the LMR is 25 percent. As of June 30, 2020, the average LCR stands at 157 percent and the average LMR at 57 percent. Since December 2018, the LCR decreased by 10 and the LMR increased by about 3 percentage points. Since the outbreak of Covid-19 in Q1 2020 both short-term regulatory liquidity ratios remained quite stable.

Figure 15. Hong Kong SAR: Average LCR and LMR for Category 1 and Category 2 Banks Respectively

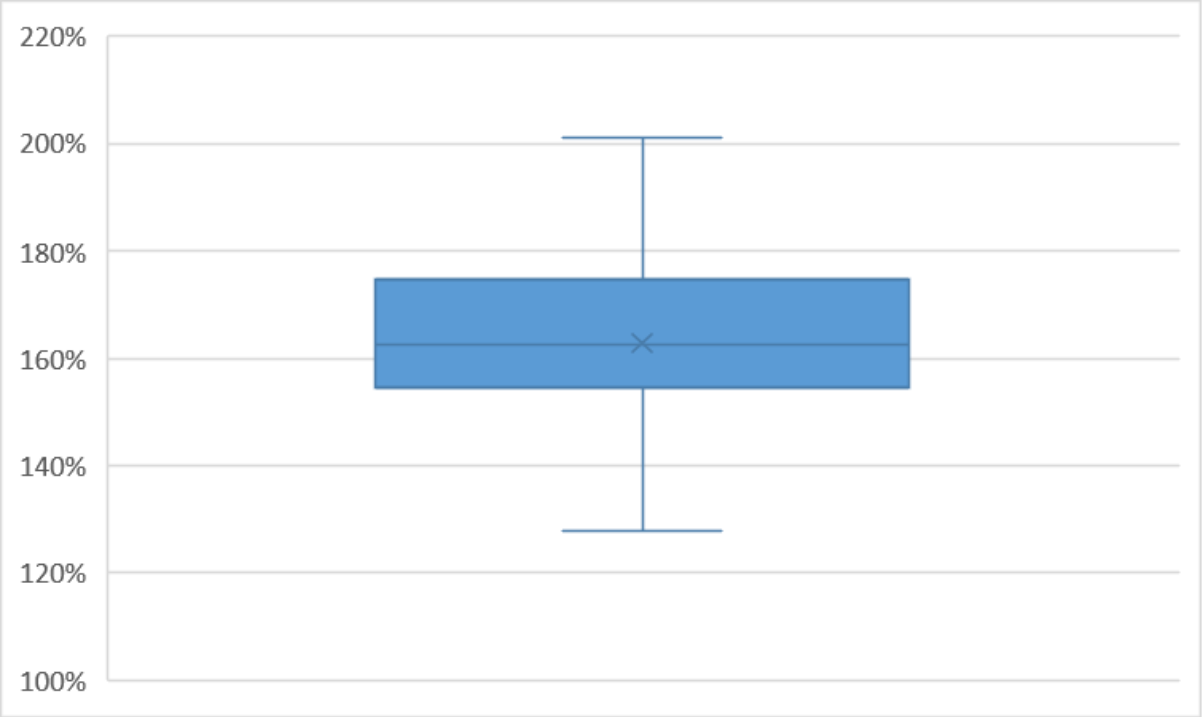


Source: HKMA.

76. All category 1 banks fulfill the regulatory minimum requirements of the LCR. After removing outliers, the median stands at about 163 percent, the 90th percentile at about 190 percent

and the 10th percentile at about 130 percent (Figure 16). Compared to December 2018[42] the dispersion of the distribution decreased somewhat.

Figure 16. Hong Kong SAR: The Distribution of the LCR Across Category 1 Banks (June 2020)



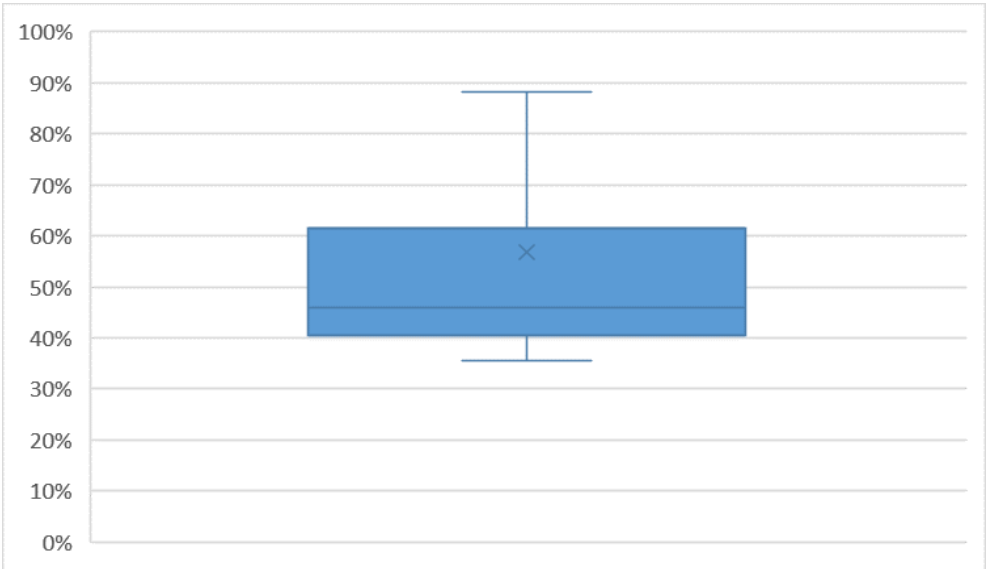
Source: HKMA.

77. For the local banks, the distribution of the LCR shifts upwards as compared to the full sample of category 1 banks. After removing outliers, the median amounts to 169 percent, the 90th percentile to about 200 percent and the 10th percentile to about 130 percent.

78. All category 2 banks fulfill the minimum requirement for the LMR. After removing outliers, the median stands at around 46 percent, the 90th percentile stands at 92 percent, and the 10th percentile at 36 percent (Figure 17).

[42] The underlying liquidity ST data obtained for the first FSAP mission was as of December 2018. Hence, December 2018 lends itself as the basis for a comparison of the pre- and post-Covid-19 liquidity positions.

Figure 17. Hong Kong SAR: The Distribution of the LMR Across Category 2 Banks
(June 2020)



Source: HKMA.

79. While there is no regulatory minimum requirement for the LCR in individual currencies, the FSAP calculated LCR in major currencies for HKSAR banks. The distribution of the USD LCR across category 1 banks is sensitive to the application of the 75 percent inflow cap.[43] If the cap is not applied, the median USD LCR is about 311 percent and the 10th percentile stands at about 78 percent. There is no regulatory minimum requirement for the LCR in individual currencies with the exception of the statutory minimum requirement of 20% on the HKD LCR. If the cap is applied to the USD LCR, the median decreases to about 81 percent and the 10th percentile amounts to about 52 percent, respectively. The cross flows of US derivatives cancel out under normal market conditions. A disruption of USD inflows only – e.g. via the FX swap market – might results in USD liquidity risk exposure.

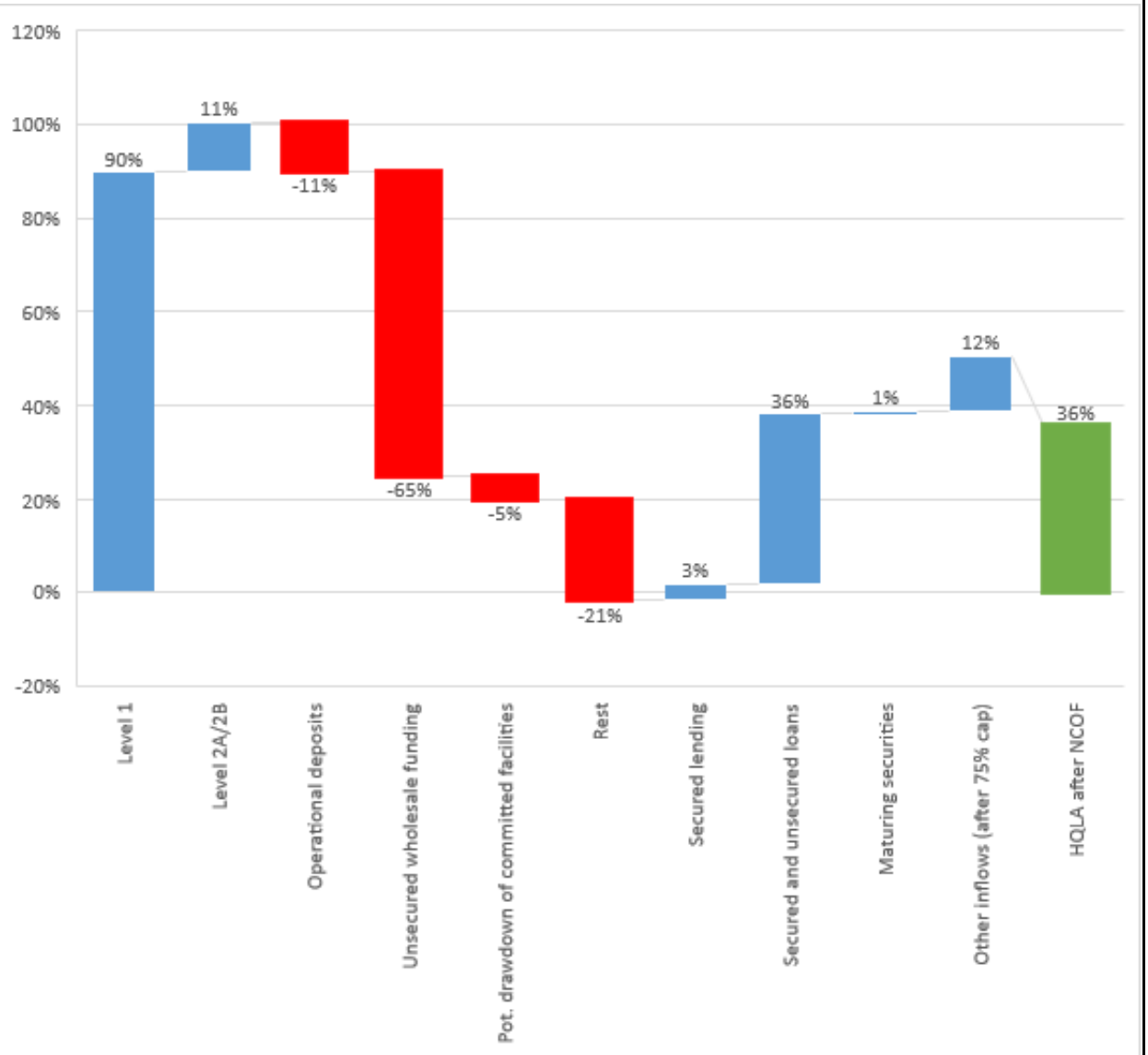
80. Similarly, the distribution of the RMB LCR across local banks is sensitive to the application of the 75 percent inflow cap. If the cap is not applied, the median RMB LCR is about 154 percent and the 10th percentile stand at about 101 percent. If the cap is applied to the RMB LCR, the median decreases to about 115 percent and the 10th percentile amounts to about 59 percent, respectively.

81. Outflows of unsecured wholesale funding constitute the main driver of the net cash outflows (NCOF) of the LCR. The largest cash inflows are those from secured and unsecured loans,

[43] Under Basel III guidelines (https://www.bis.org/publ/bcbs238.pdf): "In order to prevent banks from relying solely on anticipated inflows to meet their liquidity requirement, and also to ensure a minimum level of HQLA holdings, the amount of inflows that can offset outflows is capped at 75% of total expected cash outflows as calculated in the standard. This requires that a bank must maintain a minimum amount of stock of HQLA equal to 25% of the total cash outflows."

incl. unsecured interbank lending. In aggregate, the category 1 banks feature high-quality liquid assets (HQLA) of about 36 percent after net cash outflows.

Figure 18. Hong Kong SAR: The Main Drivers of the LCR of Category 1 Banks
(June 2020)

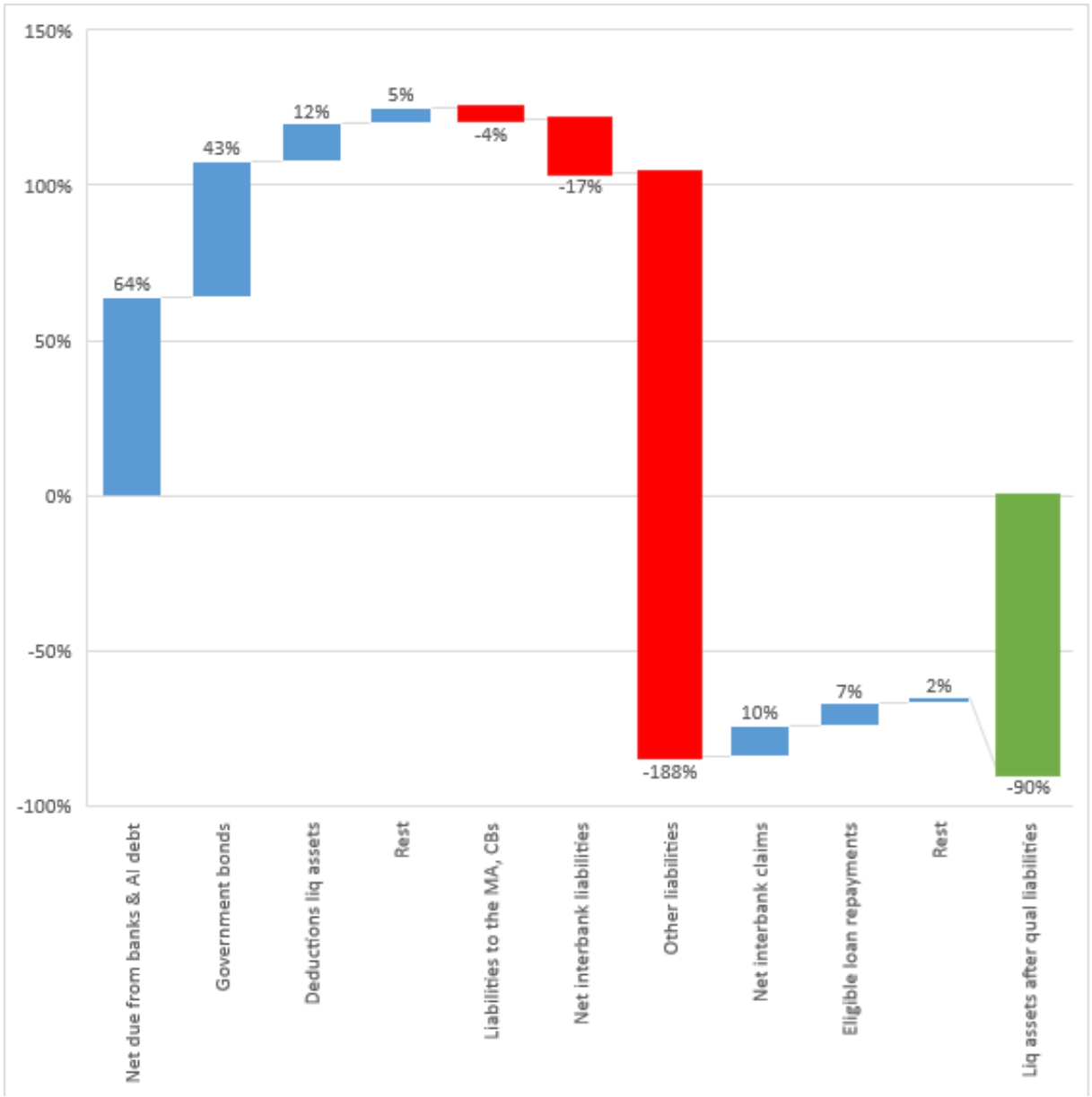


Source: HKMA and IMF staff. Rest (HQLA): Deductions/FX haircuts, Government bonds, Marketable debt & gold, Mortgage loans (HKM loan facility), Deductions liq assets. Rest (Net Cash Outflows): Small business funding, Secured funding, Debt securities issued, Securities swaps and other outflows (B10-18, 20-22, in the template MABS23).

82. The main drivers of the LMR liquefiable assets for category 2 banks are net due from banks and debt issued/guaranteed by banks (64 percent) as well as debt issued by governments (43 percent). The main components of the qualifying liabilities are other (one-month) liabilities (-188 percent). After accounting for the qualifying liabilities, the amount of liquefiable

assets is negative at 90 percent of the starting value of 64 percent (consistent with a LMR of about 50 percent). The main drivers have remained unchanged since December 2018.

Figure 19. Hong Kong SAR: The Main Drivers of the LMR for Category 2 Banks
(June 2020)



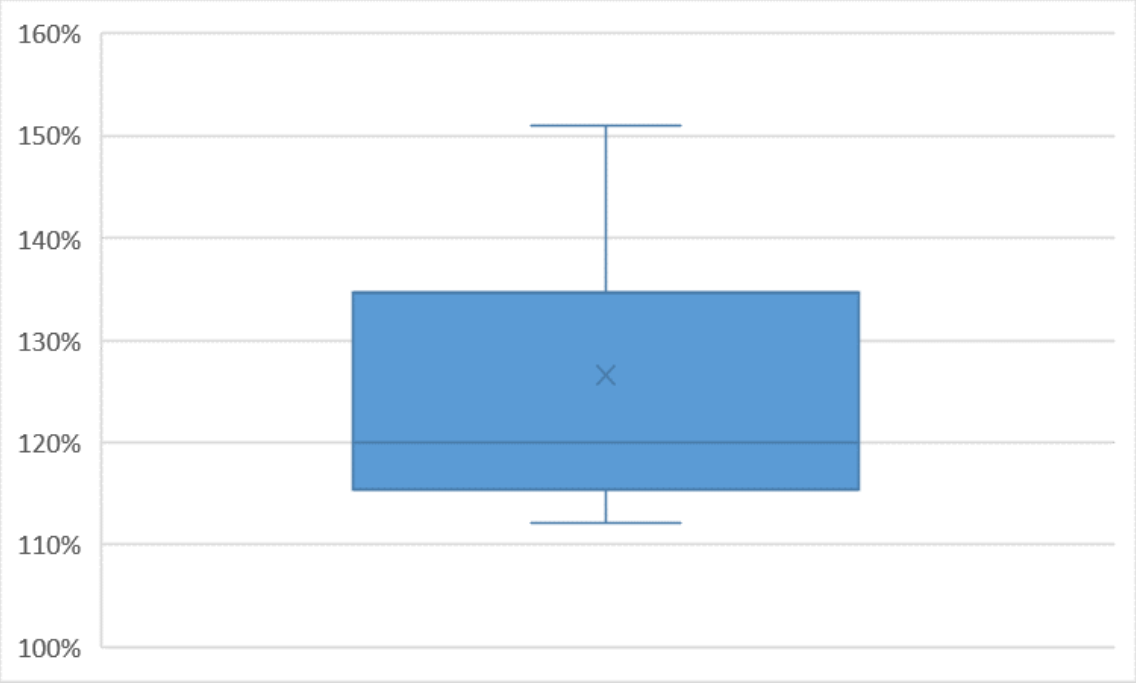
Source: HKMA and IMF staff. Rest (Liquifiable Assets): Currency, claims on MA, CBs, Expost bills, Marketable debt & gold, Mortgage loans (HKM loan facility). Rest (Qualifying Liabilities): Claims on MA, CB, 40% rule, 75% cap.

Net Stable Funding Ratio (NSFR) and Core Funding Ratio (CFR)

83. All category 1 banks fulfill the regulatory minimum requirements of the NSFR (100 percent). The median stands at about 120 percent, 90th percentile at about 150 percent and the 10th

percentile at about 115 percent. Since December 2018, the median decreased somewhat from 130 percent.

Figure 20. Hong Kong SAR: The Distribution of the NSFR for Category 1 Banks
(June 2020)

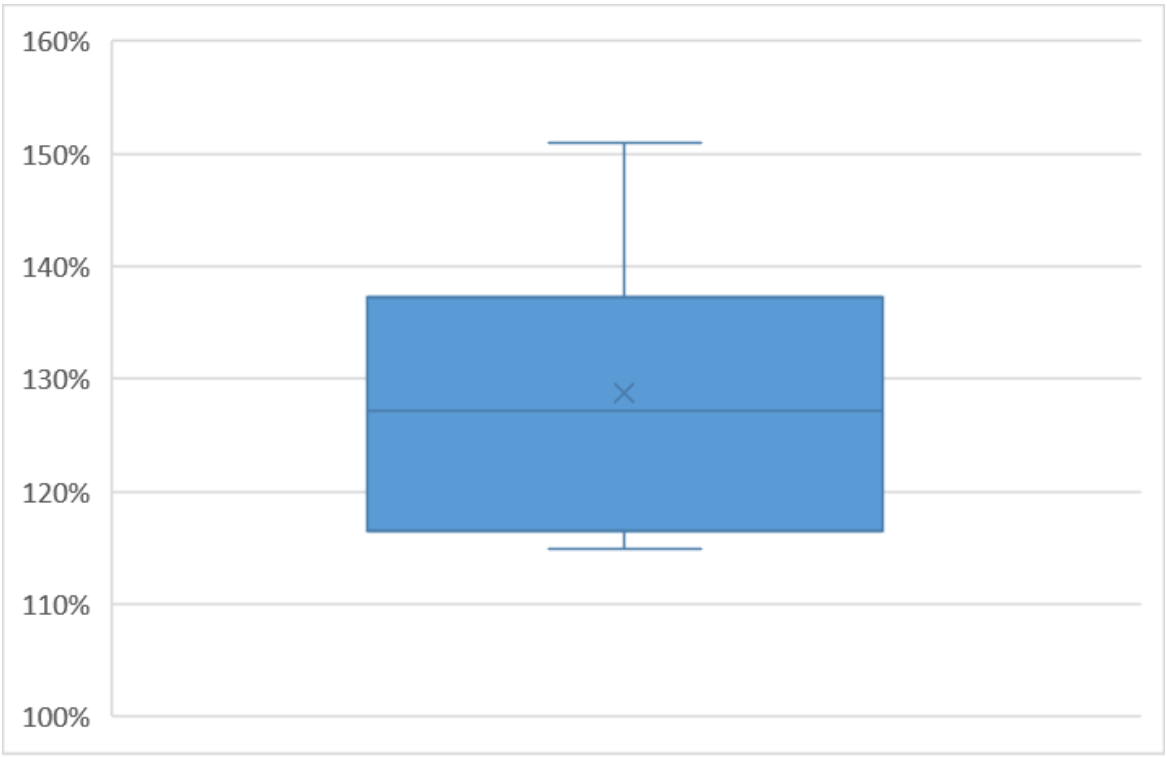


Source: HKMA.

