



AUSTRALIA

FINANCIAL SECTOR ASSESSMENT PROGRAM

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

February 2019

This Technical Note on Stress Testing the Banking Sector and Systemic Risk Analysis for Australia 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 on September 14, 2018.

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International Monetary Fund
Washington, D.C.



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January 22, 2019

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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 Australia. 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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Glossary

AFS	Available-for-Sale
APRA	Australian Prudential Regulation Authority
CCB	Capital Conservation Buffer
CCP	Central Counterparty
CCR	Counterparty credit risk
CET1	Common Equity Tier 1
CRE	Commercial Real Estate
CFR	Council of Financial Regulators
D-SIB	Domestic Systemically Important Bank
EAD	Exposure-at-Default
FSAP	Financial Sector Assessment Program
FSR	Financial Stability Report
FSSA	Financial System Stability Assessment
FX	Foreign Exchange
GDP	Gross Domestic Product
GFC	Global Financial Crisis
G-SIB	Global Systemically Important Bank
HFT	Held-for-Trading
HPI	House Price Index
HQLA	High-Quality Liquid Assets
IRB	Internal Ratings-based
LCR	Liquidity Coverage Ratio
LGD	Loss-given-Default
LTV	Loan-to-Value (ratio)
LVR	Loan-to-Value Ratio
MTM	Mark-to-Market
NFC	Nonfinancial Corporates
NIM	Net Interest Margin
NPL	Nonperforming Loan
NSFR	Net Stable Funding Ratio
P&L	Profit and Loss
PD	Probability of Default
RAM	Risk Assessment Matrix
RBA	Reserve Bank of Australia
ROA	Return on Assets
ROE	Return on Equity
RWA	Risk-weighted Assets
ST	Stress Test
STeM	Stress Test Matrix
TTC	Through-the-Cycle
VAR	Vector Autoregression
YTM	Yield-to-Maturity

EXECUTIVE SUMMARY

Bank capital levels have been strengthened and funding risks have also been reduced in recent years, while financial supervision and systemic risk oversight have been enhanced.

Additionally, authorities have taken successful policy actions to moderate rapid growth in riskier segments of the mortgage market.

At the same time, the banking system faces several challenges. Real estate valuations appear stretched while household leverage is at record highs, posing significant macrofinancial risks. A sustained period of economic growth, low policy rates, tax incentives and abundant credit have fueled the rise in household debt, pushing household debt-to-income to nearly 200 percent, which is among the highest in the world. The largest banks remain dependent on overseas wholesale funding, though reliance has declined in recent years. The ongoing Royal Commission (RC) inquiry is revealing a pattern of widespread misconduct in the financial services industry, including at the four major banks that hold some 80 percent of banking system assets.

The major four banks' homogeneous business models and reliance on offshore wholesale funding indicate vulnerability to common shocks. All major banks are heavily exposed to real estate—residential assets comprise over half the loan book, and commercial residential (CRE) a further 10 percentage points. Additionally, wholesale funding comprises around one-third of total funding for the banking system, of which nearly two-thirds is from international sources. Further extending banks' funding maturity profile and reducing their reliance on wholesale funding would reduce structural funding risks.

Bank solvency appears relatively resilient to stress, although liquidity stress tests (ST) reveal some vulnerabilities given continued reliance on wholesale funding. A test of resilience to a combination of a significant slowdown in China, a sharp correction in real estate valuations, and a marked tightening of global financial conditions, revealed some pressures on capital, although the 10 banks in the ST sample would all still meet regulatory minima. However, banks' continued reliance on wholesale funding leaves them exposed to liquidity shocks. Results from the cash flow-based liquidity stress test revealed that a stress in the funding markets would lead to multiple banks experiencing cash shortfalls and raise reliance on central bank funding. This test was meant to capture a severe stress in funding conditions, and hence adopted assumptions that are generally more severe than the Liquidity Coverage Ratio (LCR) ones for the first 30-day period, and also assumed that stress conditions continue beyond the 30-day period.

The systemic risk analysis reveals a low degree of interconnectedness between the largest Australian banks and their global counterparts. However, the cross-border and interbank exposures data corroborates the systemic importance of the four largest banks and the view that the Australian banks are particularly vulnerable to external funding shocks. While domestic interbank balance sheet exposures are relatively small, amounting to roughly 5 percent of each large

institution's asset base, off-balance sheet exposures between the four major Australian banks, and between the major banks, foreign banks, and nonbanks (mainly Central Counterparty (CCPs)), appear to be sizeable.

Australian corporates appear generally resilient but could face strong headwinds in the event of a sharp slowdown in China or tighter global financing conditions. A sensitivity analysis, testing firms' resilience to interest rate and funding costs, revealed that debt repayment capacity is particularly weak for those sectors exposed to China and the domestic real estate market. The sharp deterioration in interest coverage ratios for some of these sectors likely reflects their relatively higher leverage and increased sensitivity to interest rate shocks.

The authorities should continue to improve their stress testing methodologies, data quality, and data validation analysis to enhance the effectiveness of surveillance. The authorities would benefit from improvements in the quantity, quality, granularity and consistency of data available to the Council of Financial Regulators' (CFR) agencies to support financial supervision, systemic risk oversight and policy formulation. The authorities are also recommended to continue to enhance their monitoring, modelling and stress testing framework for assessing solvency, liquidity and contagion risk.

Table 1. Australia: Recommendations on Financial Stability and Stress Testing

Recommendations and Authority Responsible for Implementation	Time¹	Responsibility
Commission and implement results of a comprehensive forward-looking review of potential data needs over the next 5 years. Improve the quantity, quality, granularity and consistency of data available to the CFR agencies to support financial supervision, systemic risk oversight, and policy formulation.	ST	APRA, RBA
Enhance the authorities' monitoring, modelling, and stress testing framework for assessing solvency, liquidity, and contagion risk. Draw on the results to inform policy formulation and evaluation.	ST	APRA
Strengthen the integration of systemic risk analysis and stress testing into supervisory processes.	I	APRA, RBA
Encourage further maturity extension and lowering of dependence on overseas wholesale funding.	I	APRA

¹I Immediate (within 1 year); ST Short-term (within 1–2 years); MT Medium-Term (within 3–5 years)

INTRODUCTION¹

A. Financial System Landscape

1. Banks and pension (“superannuation”) funds dominate the large financial sector (Figure 1 and Table 1). Financial sector assets are about 400 percent of GDP, with the sector comprising 84 commercial banks (58 percent of financial assets), pension funds (27 percent); insurance companies (5 percent), investment vehicles (5 percent), and other finance companies (4 percent). The banking system is highly concentrated—the four largest banks (identified as domestic systemically important banks (D-SIBs)) represent about 80 percent of overall system assets. The systemic importance of banks, as well as their continued reliance on overseas funding markets, has led the Australian Prudential Regulation Authority (APRA) to require high levels of capital.

2. Banks are well-capitalized, liquid, and have a long history of delivering high profits (Figure 2). As of December 2017, banks’ total regulatory capital ratio is 14.7 percent (CET1 ratio of 10.6 percent) against the requirement of 8 percent² (excluding the capital conservation buffer of 3.5 percent for the D-SIBs and 2.5 percent for other banks). D-SIBs are subject to a 1 percent surcharge which is part of their capital conservation buffer of 3.5 percent. Each of the four major banks’ CET1 ratios is well above the minimum requirement including the surcharge, and around the top quartile of large, international banks—one of the reference metrics identified by APRA to support the policy objective that banks are “unquestionably strong.” Banking sector liquidity appears reasonable, complying fully with the LCR and Net Stable Funding Ratio (NSFR) standards. Banking sector profitability remains high in global terms, although it has declined in recent years. Asset quality remains relatively high, with average Nonperforming Loans (NPLs) of only 1 percent. Provisions are about 40 percent of NPLs, which might appear modest, but reflect low historical loan loss rates, loan portfolios that are mainly secured against collateral (with unsecured consumer loans comprising less than 4 percent of the total), loan mortgage insurance paid out to banks not borrowers, the full recourse nature of bank lending, and a swift recovery process.

3. Banks carry high exposure to residential and commercial real estate (Figure 1). Residential mortgages form over half of bank lending, and about one-third of these are potentially higher-risk interest-only mortgages. Commercial real estate averages around an additional 10 percent of the four major banks’ loan portfolios. Moreover, banks’ mortgage loan customers

¹ The Technical Note was prepared by Tumer Kapan and Narayan Suryakumar from the IMF Monetary and Capital Markets Department for the Australian FSAP. The analysis was based on information provided by the authorities, publicly available information, and discussions with the RBA, ASIC, APRA, Treasury, banks, and other financial institutions, and private sector experts.

² For the subset of 10 banks which were analyzed in the ST exercise the CET1 ratio was 10.5 percent. This subset of banks includes the largest five banks subject to the Major Bank Levy and five mid-sized banks. Collectively, they own close to 90 percent of the banking system’s domestic assets.

appear increasingly levered on a gross basis, a point raised also by some credit rating agencies.³ After a stabilization period during the Global Financial Crisis (GFC), household debt has continued to trend upward, reaching almost 200 percent of disposable income in 2017, high in comparison with other advanced economies. Nevertheless, households own significant assets against such debt, which includes physical real estate and pensions. At the same time Loan-to-Value (LTVs) on the stock of mortgage loans average just over 50 percent, making significant losses on mortgage loans highly unlikely even under substantial declines in real estate price. Meanwhile, house prices rose by about 70 percent over a 10-year period through mid-2017, before a modest house price decline of about 3 percent in the 12 months ending in July 2018. The price appreciation has been even higher in Sydney and Melbourne, where prices have doubled over the past 10 years, though these two cities have also experienced price corrections of about 5 percent and 3 percent, respectively, over the past year. Commercial real estate prices, particularly for office space, have also risen sharply in the major cities over the past decade, but have not shown any signs of cooling yet. Housing affordability is near all-time lows, despite the low interest rate environment.

4. Banks also rely on wholesale funding markets. Banks' reliance on wholesale funding has come down in recent years and deposit funding has increased, partly in response to encouragement by the authorities and the implementation of the NSFR. However, wholesale funding remains at about one-third of total (non-equity) liabilities, see Figure 3. Approximately two-thirds of the wholesale funding is from international sources, which makes the system vulnerable to changes in global liquidity conditions. Since the GFC, banks have taken steps to reduce rollover risk by increasing the average duration of their wholesale funding, and they hedge out currency risk with cross currency swaps whose tenors match the average duration of their funding. This hedging practice eliminates the need to roll over hedges before the end of the maturity of the offshore debt.

5. The nonfinancial corporate (NFC) sector is primarily financed by nonresidents and nonbank financials, and less so by banks. NFC assets total around 250 percent of GDP, with bank loans comprising only around 15 percent of aggregate liabilities. Industrials, materials, energy, and the real estate sectors dominate with a combined debt of over 65 percent⁴ of the NFC universe. Gross operating profits have been relatively strong recently, following an experience of volatile earnings during the GFC, the European sovereign debt crisis, and the slump in global commodity prices. Firm leverage trends appear generally benign, though debt servicing capacity for some levered sectors, such as real estate and materials, necessitate closer monitoring given high exposures to the housing market and China, respectively. Indeed, under an adverse scenario,⁵ firms' debt repayment capacity is estimated to be particularly weak for those sectors exposed to China and the domestic real estate market. That said, the number of firm insolvencies continues to normalize, following the increase in the aftermath of the GFC and commodity crisis in 2015, but remains above pre-GFC levels in some regions.

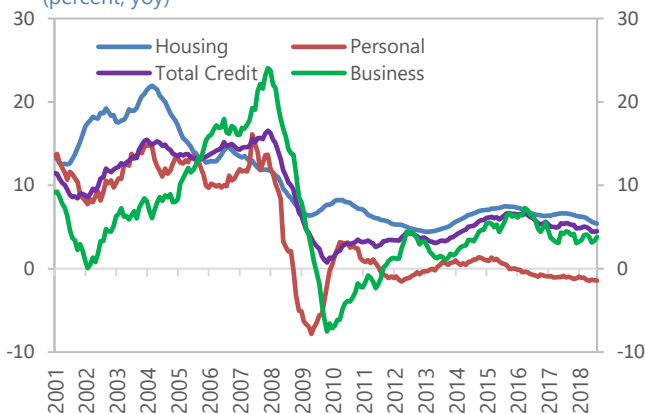
³ Standard & Poor's downgraded 23 institutions recently but affirmed the ratings of the four major banks; while Moody's downgraded 12 institutions, bringing ratings for the four major banks in line with the other ratings agencies at AA.

⁴ Using a sample of 250 firms from S&P Capital IQ.

⁵ The sensitivity analysis assumes a 1 standard deviation shock to earnings and interest expense for corporates.

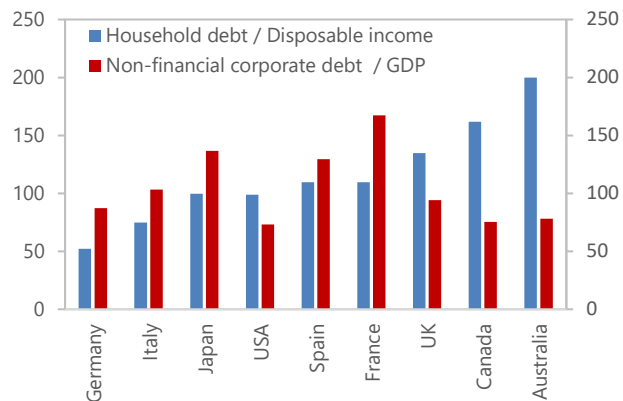
Figure 1. Australia: Macroeconomic and Financial Market Conditions

Credit Growth by Sector
(percent, yoy)



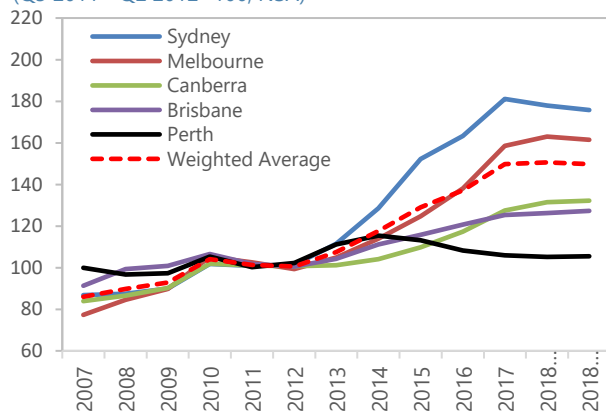
Source: Reserve Bank of Australia

Household and Corporate Debt
(percent, 2018 Q2)



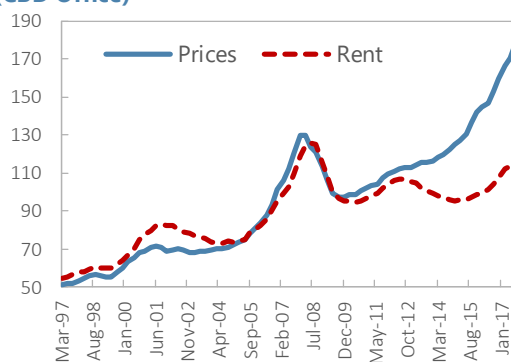
Source: Haver Analytics

Nominal House Price Indexes
(Q3 2011 - Q2 2012=100, NSA)



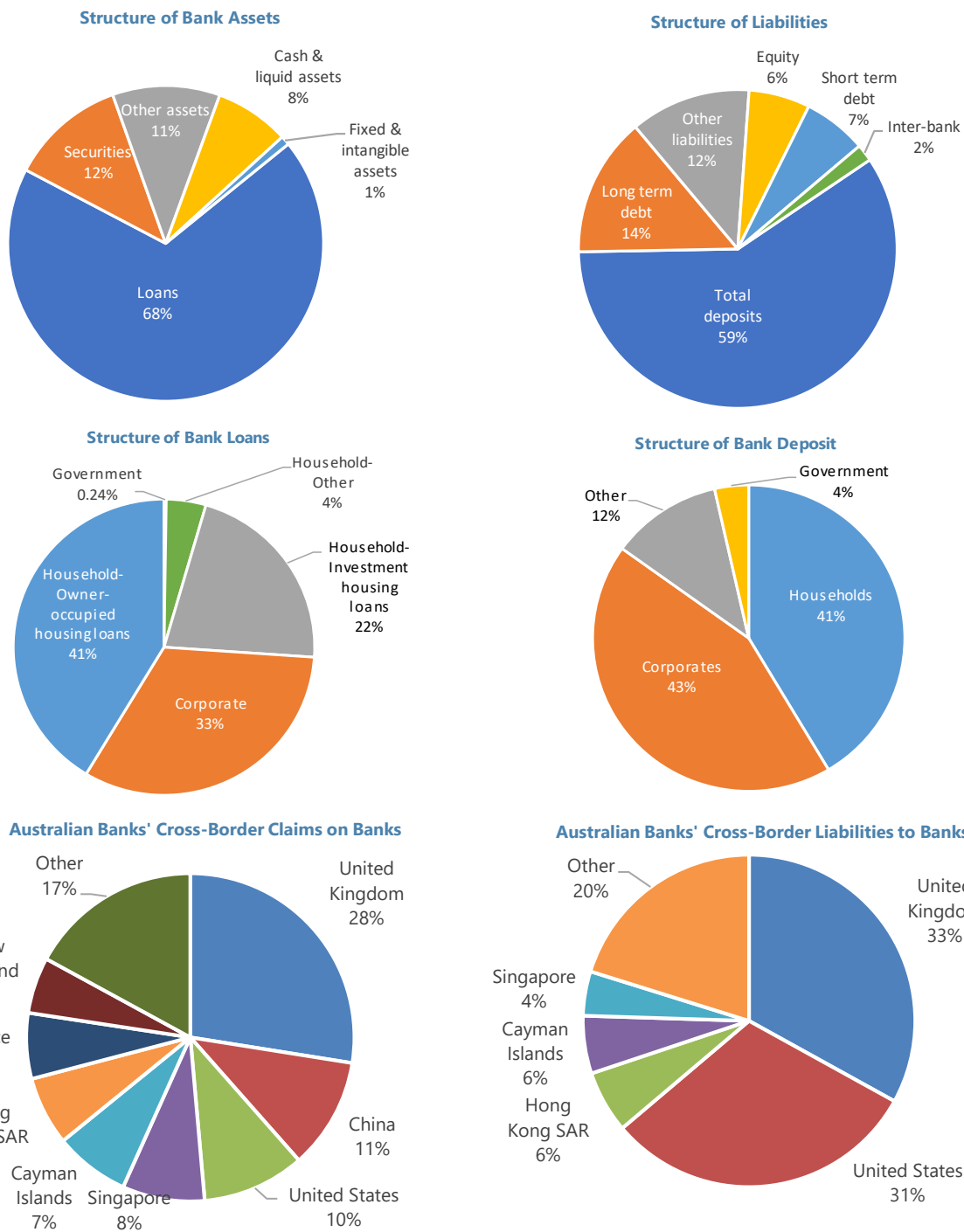
Source: Haver Analytics

Commercial Real Estate Index (CBD Office)