84. For the local banks, the distribution of the NSFR is similar as for the full sample of category 1 banks. The median amounts to 127 percent, the 90th percentile to about 148 percent and the 10th percentile to about 115 percent.

85. All category 2 banks fulfill the regulatory minimum requirements of the CFR (75 percent). The median stands at about 109 percent, the 90th percentile at about 169 percent and the 10th percentile at about 96 percent. Compared to December 2018, the CFR increased somewhat across the entire distribution.

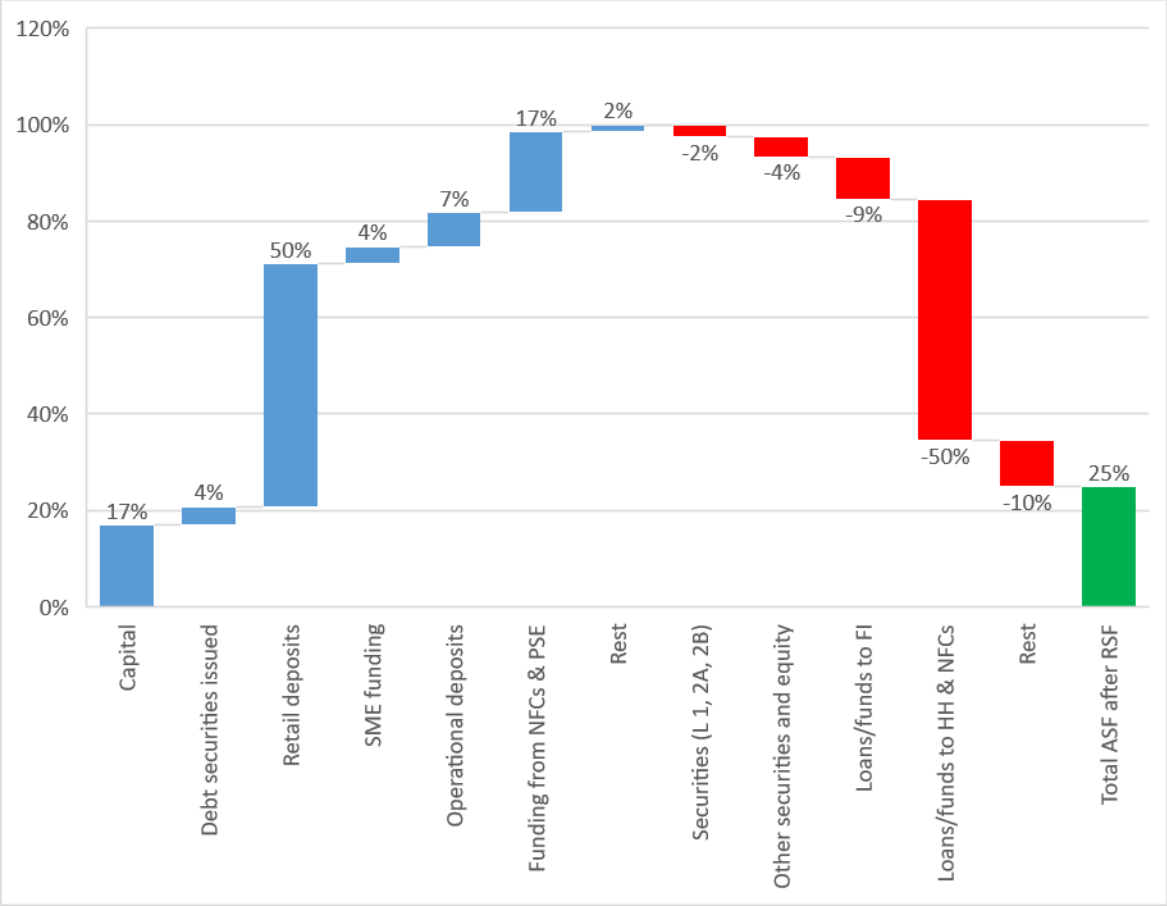
Figure 21. Hong Kong SAR: The Distribution of the CFR for Category 2 Banks
(June 2020)



Source: HKMA.

86. Retail deposits constitute the largest share of Available Stable Funding (ASF) of the NSFR for category 1 banks. They account for 50 percent of ASF. Loans to non-banks are the largest share of Required Stable Funding (RFS) with 50 percent. The composition of the NSFR has remained basically stable since December 2018.

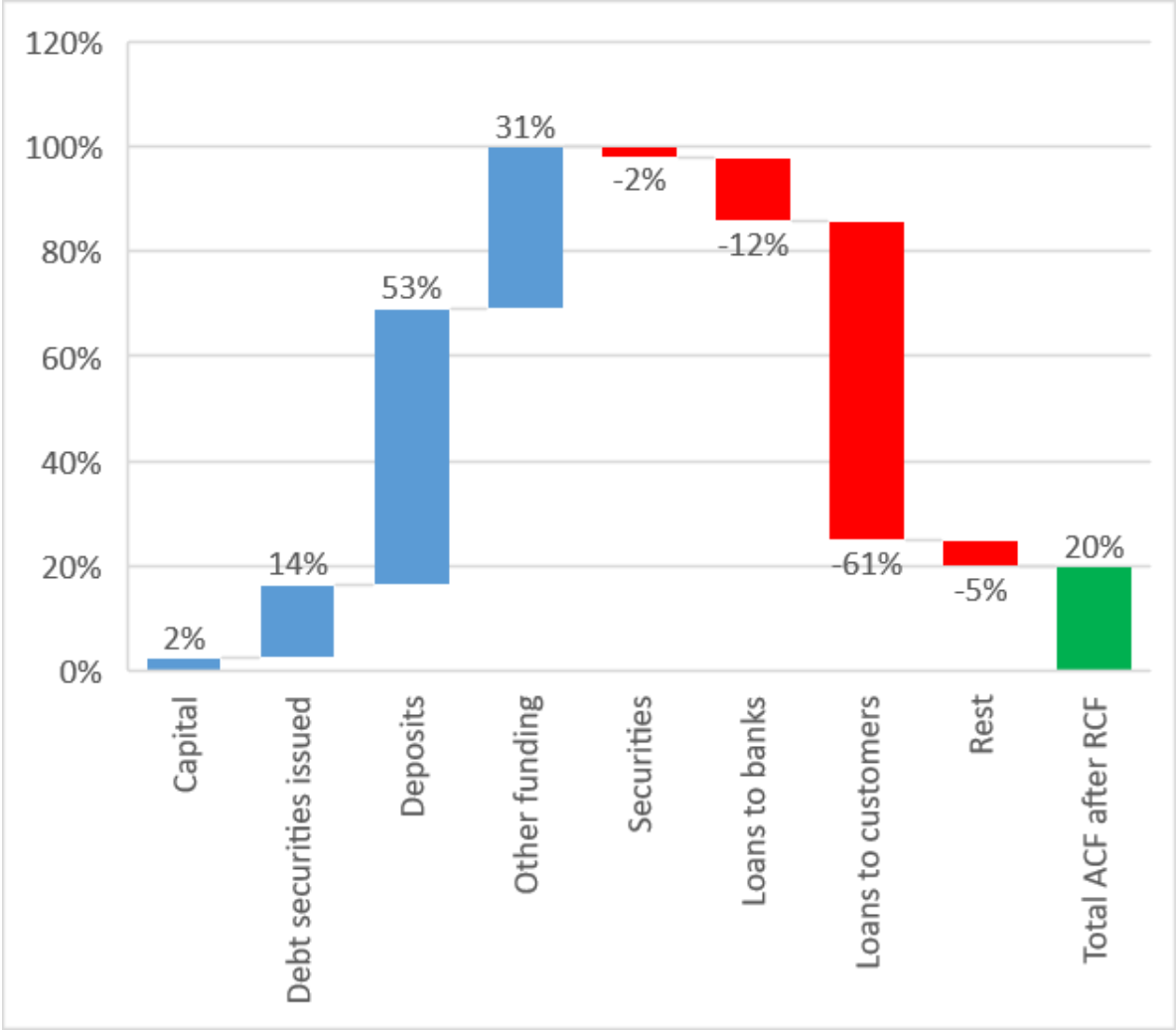
Figure 22. Hong Kong SAR: The Composition of the NSFR for Category 1 Banks
(June 2020)



Source: HKMA and IMF staff. Rest (ASF): Funding from CBs, Funding from FIs, Other funding, Net derivative liabilities; Rest (RSF): Operational deposits at other FIs, Reverse repos (Level 1 assets), Net derivative assets, Encumbered assets.

87. The main drivers of the CFR Available Core Funding (ACF) for category 2 banks are deposits which account for about 50 percent as well as other funding (about 30 percent). The main components of Required Core Funding (RCF) are loans to non-banks with 60 percent). After accounting for the RFS the amount of ASF is still positive at 20 percent of the starting value.

Figure 23. Hong Kong SAR: The Composition of the CFR for Category 2 Banks



Source: HKMA and IMF staff. Rest: Currency notes and coins; Exchange Fund/CBs, Export bills, Securities or prescribed instruments mentioned in item 6 of Table A in section 2 of Schedule 5 to the Banking (Liquidity) Rules, Net derivative assets, Gold bullion; Trade-date receivables; Assets not covered by items 1 to 9; Off-balance sheet obligations.

88. To summarize, quantitative analysis of the short-term liquidity requirements indicates that banks hold sufficient liquidity to cover short-term outflows. Similarly, the structural liquidity ratios indicate that the funding structure of HK banks is structurally sound.

C. Cash-flow Based Liquidity Stress Tests

Introduction and Objectives

89. The cash-flow based liquidity stress tests (CFLST) analyze the liquidity risk exposure and risk-bearing capacity of the sample of 23 banks in HKSAR. CFLSTs incorporate a set of embedded scenarios that allowed the FSAP team to estimate the magnitude of potential liquidity needs of individual banks and the banking system (comprising the sample of 23 banks) under a baseline and multiple stress scenarios. CFLSTs help illustrate banks' different levels of liquidity risk tolerance, i.e., the severity of liquidity shocks which banks plan to survive without recourse to central bank support. Inversely, CFLSTs identify the circumstances under which banks would need additional liquidity support because of insufficient liquefiable assets, the counterbalancing capacity (CBC), to counterbalance the liquidity mismatch from cash flows. In addition, CFLSTs contribute to the assessment of common liquidity risk exposures of banks in the system, such as the reliance on unsecured short-term funding, (e.g. retail, non-retail, and interbank deposits) and common exposures to less liquid assets in the CBC.[44]

Method and Data

90. CFLST transform reported cash-flow data and security-flow data into stressed cash-flows and security-flows based on a matrix of scenarios defined by a set of stress factors.[45] The method focuses on two key indicators, namely, banks' liquidity risk exposure and liquidity risk-bearing capacity. The first indicator is defined as the cumulated net-funding gap (CNFG). It is based on the differences between cash-inflows and cash-outflows in each time bucket (the net-funding gap NFG); the CNFG is the sum across the differences across the time buckets. The second indicator is the cumulated counterbalancing capacity (CCBC). It is based on the counterbalancing capacity (CBC), which is defined as the sum of cash inflows banks can generate under stress at reasonable prices in the respective bucket after taking into account securities flows. The CCBC is the sum of the counterbalancing capacities across time buckets and the current one after taking into account the cumulated net funding gap. In short and somewhat colloquial, it is the liquidity left at the disposal of the bank at the end of the time horizon after stress. The analysis builds on reporting data collected

[44] The CFLST exercise here does not consider potential second-round effects that amplify the shocks for weaker banks and bolster it for stronger one; for example, a further redistribution of deposits after the initial shock, from banks with insufficient liquidity buffers to those with ample liquidity buffers.

[45] For details see Schmitz, S. W. (2015), "Macroprudential liquidity stress tests", in: C. Bonner, P. Hilbers, I. van Lelyveldt, (eds.), Liquidity Risk Management and Supervision, Risk Books, London 2015, 237–264 and Schmieder, C., H. Hesse, B. Neudorfer, C. Puhr, S. W. Schmitz (2012), "Next Generation System-Wide Liquidity Stress Testing" IMF Working Paper No. 12/3.

by the HKMA.[46] Overall, the HKMA confirmed that a thorough data quality assurance process had been applied.

91. Short-term contractual outflows of banks in the sample are high. Within the first 4 weeks, they amount to about 82 percent of total assets (weighted average; including current account deposits (38 percent of TA) and derivatives outflows (22 percent of TA)). Derivatives outflows are matched by derivatives inflows at the system level; excluding them would result in short-term contractual outflows of 60 percent of total assets. A disruption of the derivatives markets – e.g. FX swap markets – might would have substantial effects on liquidity risk exposure. Compared to December 2018, the contractual outflows arising from derivatives contracts in the first 6 months declined significantly from 64 to 47 percent of TA. The contractual outflows from deposit funding remained basically unchanged, but their composition shifted somewhat further towards overnight (from 35 to 38 per cent of TA).

Figure 24. Hong Kong SAR: Heat Map of Contractual Outflows from On-Balance Sheet Assets (Including On-Balance Sheet Derivatives in % of Total Assets) (June 2020)

On-balance sheet liabilities	Next day	2 to 7 days	8 days to 1 month	> 1 month up to 3 months	> 3 months up to 6 months
Pledged deposits	0%	0%	0%	0%	0%
Demand, savings and current account deposits	38%	0%	0%	0%	0%
Term, call and notice deposits	3%	3%	6%	8%	2%
Amount payable arising from securities financing transactions (other than securities swap transactions)	1%	0%	0%	0%	0%
Amount payable arising from derivative contracts	4%	9%	9%	17%	9%
Due to MA for a/c of Exchange Fund	1%	0%	0%	0%	0%
Due to overseas central banks	0%	0%	1%	0%	0%
Due to banks	3%	0%	1%	2%	0%
Debt securities, prescribed instruments and structured financial instruments issued and outstanding	0%	0%	0%	1%	1%
Other liabilities	2%	1%	0%	0%	0%
Capital and reserves	0%	0%	0%	0%	0%
Total	51%	13%	17%	29%	13%

Source: HKMA and IMF staff.

92. The contractual inflows in the first month amount to about 62 percent of total assets (Figure 25). The main drivers of the inflows are inflows from derivatives with 22 percent of total assets (identical to the corresponding outflows). Readily monetizable debt securities account for 17 percent of total assets. Compared to December 2018, the contractual inflows from derivative contracts declined from 29 to 22 percent of TA. Inflows from the Exchange Fund increased from 0.5 to 1 percent of TA.

93. The cumulated contractual maturity mismatch over the first month reaches 25 percent of total asset. This is mostly unchanged from its December 2018 level (24 percent). Over the first 6 months the maturity mismatch increases to 31 percent. The liquidity risk exposure of the system increased somewhat since December, while the liquidity risk bearing capacity remained unchanged.

[46] Utilized data include, but are not limited to, the Contractual Maturity Mismatch Template (HKMA Return MA(BS)23).

94. During global market disruption in March and April 2020, the HKMA took a series of measures to reduce liquidity risk. There was some tightness in the Hong Kong dollar money market in late March 2020 due to fluctuations in demand and supply of funding, seasonal factors as well as strains in USD funding. The measures included providing clarifications regarding banks' access to the HKMA Standby Liquidity Facilities (SLF) to manage unexpected market tightness, including (i) the possibility to allow automatic rollover of liquidity support with a view to providing longer-term funding to banks, (ii) pricing the funding at levels that would help reduce market volatility and (iii) the scope of eligible collateral not being confined to High-quality Liquid Assets (HQLA) as defined under the Banking (Liquidity) Rules. Furthermore, the HKMA reduced the issuance size of Exchange Fund Bills by a total of HK$20 billion to make available more Hong Kong dollar liquidity in the banking system. It also launched a temporary US dollar liquidity facility. It would allow the HKMA to make USD available to banks facing a USD shortage. The funds would be obtained through the repurchase agreement facility for foreign and international monetary authorities (FIMA Repo Facility) established by the US Federal Reserve. Finally, the HKMA actively communicated to the banks and the market that the LCR was a usable buffer which could and should be drawn under stress. The HKMA reviewed banks' internal policies and processes as well as conducted drills to ensure that the banks were able to draw on the additional resources when needed. It found that banks were ready to access the SLF and had the internal policies in place that allowed for drawing on the LCR under stress. Overall, banks weathered the episode without any liquidity strains.

Figure 25. Hong Kong SAR: Heat Map of Contractual Inflows from On-Balance Sheet Assets
(Including On-Balance Sheet Derivatives, in % of Total Assets) (June 2020)

On-balance sheet liabilities	Next day	2 to 7 days	8 days to 1 month	> 1 month up to 3 months	> 3 months up to 6 months
Currency notes and coins	0%	0%	0%	0%	0%
Amount receivable arising from securities financing transactions (other than securities swap transactions)	1%	0%	1%	0%	0%
Amount receivable arising from derivative contracts	4%	9%	9%	17%	9%
Due from MA for a/c of Exchange Fund	1%	0%	0%	0%	0%
Due from overseas central banks	2%	0%	0%	0%	0%
Due from banks	4%	1%	2%	2%	1%
Debt securities, prescribed instruments and structured financial instruments held (net of short positions)	0%	0%	0%	0%	0%
Readily monetizable	17%	0%	0%	0%	0%
Not readily monetizable	0%	0%	0%	0%	0%
Pledged to customers	0%	0%	0%	0%	0%
Others	0%	1%	0%	0%	0%
Acceptances and bills of exchange held	0%	0%	0%	1%	0%
Loans and advances to non-bank customers	1%	2%	4%	4%	3%
Other assets	2%	1%	0%	0%	0%
Total	32%	13%	16%	24%	14%
Contractual Maturity Mismatch	-23%	-1%	-1%	-6%	0%
Cumulative Contractual Maturity Mismatch	-23%	-24%	-25%	-31%	-31%

Source: HKMA and IMF staff.

Note: The contractual Maturity Mismatch and the Cumulative Contractual Maturity Mismatch also contain the cash- and securities-flows of off-balance sheet items.

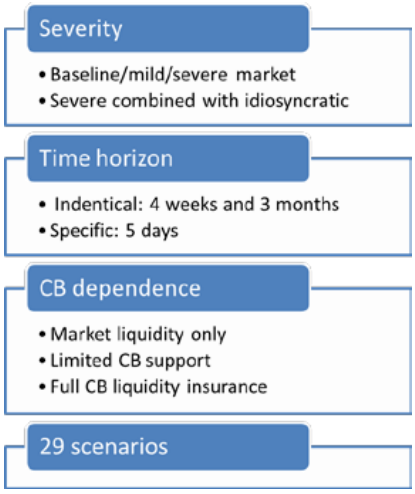
Calibration and Parameter Uncertainty

95. Despite careful, evidence-based scenario calibration, parameter uncertainty is intrinsic to liquidity stress testing. The FSAP team utilized embedded scenarios to address parameter uncertainty. Scenarios can be ordered according to three dimensions: (i) severity (i.e. level of run-off

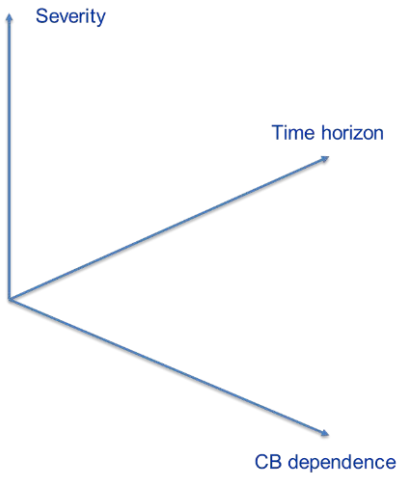
rates of liabilities), (ii) the approach to the counterbalancing capacity (i.e. level of haircuts), (iii) and the time horizon. Ceteris paribus, (i) scenario impact increases with (i) run-off rates (ii) higher haircuts on non-marketable, CB eligible assets in the counterbalancing capacity, and (iii) longer stress horizons have a higher impact. Embedded scenarios allow simulating different degrees of bank dependence on central bank support under liquidity stress by increasing the haircuts of assets that are CB eligible but not liquid in private markets.

Figure 26. Hong Kong SAR: Embedded Stress Test Scenarios

To deal with parameter uncertainty, CFLST was based on multiple embedded scenarios...



which were grouped according to the three dimensions: severity, time horizon and dependence on CB support.



Source: IMF, 2018 Euro Area FSAP, Technical Note on Stress Testing.

96. This approach to parameter uncertainty shifts discussions from parameter calibration to the liquidity risk tolerance of banks and supervisors. The objective of the liquidity tests is to gauge banks risk tolerance for liquidity risk, i.e., the maximum degree of risk that the bank is planning to manage without recourse to public support (e.g., central bank funding beyond the standard monetary policy operations) under stress conditions. The choice of "threshold" itself is based on multiple parameters, for example, the percentage of funding outflow and/or haircuts on CBC assets. If many banks fail under very mild outflows or haircuts scenario, this reveals a high liquidity risk tolerance and vice versa. The choice of "threshold" also allows for an assessment of the liquidity risk tolerance of the authorities choosing the thresholds. In addition, the broad set of scenarios allows for effective comparisons of liquidity risk exposure and liquidity risk tolerance across banks beyond the simple pass/fail dichotomy.

97. The FSAP team relied on past stress episodes from various markets for the calibration of deposit outflows. Historical evidence of past deposit runs suggests that outflows can be

significant.[47] For the CFLST the FSAP chose the following deposit run-off rates: 1 percent for stable retail, SME, and operational deposits, 4 percent for less stable retail, SME, and operational deposits, 8 percent for operational deposits not covered by deposit insurance and 15 percent for non-operational deposits. This calibration applies to the mild, medium, and severe market scenario. In the severe/combined scenario (which combines idiosyncratic and market-wide shocks), the rates are based on the LCR calibration with the values of 3 percent, 10 percent, 25 and 40 percent for the corresponding deposit categories.

Table 7. Hong Kong SAR: Scenario Parameters of the Major In- and Outflow Components

Outflows/Inflow	Range of run-off factors (in percent) across mild, medium, severe, and severe/combined scenarios
Unsecured LT/ST Issuances and financial deposits	50–100
Secured issuances	N.A.
Stable retail deposits	1-3
Unstable retail deposits	4-10
Operational corporate deposits (NFCs)	8–25
Non-operational corporate deposits (NFCs) & other deposit outflows	15–40
Repo across all collateral classes*	0
Deposits FI	50–100
FX-Swaps in-/outflows	0
Derivative in-/outflows	100
Retail / corporate inflows	0
Central bank inflows	100
FI inflows	50–100
Other inflows	100
Committed lines provided by the bank	10

N.B.: * Stressed outflow rates for repos are captured by increasing haircuts for the underlying collateral class. Calibration based on: HKMA Supervisory Policy Manual (2016), "Regulatory Framework for Liquidity Risk – LM-1." Schmieder, C., H. Hesse, B. Neudorfer, C. Puhr, S. W. Schmitz (2012), "Next Generation System-Wide Liquidity Stress Testing" IMF Working Paper No. 12/3. BCBS (2014), "Liquidity stress-testing: a survey of theory, empirics and current industry and supervisory practices", BCBS Working Paper 24. BCBS (2014), "Literature review of factors relating to liquidity stress – extended version" and the literature cited therein.

98. The haircuts differ for the three approaches to the counterbalancing capacity (CBC). The FSAP applied three different modeling approaches to the CBC to differentiate across the composition of the CBC. This contributes to a more detailed analysis of potential vulnerabilities, such

[47] Schmiedinger, Hesse, Neudorfer, Puhr, and Schmitz (2012) and Rose (2015) present evidence from various case studies around the world. Based to their classification of severity (Table 5, p. 26), the most severe scenarios in this liquidity stress test corresponds to a shock comparable to the Lehman Brothers crisis.

as high dependence on central bank support or on assets of lower quality/liquidity. The three approaches are:

i. Full CBC: the full counterbalancing capacity is taken into account and haircuts apply to all items.

ii. Marketable CBC: the focus on high credit quality and high market liquidity increases, so that the haircuts of lower quality assets, increase.

iii. Cross-border CBC: this approach focuses on the impact of operational risk and time delays of cross-border transfers of securities and cash-flows; the haircuts increase further for those assets, located outside the jurisdiction in which they are central bank eligible.

99. The haircuts utilized were based on historical stress episodes. For Exchange Fund Notes, for HK government bonds, and for US treasuries the haircuts are 3 percent, for RMB denominated assets for the PBoC liquidity facility they amount to 5 percent (Table 9, "Full CBC"). For AAA-rated securities not in the former categories and for assets eligible at overseas central banks the haircuts are 10 percent; for other investment-grade securities they are 15 percent. For assets potentially usable for repos the haircuts increase with risk weights (10 percent for 0 risk weight, 15 percent for 20 percent risk weight, and 20 percent for the rest). These haircuts apply to the counterbalancing capacity approach that takes into account the full counterbalancing capacity.

100. The haircuts increase for the approach to the CBC that focuses more on market liquidity. The haircuts for "Other investment grade securities" and for "Other assets which are reasonable expected to have potential use as collateral in secured borrowing operations" increase to 25 and 30 percent respectively.

101. The haircuts for the approach to the "cross-border" approach to the CBC increase for the assets that are located overseas but are to be used predominantly in HK and vice versa (Table 9, "Cross-border"). To reflect the potential operational risk involved in the relocation of the respective funds the haircuts were increased by 10 percentage points.

Table 8. Hong Kong SAR: Scenario Haircuts for the Major Components of Unencumbered Assets

(in % of reported market price)	Full CBC		Marketable CBC		Cross-border	
Types of unencumbered assets	Location of assets		Location of assets		Location of assets	
	Hong Kong	Overseas	Hong Kong	Overseas	Hong Kong	Overseas
1. Assets which are, or may be, acceptable as collateral under the MA's liquidity facilities and other contingency funding mechanisms						
(a)EF debt securities	3%	3%	3%	3%	3%	13%
(b)Hong Kong Government bonds	3%	3%	3%	3%	3%	13%
(c)RMB-denominated assets that can be used as collateral under RMB Liquidity Facility	5%	5%	5%	5%	5%	15%
(d)US Treasury debt securities	3%	3%	3%	3%	3%	13%
(e)AAA-rated securities not included in items (a) to (d)	10%	10%	10%	10%	10%	20%
(f)Other investment grade securities	15%	15%	25%	25%	20%	30%
(g)Interbank placements after deductions (Note)						
(h)Residential mortgage loans						
(i)Mortgage loans under Home Ownership Schemes or Private Sector Participation Schemes						
(ii)Mortgage loans which satisfy the purchasing criteria of The Hong Kong Mortgage Corporation Limited						
(iii)Other performing residential mortgage loans						
2. Assets which may be used as collateral for borrowing from overseas central banks or governments						
(a)(For completion by reporting institutions incorporated in Hong Kong) Assets held by the reporting institution (including its overseas branches or specified associated entities) that can be used as collateral for access to standing facilities offered by central banks or governments in host jurisdictions	10%	10%	10%	10%	20%	10%
(b)(For completion by reporting institutions incorporated outside Hong Kong) Assets held by the Hong Kong branch of the reporting institution that can be used by its Head Office as collateral to borrow from the central bank or government in its home jurisdiction	10%	10%	10%	10%	20%	10%
3. Other assets not included elsewhere, but may be used as collateral for secured borrowing in wholesale funding markets						
(a)Debt securities assigned with a 0% risk-weight under the standardized (credit risk) approach	10%	10%	10%	10%	10%	20%
(b)Debt securities assigned with a non-0% risk-weight that is not more than 20% under the standardized (credit risk) approach	15%	15%	15%	15%	15%	25%
(c)Other assets which are reasonably expected to have potential for use as collateral for secured borrowing purposes	20%	20%	30%	30%	30%	40%

Sources: Authors' own calculations based on: Schmiedinger, C., H. Hesse, B. Neudorfer, C. Puhr, S. W. Schmitz, 2012, "Next Generation System-Wide Liquidity Stress Testing" IMF Working Paper No. 12/3, Washington, D.C. Committee on the Global Financial System, 2010 "The role of margin requirements and haircuts in procyclicality" Table 1. De Fiore, F., M. Hoerova, H. Uhlig, 2019, "Money markets, collateral and monetary policy" European Central Bank Working Papers. Financial Stability Board, 2014, "Strengthening Oversight and Regulation of Shadow Banking."

Note: Residential mortgage loans were not considered for inflows in the analysis and hence no haircuts are reported for that asset category.

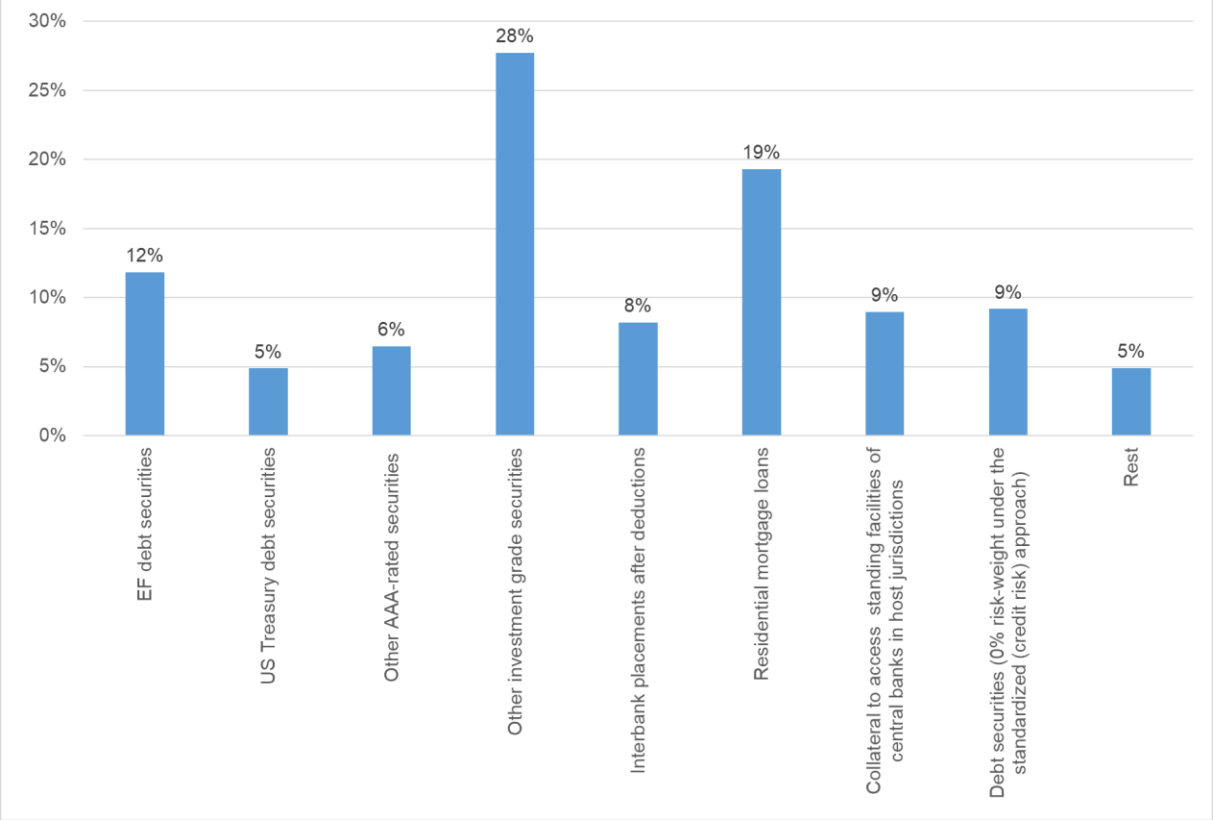
102. The FSAP team tested the resilience of the system over three horizons: 7 days, 1 month, and 3 months. For each the time horizons the team applied: a mild market scenario, a medium market scenario, and a severe scenario and a severe/combined scenario (which combines idiosyncratic and market-wide shocks). The latter includes the higher deposit run-off calibration based on the LCR, the former the lower one (see paragraph 45 above). For each of the four scenarios, we apply the three approaches to the counterbalancing capacity ("Full CBC," Marketable CBC," and "Cross-border"). For each time horizon there were a total of 12 scenarios which leads to 36 embedded stress scenarios.

103. Local banks hold relatively high shares of mortgages (19 percent) and "Other investment-grade securities" (28 percent) in their unencumbered asset portfolio. The latter contains assets of lower credit quality and liquidity and bank liabilities. This reduces the liquidity that could be generated from these assets under stress; in addition, for bank liabilities this can lead to illiquidity cascades within the banking sector.[48] Thus, higher haircuts are warranted and prudent. Regarding the mortgage portfolio, banks partly rely on the Hong Kong Mortgage Corporation (HKMC) to liquefy mortgages via its liquidity lines. The HKMC itself has a liquidity line with the

[48] ECB. 2018. Systemic liquidity concept, measurement and macroprudential instruments. ECB Occasional Paper No. 214.

HKMA. The HKMA also serves as backstop for bank liquidity risk, the DGS, the resolution fund, and the exchange fund. The FSAP team produced two technical notes – on the resolution fund and on the linked exchange rate system (LERS) – but an integrated assessment of these liquidity provision schemes by the HKMA could be helpful.

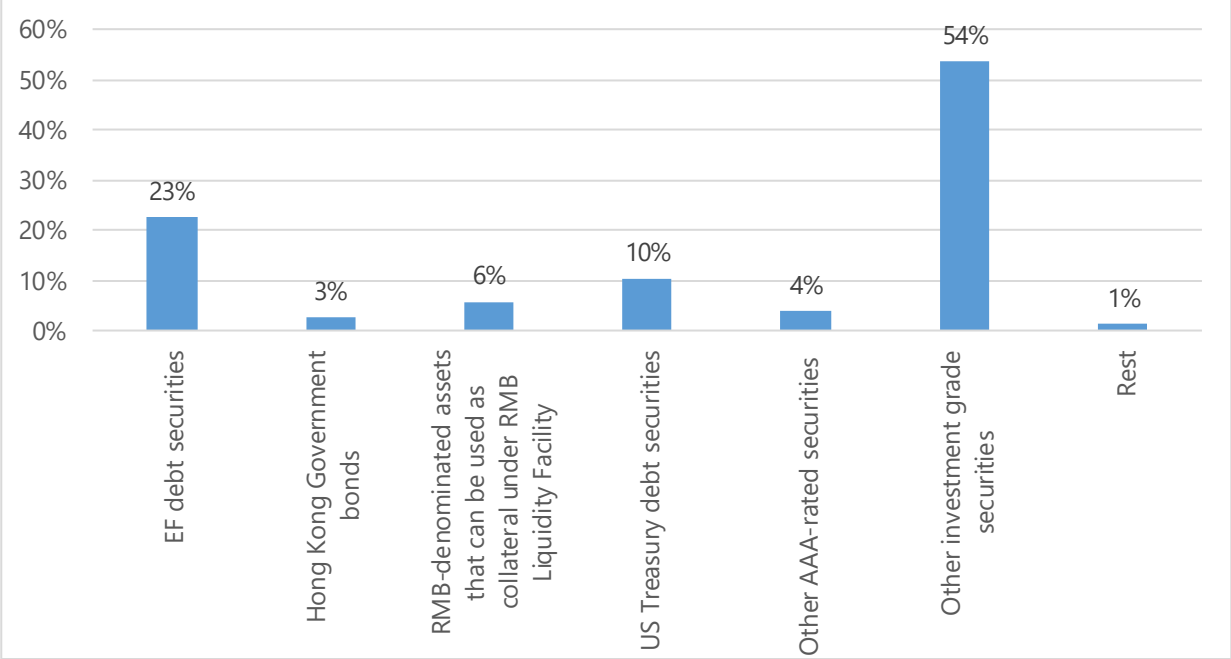
Figure 27. Hong Kong SAR: Composition of Unencumbered Assets (Local Banks)
(June 2020)



Sources: HKMA and IMF staff. Smaller asset categories were included in the figure as "Rest" to improve readability; these include HK Government Bonds (0.7%), RMB-denominated assets that can be used as collateral under RMB Liquidity Facility (1.6%); Debt securities assigned with a non-0% risk-weight that is not more than 20% under the standardized (credit risk) approach (1.2%); Other Central Bank eligible assets (0%).

104. Foreign banks hold an even higher share of "Other investment-grade securities" (54 percent) in their unencumbered asset portfolio. This reduces the cash-flows they can generate from these assets, particularly under stress. Ceteris paribus, they are likely to be more vulnerable to liquidity shocks. However, they report a lower share of mortgages (0%), reducing their reliance on assets which can only be liquefied via the HKMC, and which are mostly illiquid without the HKMC. Compared to December 2018, the composition of unencumbered assets shifted further towards Other investment grade securities (+8 percentage points).

Figure 28. Hong Kong SAR: Composition of Unencumbered Assets (Foreign Branches)
(June 2020)

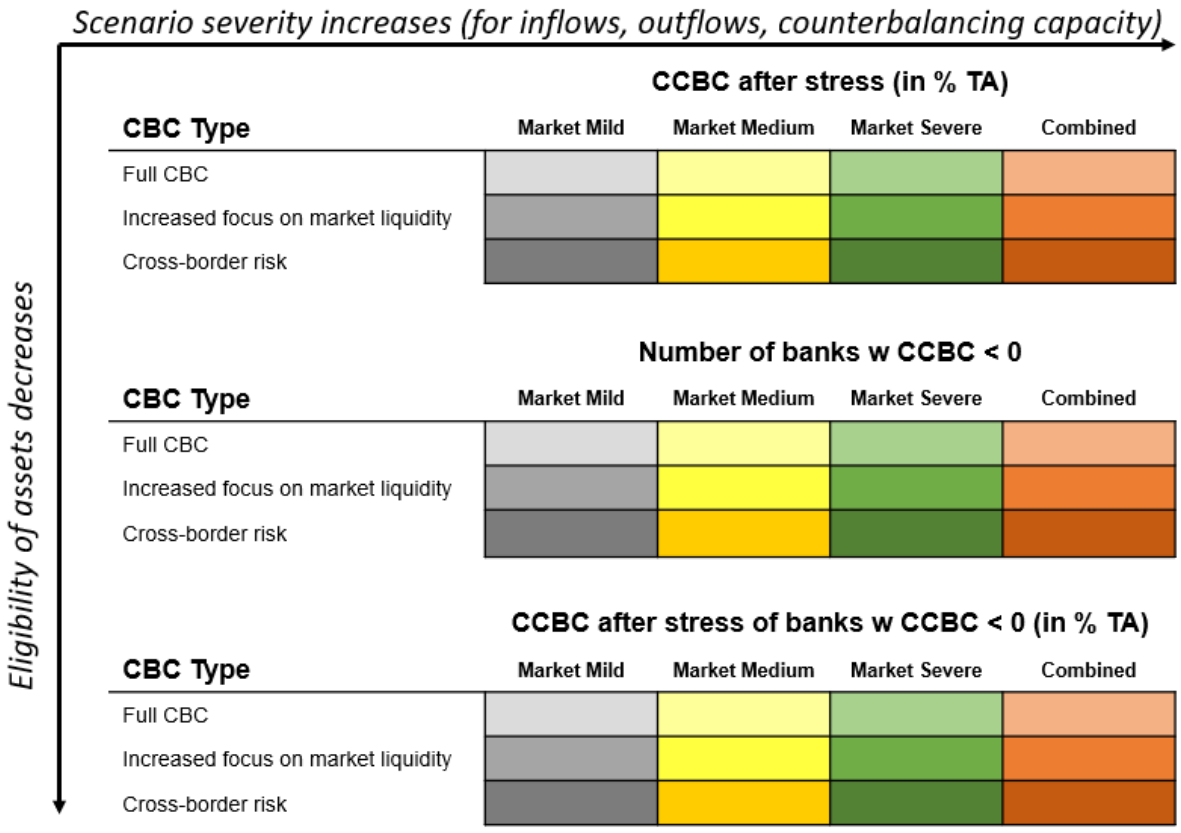


Sources: HKMA and IMF staff. Smaller asset categories were included in the figure as "Rest" to improve readability; these include Interbank placements after deductions (0.5%), Residential mortgage loans, Mortgage loans under Home Ownership Schemes or Private Sector Participation Schemes, Mortgage loans which satisfy the purchasing criteria of The Hong Kong Mortgage Corporation Limited, Assets which may be used as collateral for borrowing from overseas central banks or governments (all 0%) and Other assets not included elsewhere, but may be used as collateral for secured borrowing in wholesale funding markets (0.7%).

Results of the Cash-flow based Liquidity Stress Test

105. For each of the three horizons, 12 embedded scenarios are presented in the form of a matrix. The severity of the scenario in terms of run-off rates increases from left to right; the haircuts increase from top to bottom. The mildest scenario is the one in the upper left-hand corner of each matrix; the most severe one in the lower right-hand corner. The matrix presents three different sets of results per sample/subsample and per time horizon: (i) the cumulated counterbalancing capacity (CCBC) of the entire sample after stressed outflows in terms of the total assets of the sample, (ii) the number of banks with a CCBC below zero; and (iii) the liquidity shortage of the latter banks in terms of their average total assets. Additionally, results for the subsamples of local banks and foreign branches are presented separately, when relevant for the assessment.

Figure 29. Hong Kong SAR: Structure of the Presentation of the Results of the Liquidity Stress Test



Sources: IMF staff.

Time Horizon: 7 Days

106. The HKSAR banking sector is highly liquid and highly resilient to all 7-day stress scenarios. Table 9 presents the CCBC under different stress scenarios, at a 7-day horizon. Even under the most severe stress scenario, the HKSAR banking system remains very liquid with a CCBC of 15.1 percent of the total banking assets of the sample. Compared to December 2018, this constitutes an improvement of 0.7 percentage points. Local banks (+1.3 ppt) are responsible for this improvement, while foreign branches experience a decrease of 1.4 ppt.