Source: IMF WEO database

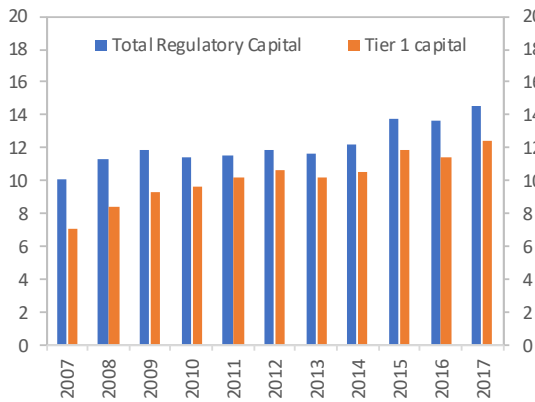
Figure 2. Australia: Banking Sector Detail, 2017
(in percent)



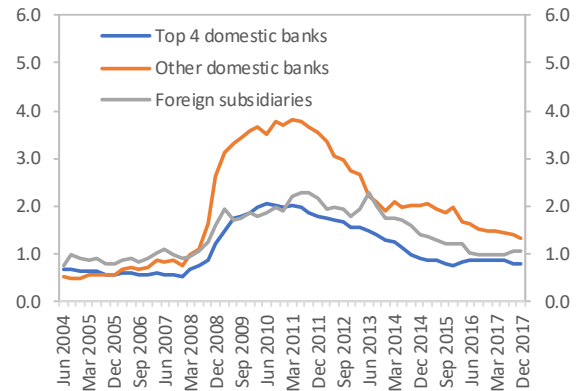
Source: APRA, RBA, BIS locational data and IMF staff estimates.

Figure 3. Australia: Financial Soundness Indicators, 2017 Q4
(in percent)

Capital to Risk Weighted-Assets



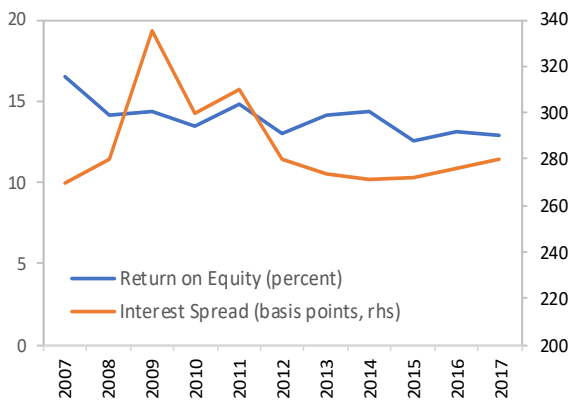
NPLs / Gross Loans



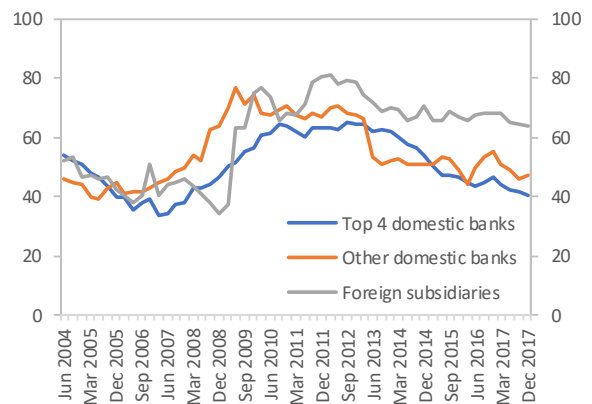
Source: IMF FSI Database

Source: APRA banking statistics

Profitability



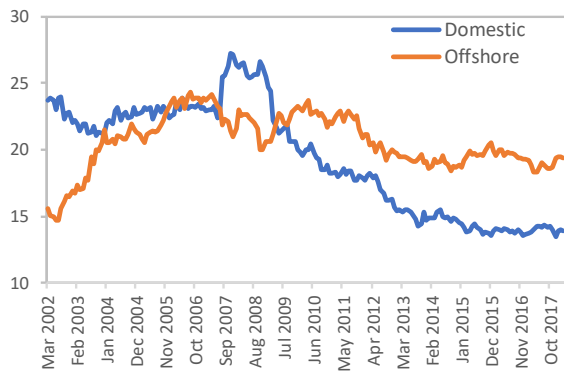
Total Provisions / NPLs



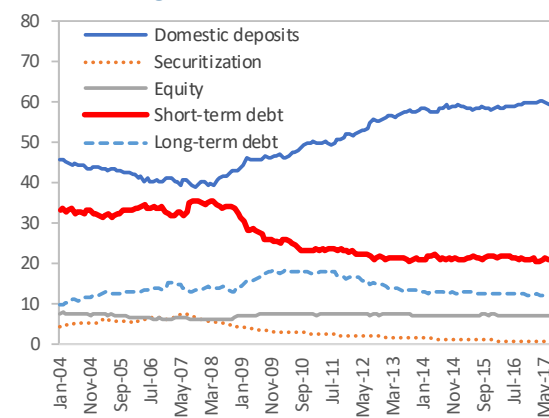
Source: APRA banking statistics

Source: APRA banking statistics

Wholesale Funding
(percent of total funding)



Banks' Funding



Source: APRA

Source: Haver Analytics

Table 2. Australia: Structure of the Financial System, 2017

	Number 1/	Assets (billions of AUD)	Assets (billions of USD)	Percent of GDP
Authorized Deposit-taking Institutions	141	4,585	3,527	254.9
<i>Of which, Major Domestic Banks</i>	4	3,524	2,711	195.9
<i>Of which, Other Domestic Banks</i>	29	458	352	25.5
<i>Of which, Foreign Banks</i>	51	553	425	30.7
Pension funds	2338	2,129	1,638	118.3
Investment funds	N/A	359	276	20.0
Insurance companies	138	388	298	21.6
Finance companies	N/A	176	135	9.8
Specialized credit institutions	60	125	96	6.9
Total financial system	2677	7762	5971	431
Nominal GDP (billions, AUD)	1799			
Exchange rate (AUD / US dollar)	1.3			

Source: APRA, IMF, World Economic Outlook (WEO), IMF staff estimates
1/ Number of licensed institutions

B. Scope of the Financial Stability Analysis

6. The financial stability analysis undertaken as part of the FSAP primarily focused on assessing the resilience of the banking system. The FSAP relied on a variety of approaches to identify the vulnerabilities in the banking system and analyzed the interlinkages of the banking sector with the other sub-sectors of the financial system. Additionally, a corporate sector vulnerability analysis was carried out to complement the banking vulnerability analysis. The FSAP analysis focused on financial stability risks related to banks' solvency and liquidity, as well as domestic and cross-border interconnectedness. The analysis consisted of the following modules:

- **Solvency stress tests.** The FSAP team conducted a top-down solvency ST based on the balance sheet approach covering the 10 largest banks, accounting for nearly 90 percent of total banking system assets. The 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. Bank balance sheets, income statements, and prudential data as of Q4 2017, were used as the starting point for the simulated scenarios. In addition, several sensitivity tests were conducted.
- **Liquidity stress tests.** The liquidity ST used three methods to evaluate liquidity risks: the LCR, and the NSFR, and a cash flow-based liquidity stress test. These tests were carried out with the aggregate cash-flows, and separately for AUD-only cash flows in the case of LCR. The liquidity ST analysis was carried out for the same set of banks used in the solvency ST.
- **Systemic Risk analysis.** The systemic risks to the banking sector from domestic and cross-border exposures are assessed using two methodologies: bank network analysis and market-based contagion analysis.

- **Network Analysis.** The network analysis captures the contagion risks from cascading defaults, stemming from cross-border as well as domestic interbank exposures. It includes a credit shock simulation whereby a credit counterparty default is likely to erode capital buffers and a funding shock simulation whereby the default of a funding counterparty might induce a liquidity shortfall. A potential fire sale of assets in a stressed market and haircuts on illiquid assets is also envisaged to simulate an extreme funding shock. The analysis is based on APRA's data on individual bank exposures and country-level locational banking statistics. The coverage of the network analysis includes the ten largest Australia-incorporated banks. The cross-border exposure data for individual banks is provided as of end-June 2018, while the country-level locational banking statistics are as of December 2017.
- **Market-based contagion analysis.** This approach assesses contagion through equity valuations of major global banks. The sample for the analysis includes 25 of the 30 global systemically important banks (G-SIBs) identified by the FSB in 2017 and the nine largest publicly traded Australian banks or banking groups. The analysis is based on the Diebold-Yilmaz (2014)⁶ methodology and uses daily data from January 2003 through July 2018.
- **Corporate sector vulnerability analysis.** The FSAP assessed corporate sector vulnerabilities through sensitivity analysis, to gauge resilience of nonfinancial corporates to interest rate risk and macroeconomic shocks. A sample of 250 large Australian corporates with a combined asset base of around A\$1 trillion is used for this analysis. Interest coverage ratios are estimated at the firm-level under an adverse scenario⁷ and mapped to debt-at-risk measures for each sector. Data limitations prevent a deeper analysis on corporate sector risks and the bank-NFC linkages.
- **The remainder of this technical note is structured as follows.** The next sub-section provides a brief overview of the systemic risk in Australia. The following two sections present the bank solvency and liquidity stress test result, respectively. The solvency and liquidity discussions are followed by a section discussing the two approaches that were used to analyze systemic risk and interconnectedness in Australia, namely network and contagion analysis. Then, the report presents the corporate sector vulnerability analysis, which complements the stress test and interconnectedness analyses. The report concludes with the recommendations to bolster financial stability.

C. Overview of Systemic Risk

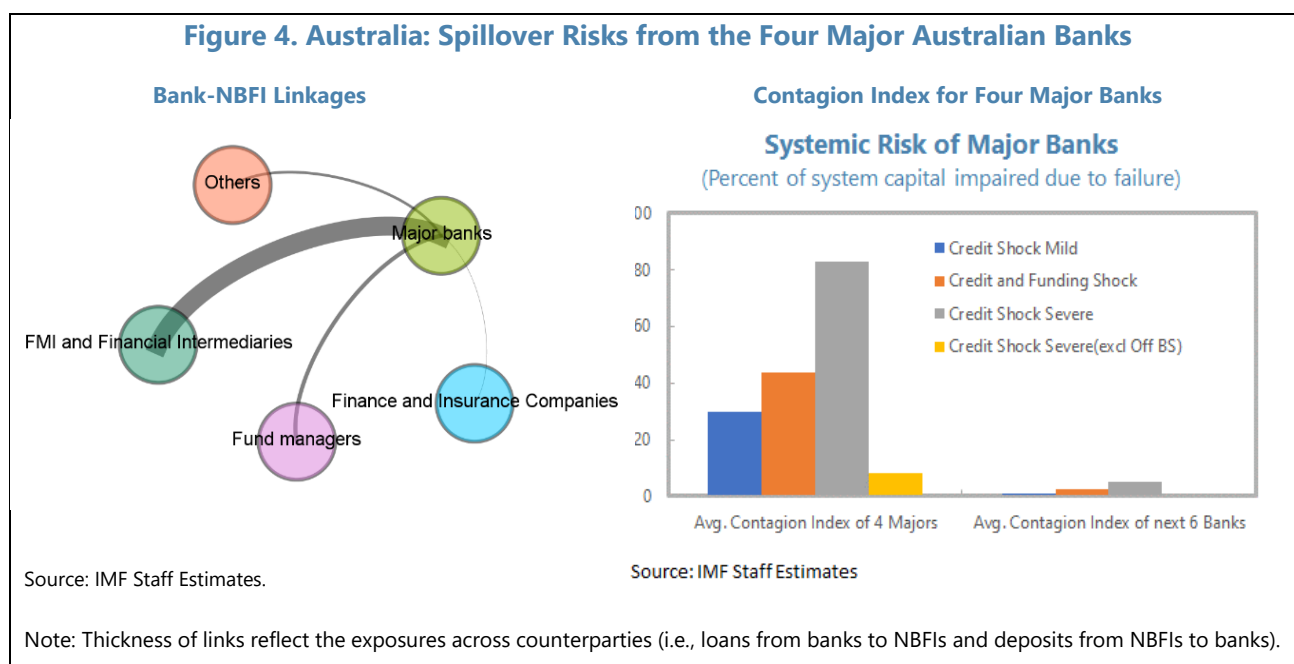
7. Balance sheet exposures and equity correlations suggest that systemic risks depend heavily on the health of the four major banks. The stability of the four major banks is crucial for the stability of the whole financial system. Due to the similarity of balance sheets and interlinkages

⁶ 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.

⁷ The adverse scenario assumes a 1 standard deviation shock to earnings as well as interest expense. The standard deviation is estimated over a 10-year time frame.

between the large banks and in turn between the large banks and NBFIs (Figure 4), a severe shock to any of the four major banks could propagate rapidly to the rest of the banking system and to the rest of the financial sector. However, potential losses to the four major banks from direct exposures to domestic counterparties appear manageable given strong capital levels. The four major banks also seem able to absorb the impact of external and domestic shocks to the rest of the system, given their large capital buffers. That said, second-round and contagion effects⁸ to the smaller institutions could still be significant and are investigated in detail in the section on Interconnectedness and Contagion below.

8. The systemic importance of the four largest banks is highlighted by their potential to generate strong cascade effects across the banking system. Estimates of index of contagion, calculated as the average percent of capital impaired in the system in the event of an institution’s failure,⁹ reveal that a failure of any of the four major banks would significantly deplete the overall system’s capital buffers (Figure 4).

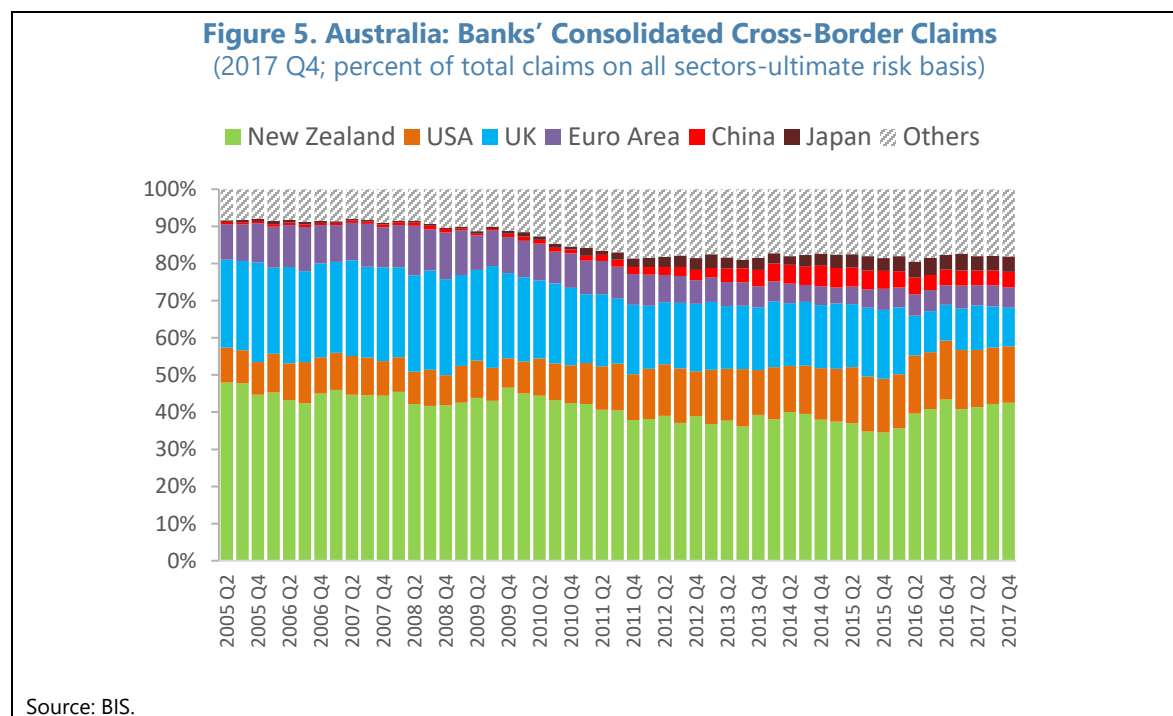


9. Cross-border exposures for the ten largest Australian banks are concentrated among a few counterparty countries, with New Zealand the largest. BIS data reveal that around 55 percent of cross-border asset exposures for banks located in Australia are through their local subsidiaries abroad, while the rest is via cross-border lending. International claims, which include all

⁸ In this rest of this report, spillover effects pertaining to a bank are categorized as either ‘inward’ or ‘outward’ spillovers. Inward spillovers pertain to risks **to the bank** from other sources. Outward spillover (or contagion) refer to the risks emanating **from the bank** to other institutions.

⁹ Under the Vega-Sole model, a hypothetical or induced failure of an institution materializes when its capital base is wiped out entirely. Any assumptions on policy support, recovery, etc. can potentially be built into the loss-given-default (LGD) and funding roll-over rates within the model.

assets such as loans, securities, and reserves at foreign central banks, amount to around 20 percent of the aggregate banking system assets on a consolidated basis. Meanwhile, claims on global banks amount to roughly 3 percent¹⁰ of total assets for Australian banks, with the largest exposures to banks operating in the United States, China, and the United Kingdom. At the individual bank level, these exposures are concentrated among the big four banks. Separately, banks' liabilities to global counterparties amount to around 22 percent of the system liabilities,¹¹ with liabilities to international banks totaling roughly 13 percent of system liabilities.



BANK SOLVENCY STRESS TESTS

A. Key Risks and Vulnerabilities

10. The main vulnerabilities of Australia's financial system are discussed below. These vulnerabilities and the risks associated with them formed the basis of the financial stability analysis of the FSAP.

11. Real estate valuations are stretched, and household leverage is high.

- Until the recent national house price correction (prices declining about 3 percent over the year ending July 2018), house prices had risen by about 70 percent over a 10-year period. The price appreciation has been even higher in Sydney and Melbourne, where prices had doubled on

¹⁰ Based on consolidated BIS data. On a locational basis, interbank claims total around 7 percent of system assets.

¹¹ Based on locational data since consolidated statistics on liabilities are unavailable.

average over 10 years, though these two cities have also experienced price corrections of about 5 percent and 3 percent respectively over the past year. Commercial real estate prices, particularly for office space, have also risen sharply in the major cities over the past decade but have not shown any signs of cooling yet. Housing affordability linking incomes to prices is near all-time lows.

- Benign credit conditions and the surge in house prices have contributed to rapidly rising household leverage. Household debt now stands at some 190 percent of disposable income (some 20–25 percentage points above the level in the 2012 FSAP) and is high by international standards. Elevated levels of debt are counterbalanced by housing and financial assets, and substantial pension savings through the mandatory superannuation system.

12. Australia and China have increasingly strong linkages through the trade channel. While Australian banks' direct exposure to China is relatively small, the economy has a much larger exposure via the trade channel. One-third of Australian goods exports, including 40 percent of commodities, go to China. Moreover, growth of services exports to China in recent years has been particularly strong in the areas of tourism and education. A significant slowdown in growth in China could have broad macrofinancial impact on Australia.

13. Australian banks rely on wholesale funding markets. Banks' reliance on wholesale funding has come down in recent years, but it remains high at about one-third of total liabilities. Approximately two-thirds of the wholesale funding is from international sources, which makes the system vulnerable to changes in global liquidity conditions.

14. Against this background, the FSAP identifies the following key macrofinancial risks (Appendix I, RAM):

- A significant slowdown in China and weak growth in advanced economies.* Rising global protectionism could provide one catalyst for the realization of this risk. Lower exports and deterioration in terms of trade would reduce GDP growth, weaken consumption, lower corporate profits and investment, and raise unemployment. Banks would likely face higher losses on their corporate loans, as well as on their broader credit portfolio due to the overall decline in economic activity.
- A tightening of global financial conditions due to an abrupt change in risk appetite.* As observed during the GFC, a spike in risk premia and more volatile financial conditions could lead to significantly higher funding costs for Australian banks as they remain dependent on international funding markets. A decline in net capital inflows and a repricing of country risk due to lower confidence would increase funding costs for Australian banks, push down asset valuations, and result in a depreciation of AUD. Credit growth would also likely decline, which could further amplify the slowdown of economic growth.
- A sharp housing market correction.* A sharp decline in house prices would lower confidence, weaken housing demand, and lower residential investment. It would also reduce banks'

supply of mortgage loans and tighten their lending standards. A vicious feedback loop of falling house prices, weaker consumption, higher nonperforming loans, and tightening of banks' lending standards could amplify the downturn.

B. Scenarios Underpinning the Financial Stability Analysis

15. The stress tests utilized two scenarios, Baseline and Adverse, over a three-year horizon.

The stress tests use the latest available balance sheet data, as of 2017 Q4, and simulate profit and losses, balance sheets, and evolution of risk-weighted assets and capital under the baseline and adverse scenarios for the three-year period 2018 Q1–2020 Q4.

16. The baseline scenario reflects the IMF World Economic Outlook (WEO) projections as of April 2018. The main macrofinancial variables utilized in the Baseline scenario are the annual GDP growth rate, unemployment rate, house price index, RBA Cash Rate, and the AUD/USD exchange rate. After several years of moderate growth, Australia's economic growth picks up in 2018 under the Baseline scenario, with stronger global economic prospects, recent strong employment growth, and higher infrastructure spending the main drivers. The first year of the scenario projects a GDP growth rate of close to 3 percent, which edges up to 3.1 percent in the second year, and moderates to 2.9 percent in the third year. Under this strong economic growth, the unemployment rate declines gradually from its beginning level of 5.6 percent as of 2017, to 5 percent by the end of the scenario period. The USD exchange rate is assumed to be stable at 1.32 throughout the scenario period.

17. The Adverse scenario is constructed based on the risks and vulnerabilities discussed in the "Key Risks and Vulnerabilities" section above. The Adverse scenario is driven by a combination of a domestic shock (a sharp decline in real estate prices) and two external shocks (a significant slowdown in external growth and a tightening of global financial conditions):¹²

- **Shock 1** entails a sharp decline in real estate prices. A vicious feedback loop of falling real estate valuations, higher nonperforming loans, tighter bank credit, and household deleveraging would amplify the downturn. The impact on banks would be largely through higher credit losses. Additionally, weaker banks might experience a significant increase in wholesale funding costs and outflow of customer deposits.
- **Shock 2** arises from a significant slowdown in China and a decline in global economic growth. This would cause a sustained decline in price of commodities and lead to pressures on the Australian economy and to associated credit losses for Australian banks.
- **Shock 3** results from global financial market turmoil and a sharper-than-expected tightening of global financial conditions. This would be accompanied by a disorderly correction in asset prices, heightened volatility, and a sharp depreciation of the Australian dollar. The impact on banks would be largely through market risk (via repricing of banks' financial assets) and through higher wholesale funding costs, as markets reprice the risk of Australian banks.

¹² The stress test analysis does not cover certain categories of risk affecting banks, such as operational or legal risk, unexpected costs from the multiple ongoing inquiries into financial sector misconduct.

18. The Adverse scenario simulates the impact of a sharp contraction in the economy. In the first two years of the Adverse scenario, real GDP is assumed to decline at annual rates of 2.5 percent and 0.5 percent respectively. The economy would start to recover in the third year with GDP growth turning positive at 1.6 percent. This Adverse path corresponds to a cumulative GDP shock of about 10 percentage points relative to the Baseline, or 3.75 times the standard deviation of three-year cumulative GDP growth rates observed in Australia in the past 30 years. The full set of macrofinancial variables are generated by the Flexible System of Global Models developed by the IMF Research Department¹³ and benchmarked to past experience of economic slowdown in Australia through expert judgment. In addition to the GDP shock in Australia, the Adverse scenario assumes a slowdown in Australia's major trading partner, China, which experiences adverse GDP growth shocks of 2.6 percent, 3.9 percent, and 1.7 percent in the three years relative to the baseline. This slowdown would reduce commodity prices and export revenues for Australia. The economic slowdown in Australia is accompanied with a significant increase in unemployment, which increases from its beginning level of 5.6 percent to 8.8 percent and 9.9 percent in first and second years of the scenario, respectively, and declines only modestly to 9.7 percent in the final year of the scenario as the economy starts to recover. With the deterioration of the terms of trade and increasing risk aversion, the Adverse scenario envisions a sharp depreciation of the currency, with the AUD losing 25 percent of its value against the USD in the first year. This depreciation only partially reverses in the second and third years of the scenario resulting in cumulative depreciations of 20 percent and 16 percent by the end of the second and third years.

19. Other assumptions in the Adverse scenario relate to a decline in house prices and the monetary policy rate, see Figure 6. To reflect the sharp correction in real estate prices envisioned in the scenario, house prices decline by 15 percent in the first year, and by 10 percent in each of the second and third years. The cumulative decline in the house price index is thus slightly over 31 percent at the end of the three years. Given the contraction in the economy and the decline in asset prices, monetary policy is assumed to respond swiftly, with a 100-basis points reduction in the RBA Cash Rate in the first year which brings it down to 50 basis points. Reflecting the continued contraction in the economy in the second year, the RBA is assumed to reduce the Cash Rate by another 25 basis points, see Figure 6 below.

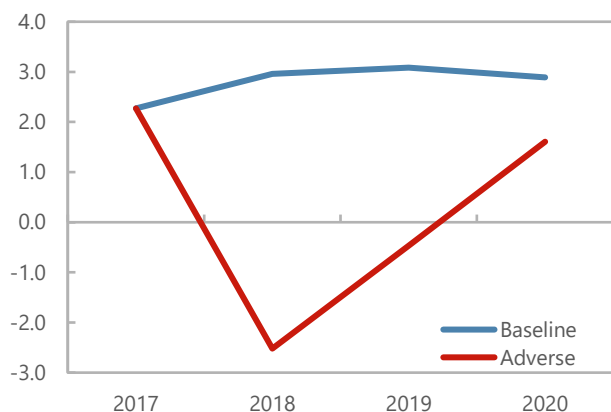
20. Given the financial tightening and increased risk aversion assumed in the Adverse scenario, credit spreads widen, affecting the short-term interbank borrowing conditions. This effect is captured by the widening of the spread between the 3-month Bank Bill rate, a benchmark bank borrowing rate, and the Cash Rate. The spread widens from its 2017 year-end level of 30 basis points to 130 basis points at the end of 2018. Short-term bank borrowing costs are thus largely unchanged in the first year despite the decline in the Cash Rate. The borrowing spread is assumed to gradually decline to 70 and 50 basis points by the end of 2019 and 2020, respectively, which pushes down the Bank Bill rate.

¹³ For more details, see the IMF working paper, [The Flexible System of Global Models – FSGM](#) (2015).

Figure 6. Australia: Stress Test Scenarios – Baseline and Adverse

Growth in Australia picks up in the Baseline, while it slows down significantly for two years in the Adverse Scenario

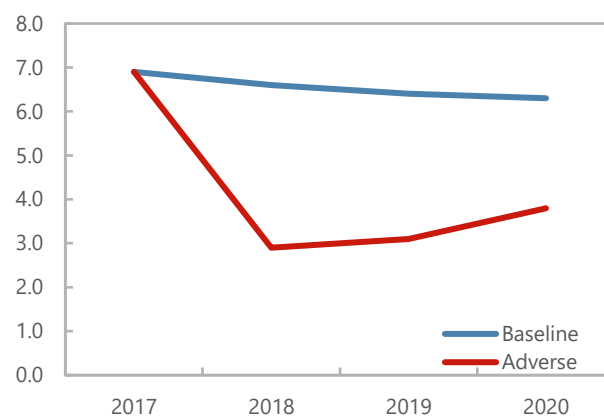
Annual Real GDP Growth - Australia
(in percent)



Source: IMF Staff

China also experiences a significant slowdown in the Adverse Scenario

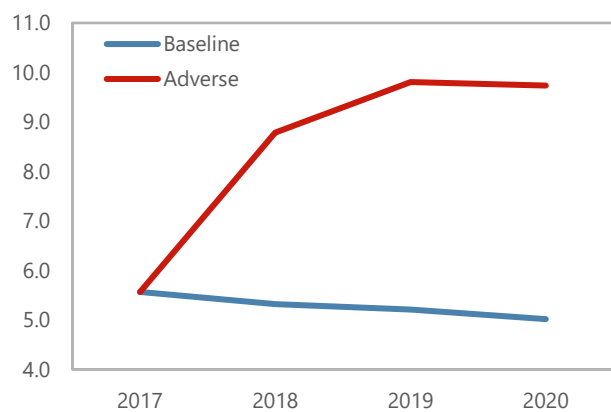
Annual Real GDP Growth - China
(in percent)



Source: IMF Staff

Unemployment increases significantly in the Adverse scenario and remains elevated

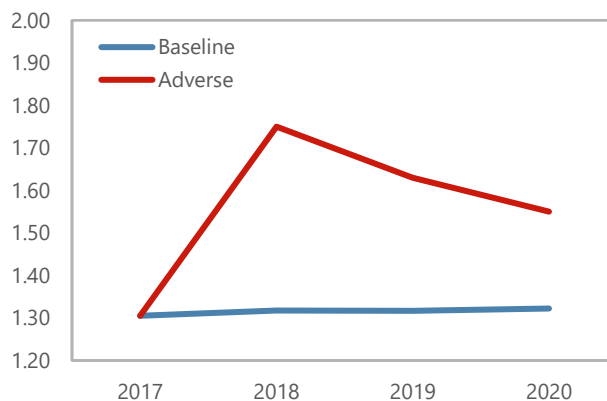
Unemployment Rate
(in percent)



Source: IMF Staff

AUD depreciates sharply in the first year under the Adverse scenario, and only partially recovers later

USD Exchange Rate
(level)

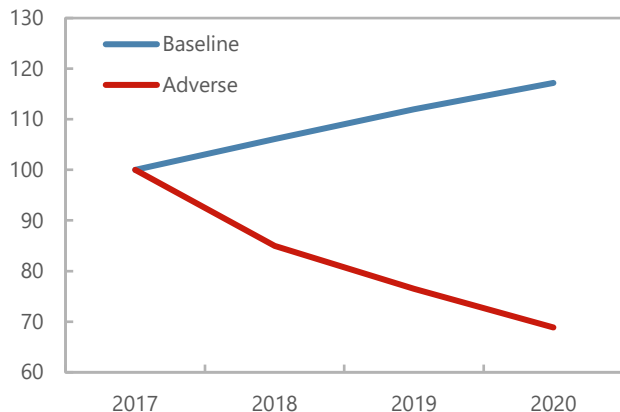


Source: IMF Staff

Figure 6. Australia: Stress Test Scenarios Baseline and Adverse (concluded)

House price index declines by more than 30 percent in the Adverse scenario

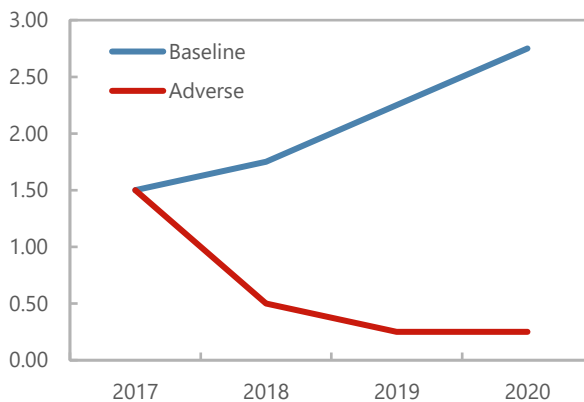
House Price Index
($t_0=100$)



Source: IMF Staff

RBA reduces the Cash Rate swiftly and significantly in the Adverse scenario

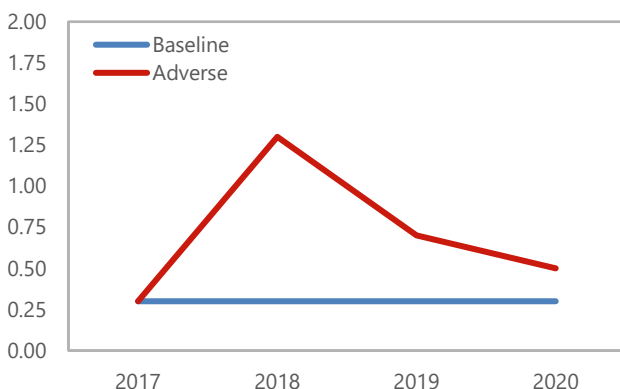
RBA Cash Rate
(in percent)



Source: IMF Staff

With financial tightening the spread between the Bank Bill rate and the Cash Rate widens

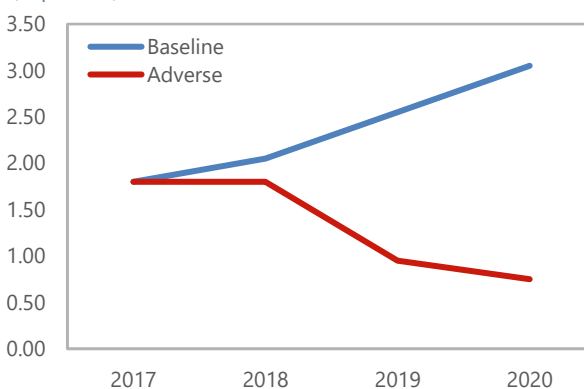
Bank Bill Rate/Cash Rate Spread
(in percent)



Source: IMF Staff

...which keeps the short-term bank borrowing rates largely unchanged in the first year

3-mo Bank Bill Rate
(in percent)



Source: IMF Staff

21. In addition to the short-term interbank borrowing markets, the Adverse scenario simulated the impact of higher risk premiums on the full set of funding sources of banks under the tightening of financial conditions. 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 data for system-wide average borrowing rates across six funding sources: (i) retail deposits, (ii) wholesale deposits, (iii) onshore short-term debt, (iv) offshore short-term debt, (v) onshore long-term debt, and (vi) offshore long-term debt. The

funding shocks were modeled in two steps: first a systemic shock that applies to all banks, and then an idiosyncratic shock that affects banks differentially.