Table 9. Hong Kong SAR: Cumulative Counterbalancing Capacity as a Percentage of Total Assets Under Different Stress Scenarios at the 7-day Horizon for the Entire Sample, for the Local Banks, and for the Foreign Branches

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	19.9	18.6	18.1	16.7
Increased focus on market liquidity	19.1	17.8	17.4	16
Cross-border risk	18.3	17	16.5	15.1

Local Banks (12)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	20.2	19	18.3	16.7
Increased focus on market liquidity	19.5	18.3	17.6	16
Cross-border risk	18.6	17.4	16.7	15.1

Foreign Branches (11)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	18.6	16.7	17.4	6
Increased focus on market liquidity	17.6	15.7	16.4	6
Cross-border risk	17	15.1	15.8	7

Sources: IMF staff.

107. No bank experiences a negative CCBC under any of the 7-day stress scenarios. Overall, the average CCBC as a percentage of total assets of the entire banking sector is above 15 percent under most scenarios.

Table 10. Hong Kong SAR: Number of Banks with a Negative Cumulative Counterbalancing Capacity Under Different Stress Scenarios at the 7-day Horizon for the Entire Sample

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	0
Increased focus on market liquidity	0	0	0	0
Cross-border risk	0	0	0	0

Sources: IMF staff.

Time Horizon: 1 Month

108. The system is also resilient with respect to any of the 1-month scenario. The overall cumulative counterbalancing capacity decreases mildly though, to an average of 12 percent under most scenarios and never dips below 10 percent, even under the most extreme case of the severe market scenario, with banks' idiosyncratic deposits run-offs and extra haircuts on overseas unencumbered assets. For the entire sample, the CCBC at the end of the stress horizon stands at 10.4 percent under the most severe scenario. For the local banks, the CCBC amounts to 10.1 percent and for the foreign branches to 11.8 percent of the total assets of the respective subsample. Banking liquidity is lower after one month of stress than after 7 days, as stressed inflows and outflows impact cumulate with counterbalancing capacity haircuts. Compared to December 2018, the analysis shows a decrease of liquidity risk in the system; the CCBC at the end of the stress test horizon increases by 0.8 percentage points (local banks +0.8 ppt; foreign branches +0.7 ppt).

Table 11. Hong Kong SAR: Cumulative Counterbalancing Capacity as a Percentage of Total Assets Under Different Stress Scenarios Under the 1-Month Horizon for the Entire Sample, for the Local Banks, and for the Foreign Branches

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	18.1	16.9	16.4	12.1
Increased focus on market liquidity	17.3	16.1	15.7	11.3
Cross-border risk	16.5	15.2	14.8	10.4

Local Banks (12)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	18.4	17.4	16.7	11.8
Increased focus on market liquidity	17.7	16.7	16	11
Cross-border risk	16.8	15.8	15.1	10.1

Foreign Branches (11)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	16.8	14.6	15.1	13.4
Increased focus on market liquidity	15.8	13.6	14.1	12.4
Cross-border risk	15.2	12.9	13.4	11.8

Sources: IMF staff.

109. At the one-month stress horizon, all local banks remain liquid while one foreign branch faces liquidity pressure. However, despite this decline in CCBC, only one foreign bank experiences negative CCBC after one-month (Table 12), and only under the most extreme scenario, with a shortfall of 1 percent of total assets (Table 13). The results indicate that impediments to the cross-border flow of collateral should be considered in liquidity stress tests. In December 2018, the comparative numbers stood at up to 3 foreign branches with negative CCBC with a shortfall of up to 2.2 percent of their total assets.

Table 12. Hong Kong SAR: Number of Banks with a Negative Cumulative Counterbalancing Capacity Under Different Stress Scenarios Under the 1-Month Horizon for the Entire Sample

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	1
Increased focus on market liquidity	0	0	0	1
Cross-border risk	0	0	0	1

Local Banks (12)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	0
Increased focus on market liquidity	0	0	0	0
Cross-border risk	0	0	0	0

Foreign Branches (11)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	1
Increased focus on market liquidity	0	0	0	1
Cross-border risk	0	0	0	1

Sources: IMF staff.

Table 13. Hong Kong SAR: CCBC as a Percent of Total Assets for Banks with Negative CCBC, Under Different Stress Scenarios for the Entire Sample, for Local Banks, and Foreign Branches

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	0
Increased focus on market liquidity	0	0	0	-0.4
Cross-border risk	0	0	0	1

Local Banks (12)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	0
Increased focus on market liquidity	0	0	0	0
Cross-border risk	0	0	0	0

Foreign Branches (11)

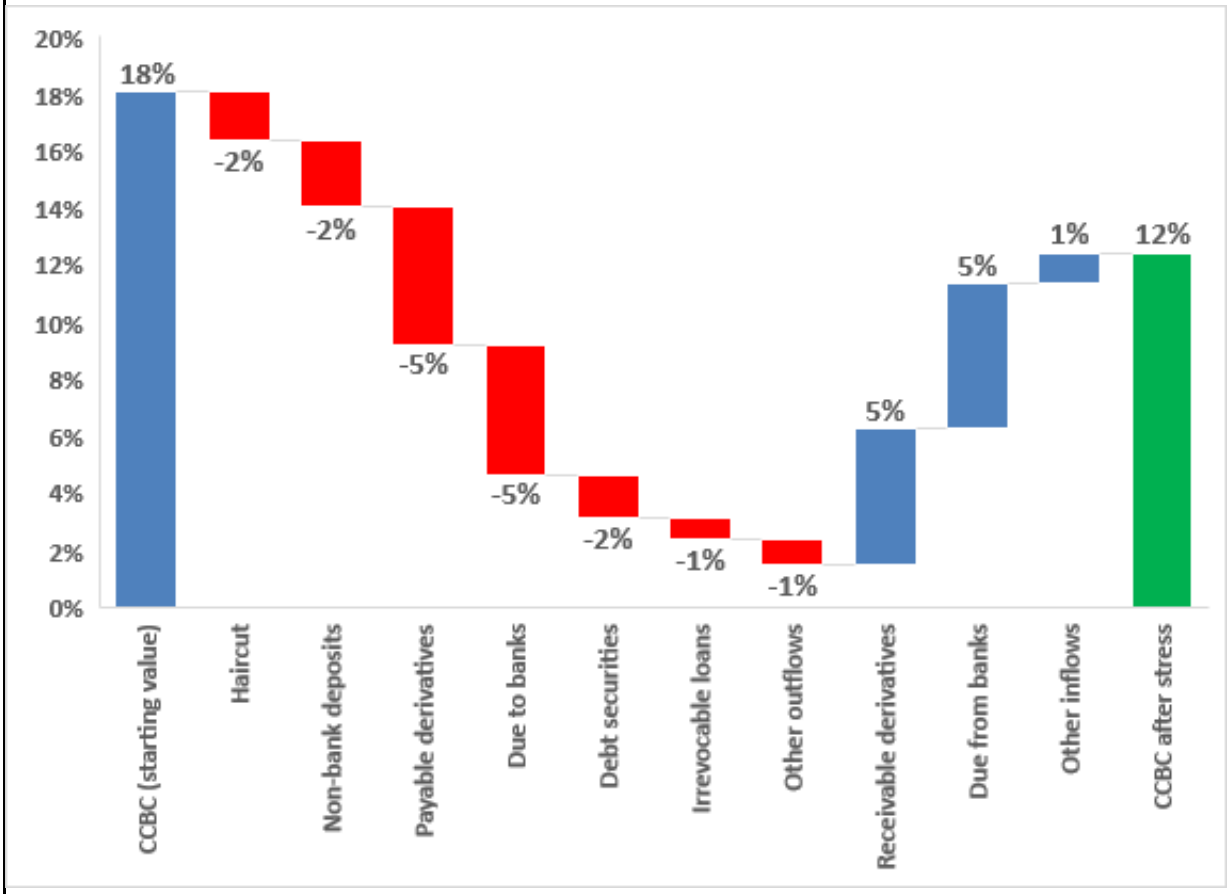
CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	0
Increased focus on market liquidity	0	0	0	-0.4
Cross-border risk	0	0	0	-1

Sources: IMF staff.

110. The reliance on unsecured interbank funding and unsecured wholesale funding from non-banks are the main drivers of the few pockets of vulnerabilities among foreign branches. The waterfall chart displays the CCBC before haircut, then the effects of the haircuts, the major stress outflows and inflows, and the resulting CCBC under stress in a sequential manner. It decomposes the dynamics of the CCBC over the 1-month horizon under the severe "combined" scenario and marketable CBC with an increased focus on market liquidity. Foreign branches experience large outflows due to derivatives transactions (-5% of total assets), but these are compensated for by corresponding inflows (+5% of TA). Thus, short-term roll-over risk in derivative markets exposes banks to liquidity risk. The other main driver of the CCBC dynamics are outflows under the "due to banks loans" category with outflows of -5% of TA. Furthermore, the haircuts on liquefiable assets (-2% of TA) and the outflows of non-bank deposits (-2% of TA) play important roles. Due from banks is a major source of inflows under stress with +5% of TA. In sum, the cumulated counterbalancing capacity after the simulated 1-month stress stands at 13% of TA. Lengthening and staggering the tenors of this funding source would contribute to financial stability in HK. The most significant changes since December 2018, are the strong decrease of derivative related in- and outflows (from

10% to 5%, respectively) which substantially reduces the roll-over risk in this area. The outflows from non-bank deposits and from haircuts doubled from a low level of 1% to 2%.

Figure 30. Hong Kong SAR: Waterfall Chart of CCBC Before Haircuts, Major Stressed Outflows, and Inflows and CCBC Under the Severe Combined Scenario and the Marketable CBC Approach Under the 1-Month Horizon for Foreign Branches



Sources: IMF staff.

Time Horizon: 3 Months

111. The banking system maintains a positive cumulative counterbalancing capacity at a 3-month horizon but exhausts most of the liquidity buffers under the most severe scenario. The overall cumulative counterbalancing capacity decreases substantially after 3-months of cumulated run-offs and haircuts, to an average of around 12 percent for most scenarios, but dips below 6 percent under the most extreme case of severe market run-offs, with banks' idiosyncratic parameters and extra haircuts on overseas unencumbered assets. For the entire sample, the CCBC at the end of the stress horizon stands at 4.9 percent under the most severe scenario. For the local banks the CCBC it amounts to 6.2 percent and for the foreign branches to -0.7 percent of the total assets of the respective subsample. After three-months, foreign branches on average have exhausted most of their counterbalancing capacity and a substantial share of them have a CCBC already in negative

territory. Compared to December 2018, this constitutes an improvement for the local banks (0.3 ppt), but for the foreign branches a deterioration (-2.1 ppt).

Table 14. Hong Kong SAR: Cumulative Counterbalancing Capacity as a Percentage of Total Assets Under Different Stress Scenarios Under the 3-Month Horizon for the Entire Sample, for the Local Banks, and for the Foreign Branches

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	15.1	13.4	12.6	6.5
Increased focus on market liquidity	14.3	12.6	11.9	5.8
Cross-border risk	13.4	11.7	11	4.9

Local Banks (12)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	16.5	15.5	14.9	7.9
Increased focus on market liquidity	15.8	14.8	14.1	7.1
Cross-border risk	14.9	13.9	13.2	6.2

Foreign Branches (11)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	9	4.2	3	0.8
Increased focus on market liquidity	7.9	3.2	2	-0.3
Cross-border risk	7.3	2.5	1.3	-0.9

Sources: IMF staff.

112. At the three-month stress horizon, local banks continue to perform well, while most of the foreign branches become illiquid. Despite the three-months continuous liquidity drain, only under the harshest scenarios are few local banks illiquid. Foreign branches, however, which lack the large depositor base of their local counterparts, are illiquid for seven of them under almost all scenarios (out of eleven foreign branches). Again, the results show that potential impediments to cross-border flows of collateral can have a substantial effect on foreign branches and an impact on some local banks, too.

Table 15. Hong Kong SAR: Number of Banks with a Negative Cumulative Counterbalancing Capacity Under Different Stress Scenarios Under the 3-Month Horizon for the Entire Sample

All Sample (23)				
CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	1	7	7	8
Increased focus on market liquidity	1	7	7	9
Cross-border risk	2	7	7	9

Local Banks (12)				
CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	1
Increased focus on market liquidity	0	0	0	2
Cross-border risk	0	0	0	2

Foreign Branches (11)				
CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	1	7	7	7
Increased focus on market liquidity	1	7	7	7
Cross-border risk	2	7	7	7

Sources: IMF staff.

113. The number of banks with a negative CCBC at the end of the stress test horizon amounts to up to 9. Local banks maintain positive CCBC under most scenarios; only in the most severe ones 1 to 2 local banks face a negative CCBC. Among the foreign branches the situation is heterogeneous; even in the mildest scenario 1 of them features a negative CCBC. This number increases to 7 under the most severe scenario. Compared to December 2018, the results are unchanged for the local banks, while the number of institutions experiencing stress increased for the foreign branches.

114. The negative CCBC for foreign branches is particularly severe after three months, while the liquidity shortage of the few illiquid local banks is smaller (Table 16). The foreign branches with negative CCBC feature shortfalls of about 9 percent of their total assets under most scenarios, while the two local banks illiquid under the harshest scenarios have a negative CCBC representing only about 4 to 6 percent of their total assets. Since December 2018, the shortfall increases for the entire system (+1.1 ppt), to which both subgroups contribute roughly equally.

Table 16. Hong Kong SAR: CCBC as a Percent of Total Assets for Banks with Negative CCBC, Under Different Stress Scenarios

All Sample (23)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	-2.9	-3.9	-7.2	-5.9
Increased focus on market liquidity	-3	-4.9	-8.2	-6.6
Cross-border risk	-1.6	-5.8	-9.1	-7.5

Local Banks (12)

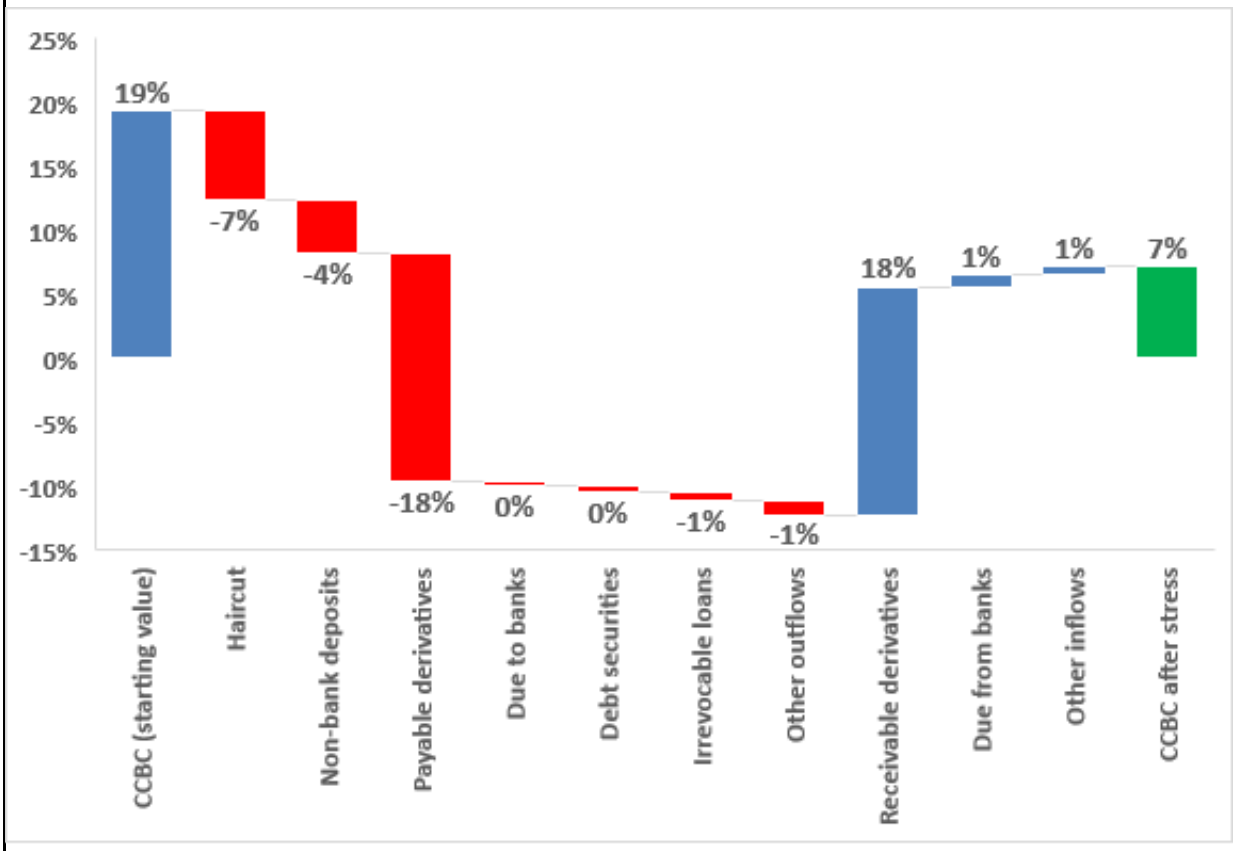
CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	0	0	0	-3.9
Increased focus on market liquidity	0	0	0	-4.7
Cross-border risk	0	0	0	-5.5

Foreign Branches (11)

CBC Type	Market Mild	Market Medium	Market Severe	Combined
Full CBC	-2.9	-3.9	-7.2	-7.9
Increased focus on market liquidity	-3	-4.9	-8.2	-8.9
Cross-border risk	-1.6	-5.8	-9.1	-9.8

Sources: IMF staff.

Figure 31. Hong Kong SAR: Waterfall Chart of CCBC Before Haircuts, Stressed Outflows, and Inflows and CCBC Under the Severe Combined Scenario and the Marketable CBC Approach (Focus on Liquidity) Under the 3-Month Horizon for Local Banks



Sources: IMF staff.

115. The funding structure and the liquidity buffers of local banks' funding allow them to sustain a 3-month liquidity drain scenario. The waterfall chart in Figure 31 presents local banks' liquidity flows sequentially. Haircuts on CBC assets represent the largest outflows for local banks, consistent with the relatively high share of "Other investment-grade securities" in their unencumbered assets. Outflows from derivatives are also very high. While outflows are usually compensated by the respective inflows, the high gross volumes expose the banks to short-term roll-over risks in the derivatives markets (i.e. the FX swap market). Outflows of deposits are limited, given the relatively low run-off rates of stable deposits under most scenarios. Their foreign counterparts see their main funding source – unsecured interbank loans – drying up. The liquidity situation deteriorated somewhat since December 2018, because the CBC at the beginning of the period decreased from 24 to 19 percent of total assets and the outflows due to non-banks deposits doubled to 4 percent.

D. Liquidity Risk Assessment for the HKSAR Banking System

116. The HKMA approach to liquidity stress testing is well advanced and comprehensive. The HKMA regularly runs four liquidity stress tests based on four scenarios: (i) the market-wide liquidity freeze scenario and (ii) the short-term confidence-driven bank run scenario are run on a quarterly basis; (iii) the USD and capital outflow scenario and (iv) the combined market and idiosyncratic shock scenario are run at a monthly frequency. The stress test horizon is 1 month, except for the short-term confidence-driven bank run scenario, which covers a seven-day stress period. The calibration is based on historical event studies.[49] The liquidity stress tests are well integrated into the supervisory process. It can lead to follow-up action in the form of thematic reviews. Thematic reviews address specific liquidity risk topics in detail in the context of on-site supervision (such as USD liquidity risk reviews in 2017 and 2018). The availability of reporting data for liquidity stress tests is high, though the data on securities flows and behavioral flows could be improved along the lines of a fully integrated reporting template for contractual and behavioral cash- and securities flows. A split into the overall currency position and those in major foreign currencies could also be envisaged. A liquidity assessment (HKD, USD, CNY) is also integrated into the half-yearly financial stability report of the HKMA.

117. The FSAP analysis indicates that HKSAR banking system is resilient to liquidity stress. Especially the local banking system has sufficient liquidity buffers to cover the outflows in the scenarios, although the contractual maturity of the deposit base is short. The availability of HKD-denominated high-quality liquid assets (HQLA[50]) in HKSAR is limited and the HKMA applies an Alternative Liquid Asset (ALA) approach under the LCR. Under stress, banks would have to rely on their Counterbalancing Capacity. After haircuts, about 20 percent there the capacity (or about 4 percent of bank assets) consists of either direct (Exchange Fund debt securities) or indirect (e.g., HK Mortgage Corporation) claims on the Exchange Fund. The Exchange Fund amounts to about 9 per cent of total bank assets and could absorb even systemic bank liquidity shocks.[51] System-wide dislocations in FX swap markets could expose banks to FX liquidity risk. Since the HKMA runs a large excess coverage of its currency board requirements, it has significant FX buffers to draw on in a potential systemic stress event.

118. The FSAP recommends that the authorities consider incentivizing banks to lengthen and stagger the funding tenor of the deposit base. While this could increase the cost of funding for banks, it would strengthen depositor confidence and the confidence of international investors in the stability of the banking system with respect to liquidity risk. Currently, banks have no incentive to pay higher rates for longer-term deposits to shift more of the deposits from demand into term. One of the reasons is the very high level of global liquidity due to QE and the free implicit liquidity guarantee provided by the HKMA as lender of last resort. This form of moral hazard could be addressed by a number of instruments, such as supervisory expectations for lengthening and

[49] HKMA (1998), "The impact of the Asian Crisis on the Hong Kong Banking Sector", Quarterly Bulletin (August).