22. For the calibration of systemic funding shocks regression analyses were carried out.

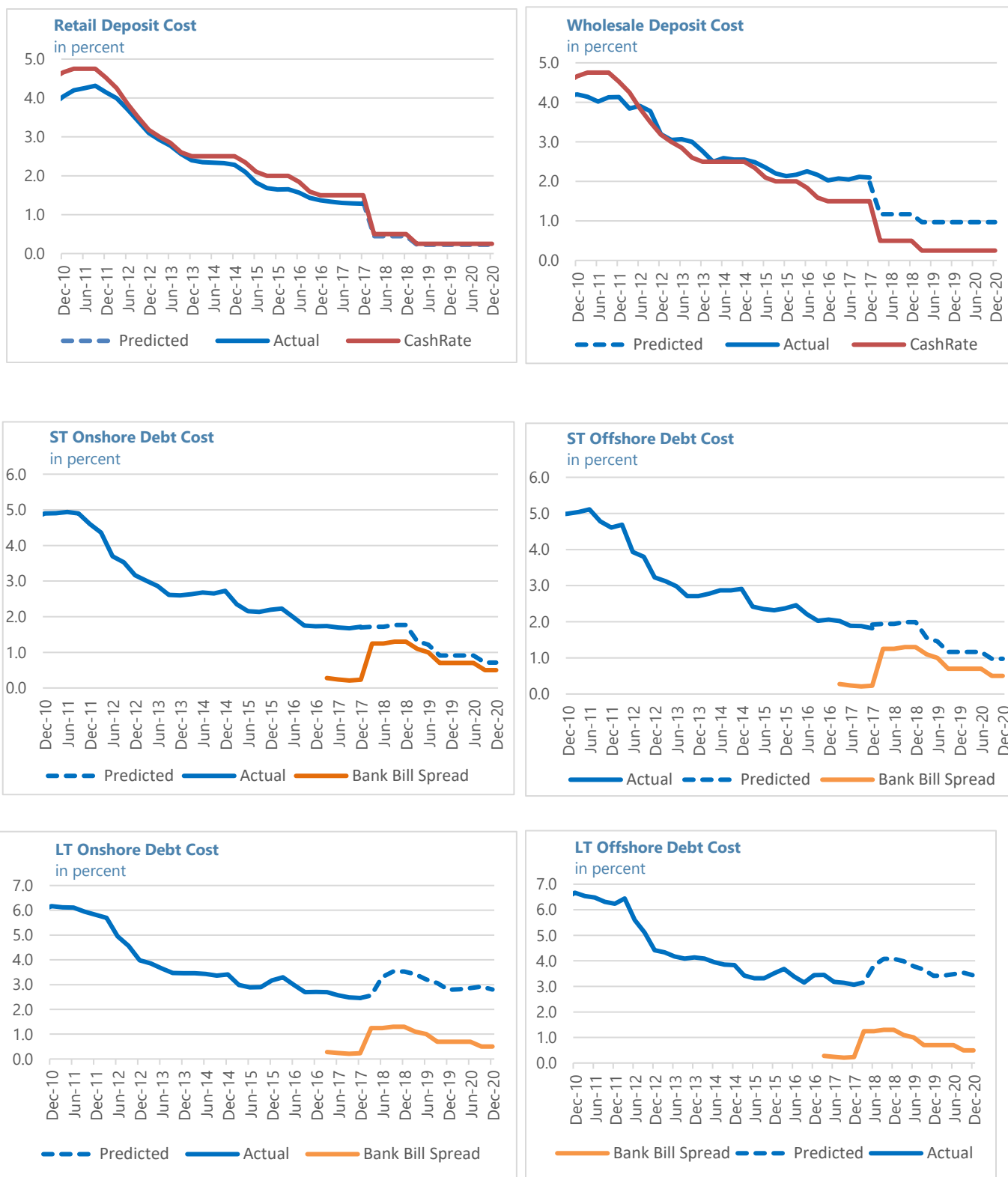
Quarterly funding cost data from 1999 to 2017 were regressed on benchmark financial variables simulated in the Adverse scenario to capture the changing conditions in both domestic and international funding markets. The benchmark variables used were the Cash Rate, 3-month Bank Bill rate, and 10-year Australian Commonwealth Government bond yield for domestic funding sources, which were complemented with 3-month USD LIBOR and the 10-year U.S. Treasury bond yield for offshore funding sources. The resulting shocks for the six funding sources are presented in Figure 7 below.

23. Deposit rates, both retail and wholesale, largely follow the Cash Rate and decline significantly in the systemic funding shock simulation. Historically, both deposit rates have been highly correlated with the Cash Rate. Short-term debt costs, on the other hand, largely follow the 3-month Bank Bill rate. As the 3-month Bank Bill spread to the Cash Rate widens in the Adverse scenario, short-term debt costs stay largely unchanged in the first year and decline only gradually as the spread narrows somewhat in the second and third years.

24. Long-term debt costs see the largest increases, driven by the widening of the Bank Bill spread and the steepening of the yield curve. Both onshore and offshore debt costs increase by approximately 100 basis points in the first year and decline gradually as the spread contracts in the second and third years.

25. The idiosyncratic funding shocks among the banks were designed to capture the flight-to-safety effect that is likely to be observed during a severe crisis. While all banks are likely to experience a reduction in the supply of funding and corresponding increases in funding costs during the Adverse scenario with the financial tightening, there is also likely to be some re-allocation of funds within the banking system. When all banks are suffering losses during a crisis, wholesale fund providers especially are likely re-allocate their funds towards the relative safety of the largest banks given a market perception that they are “too-big-to-fail.” Mid-sized and small banks would suffer further declines in the supply of available funding in that situation.

Figure 7. Australia: Funding Cost Shocks – Systemic Component



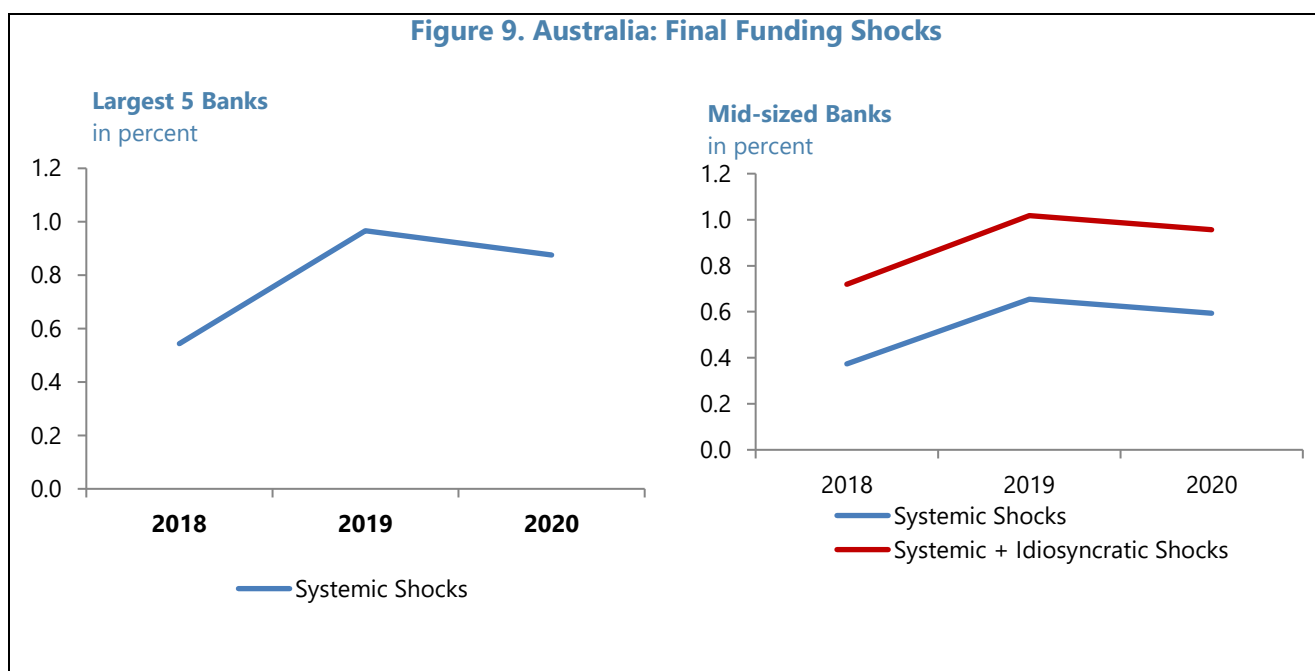
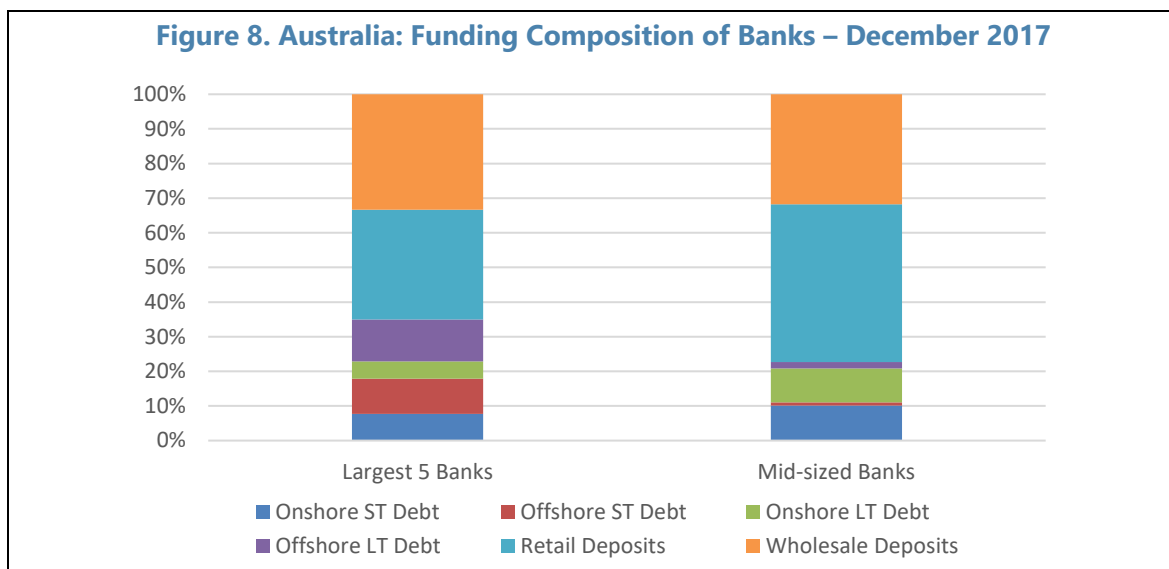
26. The FSAP team assumed the same idiosyncratic funding shock, 50-basis points, for all mid-sized banks included in the ST sample to capture this flight-to-safety effect.¹⁴ Since retail fund suppliers are likely to be less sensitive to the changes in the perceived safety of mid-sized banks during a crisis reflecting deposit insurance, the 50-basis points shock was applied to non-retail deposit sources of funding of mid-sized banks and their retail deposits costs were assumed to increase by some 20 basis points.

27. With the systemic and idiosyncratic funding shocks determined for each of the six funding sources, the final funding shocks at the bank level were calculated as weighted averages based on the share of each funding source for each bank. The average shares of each funding source for the largest five banks and the mid-sized banks are presented in Figure 8 below. With retail deposits receiving the lowest shocks, those banks that rely most on retail funding receive smaller aggregate shocks.

28. There is significant variation in the funding composition across banks. Mid-sized banks have a larger share of their funding in the form of deposits, particularly retail deposits. On average, close to 46 percent of their total non-equity funding consists of retail deposits, with an additional 32 percent in the form of wholesale deposits, mostly deposits of nonfinancial corporates and SMEs. The remaining 22 percent of funding consists of long-term and short-term debt (secured and unsecured), see Figure 8 below for details of the funding composition of the largest five banks and the mid-sized banks used in the ST sample. The final funding shocks are presented in Figure 9 below.

29. The simulated funding shocks lead to a direct compression of banks' net interest margins. While their funding costs increase during the Adverse scenario, the FSAP analysis assumed that banks will not be able to pass the higher funding cost to their borrowers in the first two years of the scenario. The Adverse scenario simulates a significant slowdown in economic activity, with GDP contracting in the first two years of the scenario accompanied by a slowdown in credit demand. In such an environment, banks will likely be constrained in their ability to pass on the increase in their funding costs to borrowers. As the economy starts recovering in the third year of the scenario, with GDP growth turning positive, the analysis assumed that banks will be able to pass 75 percent of the increase in their funding costs to the borrower. As a result, the effect on banks' net interest margins starts dissipating in the third year.

¹⁴ Bank-level historical funding costs were not available to calibrate the idiosyncratic funding shock, hence the FSAP team used an assumption of 50 basis points for all mid-sized banks. Recent academic research suggests a causal effect of bank downgrades on their funding costs. Adelino and Ferreiro (2016) report an estimated effect of 45-65 basis points increase in funding costs following bank downgrades. The 50-basis points shock assumed by the FSAP team is consistent with additional downgrades that mid-sized banks might experience during a severe crisis.



C. Methodology of the Solvency Stress Tests

30. The solvency stress testing exercise consisted of scenario analysis and sensitivity tests based on data as of 2017 year-end. The scenario analysis assesses banks’ solvency over a period of three years (2018 Q1–2020 Q4), while the sensitivity tests are static; that is, they assess the instantaneous impact of single risk factors on banks’ balance sheet positions as of 2017 Q4. For the scenario analysis, the FSAP carried out a top-down exercise based on the methodology described below.

31. The solvency stress tests followed a balance sheet approach broadly aligned with Australia's regulatory framework. The largest five banks in the ST sample follow the Internal Ratings-Based approach (IRB) while the five mid-sized banks followed the Standardized Approach (STA) as of year-end 2017. In line with this regulatory framework, banks' performance was assessed based on total capital adequacy ratio (CAR) and CET 1 capital ratio. The hurdle rates used were 4.5 percent for the CET 1 ratio and 8 percent for CAR. In addition to these minimum capital requirements, all banks are expected to maintain a capital conservation buffer of 2.5 percent of CET 1 capital, except for the four largest banks in the system for which the capital conservation buffer is 3.5 percent of CET 1, reflecting the D-SIB surcharge.

32. The balance sheet approach is based on projecting 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 scenario.

33. The tests are carried out under a passive balance sheet assumption. Growth of gross exposures, such as total gross loans and gross holding of debt securities, is assumed to follow nominal GDP, with a zero-growth floor. Thus, the size of the banking system assets remains broadly stable relative to the size of the economy. This assumption ensures that banks continue to maintain their fundamental function of financial intermediation even in a severe crisis environment and do not 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.

34. 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, and NPLs. It is assumed that banks would not receive interest income from NPLs. Non-interest income items were based on simple assumptions instead of models. Net fee and commission income was assumed to decline by 30 percent from its initial level, to account for the decline in economic activity. Other non-interest income items, such as operational and administrative expenses and other non-interest income, were assumed to grow in line with the overall size of banks' balance sheets. Finally, the loss provisions are estimated separately for standardized and IRB banks. The two approaches are discussed in more detail below.

Calculation of Loss Provisions for Standardized Banks

35. The two main components of credit loss projection for standardized banks are the projection of additional flow of NPLs and the projection of loan provisioning rates. The FSAP team estimated satellite credit risk models to project the flow of additional NPLs during the scenario period for each loan exposure class (mortgages, corporate loans, CRE loans, and retail loans) for all banks in the ST sample (IRB and standardized). The NPL ratio estimates for standardized banks directly fed into their loss provision calculations. As for the provisioning rates, for all loans other than mortgages, provisioning rates in the Adverse scenario were based on stressed loss rates on defaulted exposures used in Phase 2 of the 2017 APRA stress tests. For mortgage loans, the FSAP team constructed provisioning rates from the ground up, using the LVR distribution of banks' mortgage portfolios as of 2017 and the simulated house price index declines for each year of the scenario. The estimated flow of additional NPLs in each year were multiplied by bank-level provisioning rates to calculate loss provisions for standardized banks.

Calculation of Loss Provisions for IRB Banks

36. Loss provisions for IRB banks are based on the Expected Loss (EL) approach, which was calculated separately for each exposure class. The EL calculation, based on the formula $EL = PD \times LGD \times EAD$, requires point-in-time (PiT) PDs which would reflect the current risk profiles of banks' portfolios and would increase in response to a deterioration in the economic environment. Historical PiT PD series were not available, hence for the IRB banks the FSAP team used the PDs from Phase 2 of the 2017 APRA stress tests. These stressed PD estimates were benchmarked against bank's historical through-the-cycle PDs and the NPL ratios estimated by the FSAP team for those banks. For LGDs, the stressed loss rates on defaulted exposures from Phase 2 of the 2017 APRA stress tests were used for all exposures other than mortgages. For mortgage loans, again the FSAP team constructed the LGDs from the ground up, using the LVR distribution of banks' mortgage portfolios as of 2017 and the house price index path simulated in the scenario. For all banks in the ST sample, the provisioning rates reflect the higher losses that are likely to be experienced in a significant economic downturn that is simulated in the Adverse scenario. The provisioning rates for corporate loans vary between 35 and 50 percent in the scenario. For consumer loans, which are mostly uncollateralized, the provisioning rates reached as high as 90 percent. For mortgage loans, the provisioning rates were more modest. Given the low average LVR of banks' mortgage portfolios at the starting point of the scenario analysis, even with substantial declines in house prices and transactions costs related to foreclosed properties, the provisioning rates were in the 10 to 17 percent range.