[50] According to the definition in the context of the LCR.

[51] The HKMA has been sterilizing substantial capital inflows since 2009 and, as a result, it is running a large excess coverage on top of the regulatory backing. As of December 2020, the HKMA's foreign reserves stood at USD 491 billion, corresponding to almost fifty percent of HKD M3.

staggering deposit funding, ex-ante pricing of the lender of last resort facility (see for example the approach of the Australian Reserve Bank, which provides a priced liquidity line to banks) or differentiated required reserve ratios based on deposits maturity. Alternatively, liquidity regulation or the pricing of deposit insurance premia could be employed.

119. Some of the foreign branches are more vulnerable to liquidity stress. This is largely due to their higher reliance on unsecured interbank funding. The HKMA tries to ascertain the reliance on headquarters overseas; it conducts regular tests and drills in this respect with foreign branches. The most straightforward way to ascertain the funding commitment of overseas HQ would be to lengthen and stagger the tenors of unsecured interbank funding from HQs (and from other banks). This would improve the resilience of foreign branches under liquidity stress. To the extent that the funding stems from their own overseas headquarter, that measure would reduce the import of liquidity risk from the home country of the HQ to HKSAR. As such, it would contribute to financial stability in HKSAR. The HKMA's actions regarding the unsecured lending of HK subsidiaries to HK branches of the same overseas banks – i.e. intragroup lending limits – are welcome.

120. The sizeable share of mortgage loans in banks' unencumbered portfolios could be liquefied by the introduction of an HK covered bond regime. This would reduce the indirect exposure of the HKMA via the HKMC. In their resolution plans, banks explicitly state that they would sell mortgages to the HKMC. Given the high share of mortgages in bank unencumbered assets, the burden for the HKMC - and indirectly for the HKMA can be high – which an additional funding option could reduce. Particularly under stress, covered bonds can be a substitute for less stable unsecured funding sources. Cross-country experience shows that, covered bonds provided relatively stable funding at reasonable funding costs under stress in other jurisdictions. Given the high reliance of HKSAR banks on their Counterbalancing Capacity (CBC) under stress and the implications for systemic liquidity under LERS, a reduction of the reliance on the CBC would contribute to the stability of the overall system. The liquidity risk exposure of the HK Mortgage Corporation and the indirect pressure on the Exchange Fund would be reduced. In normal times, covered bonds provide an additional and low-cost funding source for the system. Finally, covered bonds would increase the volume and diversification of HQLA in HKSAR, which would particularly beneficial as HKSAR is a jurisdiction with a low supply of HQLA. Successful funding operations under stress can contribute substantially to investor and depositor confidence and, thus, to the resilience of the financial system to liquidity stress without recourse to the HKMA.

121. Similarly, a liquid, deep, and broad repo market can provide valuable alternative funding under stress. Currently, banks have little incentive to secure transactions, as the lender of last resort function of the HKMA is not priced and can be perceived as implicit liquidity backstop of the system provided by the HKMA. Encouraging further the evolution of this market can reduce the liquidity risk exposure of the backstop and increase the self-healing capacity of the system under stress. In fact, this matches banks expectations, as switching to from unsecured funding to repos constitutes a key component of HK banks' resolution plans.

122. In terms of liquidity risk, the HK banking system went through the COVID-19 pandemic quite well. The FSAP team ran the liquidity risk assessment based on December 2018 data as well as on June 2020 data. This provides a unique opportunity for a comparison across time.

i. **The balance sheet structure has remained quite stable**, although a marginal shift from interbank assets towards loans to non-banks and other assets is observable. On the liability side, interbank liabilities decreased and other liabilities (incl. capital) increased. The lower reliance on unsecured interbank funding reduced liquidity risk exposure.

ii. **Since the outbreak of COVID-19 in Q1 2020, both short-term regulatory liquidity ratios remained quite stable**. In June 2020, the average LCR decreased by 10 percentage points from its peak point in December 2018 to about 157 percent, which is just above its average level of the past five years (2015-2019). At the same time, the LMR increased by about 3 percentage points from December 2018 to 57.2 percent in June 2020.

iii. **The contractual inflows and outflows arising from derivatives contracts in the first 6 months of the maturity mismatch template declined significantly**. The contractual outflows from deposit funding remained basically unchanged, but their composition shifted somewhat further towards overnight. While the former reduced roll-over risk significantly, the latter increased it somewhat.

iv. **The composition of unencumbered assets shifted somewhat to less liquid assets**, such as mortgages (local banks) and other investment grade securities (foreign branches).

v. **The liquidity stress tests show a mix assessment of the changes since December 2018**. The approach allows for the condensation of these changes into an overall assessment: the results improve somewhat for the local banks in the stress test horizons 1 week and 1 month; for the foreign branches the results are somewhat weaker. In the three months horizon, the results are somewhat weaker for both sets of banks. This is largely due to the lower CBC at the beginning of the period and the higher outflows due to non-bank deposits.

123. The HKMA supported the resilience of the HK banking system with respect to liquidity risk by the pro-active and the clear communication that the LCR is a buffer usable under stress and a series of systemic liquidity measures.

Recommendations

The authorities should consider the following recommendations, to increase further the liquidity resilience of the banking system.

124. Streamline the requirements for liquidity monitoring and liquidity stress testing. Currently, the HKMA collects a substantial amount of data to monitor liquidity risk and to run liquidity stress tests. However, data are dispersed across various HKMA returns (esp. MA(BS)1, MA(BS)1E, MA(BS)18, MA(BS)23). The definitions of items, the currency split, the granularity of sub-items as well as the availability of remaining contractual maturities differ across returns. The authorities should, therefore, consider streamlining the cash-flow/securities-flow reporting in MA(BS)23 and MA(BS)18 and integrating all existing liquidity stress-tests into a single framework that is in line with LCR. This alignment would reduce the reporting costs for banks, especially for large internationally active banks, as the LCR is a global standard. The new reporting template should allow for a clear distinction between HQLA Level 1, 2A and 2B and other CB eligible and other

non-CB eligible assets. Since the contractual maturity mismatch is intrinsically large for banks, the question necessarily emerges how banks plan to fund it. The behavioral flows provide additional information about banks reactions to changes in the underlying market conditions. Stress tests based on contractual data require a two-step approach: first, supervisors have to derive the "business as usual" liquidity situation based on their own assumptions; second, they stress this unstressed liquidity profile. If behavioral flows are available, supervisors can stress these directly.

125. Integration of all four HKMA liquidity stress tests in one framework and with the LCR. Once comprehensive cash-flows and securities flows reporting data is available in different currencies, supervisors can complement the implied cash-flow cum liquidity coverage approach to stress testing with the cash-flow/securities-flow based stress test cum counterbalancing capacity approach. They would then also be in a better position to add stress horizons beyond 1 month (i.e. 3 and 12 months). The integration with the LCR would allow the HKMA also to monitor the build-up of cliff-effects after 30 days.

126. The HKMA should continue to incentivize banks to diversify funding sources, lengthen and stagger funding tenors of the deposit base. The Hong Kong banking system heavily relies on short-term deposit funding. While retail and non-financial wholesale deposits provide a number of advantages from a financial stability point of view (e.g. relative stickiness), they are often short-term and term deposits are subject to early withdrawal risk. The contractual maturity of derivative flows is also short. While the respective in- and out-flows largely cancel out at the system level, the gross flows are substantial. Lengthening and staggering the tenors of the underlying contracts would improve confidence, particularly under stress conditions. Apart from existing measures to monitor and supervise banks' funding profile, the HKMA may consider other measures such as supervisory expectations and internal limits on short-term contractual cash-outflows.

127. The authorities should support the development of funding sources that are more likely to be available also under stress. These sources could include broad and deep repo markets as well as the development of safe assets to reduce the shortage of high-quality liquid assets in HK (e.g. a covered bond regime). Under stress, secured funding sources, such as repo or covered bonds, can be important and less expensive substitutes for unsecured funding, if the infrastructure is in place and the funding sources are also tapped regularly under unstressed conditions. In this respect, the authorities might consider the introduction of a Hong Kong covered bonds regime. The latter would also contribute to alleviating the HQLA shortage in HKSAR.

128. The FSAP appreciates the HKMA efforts to investigate banks' practices regarding the classification of operational deposits[52]. The materiality tests above demonstrate that the reclassification risk for operational deposits is material. Banks' liquidity position might be less stable under stress than the LCR insinuates. The supervisory review is an adequate instrument to address this risk by ensuring that the criteria applicable to operational deposits are applied rigorously by all banks, that banks have measures in place to monitor the behavior of these deposits, and that banks

[52] According to section 5.8.20 LM-1 and section 7(1) of the Code of Bank Practices.

react swiftly to reclassify those deposits for which the behavior is more akin to non-operational deposits than to operational deposits.

129. The HKMA should analyze the early redemption risk for time deposits and banks' measures to address early redemption risk[53]. The materiality tests above demonstrate that early withdrawal risk is material. Retail deposits might be less stable than expected and banks liquidity position might be less stable under stress than the LCR insinuates. The supervisory review is an adequate instrument to address this risk by ensuring that the banks policies and practices (incl. the significant penalty for early withdrawal) are effective. The review should draw on banks' historical data relating to early withdrawal risk in normal or stressed situations.

130. Given the important role of the HKMA in banks liquidity risk management, the authorities should consider measures to address moral hazard, stemming from potential market perception that, under stress, the HKMA, acting as the lender of last resort, would provide support. The recent reorganization of the liquidity facilities at the HKMA has not clarified the maximum capacity of the HKMA to step in to support financial institutions in Hong Kong. This may lead market participants to believe that the HKMA would be able to support them in all circumstances. However, the HKMA has specified in its policy statement that liquidity support to banks would be provided on a collateralized basis and the terms and conditions would be considered case by case. This unpriced liquidity insurance might lead to an inefficient excessive liquidity risk exposure of HKSAR banks.

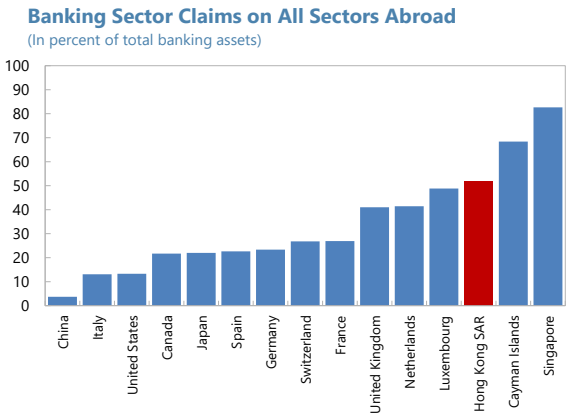
INTERCONNECTEDNESS AND CONTAGION ANALYSIS

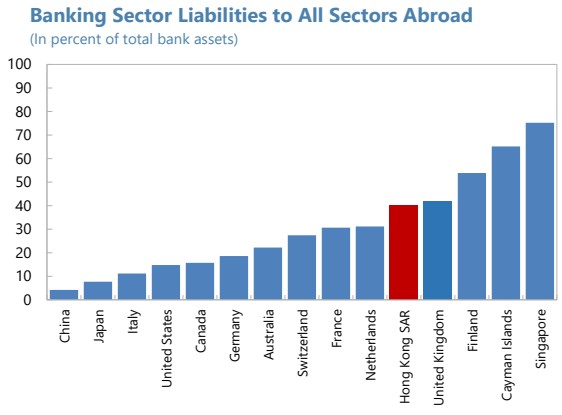
A. Background

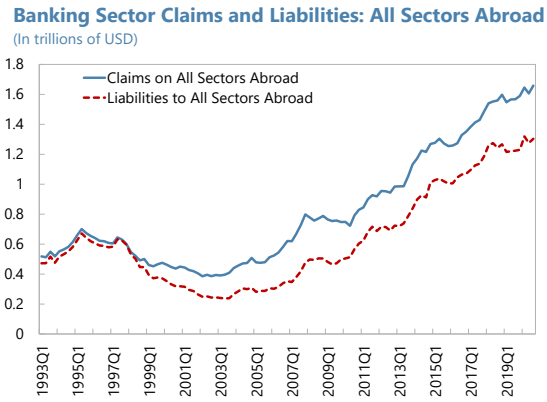
131. HKSAR's banking sector has one of the highest levels of cross-border exposures in the world. BIS locational banking statistics indicate that HKSAR banks' cross-border exposures to counterparties are significantly higher on the asset side, with total cross-border claims exceeding liabilities by close to 30 percent in 2019. This pattern is observed consistently in the data since the Asian Financial Crisis (AFC). In the years leading to the AFC, HKSAR banks have been in a net borrowing position with respect to other banking sectors abroad. However, with the onset of the AFC, HKSAR banks sharply reduced their cross-border liabilities and have been a net lender to other banking sectors abroad since late 1999 (Figure 32).

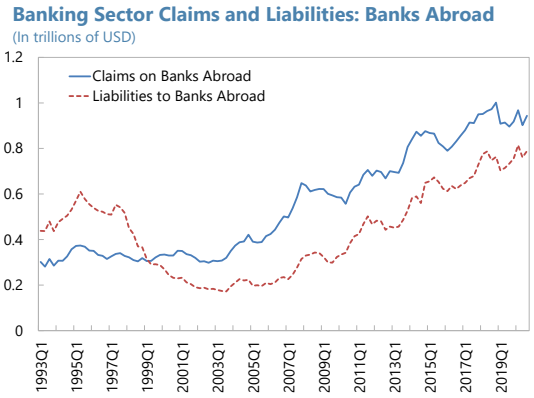
[53] For example, the material penalty for early withdrawal of term deposits) based on section 5.8.13 -14 of the Regulatory Framework for Supervision of Liquidity Risk (LM-1).

Figure 32. Hong Kong SAR: Banking Sector Cross-border Claims and Liabilities





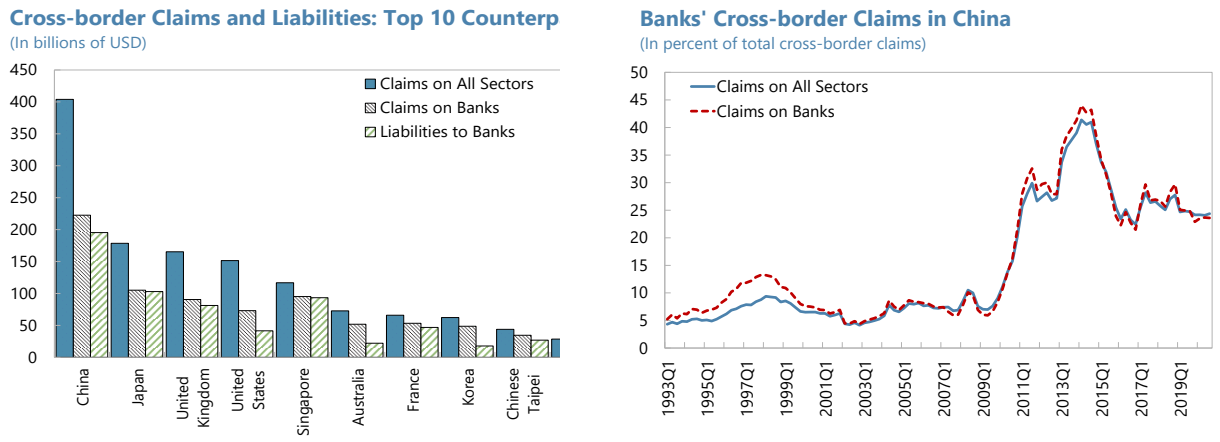




Source: BIS Locational Banking Statistics.

133. Mainland China's banking sector receives the largest share of HKSAR's cross-border lending by far. HKSAR lending to Mainland China increased substantially after the GFC, in parallel with the fast credit growth in Mainland China during that period. Mainland China's share within total HKSAR cross-border lending went up from less than 10 percent in 2009 to close to 25 percent in recent years (Figure 33). This is consistent with HKSAR serving as a financial gateway for Mainland China. At the same time, large interbank claims to the Mainland China banking system add to HKSAR's significant non-financial sector loan exposures there[54] and increase the total interconnectedness between HKSAR banking system's and Mainland China.

Figure 33. Hong Kong SAR: Banking Sector's Main Cross-border Counterparties



Source: BIS Locational Banking Statistics.

134. A significant portion of the cross-border interbank lending from HKSAR is intermediated by foreign branches. Despite being substantially smaller than the local banking sector, foreign branches account for a majority of total cross-border interbank claims.

135. A closer look at foreign branches' cross-border lending reveals that a large majority of their cross-border interbank claims are on "related offices." These are entities that are part of the same banking group (parent, branches, and subsidiaries). Together with the related office lending of local banks, the share of total related office claims account for majority of HKSAR's total cross-border interbank claims. This pattern indicates that international banks in HKSAR, *especially the foreign branches*, use HKSAR as a source of funding and lend abroad for their global operations.

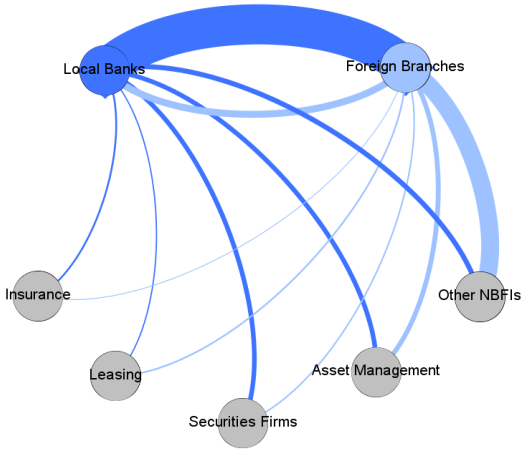
Domestic Financial Connectedness

136. Domestic financial system exposures of HKSAR banks reveal strong fund flows from local banks to foreign branches and from foreign branches to nonbank financial institutions (Figure 34). There is a very active interbank market with exposures corresponding to significant amounts relative to the banks' balance sheets (see the domestic contagion analysis below).

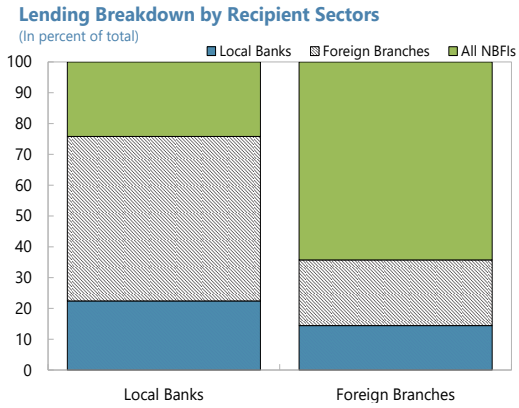
[54] Close to 40 percent of all (non-bank) customer loans of the HKSAR's total banking system are Mainland China-related loans.

Figure 34. Hong Kong SAR: Domestic Financial System Interconnectedness

1. Domestic Financial System Exposures of Banks



2. Intra-financial System Lending by Recipient Sectors



Source: Bank-level data, IMF staff calculations.

Note: In Panel 1, dark blue lines represent lending from Local Banks to other financial sectors. Light blue lines represent lending from Foreign Branches to other financial sectors. The domestic connectedness analysis is based on the bank-level data submitted by a sample of the 20 largest banks (including foreign branches), ranked by assets held by their HKSAR offices.

137. The largest portion of local banks' intra-financial system lending goes to foreign branches, which account for more than 53 percent[55]. Interbank lending to local banks and lending to nonbank financial institutions (NBFIs) account for just over 20 percent each. Foreign branches, on the other hand, are much more exposed to NBFIs, which account for 64 percent of their intra-financial system lending (Figure 34). While the FSAP team does not have a full breakdown of the list of NBFI borrowers of foreign branches, several banks list financing arms or investment vehicles that belong to group companies of corporate borrowers. Some of these NBFIs are likely to be lenders to corporates borrowers.

138. Foreign branches could be a source of significant spillovers to other financial sectors both at home and abroad. The cross-border and domestic intra-financial system lending data suggest that foreign branches in HKSAR source funding from local banks and extend significant amounts of lending to other financial entities: NBFIs in HKSAR and other banking systems abroad.

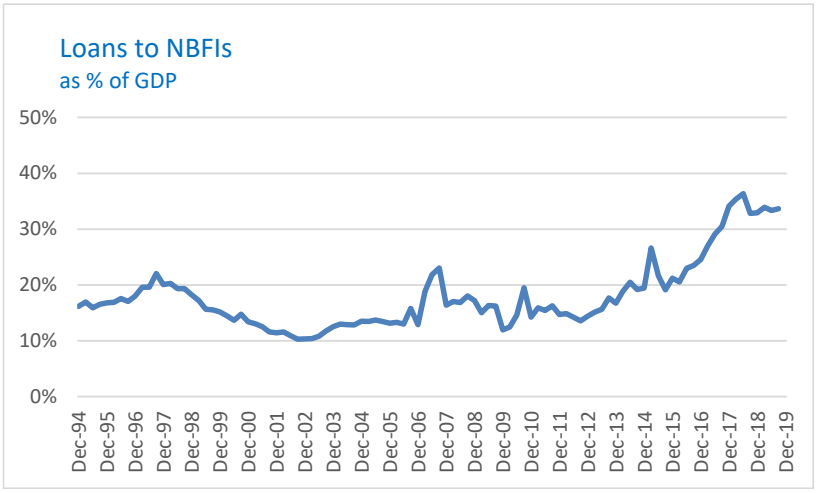
139. At the time of the FSAP there was no available data on certain sector-by-sector exposures between non-bank sectors that would otherwise enable mapping some of the key financial linkages in the whole system. The domestic interconnectedness analysis was based on partial information on the exposures of the banking system (local banks and foreign branches) on

[55] The domestic connectedness analysis is based on the bank-level data submitted by a sample of twenty banks, including local banks foreign branches, which are the twenty largest banks ranked by the assets held by their HKSAR offices.

the other sectors. The ideal dataset would have been the who-to-whom exposures across all major sectors of the economy: banking system, NBFIs, non-financial corporates, households, government sector, and the rest of the world.