Changes in Risk-Weighted Assets (RWA)

37. The stress test accounted for changes in RWA under the scenarios. For IRB banks, the RWA formula uses the through-the-cycle (TTC) PDs and downturn LGDs. The changes in TTC PDs were derived from the PiT PDs used for EL calculation using the formula:

$\Delta \text{TTC PD} = 0.5 * \Delta \text{PiT PD}$. That is, the increase in TTC PDs were assumed to be 50 percent of the increase in PiT PDs. The downturn LGDs used by the banks in their RWA calculation were left unchanged, apart from for those exposure classes for which the LGDs reported in the APRA ST

exceeded the downturn LGDs. In such cases, downturn LGDs were increased by 10 percent¹⁵ to capture the potential increase in downturn LGDs in a severe stress.

38. For the STA banks, the risk weights are determined by the risk ratings of most exposures and captured by LVR of mortgages according to local regulations. For mortgages, the FSAP team used the initial LVR distributions of banks' mortgage portfolios and projected forward the portfolio LVR distributions based on the house price index (HPI) declines simulated in the Adverse scenario. As the LVRs increased with the declining HPI, the new higher risk weights corresponding to the new LVR distribution were calculated at each year of the scenario, and a floor of 15 percentage point of three-year cumulative increase for risk weights was adopted. The average increase in mortgage risk weights across the STA banks in the sample was approximately 16 percentage points. For most exposures other than mortgages the initial risk weights were already close to 100 percent and the increase in risk weights was minimal.

D. NPL Projections

Mortgage NPLs

39. The Australian economy has notably delivered 26 years of uninterrupted economic growth, without experiencing any country-wide downturn that put households under significant stress. During this period of growth, mortgage defaults have been muted. The NPL data, which start in 2004, show that the NPL ratios for banks' national mortgage portfolios have been low, staying below 1 percent throughout the period, and stable (see Figure 10). Econometric analysis of the data also indicated that NPL ratios have not been strongly correlated with the main macroeconomic variables. The lack of a major downturn experience and low correlation with macroeconomic variables make modeling and projection of NPL ratios for the severe stress simulated in the Adverse scenario challenging.

40. For modeling mortgage NPLs, the FSAP team utilized the period of economic slowdown that the state of Western Australia (WA) experienced starting in 2014 associated with the significant decline in commodity prices. Western Australia is a key mining region of Australia with large amounts of iron ore and gas reserves. From mid-2000s to early 2010s, the state enjoyed a terms of trade boom, with the prices for these minerals increasing significantly. During this period the state experienced above-trend investment and growth, accompanied by low unemployment. In the subsequent downturn of the global commodity cycle, falling commodity revenues led to a regional economic downturn. Unemployment increased from 4.4 percent in Q4 2012 to a peak of around 6.5 percent in Q4 2016 and has remained elevated since then. The regional HPI also declined during this period of economic slowdown, by about 9 percent between its local peak in Q1 2014 and Q4 2017.¹⁶ While the regional economic slowdown was more modest than that

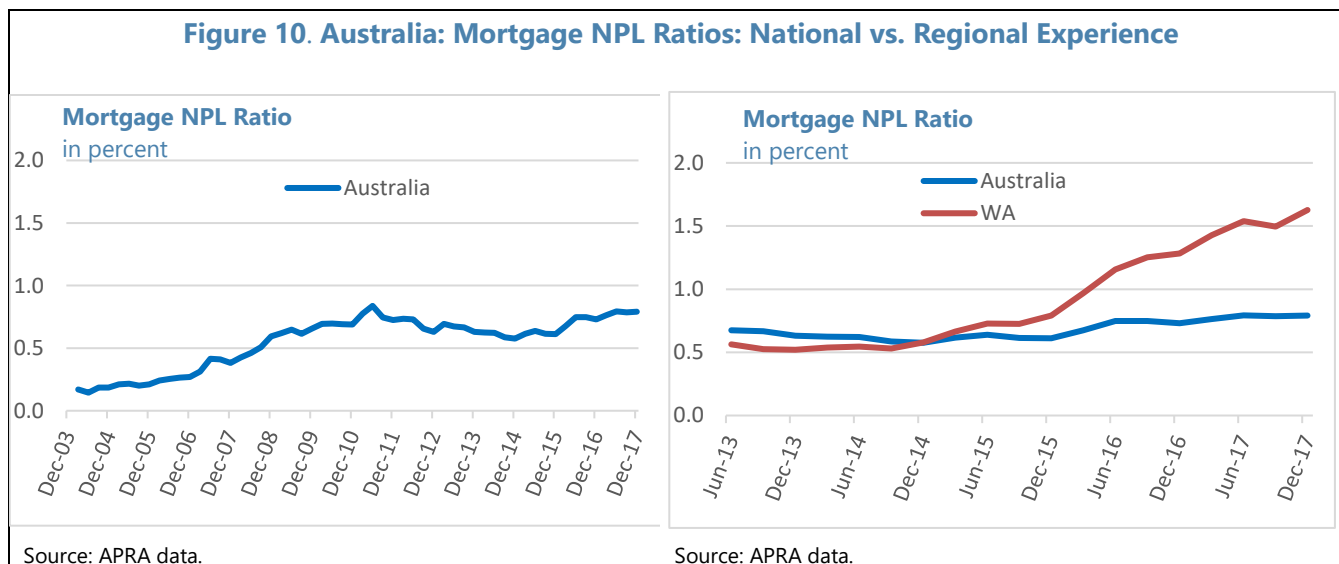
¹⁵ For example, an initial downturn LGD of 30 percent was increased to 33 percent for the RWA calculation.

¹⁶ During the same period (Q1 2014-Q4 2017), the overall Australian economy continued to enjoy annual economic growth of close to 2.5 percent, only modest and temporary increases in the national unemployment rate, and the national HPI increased by 29 percent, largely driven by activity in major urban areas.

simulated in the Adverse scenario, the state mortgage NPL ratio increased significantly, from around 0.5 percent at year-end 2013 to around 1.6 percent at year-end 2017. By comparison, the national mortgage NPL ratio increased by less than 0.2 percentage point during the same period. The FSAP team used the regional mortgage NPL ratio data, which have been collected by APRA since Q2 2013, and the regional economic variables to calibrate the mortgage NPL model.

41. An econometric analysis of the regional data indicated that unemployment is the most important driver of increases in the NPL ratio. The decline in HPI also contributes, but to a much smaller extent. The model estimates from the regional model were used to project NPLs for banks’ overall mortgage portfolios during the Adverse Scenario. These estimates suggest that banks would experience significant increases in their mortgage NPLs under the Adverse scenario. The system-wide average NPL ratio would rise from 0.8 percent at year-end 2017 to just over 3 percent at year-end 2020, see Figure 11. This is significantly higher than the levels observed during the full sample period of 2004 to 2017.¹⁷

Figure 10. Australia: Mortgage NPL Ratios: National vs. Regional Experience



Other Loan NPLs

42. For the loan products other than mortgages, the FSAP team used the national NPL history to calibrate the NPLs for the scenario period.¹⁸ NPL ratios for NFC loans and CRE loans¹⁹ increased significantly during the global financial crisis. Both peaked around mid-2010 and have subsequently declined to pre-GFC levels since then (see Figure 11). The increase in non-performance

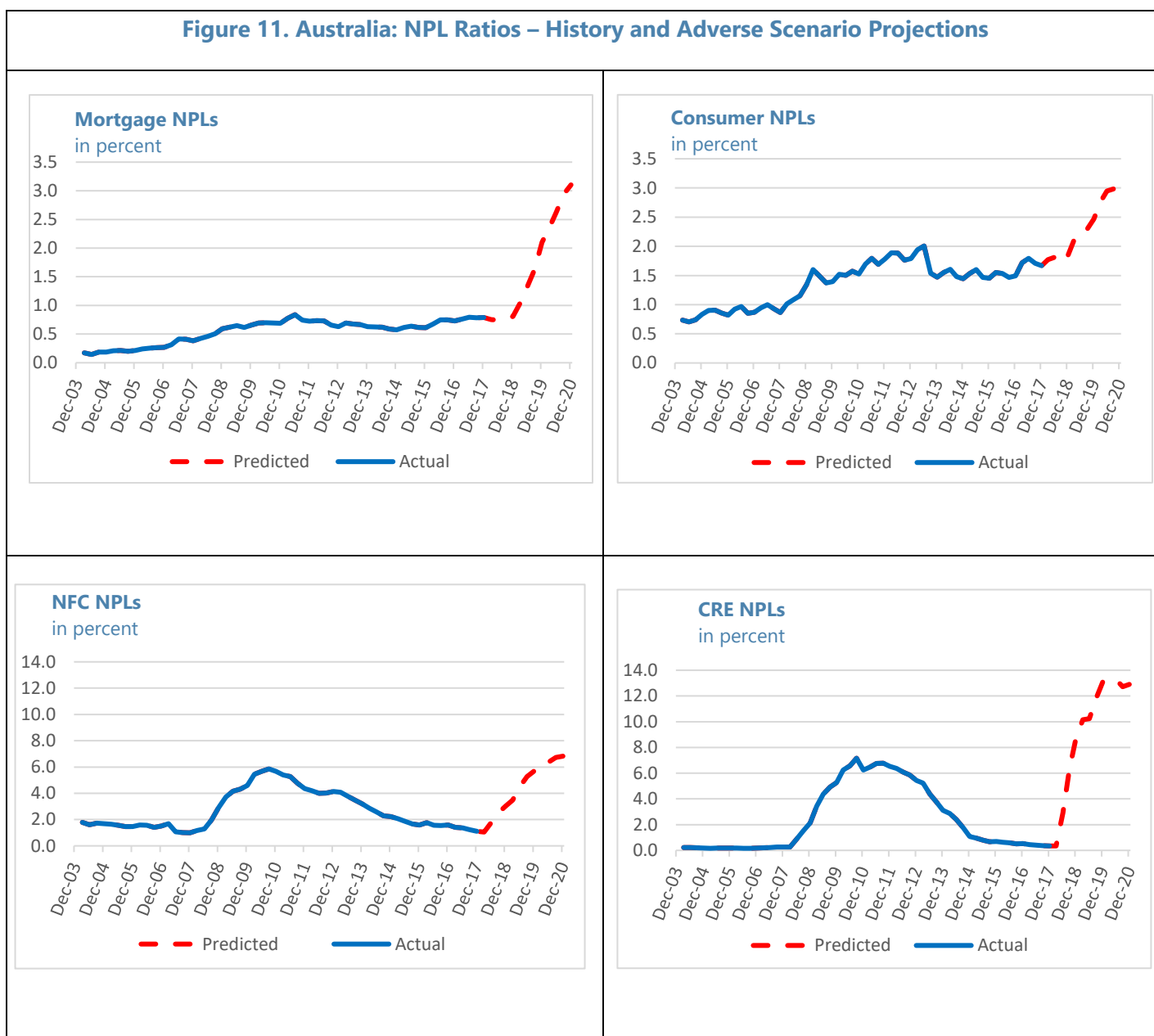
¹⁷ Separate default series for interest-only and principal-and-interest loans were not available for the FSAP team’s analysis. As interest-only loans switch to a principal-and-interest basis after an initial period (typically five years), a large concentration of interest-only loans starting their principal payments during a severely adverse economic environment may lead to defaults higher than the levels suggested by historical default series. The data limitations related to the interest-only loans pose a downside risk to the default estimates used in the FSAP analysis.

¹⁸ APRA collects regional NPL data only for mortgage loans.

¹⁹ For CRE loans, NPL ratio data were not available and the FSAP team used the “impaired loan ratio” data. Aggregate NPLs consist of impaired loans and past due loans. The FSAP team assumed that aggregate CRE NPLs consist of 2/3 impaired loans and 1/3 past due loans and scaled up the impaired loan ratio series to obtain the proxy NPL ratio series.

of CRE loans during the GFC was particularly large, with the NPL ratio increasing from less than 0.5 percent in late 2007 to around 7 percent around mid-2010. The NPL ratio for consumer loans was relatively muted and less correlated with the economic slowdown during the GFC. This pattern is consistent with that of the national mortgage NPLs during the GFC. The corporate sector overall suffered significant declines in profitability and higher NPLs during the GFC, whereas the stress on households was more modest. Drawing on that experience, banks that are relatively more exposed to the more cycle-sensitive nonfinancial corporates and CRE loan categories would experience larger increases in their overall NPLs during the scenario period. The NPL ratios projected for each of these major loan categories for the Adverse scenario are presented in Figure 11 below.

Figure 11. Australia: NPL Ratios – History and Adverse Scenario Projections



E. Stress Test Results

43. Under the Baseline scenario, banks continue to generate ample profits, and the banking system in the aggregate slightly increases its existing capital buffers. With the continuing GDP growth of approximately 3 percent per annum during the scenario period and the gradual decline in the unemployment rate, banks experience low defaults, similar to the pre-scenario period. As a result, credit losses remain subdued and all banks generate ample interest income on their loan portfolios. With a stream of positive profits, the average CET 1 of the system increases slightly, from 10.5 percent in 2017 to 10.8 percent in 2020. While all banks generate positive profits and accumulate new capital, with the assumed dividend pay-out ratio of 50 percent, the size of their balance sheet is also assumed to grow in line with the nominal GDP growth (about 5.3 percent per year). The growing asset base assumed in the Baseline scenario limits further increases in capital ratios. All banks remain comfortably above the regulatory capital requirements.

44. The ST results indicate that banking system is broadly resilient to the severe macrofinancial shocks described in the Adverse scenario. Under this scenario, banks experience significant credit losses and their profitability declines substantially, and as a result, they experience significant reductions in their capital levels. Even with those significant declines, all banks remain above the regulatory threshold of 4.5 percent for the CET 1 ratio. Banks' high initial capital buffers and profitability allow them to withstand significant amount of credit losses and increase in funding shocks. While no bank falls below the regulatory threshold, those banks experiencing significant declines in their capital levels will likely reduce their credit supply significantly if the simulated scenario realizes. Losses experienced by any of the four major banks have the potential to reduce total credit provision due to the highly concentrated nature of the banking system. As a result, the economy is likely to experience below-trend growth for a protracted period beyond the three-year scenario period that was analyzed in the ST, if the severe shocks simulated in the Adverse scenario were realized.

45. Under the Adverse scenario, the average CET 1 ratio of the system decreases from 10.5 percent in 2017 to 7.2 percent in 2020, see Table 3. All the 10 banks in the ST sample would still stay above the regulatory minima of 4.5 percent of CET 1 ratio. At the same time, the capital ratio for several banks fall below the top of the capital conservation buffer (4.5 + 3.5 percent for the four major banks, and 4.5 + 2.5 percent for all other banks) by the end of the scenario period. For the Largest 5 banks the CET 1 ratio decreases by 3.3 percentage points, from 10.6 percent in 2017 to 7.2 percent in 2020, while the mid-sized banks experience somewhat smaller declines in their average CET 1 ratio, which decreases from 9.7 percent in 2017 to 7.0 percent in 2020. The credit losses are largely comparable across the two groups of banks; however, mid-sized banks experience a smaller increase in their risk-weighted assets, which contributes to the relatively smaller declines in their capital ratios. The average leverage ratio²⁰ of the sample declines from 5.3 percent in 2017 to just under 4.7 percent in 2017, with all banks staying well above the Basel III guidance of 3 percent.

²⁰ Defined here as Tier 1 Capital/Total Assets.

As the leverage ratio does not utilize risk weighted assets, the decline in the leverage ratio is milder compared to the decline in the CET 1 ratio, which factors in changes in risk weights.

46. The largest drivers of the change in capital ratios in the Adverse scenario are loan loss provisions, increases in RWA, and declines in net interest rate margins due to funding shocks (interest rate risk), see Figure 12. In line with the simulated deterioration in the economic outlook, loan defaults increase substantially which, along with the higher provisioning ratios, leads to large loan loss provisions for the banks. The increase in risk weights also contributes to the decline in the capital ratios, especially for the largest five banks. The losses from market risk, from mark-to-market (MTM) decline in the price of sovereign and other securities holdings of banks, leads to minimal declines in capital ratios. For the largest five banks, the spread widening for corporate bonds leads to a decline of about 0.5 percentage point of capital, however, the significant decline in the Cash Rate acts to offset the overall impact of the MTM changes in the value of their securities portfolio. For mid-sized banks, the MTM impact of both the spread changes and the change in the Cash Rate is minimal.

Table 3. Australia: Solvency Stress Test Results

	CET 1 Ratio (in percent)			
	Starting Position	Adverse		
	2017	2018	2019	2020
Full Sample	10.5	9.4	7.9	7.2
Largest 5 Banks	10.6	9.4	8.0	7.2
Mid-sized Banks	9.7	8.6	7.3	7.0

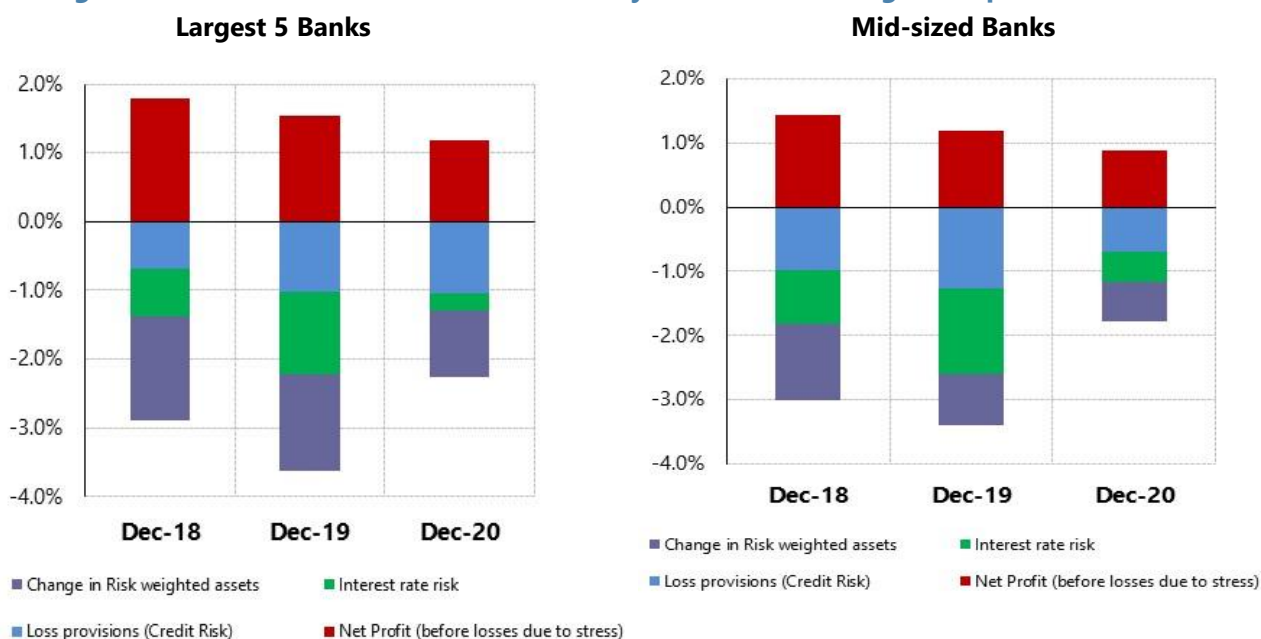
Source: IMF Staff estimates

Table 3. Australia: Solvency Stress Test Results (concluded)

	CAR (in percent)			
	Starting Position	Adverse		
	2017	2018	2019	2020
Full Sample	14.7	13.1	11.3	10.3
Largest 5 Banks	14.9	13.3	11.4	10.4
Mid-sized Banks	12.9	11.5	10.0	9.5

Source: IMF Staff estimates

Figure 12. Australia: Stress Test Results – Major Drivers of Change in Capital Levels



Source: IMF Staff Estimates.

F. Interest Rate Sensitivity Analysis

47. In addition to the stress scenario analysis, a sensitivity test was used to assess the vulnerabilities of the banking system to a stand-alone interest rate shock. The sensitivity analysis assesses the impact of a risk factor on a stand-alone basis. In addition to considering one shock at a time, this analysis also differs from the stress scenario analysis in the time dimension. These tests are static, that is, they assess the instantaneous impact of a shock on banks' balance sheet positions as of the starting point.

Interest Rate Risk: Impact on Net Interest Income

48. The sensitivity analysis assessed the impact of an increase in interest rates using a maturity gap analysis. The test simulated an instantaneous change of 100 basis points in the yield curve for one year, which affects both assets and liabilities of banks, and evaluated the impact on the net interest income that banks generate. Each bank's gap between its interest earning assets and its interest paying liabilities, with repricing maturities up to one year, determine the effect of the simulated interest rate shock on the net interest income of the bank. For example, after an interest rate increase, deposits maturing within one year must be rolled over at the higher deposit rates, which results in higher interest payments for the bank. Similarly, any other source of funding which are repricing within one year will be funded at higher interest rates. On the asset side, any loan which is repricing within one year will start paying the new higher interest rates, increasing bank interest income. The results indicate that a 100-basis points increase in the yield curve will lead to an increase of 0.3 percentage points in the system-wide CET 1 ratio. This positive effect from net

interest income is due to the fact that banks, on average, have higher amount of assets repricing within one year than liabilities. With most bank loans having variable interest rates, when interest rates on both assets and liabilities increase by the same amount, banks benefit from the differential interest rate sensitivity. On the flip side, a 100-basis points decrease in the yield curve will lead to a decline of 0.3 percentage points in the system-wide CET 1 ratio. In a severe economic downturn, similar to the one simulated in the Adverse scenario of the FSAP ST, a significant reduction in the yield curve will lead to a decline in bank capital, if assets and liabilities of loans reprice by the same amount. It is important to highlight that this analysis does not model the impact of changes in policy rates on banks' assets and liabilities separately. Instead, interest rates on all assets and liabilities repricing within one year are assumed to increase (decrease) by the same amount. Additionally, it does not take into account potential behavioral aspects, such as borrowers prepaying their mortgages earlier than their contractual maturity date.

49. This sensitivity is somewhat smaller for mid-sized banks compared to the largest five banks. The estimated change in average capital of mid-sized banks is under 0.2 percentage points per 100 basis points change in rates, compared to 0.3 percentage points for the largest five banks. Mid-sized banks in the ST sample, have a smaller interest rate sensitivity mismatch in between their assets and liabilities which leads to a smaller effect on their net interest income.

G. Spread Sensitivity Analysis

50. The FSAP team also assessed the impact of an increase in interest spreads of banks' securities portfolios. Unlike the Adverse scenario where multiple shocks are at play, with the spreads on securities increasing significantly but the Cash Rate declining, this sensitivity analysis assumes a stand-alone shock of 300 basis points increase in the spread on banks' non-sovereign securities portfolios.²¹ The total balance of non-sovereign securities in banks' portfolios designated as held-for-trading (HFT) or available-for-sale (AFS) are marked to market under the assumed spread widening. The MTM effect of the widening for the full sample of banks is a decline of 0.5 percentage points in the average CET 1 ratio. For the largest five banks, the decline is slightly over 0.5 percentage points, while the effect for mid-sized banks is about half of that amount at less than 0.3 percentage points, due to their smaller securities portfolio balance.

H. Concentration Risk

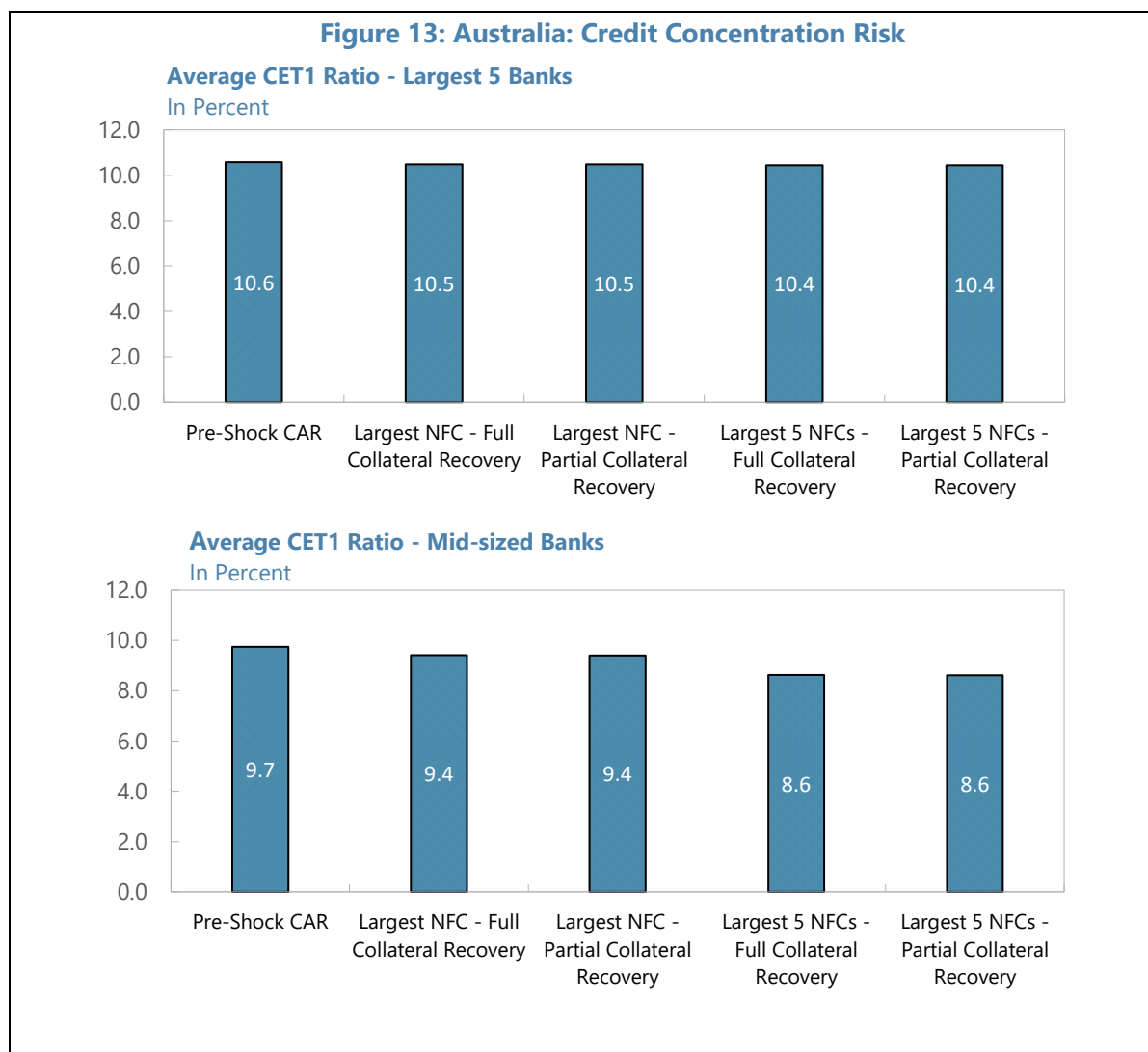
51. Single-name concentration risk (i.e., exposure to a single borrower) was tested by assessing the impact of the default of banks' largest nonfinancial corporate exposures. The test assessed the impact of the hypothetical default of the largest and the five largest NFC borrowers and calculated implied losses from these exposures under two different assumptions on the level of recovery rates. These shocks were applied to banks' capital levels from balance sheets as of 2017 Q4. However, large exposures to non-financial corporates are not specifically collected as part of

²¹ Largely, corporate bonds.

standard supervisory data, for this reason the FSAP team used the large exposures data from May 2017 balance sheets that were collected from banks during the APRA ST.

52. The system-wide average size of the largest NFC exposure is modest, at 1.1 percent of total CET1 capital. The average of the largest exposure is 0.9 percent for the largest five banks, while it is 3.7 percent for the mid-size banks. The system-wide average of the five largest NFC exposures is 2.2 percent of capital; 1.5 percent for the largest five banks, and 12.2 percent for mid-sized banks. However, the average for the mid-sized banks is pulled higher by one bank which has significantly higher large exposures compared to the others. These data indicate that concentration risks are generally small, particularly for the largest five banks, whereas there is more variation in the concentration risks among the mid-sized banks.

53. Concentration tests shows that Australian banks are adequately capitalized to absorb losses from the default of large NFC exposures. In this analysis, the FSAP team assumed zero recovery on the unsecured part of the exposure and full recovery of the value of any available collateral. Under this scenario, the default of the largest NFC exposure of each of the largest five banks would imply an average decline of 0.1 percentage points in the total CET1 ratio for the group of largest five banks. The largest decline at the bank level would be close to 0.3 percentage points, and all of the largest five banks will remain well above the 4.5 percent total CET1 ratio threshold. For mid-sized banks, the default of the largest NFC exposure of each bank would imply a decline of 0.3 percentage points in the CET1 ratio. The largest decline at the bank level would be 1 percentage point, and all banks will also remain well above the 4.5 percent total CET1 ratio. If we assume the default of the five largest NFC exposures in each bank, the decline in capital would increase only slightly to 0.14 percentage points for the largest five banks. Following the default of the five largest NFC exposures of each mid-size bank, the decline in the capital would increase to 1.1 percentage points, with the largest bank-level decline increasing to 3.4 percentage points. These declines indicate that all banks would still remain above the 4.5 percent CET1 ratio, see Figure 13. These results were largely unchanged under a more severe scenario of zero recovery on the unsecured part of the exposure following the default of the NFC *and* a 50 percent haircut on the value of any collateral. This lack of sensitivity to the assumption on collateral recovery is due to these NFC exposures' being, generally, not backed by collateral.



BANK LIQUIDITY STRESS TESTS

A. Overview

54. Although Australian banks' reliance on wholesale funding has declined since the GFC, wholesale funding still constitutes a significant portion of total funding. This is particularly the case for the largest five banks, which have a higher reliance on wholesale funding. Approximately 33 percent of their funding takes the form of wholesale deposits, 35 percent consists of secured and unsecured debt from wholesale debt markets, with the remaining 32 percent coming from retail deposits.

55. Mid-sized banks have a larger share of their funding in the form of deposits, particularly retail deposits. On average, close to 46 percent of their total non-equity funding consists of retail deposits, with an additional 32 percent in the form of wholesale deposits, mostly deposits of nonfinancial corporates and SMEs. This difference in funding composition makes the

largest five banks more vulnerable to stress in wholesale funding markets and provides a degree of diversification within the system given the mid-sized banks’ lower reliance on wholesale funding. At the same time, this diversification is relatively small due to the substantially higher market share of the largest five banks.

56. A closer inspection of the maturity structure of Australian banks indicates that banks’ loan portfolios have a very long-dated maturity profile (see Figure 14 below). This is mainly due to the large share of mortgage loans on banks’ loan portfolios. Slow amortization profile of mortgage loans, especially for the interest-only loans which do not amortize for the first several years of their term, leads to a back-dated profile of cash inflows. It is important to highlight that the input data used for this analysis do not reflect account behavioral aspects, such as borrowers prepaying their mortgages earlier than their contractual maturity date. Prepayments, which are observed regularly, increase the inflow of loan principal and reduce the average life of cash inflows. Hence, the actual cash inflows from mortgage loans are likely to have a less back-dated profile.

57. The maturity structure of funding sources is much more front-loaded compared to that of the loan portfolio. This is largely due to prevalence of sight deposits in Australia, which are treated to have instantaneous maturity in this analysis. The differences between the maturity profiles of loans and funding indicate that there is a significant amount of maturity transformation in the Australian banking system.

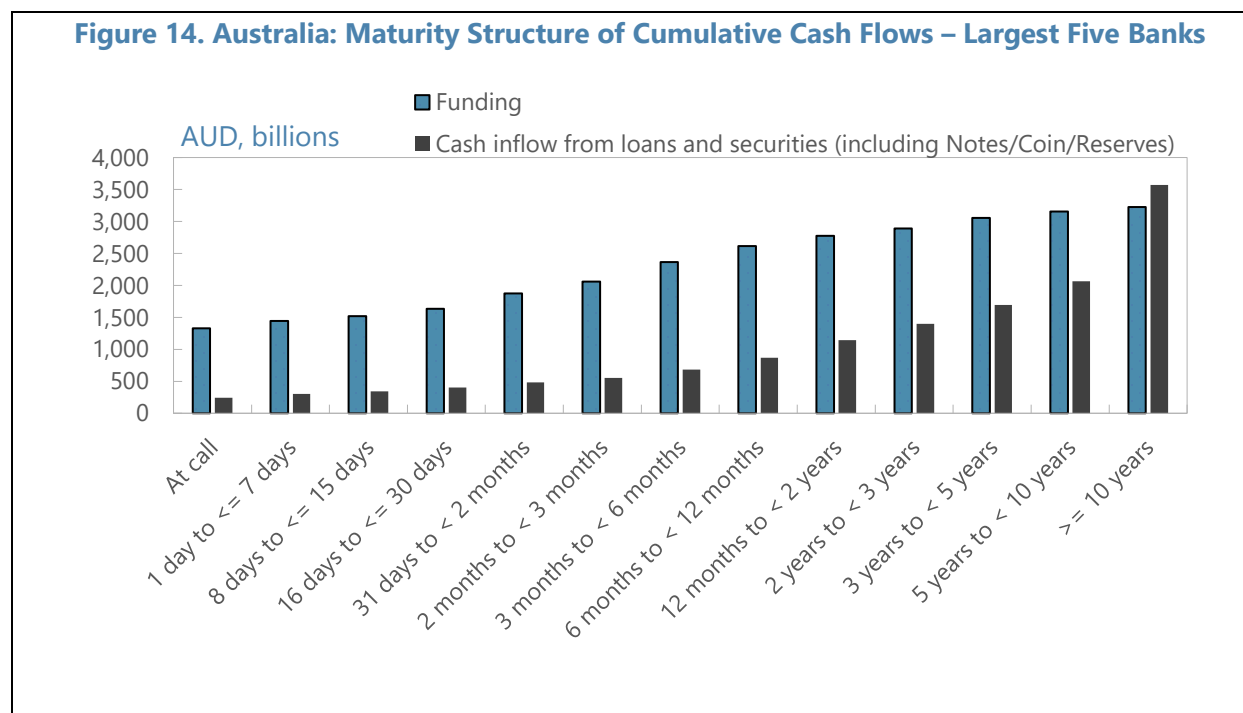
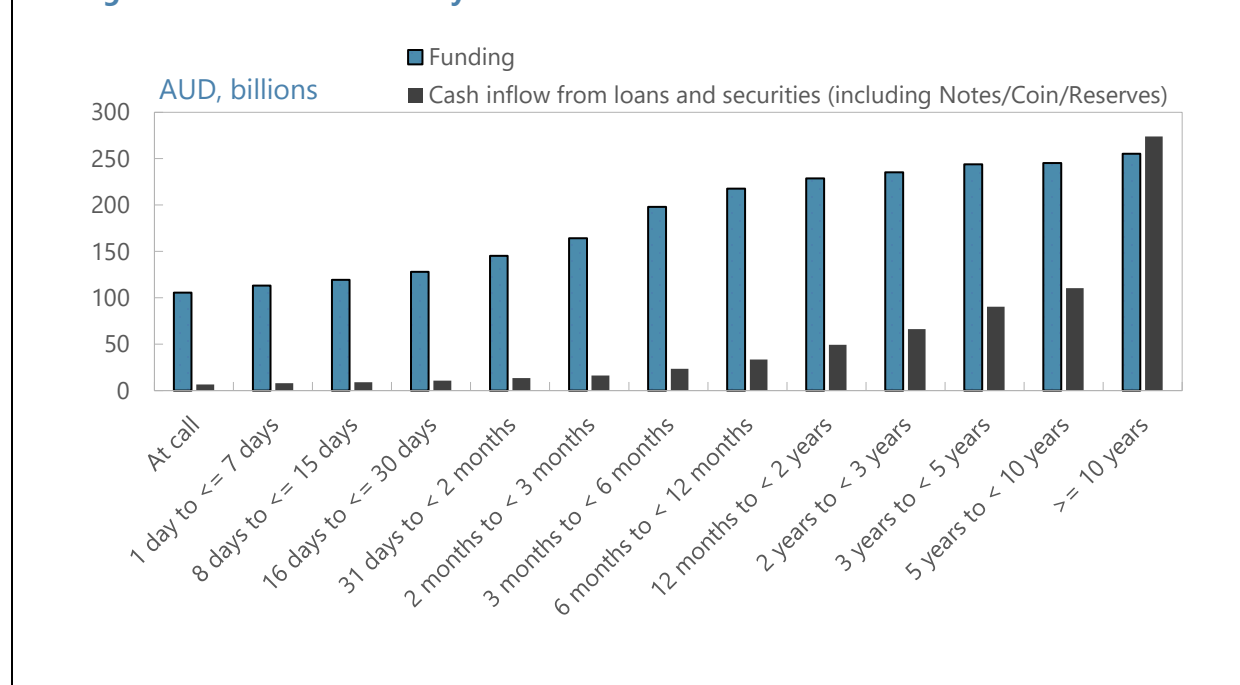