140. The data gaps in HKSAR could potentially limit the ability of policymakers to identify build-up of financial stability risks that do not originate directly from the banking sector. The foreign branches are a major provider of funds to the NBFIs, some of which are potentially lenders to corporates or households. The NBFI borrowing from the banks has started increasing in recent years, with the NBFI loans-to-GDP ratio increasing by close to 20 percentage points since 2012 and reaching 34 percent recently (Figure 35). A build-up of indebtedness in the corporate or the household sectors, beyond the loans provided by the banking system, may not be detected in a timely manner and may reduce the effectiveness of macroprudential measures applied to the banking sector and increase the indirect exposures of the banking sector to other sectors of the economy.

Figure 35. Hong Kong SAR: Banking Sector Loans to NBFIs



Source: Source: Bank-level data, IMF staff calculations.

B. Contagion Analysis

Domestic Contagion Analysis

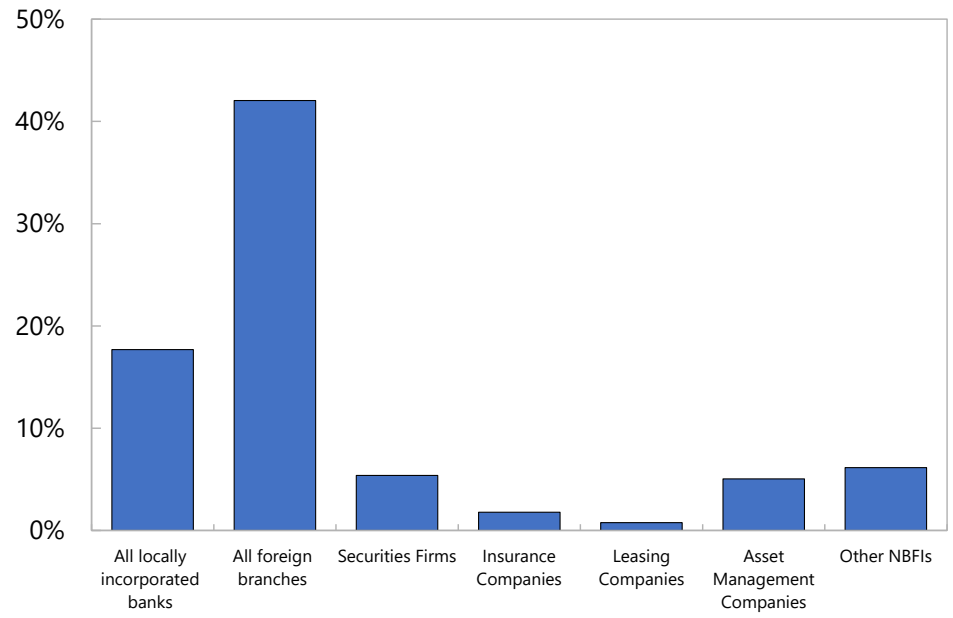
141. The domestic contagion analysis investigated the potential for contagion between local banks and other financial institutions in HKSAR, using bank-level data provided by banks in the sample. Given the substantial size of the local banking system in HKSAR relative to the GDP and the importance of bank funding for the non-financial sectors, an adverse shock to banks from within the financial system could have significant effects on the rest of the economy.

142. While local banks' direct exposure to NBFI sectors are modest, their direct exposure to other banks, especially to foreign branches, is significant. The domestic contagion analysis first

considered the impact of the failure of other sectors, treating each sector as a single combined entity, on the combined set of local banks in the sample (considering their combined capital). Figure 36 shows that local banks' direct exposures to NBFIs are modest, with the exposures to each NBFI sector amounting to around 5 percent, or less, of the banks' CET1 capital. The exposures to other banks, however, is much higher, especially with the total exposure to the group of foreign branches at just over 42 percent of total CET1 capital. The interbank lending exposures to other local banks amounts for less than 18 percent of total CET1 capital of local banks.

Figure 36. Hong Kong SAR: Local Banks' Exposure to the Financial System

Local Banks' Exposures to Other Financial Sectors
(In percent of total CET1 Capital)



Source: Bank-level data, IMF staff calculations.

143. Most interbank lending is short-term, with maturities of three months or less. Among the sample of banks, more than half of total domestic interbank lending has a maturity of one month or less, and more than seventy percent has a maturity of three months or less. While most interbank lending is short-term, the large absolute size of the flows warrants closer investigation.

144. A bank-by-bank analysis of the potential impact of interbank defaults indicate that the distribution of interbank exposures is highly skewed with large outliers. Note that Figure 36 above, treated other banks as a single combined entity and assessed the impact of the failure of this combined entity on the combined set of local banks, ignoring the bank-level variation in the sample. The FSAP team also investigated the impact of individual failures on each local bank. At the median of the sample, the maximum impact of the failure of other individual banks[56] is 7 percent of CET1

[56] With an LGD assumption of 100 percent.

capital for the lender bank. However, for a few banks the maximum impact is much higher with the highest impact exceeding 100 percent of CET1 capital for the bank with the largest exposures.

145. A closer look at interbank positions reveals that most of the outsized positions are between related offices. That is, some local banks which are subsidiaries of international banks have large exposures to foreign branches that belong the same banking group as themselves. These exposures could be related to business model specialization or correspondent bank relationship between the local bank subsidiary and the foreign branch that co-exist in HKSAR. Since these exposures are between intragroup entities, they are exempt from statutory intra-group exposure limits under the Banking (Exposure Limits) Rules (BELR), but HKMA asks banks to establish internal limits for intra-group exposures as appropriate. With these intra-group transactions, the ultimate exposure is to the global parent and hence the credit risk could be deemed to be very low. At the same time, large intragroup positions may expose local banks to potential liquidity problems faced by other group entities. For example, during times of market stress a bank may need to provide liquidity support to another entity that belongs to the same group. Similarly, a bank may suffer from reputational risk following an adverse shock experienced by other group entities. The risk could be reflected in the form of reduced interbank liquidity for the bank that is not affected by the initial shock to other group entities. This highlights the importance of heightened monitoring by the HKMA of liquidity risk both at the group and at the entity level for banks that operate with multiple group entities in HKSAR.[57]

146. The significant interbank flows from local banks to foreign branches, whether between same group entities or unrelated ones, creates indirect linkages between the local banks and other sectors of the economy. Local banks have access to a very strong base of local deposits in HKSAR. The interbank market provides a venue for liquidity management and enables local banks to deploy short-term excess funding. At the same time, foreign branches source funding from local banks and lend to large corporates and NBFIs, some of which provide household loans. These indirect linkages between local banks and other sectors have the potential to create leakages for any regulation that aims to mitigate build-up of risks in the economy. For example, the effectiveness of a capital-based regulation aiming to mitigate risks related to bank lending to certain groups of nonfinancial corporates may be reduced, if a portion of the lending shifts from local banks to foreign branches. This highlights the importance of oversight over banking groups that have both foreign branches and local subsidiaries in HKSAR.

Cross-border Contagion Analysis - Balance Sheet-based Approach

147. The cross-border contagion analysis aimed at assessing the HKSAR banking system's resilience to shocks from other banking systems as well as its potential to act as a source of shock to other banking systems. Stress abroad could affect HKSAR banks through a credit shock to their claims on cross-border counterparts. Similarly, a funding shock from abroad may cause funding strains on HKSAR banks' and force fire sales and potential losses. The analysis used the network contagion framework of Espinosa-Vega and Sole (2010). An initial shock to a jurisdiction's

[57] HKMA's requirements on intragroup liquidity risk management are described in the Supervisory Policy Manual LM-2 on "Sound Systems and Controls for Liquidity Risk Management."

banking system could be propagated through direct claims between banking systems and could lead to distress in other banking systems that are not directly linked to the initial source of shock, via indirect linkages via other jurisdictions' banking systems. If any banking system incurs losses larger than their capital base, it is deemed to "fail." This failure can subsequently cause other banking systems to fail, via credit or funding shocks to its counterparts. The numerical analysis used cross-border interbank claims and liabilities of 33 banking systems as reported in the BIS locational banking statistics.

148. The analysis used two contagion scenarios. Scenario 1 simulates a credit shock. The simulated failure of a banking system will lead to credit losses for any system that has claims against the failing system. The scenario assumes a 100 percent loss rate on claims against a failing counterparty. Scenario 2 simulates a combination of credit and funding shocks. The credit shock is the same one described in Scenario 1 above. In addition, the scenario assumes that a shock to a banking system will lead to the loss of funding for all other banking systems borrowing from the initial system that received the shock and force them to replace their funding with alternative sources. The fraction of lost funding that is not replaceable is assumed to be 35 percent (i.e., 65 percent rollover). In addition, this reduction in funding is assumed to result in the fire sale of assets by the affected systems with a haircut of 25 percent.

149. The results indicate that HKSAR's banking sector is more vulnerable to credit shocks from abroad than to funding shocks. Index of Vulnerability (Figure 37) is a measure of inward spillover and it represents the average share of capital lost for the reported bank due to the failure of other banking systems. The results of Scenario 1 show that HKSAR's banking system is among the systems with highest vulnerabilities to credit shocks from abroad. The results are intuitive given that HKSAR's banking system has one of the highest levels of cross-border asset exposures on other systems.[58] The average impact of other banking systems' failure on HKSAR is a loss of about 13 percent of its initial capital. Index of Contagion is a measure of outward spillover and it represents the average share of capital lost for the other banking systems due to the failure of the reported system. The figure shows that HKSAR's banking system is among the systems with high estimated impacts on other systems, but its ranking is lower compared to that implied by the Index of Vulnerability. HKSAR's hypothetical failure would lead to an average loss of about 6 percent of capital for other systems' that have asset exposures to HKSAR. The lower outward spillover potential (contagion) compared to its vulnerability to inward spillovers, is in line with the fact that HKSAR banking system's cross-border exposures to counterparties are significantly lower on the liability side compared to its exposures on the asset side.

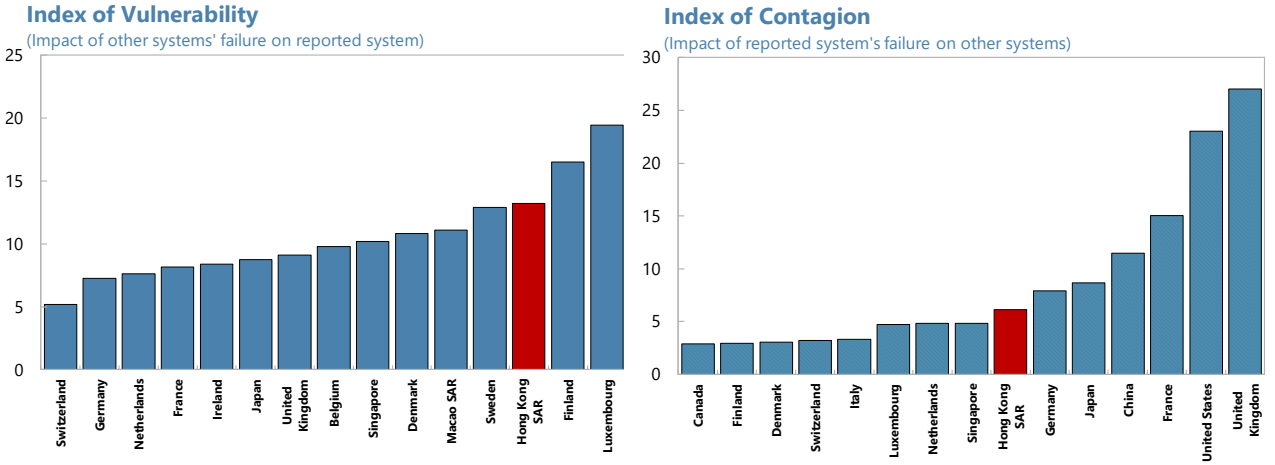
150. The results of the Scenario 2 show that the additional impact of loss of funding on top of credit shock is relatively mild for HKSAR. The patterns from Scenario 2 are similar those observed under Scenario 1. HKSAR's banking system is again among the systems with highest vulnerabilities to credit shocks from abroad and it has a lower outward spillover potential compared to its vulnerability to inward spillovers. Moreover, the average losses of HKSAR's banking system

[58] Note that this analysis does not assess the credit quality or likelihood of defaults of the exposures. It simply assumes the failure of counterparties one at a time and reports the average impact on creditors based on the 100 percent LGD assumption.

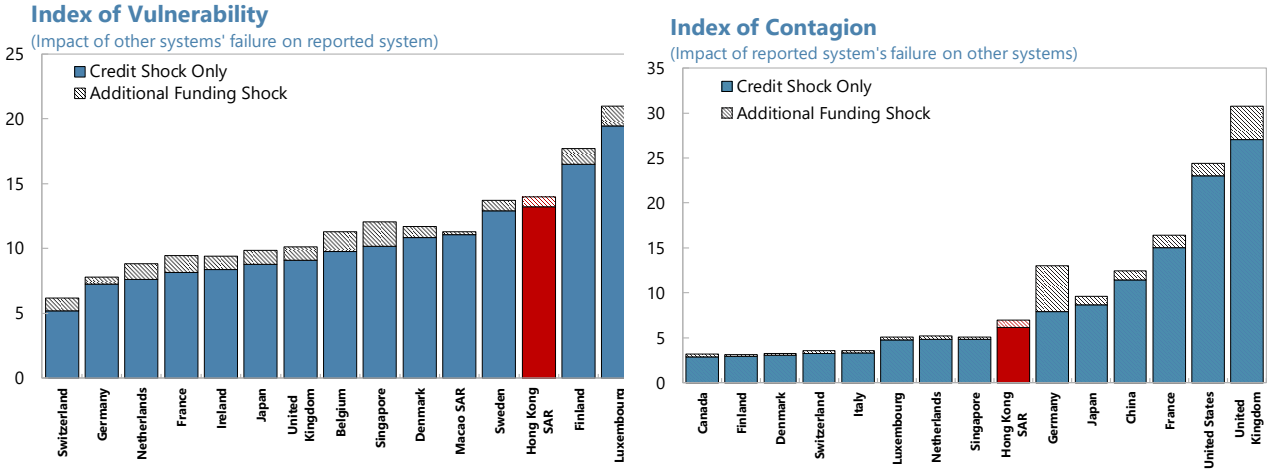
goes up only by a modest amount (less than six percent of the base losses) when the additional funding shock is layered onto Scenario 1. This small increase in losses is due to the fact that HKSAR's cross-border exposures to counterparties are significantly lower on the liability side compared to its exposures on the asset side.

Figure 37. Hong Kong SAR: Cross-border Contagion Analysis

Scenario 1: Credit shock only



Scenario 2: Credit and funding shocks



Source: BIS Locational Banking Statistics, IMF estimates.

Cross-border Contagion Analysis – Market-based Approach

151. Market-based approaches try to capture indirect linkages between financial institutions or systems. Different institutions may have similar business models or common exposures to same products or markets. If a particular institution receives a shock, market

participants may revise their expectations about other institutions that have similar business models or common exposures as the bank in distress, even though there may be limited direct linkages between the institutions. This indirect linkage channel is captured via equity prices of the banks, which reflect investors' perception of the transmission of risk among banks.[59]

152. The spillover approach developed by Diebold and Yilmaz (2014) utilizes directional interconnectedness measures to estimate the contribution of individual institutions to systemic risk. Using a Vector Autoregression (VAR) model, the approach decomposes the variation in an asset's volatility into contributions from shocks to other assets. A financial market spillover from institution A to institution B is broadly defined as the share of the variation in institution B's equity return shocks that can be attributed to contemporaneous or preceding shocks in institution B's equity returns. When aggregated across institutions, the inward-spillover measure indicates the exposure of an individual bank to systemic shocks from the network, while the outward-spillover measure captures contributions of individual banks to systemic shocks in the network. The pattern and direction of transmission of financial stress among institutions could be analyzed using measures of gross contribution and net contribution.[60] A positive value of net contribution indicates that the bank is a net originator of financial spillovers while a negative value of net contribution indicates that the bank is a net recipient of financial spillovers. The FSAP calculated the spillover measures using daily volatility of equity returns for the sample of G-SIBs[61], many of which have substantial presence in HKSAR, and five publicly traded HKSAR banks.

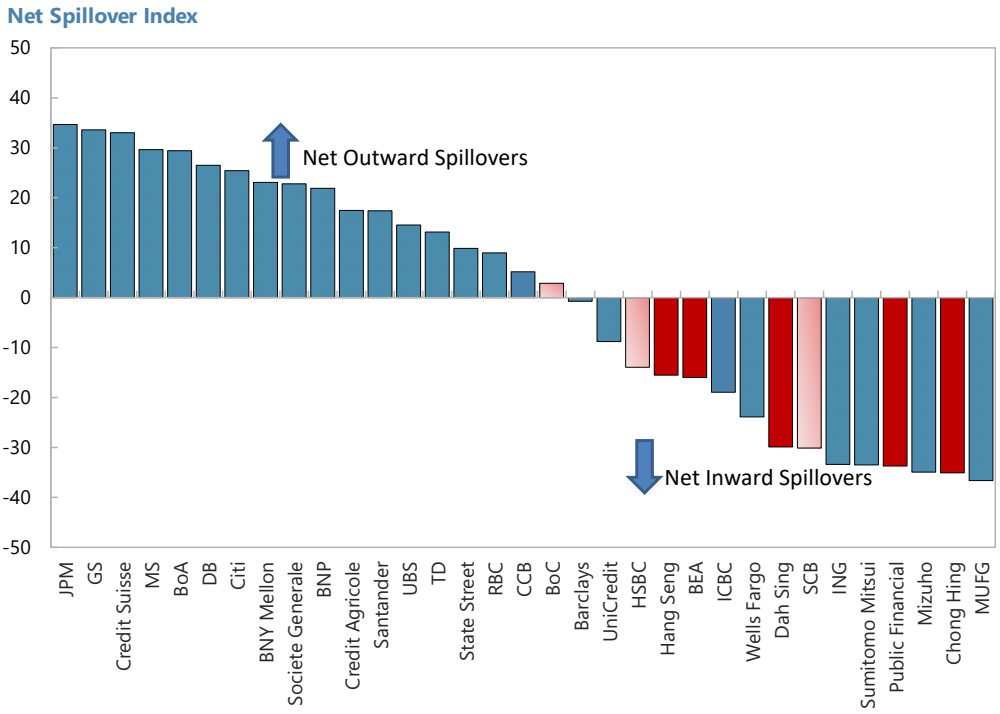
153. The D-SIBs in HKSAR appear to be a key recipient of spillovers from GSIBs as measured by bilateral linkages (Figure 38). The analysis of spillovers across major banks in HKSAR and other GSIBs indicates that HKSAR banks are generally net recipients of shocks from GSIBs in the US and the Euro Area. This result is in line with the exposure-based contagion analysis discussed above which indicated that HKSAR's banking system had a lower outward spillover potential compared to its vulnerability to inward spillovers. An important caveat of this analysis is that most HKSAR banks used in this analysis are subsidiaries of large international banking groups and the equity prices used are those of the global parents, rather than prices of local subsidiaries. Hence the reported spillover estimates for these banks are not fully attributable to the local banking system conditions in HKSAR.

[59] At the same time, stock returns may move together during crisis times and extreme risk-off sentiment or due to trading requirements (e.g., short covering) and the observed co-movement may not be entirely due to fundamental linkages and interconnections. For this reason, the results of the market-based interconnectedness analysis should be evaluated in combination with balance sheet-based approaches.

[60] Gross contribution of each institution is a total of the institution's outward spillovers to other institutions and other institutions' spillover to the institution. Net contribution of each institution is a difference between the institution's total outward spillover to other institutions and other institutions' total spillover to the institution.

[61] As identified by the FSB as of November 2020.

Figure 38. Hong Kong SAR: Interconnectedness Between HKSAR Banks and G-SIBs



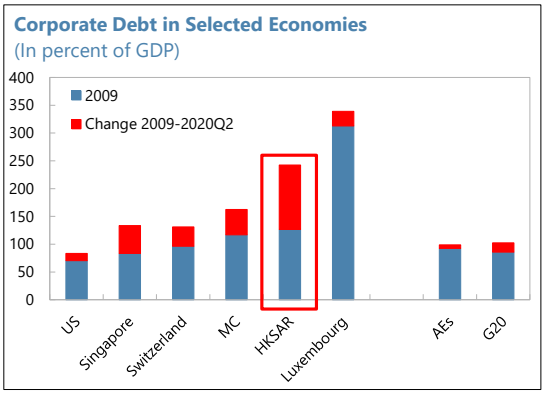
Source: Bloomberg, IMF staff calculations.

Notes: Blue bars are G-SIBs, light red bars are G-SIBs whose HKSAR subsidiaries account for a significant share of their total assets, dark red bars are local HKSAR banks.

154. The FSAP makes several recommendations related to further enhance banking system stability. First, the FSAP recommends enhancing HKMA's data collection of intersectoral claims across major sectors of the economy (banking, NBFIs, non-financial corporates, households, government, and the rest of the world) with a focus on claims of the NBFI, which that would allow to better gauge the importance of intersectoral linkages and to develop an aggregate balance sheet approach in systemic risk assessment. Second, enhanced oversight over banking groups that have both foreign branches and local subsidiaries in HKSAR would further improve the authorities' ability to monitor and mitigate risks, given their potential for contagion. Third, the FSAP recommends heightened monitoring of liquidity risk both at the group and entity level for banks that operate with multiple group entities in HKSAR to ensure that banks adhere to internal risk management practices.

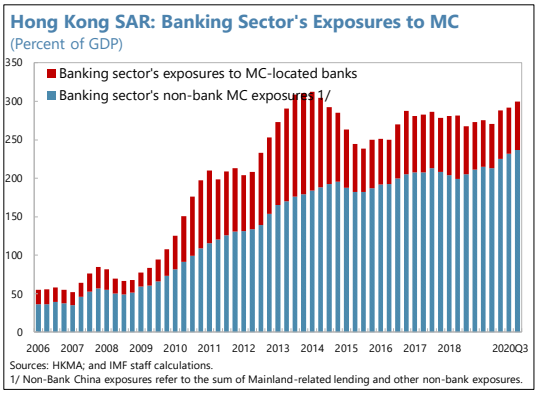
CORPORATE SECTOR ANALYSIS

A. Recent Developments



155. Corporate debt has increased rapidly in HKSAR since the Global Financial Crisis (GFC). Easy global financial conditions after the GFC have extended the corporate credit cycle with further financial risk-taking by firms and continued buildup of debt (IMF, 2019a). As a global financial center with free capital movement, HKSAR also experienced a prolonged corporate credit cycle as it provides a fund-raising platform for both local firms and firms from Mainland China (MC). As a result, HKSAR's non-financial corporate debt increased rapidly from 127 percent of GDP in 2009 to 243 percent in 2020Q2, which remains significantly higher than the average of advanced economies with the increase since the GFC exceeding most advanced economies and peer financial centers.[62] Less than half of that borrowing was intended for use in HKSAR, with the remainder being cross-border credit, mostly to MC firms.

B. Key Vulnerabilities and Risks



156. Given the large presence of Mainland China firms in HKSAR, vulnerabilities in both local and Mainland China firms in HKSAR are important for HKSAR's financial stability. As a global financial center, HKSAR provides an important fundraising platform for Mainland China firms while offering a full range of asset management services. In recent years, HKSAR's banking sector has become increasingly active in Mainland-related lending, which accounted for nearly 40 percent of total bank loans as of September 2020. HKSAR's banking sector exposures to Mainland China's non-banks (mostly firms) increased to HK$6.5 trillion by end-September 2020 (about 237 percent of GDP) and accounted for the majority of total banking sector exposures to Mainland China (text figure). Despite the COVID-19 pandemic, those firms raised a total of US$84 billion equity through HKSAR stock exchanges in 2020, equivalent to 88 percent of total equity fund raised in HKSAR, and issued a total of US$128 billion USD-denominated bonds in HKSAR over the same period, accounting for more than 60 percent of total offshore issuances by Mainland China firms. As a result, deteriorations in corporate balance sheets

[62] The non-financial corporate debt-to-GDP ratio should be interpreted with caution as it tends to overstate the corporate leverage in HKSAR and affected by lower GDP in 2020. This is mainly due to the fact that HKSAR is an international financial center and therefore many multinational and non-local corporates (including from MC) borrow funds from HKSAR to finance their overseas operations. Their economic activities and thus incomes are not fully reflected in HKSAR's GDP.

driven by, for example, weaker Mainland China growth, could reduce asset prices and increase credit risk for financial institutions in HKSAR.

C. Firm-Level Analyses

157. We assess the vulnerabilities of HKSAR's non-financial corporate sector and its resilience to adverse shocks using scenario-based firm-level analyses. Given the importance of Mainland China firms in HKSAR, two types of listed firms are considered in the analyses.[63] The first type is the real "local" firms that are domiciled in HKSAR, listed in HKSAR stock exchanges, and mainly exposed to HKSAR (denoted as HKSAR-oriented firms).[64] The second type is the firms that are listed in HKSAR, domiciled in either HKSAR or Mainland China, but exposed to Mainland China, denoted as Mainland China-oriented (MC-oriented) firms. Using the firm-level data, the following scenario-based analyses are conducted to assess the resilience of the non-financial corporate sector:[65]

- *Debt-at-risk analysis*,[66] which uses firms' balance sheet and cashflow data to assess to what extent the overall corporate sector vulnerabilities (i.e., debt repayment capacity) have changed over time, examine which sectors are the most vulnerable to shocks in the adverse macroeconomic scenario of the bank stress test, and estimate the impact of the adverse shocks on the ICR-implied default risk by sector.

- *Bottom-up default analysis (BuDA)*, which uses both market-based information and balance sheet indicators to estimate the corporate default risk, assess the sensitivity of corporate defaults to shocks in the adverse macroeconomic scenario, and identify which sectors are the most vulnerable to the adverse shocks (Duan *et al.*, 2015).

[63] Only listed firms are included in the analysis because data of non-listed firms (e.g., from the ORBIS database of Bureau Van Dijck) are only available either before or by 2018, while data of listed firms are available at least until 2019 and about 20 percent of listed firms have financial statement data available by 2020H1. Given the economic recession in HKSAR in late 2019, using data for listed firms has the advantage of capturing more recent developments in firms' financial soundness. In addition, the total debt of list firms domiciled in HKSAR accounted for nearly 90 percent of HKSAR's total non-financial corporate debt in 2019, which should provide a reasonable coverage for HKSAR financial sector's non-financial corporate debt exposures. The data source is Bloomberg, L.P., and there are about 2,000 firms in total in the sample. We also use WIND as an alternative data source for robustness check and the main results from the firm-level analysis remain qualitatively unchanged.

[64] The criterion of "mainly exposed to" is decided according to the firm's country of risk—a variable defined by Bloomberg based on a number of criteria, including its country of domicile, the primary stock exchange on which it trades, the location from which the majority of its revenue comes, and its reporting currency.

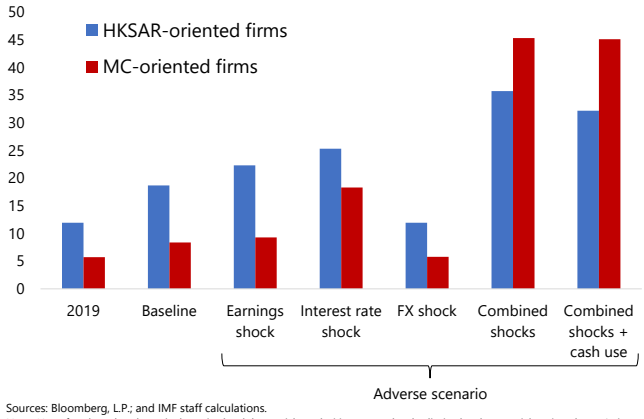
[65] See Box 2 for the key assumptions of the analyses.

[66] Debt-at-risk is defined as the share of debt owed by firms with interest coverage ratio (ICR) below 1 in total debt.

Debt-at-Risk Analysis

158. Debt-at-risk would increase significantly under the adverse scenario, with the largest contribution from the MC-oriented real estate sector. The interest rate shock of a 3.77-ppt increase in borrowing interest rate (in line with the peak of the corporate yield increase in the bank solvency stress test adverse scenario) would have the largest impact on the debt-at-risk (text figure). The shocks to earnings would have a larger impact on HKSAR-oriented firms, partly reflecting the larger decline in HKSAR's real GDP growth rate in the adverse scenario. The RMB depreciation shock (against the USD) would significantly reduce firms' earnings in USD, particularly MC-oriented real estate firms whose business revenues are mostly from onshore Mainland China property development and denominated in RMB.[67] However, the impact on debt-at-risk is mitigated by their RMB-denominated debt. All the shocks combined would significantly raise the debt-at-risk of both HKSAR- and MC-oriented firms beyond their levels in the GFC, with a more prominent increase in MC-oriented firms. In addition, MC-oriented firms would have a higher debt-at-risk than that of HKSAR-oriented firms despite having a lower debt-at-risk in the baseline, mainly due to the higher sensitivity of "marginal" MC-oriented firms to a combination of the earnings and interest rate shocks. From a sectoral perspective, debt-at-risk in the MC-oriented real estate would experience the largest increase in its debt-at-risk under the adverse shocks among all sectors and contributes the most to the total debt-at-risk (Figure 39). Firms' holdings of cash and other liquid assets could help lower the post-shock debt-at-risk but only marginally.[68]

Non-Financial Corporate Debt-at-Risk: By Shock
(Share of debt owed by firms with ICR below 1 in percent of total debt)



Sources: Bloomberg, L.P.; and IMF staff calculations.
Note: Use of cash and cash equivalents in the debt-at-risk analysi is assumed to be limited to keep quick ratios above 1 since cash and cash equivalents would also be used to pay for other non-debt-servicing short-term liabilities; this is a conservative assumption because it limits the depletion of all liquid assets.

Default Risk

159. Two approaches are used to estimate firms' probability of default (PD) for robustness. The first approach directly maps the firm-level ICRs from the debt-at-risk analysis to PDs, and the second approach applies the BuDA model, which uses both market-based information (equity prices) and balance sheet indicators to estimate firm-level PDs.

160. The strong correlation between ICR and credit ratings can be used to map firm-level ICRs from the debt-at-risk analysis into PDs. Given that ICR has a strong monotonic relationship with credit ratings and is sometimes used as a proxy for the latter (Moody's, 2006; Damodaran, 2014), we follow the approach by the IMF's Global Financial Stability Report (IMF, 2013) to map each

[67] A firm-level panel regression analysis suggests that the RMB depreciation could reduce MC-oriented real estate firms' earnings before interest and tax by about 50 percent.

[68] The limited impact of cash use on the post-shock debt-at-risk comes from the conservative assumption following IMF (2019b) that firms can only use their cash buffers to the extent that their quick ratios (defined as defined as the sum of cash, other liquid assets, and accounts receivable divided by current liabilities) are kept above or equal to 1.

firm's ICR levels into cumulative default rates over the next two years based on the historical default rates of firms rated by rating agencies (Table 17). The PDs of individual firms are then aggregated into aggregate PD on the corporate debt owed to HKSAR banks by taking the average of firm-level PDs weighted by the share of each firm's debt owed to HKSAR banks in total debt of all firms. We approximate the share of each firm's debt owed to HKSAR banks in total debt by the sum of bank lending for domestic use in HKSAR (excluding loans to households and financial sector) and Mainland China-related lending divided by the total debt of all firms, which is about 46 percent.[69]

Table 17. Hong Kong SAR: Mapping of Corporate Vulnerability Indicators to PDs

Corporate Vulnerability Indicators[1,2]				Cumulative Default Rates[3]					
				Moody's		Standard & Poor's		Fitch	
ICR	Profitability	Leverage	Implied Rating	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
27.0	21.1	0.6	Aaa/AAA	0.0	0.0	0.0	0.0	0.0	0.0
14.7	13.5	1.5	Aa/AA	0.0	0.1	0.0	0.0	0.0	0.0
9.3	12.0	2.0	A/A	0.1	0.2	0.1	0.2	0.1	0.2
5.2	9.9	2.6	Baa/BBB	0.2	0.5	0.2	0.6	0.2	0.7
3.4	9.3	3.2	Ba/BB	1.1	3.1	0.9	3.0	1.1	2.8
1.6	7.3	4.8	B/B	4.1	9.6	4.5	10.0	2.0	4.8
0.5	3.2	7.6	Caa-C/CCC-C	16.4	27.9	26.8	36.0	24.9	31.9

Sources: IMF (2013); Fitch; Moody's; and Standard & Poor's.

[1] Profitability is defined as EBIT/average assets, and leverage is defined as debt/EBITDA (earnings before interest, taxes, depreciation, and amortization).

[2] The PDs are extrapolated beyond those coresponding to the implied rating C for firms with weaker vulnerability indicators.

[3] Based on 1970-2012 for Moody's, 1981-2011 for Standard & Poor's, and 1990-2012 for Fitch.

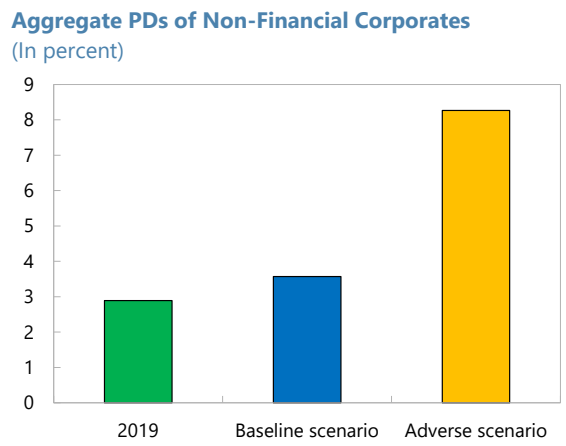
161. Results from the ICR-mapped PDs suggest that the applied shocks in the adverse scenario would lead to a significant increase in new corporate defaults, particularly in the MC-oriented real estate sector.[70] The analysis indicates that the aggregate PD would increase to 8.3 percent of the overall bank corporate loan book from 2.9 percent in 2019 and 3.6 percent in the baseline (cumulative new defaults over two years) (Figure 39).[71] While the magnitude of shocks is different from previous crises, the increase in the aggregate PDs in the adverse scenario relative to the baseline is slightly below the 5 percentage point increase in the aggregate PD during the AFC when corporate distress was high. From a sectoral perspective, the combined shocks would have the largest impact on the aggregate PD of the MC-oriented real estate sector, as the shocks are estimated to increase new defaults in the sector from 1.1 percent in the baseline scenario to 7.9 percent in the adverse scenario.

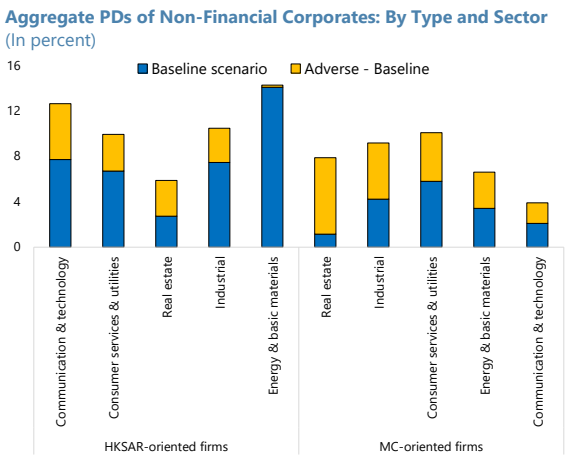
[69] This is a simple assumption given the lack of firm-level data on how much debt is borrowed from HKSAR banks.

[70] The presented calculations are based on Moody's PDs. The calculations based on alternative PDs are not significantly different.

[71] The estimated aggregate PDs here are likely to be different from the actual PDs of the overall bank corporate loan book, given the assumptions on the representativeness of our firm sample and the share of firms' borrowing from HKSAR banks in total debt, and should thus be interpreted with caution. The banks' corporate loan book is assumed to remain constant during the shock period.

Figure 39. Hong Kong SAR: PDs Mapped from ICRs 1/

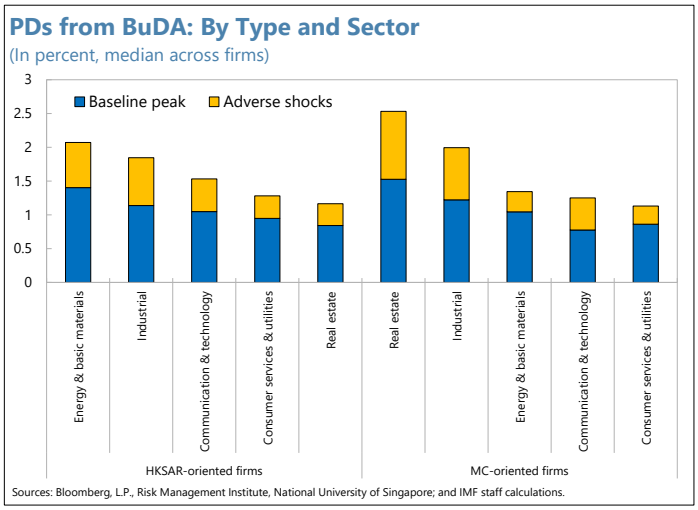




Sources: Bloomberg, L.P. and IMF staff calculations.

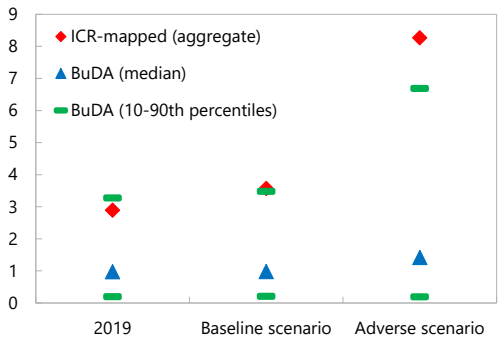
1/ PDs presented in this figure are cumulative new defaults over two years.

162. Projections of PDs using the BuDA model also suggest higher PDs in the adverse scenario, particularly in the MC-oriented real estate sector. Given the continued economic downturn in HKSAR in 2020 in the baseline, the model projects an increase in the median PD in the near term under the baseline scenario but a gradual decline after the economy starts to recover (Figure 40). In the adverse scenario, default risk would rise rapidly in the first two years, approaching their GFC levels, but would remain below the AFC peaks, likely reflecting the still low corporate credit spreads in the adverse scenario compared to the AFC period. From a sectoral perspective, a significantly higher default risk would be priced in for the MC-oriented real estate sector than other sectors in the adverse scenario, mainly reflecting the higher sensitivity of this sector's PDs to the assumed tightening in HKSAR's financial conditions and the housing market correction in Mainland China (text figure).



163. It is worth noting that, although the levels of BuDA-estimated PDs are generally lower than the ICR-mapped PDs, both approaches imply significantly higher PDs in the adverse scenario than the baseline, particularly in the MC-oriented real estate sector. In particular, the peak of the BuDA-estimated median PD in the adverse scenario is about 1½ times that in the baseline for both HKSAR- and MC-oriented firms, while the ICR-mapped aggregate PD in the adverse scenario is over 2 times the baseline level. However, the ICR-mapped aggregate PDs are relatively closer to the 90th-percentile of the BuDA-estimated PDs (text figure). Also, both approaches find that the MC-oriented real estate sector would experience the largest increase in PD among all sectors in the adverse scenario relative to the baseline. Finally, it is worth mentioning that the BuDA-estimated PDs should be interpreted as a measure of the default risk for non-financial corporate debt, which differs from the PDs in the bank solvency stress test in the following aspects: i) firm sample in the BuDA model is likely different from banks' corporate customers, ii) the BuDA model has different assumptions, iii) default risk in the BuDA model covers all types of debt instruments which goes beyond bank exposures, and iv) the BuDA-estimated PDs presented are the median PD across firms rather than aggregate PD for the overall bank corporate loan book.

Estimated PDs of Non-Financial Corporates 1/
(In percent)



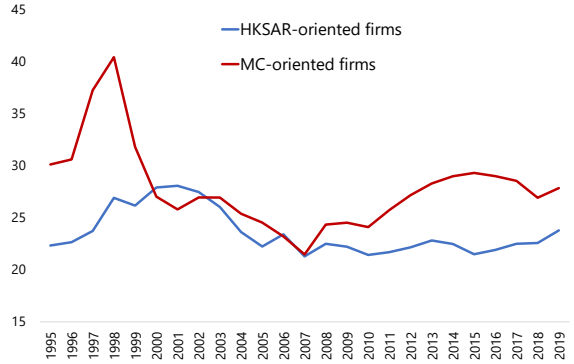
Sources: Bloomberg, L.P.; Risk Management Institute, National University of Singapore; and IMF staff calculations.
1/ The ICR-mapped aggregate PDs represent cumulative new defaults over two years. The BuDA-estimated PDs for 2019 are as of end-2019 while those in the baseline and adverse scenarios are peak PDs over the bank stress test horizon. Specifically, we first calculate the 10th, 50th, and 90th percentiles over all firms and then calculate the peak for each percentile over the bank stress test horizon.

164. It is important to treat the results with some caution for several reasons. First, the debt-at-risk and default risk analyzed in this note are for the aggregate non-financial corporate sector, and the implications for individual banks could be quite different given the differences in the composition of their corporate exposures. In particular, the debt-at-risk should not be directly interpreted as an indicator for bank losses, but as a vulnerability indictor for the aggregate non-financial corporate sector. Second, only listed firms are included in the analyses while most small firms are not included, which could be subject to higher stress in the adverse scenario. Although considering only listed firms allows us to use the most recent available data to capture the recent developments in firms' financial variables, this may underestimate the impact of the shocks on the overall non-financial corporate sector. This caveat also extends to the findings on the Mainland China borrowers from HKSAR banks, which only include listed borrowers. Last but not least, the BuDA analysis for default risk takes a market-based approach based on regression analysis (in contrast to the balance sheet-based debt-at-risk analysis) and hence could be subject to modeling and estimation errors, particularly at the individual firm level.