Figure 15. Australia: Maturity Structure of Cumulative Cash Flows – Mid-sized Banks

B. Methodology

58. The FSAP team assessed risks due to the potential volatility that banks' funding sources might display. The team used three methods to evaluate liquidity risks: the liquidity coverage ratio (LCR), a cash flow-based liquidity stress test, and the net stable funding ratio (NSFR). These tests were carried out with the aggregate cash-flows, and separately for AUD-only cash flows in the case of LCR. Australian banks' funding consists of mostly deposits while wholesale funding still contributes a significant amount, especially for the largest five banks. At the same time, a large majority of the deposits are sight deposits. As discussed earlier, there are also differences between the funding composition of the largest five banks vs. mid-sized banks.

LCR-based Liquidity Risk Analysis

59. The LCR measures the bank's ability to meet its liquidity needs under a 30-day liquidity stress scenario by using a stock of unencumbered high-quality liquid assets (HQLA). Banks must maintain an LCR above 100 percent in both aggregate currency version and in AUD-only version to meet their liquidity needs for a 30-day period under a severe stress scenario. Specific deposit run-off rates, roll-off rates for cash inflows and assets haircuts are included to simulate stressed conditions in three different scenarios.

60. In the LCR analysis, funding pressures from liquidity stress are captured through specific run-off rates for different funding sources. Broadly, more financially sophisticated depositors withdraw funding more rapidly than less sophisticated ones. As a result, the run-off rates applied to wholesale funding sources are higher than those applied to retail funding sources.

Additionally, run-off rates on unsecured funding sources are higher than those applied to secured funding sources.

The FSAP team carried out LCR-based liquidity risk analysis based on three scenarios, with three sets of parameters for deposit run-off rates and cash inflow roll-off rates. The first scenario consisted of the LCR parameters prescribed by the Australian regulation (baseline LCR). The other two scenarios are stressed versions of the baseline LCR which increases the stress that the LCR regulatory scenario simulates while targeting different components of funding. The first stress scenario simulates a “retail stress” which assumes retail deposit withdrawals that are 1.5 to 2 times higher than the regulatory LCR assumptions. The second one is a “wholesale stress,” which simulates a dry-up of wholesale funding, similar to the conditions experienced in other countries during the GFC. This stress scenario simulates higher run-off rates on unsecured wholesale funding, including corporate and SME deposits, as well as shocks to the secured funding market via repo and covered bonds, and the commercial paper market. This stress scenario assumes run-off rates that are 2 to 5 times higher than the regulatory LCR assumptions. These rates, together with the assumed asset haircuts, are presented in Table 4.

Table 4. Australia: LCR-based Liquidity Risk Assumptions on Run-off, Roll-off Rates and Haircuts
(in percent)

	AUS Regulatory Parameters	FSAP Scenario: Retail Stress	FSAP Scenario: Wholesale Stress
Run-off rate on potential outflows			
Households Deposits	3-100	6-100	3-100
Corporate Deposits	3-100	3-100	15-100
Interbank Deposits	3-100	3-100	15-100
Non-deposit liabilities maturing in 1 month	0-100	0-100	0-100
Total contingent commitments	1-100	1-100	1-100
Roll-off rate on cash inflows			
Secured Lending			
level 1 assets	0	0	0
level 2a assets	15	15	15
level 2b assets	25-50	25-50	25-50
Margin lending backed by all other collateral	50	50	50
All other assets	100	100	100
Other inflows, by counterparty			
Retail counterparties	50	50	50
Non-financial wholesale counterparties	50	50	50
Financial institutions and central banks	100	100	100
Other cash inflows, including derivatives inflows	100	100	100
Haircuts on liquidity buffers			
HQLA1a	0	0	0
HQLA2a	15	15	15
HQLA2b	25-50	25-50	25-50
Available amount of the CLF with the RBA	0	0	0

61. Banks’ liquidity inflows are mostly from maturing loans, deposits, and credit facilities.

Banks can counterbalance gaps between the simulated inflows and outflows by using their HQLA, and Alternative Liquid Assets. The Committed Liquidity Facility (CLF) provided by the RBA is significant buffer of liquidity that contributes to banks’ LCR. The CLF is an alternative liquidity

treatment allowable under the Basel Committee LCR rules, and it was designed largely due to the insufficient amount of liquid assets at the system level in Australia.²²

NSFR-Based Liquidity Risk Analysis

62. The NSFR metric goes beyond the 30-day horizon used by the LCR metric and compares the relatively liquidity of banks' assets and liabilities. It is based on the principle that illiquid assets should be largely funded by relatively more stable sources of funding. The average NSFR at the system is 113 percent, and it is relatively similar between the large and the small banks. All the banks are above the regulatory limit of 100 percent. The NSFR metric still does not consider the full maturity structure of banks' cash flows. For example, it does not distinguish between the required stable funding for any loan that has longer than one-year maturity. The whole stock of mortgage loans that qualify for a 35 percent risk weight and have more than one-year maturity, is treated with a required stable funding coefficient of 65 percent. To gain additional insights into the maturity profile of Australian banks' inflows and outflows, the FSAP team carried out a cash flow-based liquidity risk analysis.

Cash Flow-Based Liquidity Risk Analysis

63. The cash flow-based analysis assesses risks due to the potential volatility that banks' funding sources might display based on banks' net cash balance after the funding outflow shocks at various maturity buckets. It aims to capture the time structure of banks' cash inflows and outflows, up to one-year horizon. The net cash balance at every maturity bucket consists of the existing cash position, the amount of net fund flows, and the counterbalancing capacity (i.e., the ability to obtain additional liquidity). The analysis simulates severe funding shocks that reflect a situation in which banks are facing significant liquidity pressures, with large funding outflows affecting all funding sources (see Table 5 for the assumptions used in the analysis). If banks have a negative net cash balance after utilizing their counterbalancing capacity in the simulation, they would experience a liquidity shortfall.

64. Net fund flows correspond to the difference between cash inflows and outflows. Outflows consider potential cash drain from all non-equity liabilities, such as deposits, maturing loans, accounts payable, and from off-balance sheet items such as derivatives and credit lines. Inflows will largely come from loans extended and securities held by banks that mature during the scenario period and off-balance sheet items such as derivatives. The analysis uses the information of contractual flows, such as the due dates of term deposits and loans extended. Behavioral flows are calibrated based on the run-off rates applied to funding sources and the rollover rates applied to assets (e.g., re-investment of maturing loans and rollover of maturing securities held by the banks).

²² With the government debt to GDP ratio roughly around 40 percent, there is limited supply of domestic HQLA that banks could purchase in Australia. The CLF was designed as an alternative liquid asset in response to the low government debt supply.

65. Both contractual and behavioral aspects of flows were considered to derive the amount of net fund flows. Contractual flows are incorporated from the contractual maturity data provided by APRA, which collects data based on financial agreements such as amortization schedule of loans, maturing of loans and due term deposits, and contractual cash flows of other financial agreements such as derivatives. It is important to note that the analysis only considered the cash flows of FX-related derivatives, as the data on the cash flows of other derivatives, e.g., interest rate swaps, were not available. The behavioral flows are calibrated based on the run-off rates applied to funding sources and credit facilities,²³ and the roll-off rates applied to assets (e.g., re-investment of maturing loans and roll-over of maturing funding). These contractual and behavioral flows also include off-balance sheet items.

66. In addition to net fund flows, banks can utilize their counterbalancing capacity when faced with liquidity shocks. Banks can use their existing cash reserves, obtain liquidity through the standing repo facility of the RBA with eligible collateral, obtain additional liquidity from the markets through sale of unencumbered liquid assets, and, finally, can access the RBA's Committed Liquidity Facility. Note that the analysis only used the amount of liquidity available via CLF that was approved by the RBA as of 2017 year-end. Under severe stress, and subject to RBA and APRA agreement, banks may request additional amount of liquidity access utilizing their surplus RBA repo-eligible self-securitization capacity. Finally, the analysis also incorporated fire-sale dynamics through hair-cuts on collateral, given the system-wide funding shocks that lead to distressed sales and to a decline in the market price of those assets.

C. Results

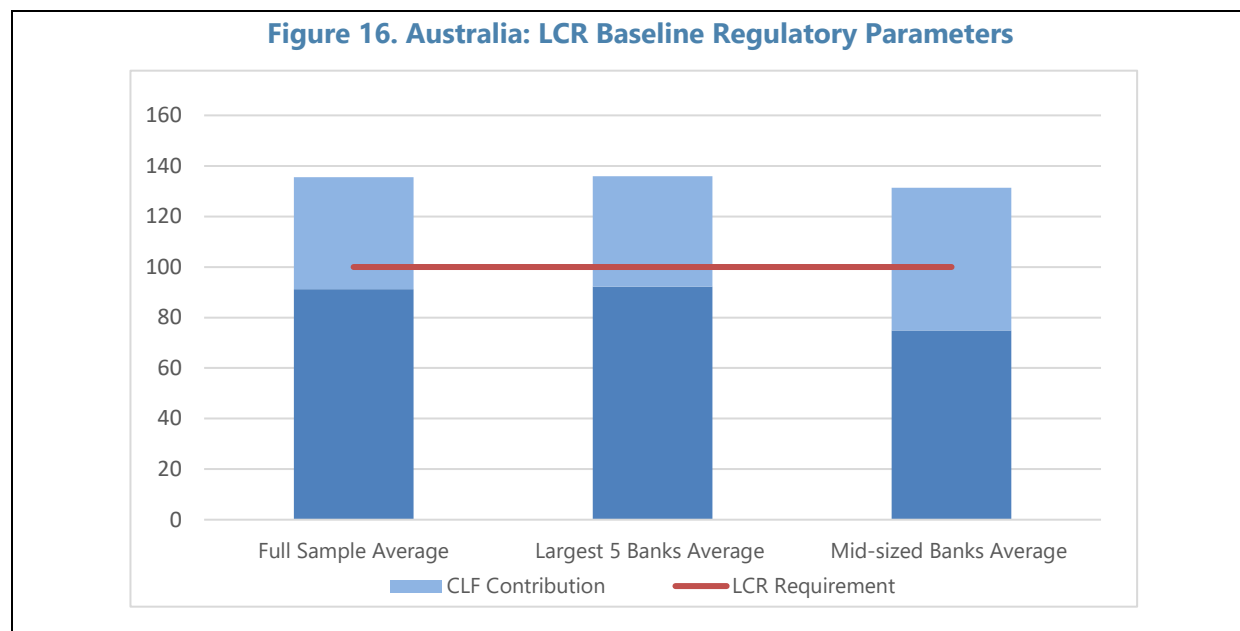
LCR-Based Liquidity Risk Analysis

67. The LCR-based analysis indicates that short-term liquidity risks are limited in a mild stress scenario (the baseline regulatory parameters). The average LCR across the banks in the ST sample is equal to 136 percent at December 2017. The average across the large banks and mid-sized banks are close to each other at 136 percent and 131 percent, respectively. Every bank passes the 100 percent hurdle rate by a comfortable margin. At the same time, the results highlight the role of the CLF buffers in a system without a sufficient of quantity of high quality liquid assets otherwise, as a significant portion of banks' HQLA consists of CLF buffers.

68. The "retail stress" version of the LCR tested the resilience of the system in the event of very large deposit withdrawals. For this test, higher run-off rates were applied to retail deposits and SME deposits, and higher outflow rates were assumed for credit and liquidity facilities provided to retails and SME customers. The assumptions on inflows and haircuts on liquid assets were left unchanged. The results indicate that banks in the system would be relatively resilient to an episode of retail stress. Due to the higher reliance on retail funding, mid-sized banks experience large declines in LCR under this scenario with the average LCR falling to 105 percent. Only one bank falls

²³ As noted earlier, the analysis does not take into account behavioral aspects such as mortgage prepayments.

below the 100 percent level. Due to their lower reliance on retail funding, the largest five banks fare better, with the average LCR declining to 117. All of these banks stay above the 100 percent level.



69. The second stress scenario simulating a dry-up of wholesale funding provides shows greater vulnerability across the system. Banks were assumed to face as high as 100 percent run-off rates on wholesale deposits (highest run-off assumed for non-operational deposits), run-off rates for funding secured by HQLA2B assets were increased to 50-100 percent, and the outflow rates for credit and liquidity facilities provided to banks and other financial institutions were increased to 80 percent, to simulate a liquidity shortage being experienced by other financial institutions. The results show that the aggregate LCR would fall to 91 percent, with six banks falling below the 100 percent level. In this scenario, due to the lower reliance on wholesale funding, mid-sized banks experience smaller declines compared to the majors, with their average LCR falling to 98 percent. The largest five banks on the other hand, experience significant declines, with the average LCR falling from 136 percent in the baseline case to 91 percent. These results highlight the sensitivity of the Australian banks, and particularly the large banks, to the conditions in the wholesale funding markets. A severe stress in the wholesale funding markets would lead to a significant portion of the banking system depleting their LCR buffers.