Figure 40. Hong Kong SAR: Non-Financial Corporate Sector Vulnerabilities

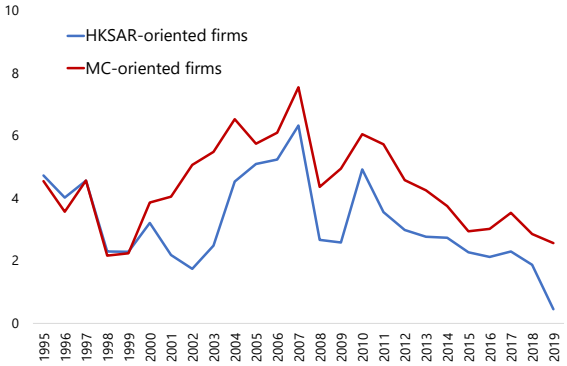
Non-financial corporate leverage increased after the global financial crisis, …

Non-financial Corporate Leverage: Debt-to-Asset Ratio
(Percent)



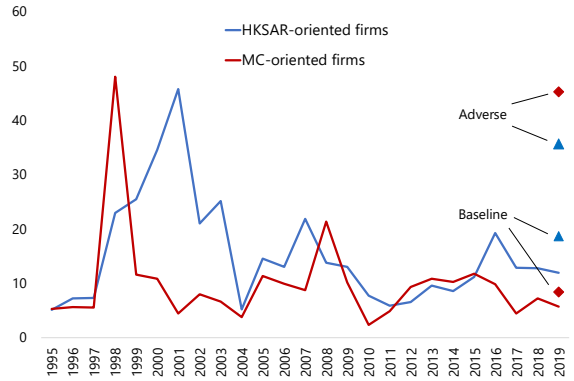
…while profitability has declined.

Non-financial Corporate Profitability: Return on Assets
(Percent, median across firms)



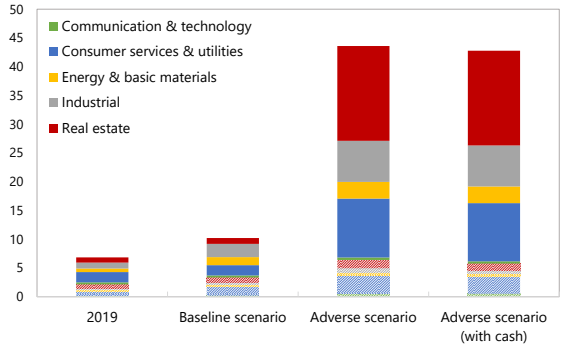
Debt-at-risk would increase significantly in both types of firms in the adverse scenario, …

Non-financial Corporate Debt-at-Risk
(Share of debt owed by firms with ICR below 1 in percent of total debt)



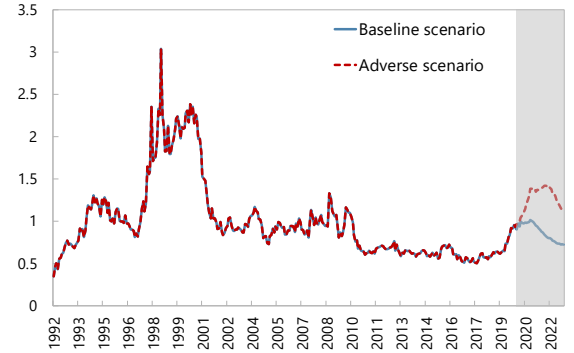
…with particularly high contributions from the MC-oriented real estate sector.

Non-Financial Corporate Debt-at-Risk: Sectoral Contributions 1/
(Share of debt owed by firms with ICR below 1 in percent of total debt)



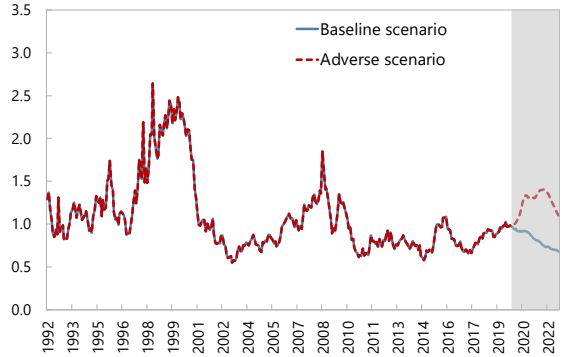
PDs in HKSAR-oriented firms would increase significantly in the adverse scenario but remain below AFC levels, …

PDs of HKSAR-oriented Firms
(In percent; Median across firms)



…and PDs in Mainland China-oriented firms would also increase, particularly for those in the real estate sector.

PDs of MC-Oriented Firms
(In percent; Median across firms)



Sources: Bloomberg, L.P.; Risk Management Institute, National University of Singapore; and IMF staff calculations.

1/ The solid bars and pattern bars represent Mainland China - and HKSAR-oriented sectors, respectively.

165. The corporate sector vulnerability analysis suggests that the authorities should continue to closely monitor credit risks of MC-oriented real estate firms and ensure that banks' internal risk models used to determine capital charges for potential high-risk Mainland China borrowers are sufficiently forward-looking. Given the high sensitivity of some sectors' debt-at-risk and default risk to adverse shocks, particularly the MC-oriented real estate sector, the authorities should consider incorporating non-financial corporates in the stress testing framework and communicate the key findings in the HKMA's Monetary and Financial Stability Report on a regular basis. Moreover, the authorities should continue to closely monitor and assess the credit risks facing these borrowers and to ensure that the internal risk models used to determine the capital charge for potential high-risk Mainland China borrowers, particularly MC real estate borrowers with low credit ratings, are sufficiently forward-looking.

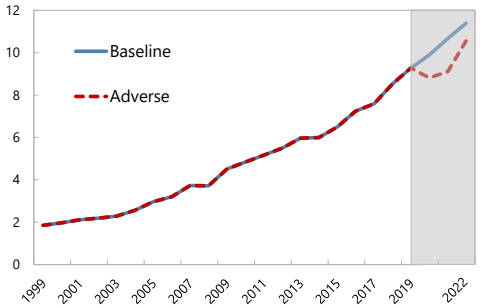
Box 2. Key Assumptions of Corporate Vulnerability Analysis

Scenario-based firm-level analyses are conducted to stress test firms' debt-at-risk and PDs under the adverse scenario of the bank stress test. The debt-at-risk is assessed based on the interest coverage ratios (defined as ratio of earnings before interest and tax to interest expense) after applying shocks to earnings, interest rates, and the RMB/USD exchange rate derived from the baseline and adverse scenarios in the bank solvency stress test. The bottom-up default analysis (BuDA), which considers both market-based information and balance sheet indicators (Duan *et al.*, 2015), is used to estimate firm-level PDs and make projections under the baseline and adverse scenarios.

- ***Debt-at-risk analysis.*** The baseline and adverse scenarios are mapped into shocks to earnings, interest rate, and the RMB/USD exchange rate in the following way. First, sector-specific shocks to earnings are calibrated using the estimated sensitivities of sectoral earnings to real GDP growth during the global financial crisis and the declines in real GDP growth in the baseline and adverse scenarios. Second, the interest rate shocks are assumed to follow the assumptions on corporate yields in the bank stress testing scenarios, with a reduction of 68 bps and an increase of 377 bps in the baseline and adverse scenarios, respectively. We also assume that the interest rate shock applies to 90 percent of total debt (i.e., 10 percent of total has fixed rates). Finally, a depreciation of the RMB by 7.4 percent against the USD is assumed to test the MC-oriented firms' sensitivity to exchange rate shock. Given the lack of detailed currency breakdown of firms' debt and earnings, we use a regression-based approach to estimate the impact of the RMB depreciation on firms' debt and earnings. Results suggest that the interest rate shock would have the largest impact on the debt-at-risk.

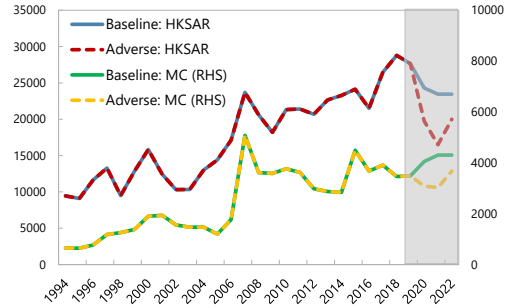
- ***BuDA.*** In addition to the shocks in the bank ST scenarios, the BuDA scenarios also assume the following shocks over the stress test horizon of 2020-22. First, the residential property price in Mainland China is assumed to grow in line with the baseline projections from the October 2020 WEO baseline scenario. For the adverse scenario, the Mainland China residential property price is assumed to decline by 20 percent at the peak during 2020-21 (relative to the baseline) before recovering to 5 percent below the baseline by end-2022. Second, stock prices in HKSAR and Mainland China take historical values for 2020Q1-Q3 and are assumed to remain at their end-Q3 2020 levels over 2020Q4-2022 in the baseline scenario. For the adverse scenario, stocks prices in both jurisdictions are assumed to decline by 40 percent at the peak during 2020-21 before recovering to 10 percent below the baseline by end-2022. The magnitude of the decline is comparable to the AFC period for HKSAR stock market and the 2008-15 period for MC stock market. Finally, the RMB/USD exchange rate in the baseline scenario is assumed to take historical values for 2020Q1-Q3 (an appreciation of 3.1 percent relative to its end-2019 level) and remain unchanged after 2020Q3. In the adverse scenario, the RMB/USD exchange rate is assumed to depreciate by 7.4 percent to 7.55 RMB per USD at the peak during 2020-21 before recovering to 7.3 RMB per USD by end-2022. The peak of the exchange rate shock in the BuDA adverse scenario is the same as the shock in the debt-at-risk analysis.

BuDA Scenarios: Residential Property Price in MC 1/
(Thousand RMB per sq. m.; seasonally adjusted period average)



Sources: Haver Analytics; CEIC; and IMF staff calculations.
1/ The shadowed areas represent projections.

BuDA Scenarios: Stock Prices in HKSAR and MC 1/
(Index; period average)



Sources: Haver Analytics; CEIC; and IMF staff calculations.
1/ The shadowed areas represent projections.

Appendix I. Risk Assessment Matrix

Source of Risk	Transmission Channels	Likelihood	Impact
Global Risks			
Unexpected shift in the Covid-19 pandemic	**Prolonged pandemic**: The disease proves harder to eradicate (e.g., due to new virus strains, short effectiveness of vaccines, or widespread unwillingness to take them), requiring costly containment efforts and prompting persistent behavioral changes rendering many activities unviable.	Medium	Medium
Accelerating de-globalization	Despite renewed efforts to reach multilateral solutions to existing tensions, geopolitical competition leads to further fragmentation. Reshoring and less trade reduce potential growth.	Medium	High
A sharp rise in global risk premia exposes financial and fiscal vulnerabilities	A reassessment of market fundamentals (e.g., in response to adverse Covid-19 developments) triggers a widespread risk-off event. Risk asset prices fall sharply and volatility spikes, leading to significant losses in major non-bank financial institutions. Higher risk premia generate financing difficulties for leveraged firms (including those operating in unviable activities) and households, and a wave of bankruptcies erode banks' capital buffers.	Medium	High
Domestic Risks			
A further slowdown in China	A further slowdown in China would reduce trade flows and lead to a sharp decline in economic activity in HKSAR. Lower trade volumes would reduce corporate profits and investment, raise unemployment, and weaken consumption. Trade, logistics, tourism, and retail sectors would be affected most adversely. Banks would likely face higher losses on their loans to Mainland China-related and other corporate borrowers, as well as on their broader credit portfolio due to the overall decline in economic activity.	Medium	High
A sharp housing market correction and decline in demand	A sharp decline in house prices would lower confidence, weaken housing demand, lower residential investment, and constrain new bank lending as many loans are secured by property, leading to a larger downturn.	Medium	High

Notes: This table shows the shocks that will be used for the analysis of resilience of financial institutions. The Risk Assessment Matrix (RAM) shows events that could materially alter the baseline path (the scenario most likely to materialize in the view of IMF staff). The RAM reflects staff views on the source of risks and overall level of concern as of the time of discussions with the authorities. Non-mutually exclusive risks may interact and materialize jointly and amplify each other's effects.

Appendix II. Stress Testing Matrix

Domain		Top-down by FSAP Team: Assumptions
Banking Sector: Solvency Stress Test		
1. Institutional Perimeter	Institutions included	• Largest 11 locally incorporated banks (ranked by the size of consolidated balance sheets), including five D-SIBs (the sixth D-SIB, Hang Seng Bank, is a majority owned subsidiary of HSBC Ltd and it will be included as part of the consolidated balance sheet of HSBC Ltd, instead of a stand-alone basis).
	Market share	• Close to 93 percent of total consolidated assets of all locally incorporated banks.
	Data source and starting date	• Data Source: Supervisory and publicly available data. • Baseline date: Balance sheets as of 2019Q3, credit and funding risk historical data up to 2019Q1. • The FSAP team started the solvency ST exercise with 2018 bank-level balance sheet data and refreshed the balance sheets to the 2019 data during the course of the work. Due to the extraordinary COVID-19 pandemic circumstances, which imposed additional burdens on the banks, a further update of the balance sheet data to a point in 2020 was deemed impractical. The use of 2019 balance sheet data has limited effect on the solvency assessment due to the fact that there were no significant changes in the average bank capital levels between 2019 and 2020. • Scope of Consolidation: Consolidated balance sheets of locally incorporated banks.
2. Methodology	Overall framework	• IMF Balance sheet-based approach.
	Satellite models for macro-financial linkages	• Satellite models for PDs, LGDs, NPL ratio, and provisioning ratio for credit losses. • Methodology to calculate market losses from holdings of debt instruments (sovereign and other issuers). Haircuts calculated based on modified duration. • Methodology to calculate shocks to bank funding costs. • Non-interest income projected based on nominal GDP growth and expert judgment.
	Stress test horizon	• 3-years (2020-2022).
	Assumption	• Passive balance sheet assumption: (i) the balance sheet growth is identical to the overall credit growth, which is linked to nominal GDP growth; (ii) the balance sheet composition remains constant throughout the stress test horizon; (iii) banks build capital only through retained earnings; and (iv) maturing capital instruments are not renewed. • Banks can pay dividends only if net income after taxes are positive and if they are adequately capitalized. The dividend payout ratio is assumed to be 50 percent.
3. Type of analyses	Scenario analysis	• Scenario-based tests, that assess the impacts on the entire portfolio including the loans and the trading book. • Two macrofinancial scenarios agreed between HKMA and the IMF FSAP team. • The scenarios include domestic macro-financial variables (e.g., GDP, inflation, interest rates, unemployment rate, exchange rate, equity and property prices), and global variables (US and China GDP, interest rates, and commodity prices). • Baseline scenario based on the October 2020 WEO projections and is informed by the macroeconomic indicators observed since the COVID-19 outbreak started. • The Adverse Scenario is simulated using IMF's Flexible System of Global Models. • The Adverse Scenario reflects macro-financial risks in the RAM. It is driven by a combination of external and domestic shocks amplified by domestic vulnerabilities. The four major drivers of the Adverse Scenario are: - Shock 1: Prolonged COVID-19 pandemic,

Domain		Top-down by FSAP Team: Assumptions
		- Shock 2: Accelerating de-globalization and heightened protectionism accompanied by a further slowdown in China, - Shock 3: A sharp rise in global risk premia compounded by escalating US-China tensions, - Shock 4: A sharp housing market correction and a decline in demand. • Under the baseline scenario, the HKSAR economy suffers a large contraction on 2020, but growth turns to positive in 2021, with the annual GDP growth rates of -7.5 percent, 3.7 percent, and 3.4 percent. • Under the adverse scenario, the Hong Kong SAR economy suffers an L-shaped growth path and an L-shaped deep recession, with the annual GDP growth rates of -8.5 percent, -4.9 percent, and 2.5 percent (cumulative GDP contraction of 13 percent over the first two years). This growth path corresponds to a 9-percentage points deviation over the first two years compared to the baseline path, which is equivalent to 1.5 standard deviations of annual growth rates calculated over 1984-2019. • The cumulative price decline at the end of the 3-year scenario period reaches 40 percent for residential properties under the adverse scenario.
	Sensitivity analysis	• Sensitivity analyses will be conducted to supplement the scenario analysis. • They will evaluate impacts of three different single risk factors on the existing capital buffers: - Interest rate risk, - Spread increase for securities portfolios, - Concentration risk.
4.Risks and Buffers	Risks assessed	• Credit loss from banks' loan portfolios and bank exposures, including off-balance sheet credit exposures. • Market loss from valuation adjustments of banks' holding of debt securities and existing net open foreign exchange positions. • Losses from bonds and money market instruments (sovereign and other issuers) in the banking and trading books. • Interest rate risk in the banking book, increase in funding costs.
	Buffers	• Existing capital buffers. • Internal capital generation from net income after taxes. • No new capital injection.
5. Regulatory Standards	Regulatory Standards	• National regulatory framework • Basel III approach
6. Reporting Format for Results	Output presentation	• System-wide capital shortfalls from macroprudential perspectives. • Number of banks and percentage of banking system assets in the system that fall below the capital hurdle. • Impact of different result drivers, including profit components, losses due to realization of different risk factors. • Hurdle rates – Baseline scenario: the sum of regulatory minimum (CET1, Tier1, and total capital), D-SIB surcharge, capital conservation buffer, and countercyclical capital buffer. – Adverse scenarios: the Basel III regulatory minimum.
Banking Sector: Liquidity Stress Test		
1. Institutional Perimeter	Institutions included	• 23 banks: 12 local banks (including all six D-SIBs) and 11 foreign branches.

Domain		Top-down by FSAP Team: Assumptions
	Market share	• The sample covers about 96 percent of total assets on a solo basis (that is, positions of banks' HKSAR offices plus their overseas branches).
	Data and Starting position	• Baseline date: Q2 2020 • Data Source: Supervisory and publicly available data. Cash flow data and unencumbered asset data (HKMA reporting template MA(BS)23)
2. Methodology	Overall framework	• Cash-flow cum counterbalancing capacity-based liquidity stress test • Basel III-LCR ratio and HK LMR ratio. • Analyses to be carried out separately for HKD, USD, and RMB, based on availability of granular data for various tests.
3. Type of analyses	Scenario analysis	• 36 embedded scenarios: 4 degrees of severity, 3 different approaches to the counterbalancing capacity over 3 different time horizons. • This approach employs multiple embedded scenarios of increasing severity covering several horizons (7 days, 1 month, and 3 months) with varying assumptions regarding shocks to cash inflows and outflows and haircuts on liquidity buffers. The most severe scenario includes historically relatively high outflow rates (e.g. 10 percent for less stable retail deposits, 40 percent for non-operational NFC deposits, and 100 percent for FI deposits) combined with haircuts of up to 25 percent for other investment-grade securities held locally and 30 percent for those held overseas. The scenarios differ from the actual effects of the pandemic on liquidity risk, because the latter led to substantial inflows of deposits rather than outflows and public support for non-financial corporates as well as monetary policy accommodation contributed to avoiding substantial decreases of the liquidity values of assets in the counterbalancing capacity. One of the scenarios includes an assessment of the impact of a disruption of the derivatives markets (e.g., FX swaps) on USD liquidity. The calibration of shock scenarios was based on historical evidence. The analysis of the USD LCR found that banks rely on inflows in USD (i.e. from FX swaps) to match high outflows (also FX swaps) and on the well-functioning of the underlying markets.
4. Risks and Buffers	Risks	• Cash-flow based LST: Retail and wholesale deposit run-off, (partial) closure of funding markets, reduction of liquidity / price declines of asset • LCR/LMR: reclassification risk
	Buffers	• Cash-flow based LST: Capacity of banks to generate liquidity from assets under stress (counterbalancing capacity) and central bank facilities • LCR/LMR: Regulatory buffers
5. Regulatory Standards	Regulatory Standards	• National regulatory framework: The LCR and NSFR (hurdle of 100 percent for both) for larger (mostly) local banks in the sample, and the LMR (hurdle of 25 percent) and the CFR (hurdle of 75 percent) for the smaller banks (largely foreign banks) in the sample. • The LCR and the LMR are subject to so-called reclassification tests which test their sensitivity with respect to the reclassification of liabilities/assets between various regulatory positions which would entail higher run-off rates and lower regulatory ratios. • The hurdle for the cashflow-based test is zero HK dollars.
6. Reporting Format for	Output presentation	• System-wide LCR and LMR under the reclassification scenarios • System-wide liquid cumulated counterbalancing capacity (CCBC in % of total assets),

Domain		Top-down by FSAP Team: Assumptions
Results		the number of banks with a CCBC below zero, and their CCBC (in % of TA) under the cashflow-based stress scenarios.
Financial System: Interconnectedness Analysis		
1. Institutional Perimeter	Institutions Included	• Interbank network: Largest 20 banks ranked according to their HK office basis assets (9 locally incorporated banks and 11 foreign branches). • Intra-financial sector network: Banks and major nonbank financial sectors. • Cross-border bank network: the banking systems of all major counterparty countries.
	Data and Starting position	• Data source: Supervisory data, market data, and BIS international banking statistics. • Starting position: 2019 year-end data. • Data granularity: – Intra-financial sector: major financial sub-sectors. – Cross-border: banking system-level.
2. Methodology	Overall framework	• Intra-financial sector: Balance sheet-based exposures. • Cross-border network: Balance sheet-based interbank model Espinosa-Vega and Solé (2010). • Market price-based spillover model by Diebold and Yilmaz (2014).
3. Risks and Buffers	Risks	• Credit and funding losses related to interbank exposures, intra-financial exposures, and cross-border banking exposures. • Default of large common borrowers in the banking system.
	Buffers	• Intra-financial sector: banks' own capital buffers. • Cross-border bank network: capital buffers of the banking system.
4. Reporting Format for Results	Output presentation	• Intra-financial sector: a network chart, size of exposures relative to capital. • Cross-border network: index of vulnerabilities and contagion, and spillover charts. • Evolution and direction of spillovers.

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