Figure 17. Australia: LCR Scenario Analysis

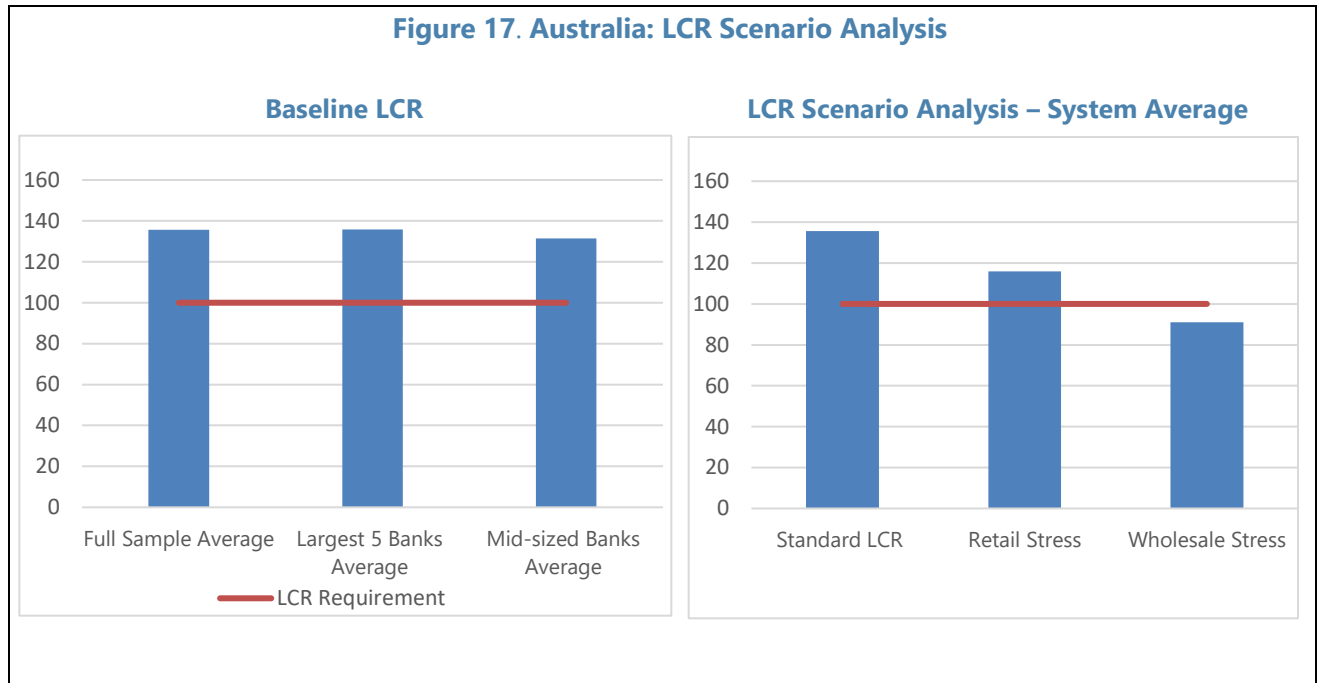
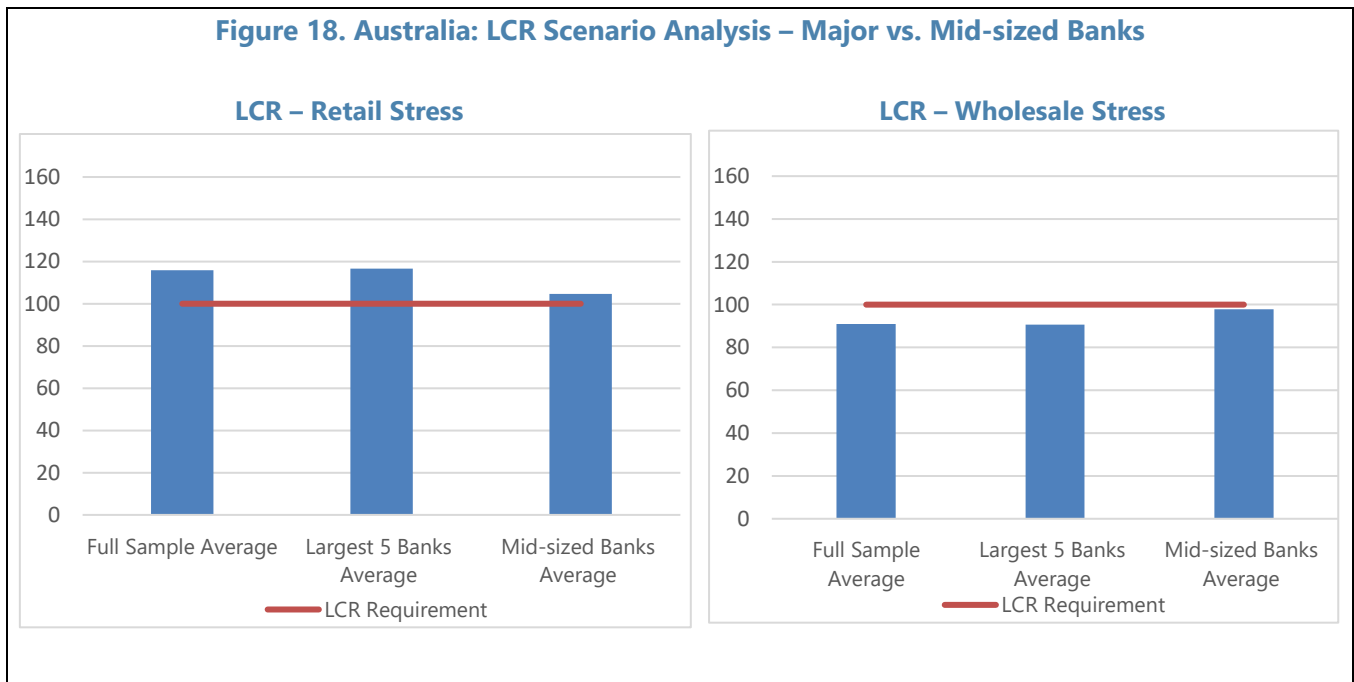


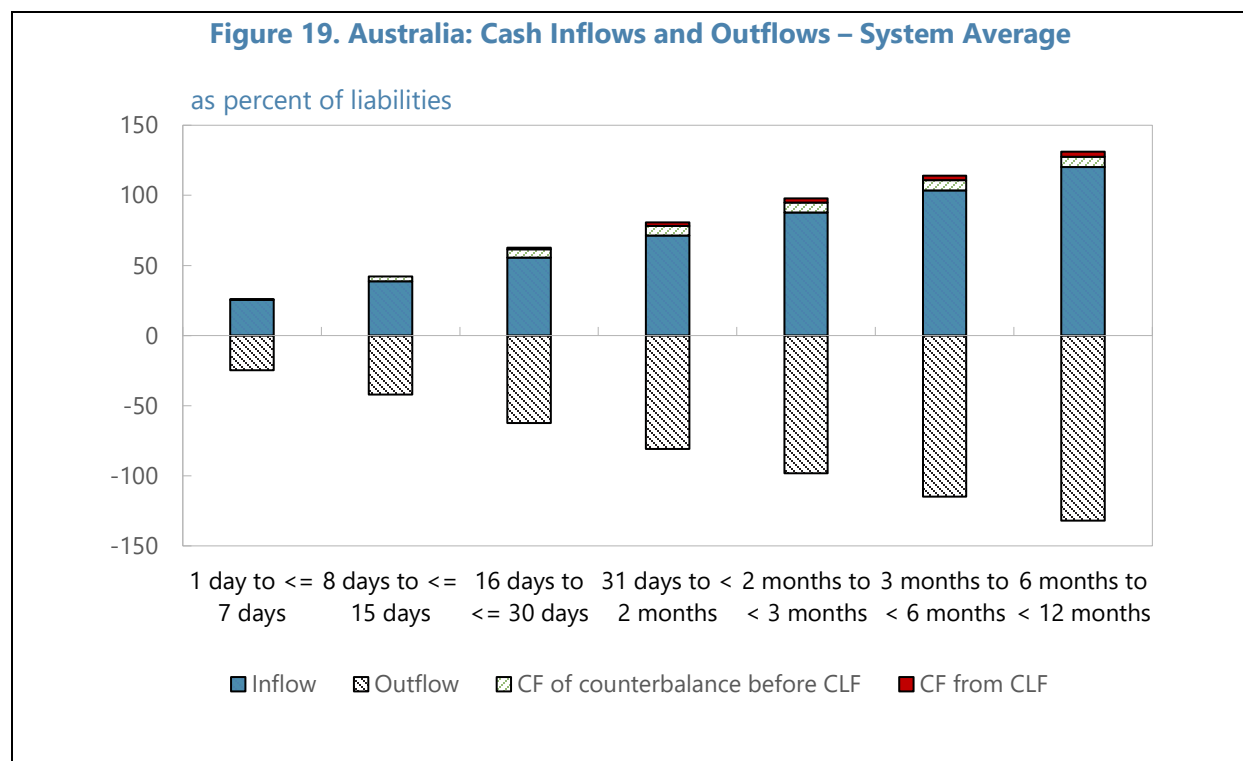
Figure 18. Australia: LCR Scenario Analysis – Major vs. Mid-sized Banks



Cash Flow-Based Liquidity Risk Analysis

70. The cash flows-based liquidity stress test indicated some vulnerability to the cash outflow shocks simulated in the scenario. Several banks experience shortfalls based on their cash inflows and outflows and their existing counterbalancing capacity but before utilizing their CLF. Even after utilizing their existing CLF amount with the RBA, three banks experience cash shortfalls in the simulation.

71. Note that all banks maintain positive cash balances in the first 30 days, which is the horizon covered by the LCR metric. The cash flow analysis simulates a continued stress environment after the first 30-day horizon. In this environment of protracted funding stress, one bank starts experiencing cash shortfalls in the “1 month to 2 months” window, followed by a second bank in the “3 months to 6 months” window, and a third one in the “6 months to 12 months” window. At the same time, the nominal amount of the cash shortfalls is modest; the total shortfall peaks at less than 0.5 percent of banking system assets during the “3 months to 6 months” window.



72. The liquidity cash flow-based liquidity risk analysis also highlights Australian banks’ exposures to short-term liquidity risks from their reliance on wholesale funding which was discussed during the LCR analysis. In a scenario of severe funding outflows in the short-run, the long-dated maturity structure of banks’ loan cash flows leaves them vulnerable to cash shortfalls. One mitigating factor in a severe funding outflow situation would be banks’ ability to request additional amount of liquidity access utilizing their surplus RBA repo-eligible self-securitization capacity. Nevertheless, the authorities could consider encouraging banks to continue to reduce their

reliance on wholesale funding sources and to term out their funding. The authorities could also enhance the collection of cash flow information, including flows from derivatives and other off-balance sheet positions, which would support additional liquidity risk analysis based on cash flows at various maturities.

Table 5. Australia: Cash Flow-based Liquidity Risk Analysis Assumptions on Run-off and Roll-off Rates
(in percent)

	1-7 days	8-15 days	16-30 days	31-60 days	61-90 days	91-180 days	>180 days
Run-off rate on potential outflows							
Retail funding - sight deposits							
Stable	3	2	1	2	2	0	0
Unstable	7	3	3	3	2	0	0
Retail funding - onshore term deposits							
Stable	10	10	10	5	5	5	5
Unstable	20	20	20	17	17	15	10
Other deposits							
Sight	15	8	7	5	2	0	0
Term	40	40	40	20	20	20	10
Secured funding (repo) from other financial institutions							
Domestic	15	12	12	10	10	7	7
Offshore	20	16	16	13	13	9	9
Unsecured wholesale funding							
Deposits from ADIs							
Sight	20	15	15	10	5	0	0
Term	100	100	100	75	75	75	50
Debt securities							
Domestic	60	60	60	40	40	40	35
Offshore	80	80	80	60	60	60	50
Outflow from derivatives	100	100	100	100	100	100	100
Other obligations	100	100	100	100	100	100	100
Undrawn volume of committed credit/liquidity lines							
Non-financial	5	10	10	5	0	0	0
Financial	20	20	20	20	0	0	0
Roll-off rates on cash inflows							
loans maturing							
Financial	100	90	90	70	50	50	50
Non-financial	50	50	50	30	30	30	10
Inflows from derivatives	100	100	100	100	100	100	100
Other	50	50	50	30	30	30	10

INTERCONNECTEDNESS AND CONTAGION ANALYSIS

A. Inter-Sector Financial Linkages

73. National accounts data reveal tight interlinkages between the banking system and the non-bank financial sector, households and nonresident balance sheets (Figure 20).

Nonresidents hold around 30 percent of bank liabilities, primarily via equity and bond instruments, while households and nonbank financials hold a combined 45 percent of banking system liabilities. On the asset-side, banks' largest exposures are to the households, at roughly 40 percent, while exposures to nonresidents, corporates and nonbank financials are around 17 percent each. Interbank linkages based on balance sheet exposures seem relatively small, with exposures to all other banks amounting to around 4 percent of assets for the aggregate system.²⁴ However, exposures between the four largest lenders necessitate further investigation given the similarity in business models and sizeable off-balance sheet assets.

74. Cross-border exposures are concentrated among the ten largest Australian banks, with consolidated and locational statistics highlighting some caveats (Figure 21).

Consolidated bank-level statistics from APRA²⁵ reveal that international claims for the top 10 Australian banks²⁶ on their 10 largest counterparty countries amount to roughly 20 percent of banking assets, with a combined 75 percent of these claims based in New Zealand, the United States, and the United Kingdom. Meanwhile, interbank claims amount to around 3 percent of banking assets, with the largest exposures to the United Kingdom, the United States, Canadian, and Chinese banks. On a locational basis, total international claims of the top 10 banks amount to roughly 8 percent of banking assets, while interbank claims total around 5 percent of banking system assets. Interbank cross-border liabilities on the other hand²⁷ amount to around 9 percent of system liabilities for the top 10 lenders. Neither the consolidated nor locational statistics include off-balance sheet exposures of the reporting banks.

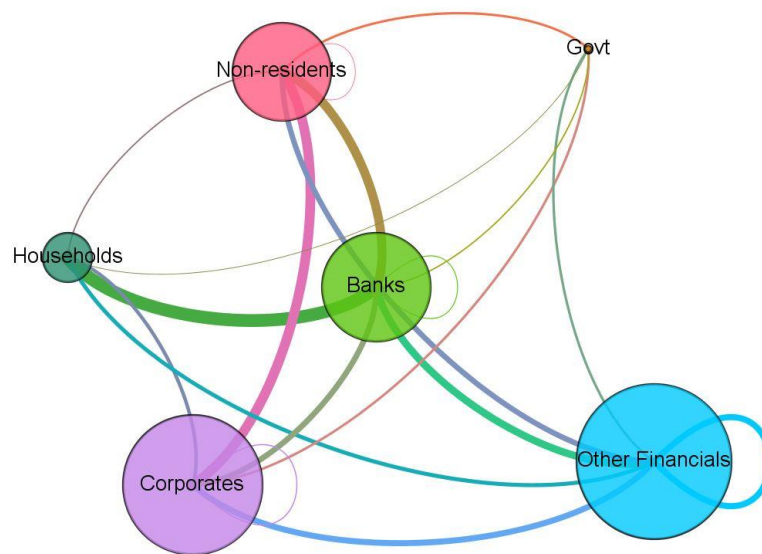
²⁴ This estimate excludes off-B/S exposures, which can be sizeable on a gross basis.

²⁵ Consolidated data captures the foreign claims of banking groups (including subsidiaries), and exclude intragroup positions, effectively measuring banking activity on a nationality basis (focus on the country where the parent bank is headquartered). Locational data captures banking activity from a residence perspective (focus on the location of the banking office), with banks reporting claims and liabilities on an unconsolidated basis, including intragroup positions.

²⁶ International claims on non-banks (includes official sector) for the top 10 Australian banks account for nearly 94 percent of such claims for the entire banking system.

²⁷ Banking liabilities are reported only on a locational basis.

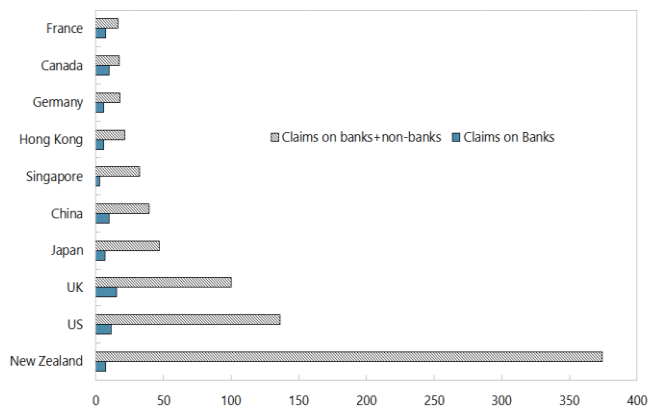
Figure 20. Australia: Domestic Interconnectedness – National Accounts



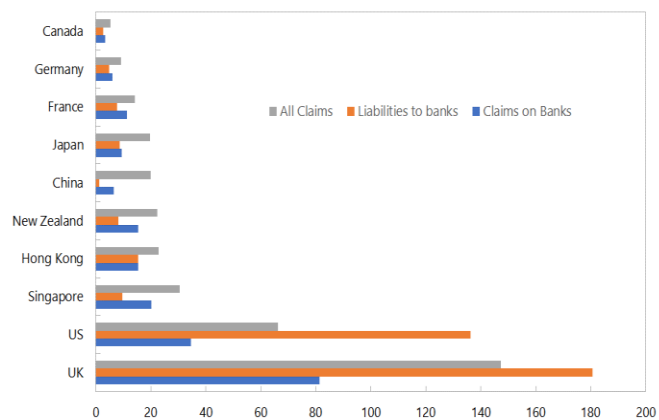
Source: ABS, National Accounts. Chart constructed with Gephi. Node size reflects total assets for each balance sheet, while thickness of edges (links) reflect the net exposure to each counterparty. The color of the edges reflects the color of the dominant counterparty in the relationship or a blend of the counterparties if neither is dominant. For instance, the link between Corporates and Other Financials is blue, reflecting the large net liability position of the corporates vis-à-vis Other financials.

Figure 21. Australia: International Interconnectedness

Top 10 Australian Banks: Consolidated International Claims (A\$ billions)



Top 10 Australian Banks: Locational International Claims and Liabilities (A\$ billions)



B. Methodologies

75. The network analysis aims to assess the potential for distress at a financial entity to spillover to the rest of the system and adversely impact financial stability. The analysis addresses two missing links of the traditional solvency stress test—firstly, the solvency effects emanating from banks facing funding pressures and secondly, the potential for default cascades triggered by an insolvent bank on its creditors, leading in turn, to strains on the latter counterparties, transmitting distress throughout the entire banking sector. The interconnectedness is assessed both at the domestic as well as the cross-country levels.

76. The transmission of a shock from a failing bank to the broader banking system is assumed to spread through the following channels:²⁸

- **Bilateral Exposures:** Counterparties with significant exposures to the failing bank may suffer material losses resulting in their inability to satisfy their obligations. This channel is captured using the bilateral matrix of exposures data at the institutional-level provided by the authorities, as well as using locational data at the country-level from the BIS. The stress test assesses the solvency impact of liquidity strains from fire sales and rising funding costs, and the potential for indirect default cascades both within the Australian interbank market as well as at the cross-border level.
- **Balance Sheet Approach: The analysis based on the network framework of Espinosa-Vega and Sole (2010) considers both credit and funding shocks to the banking systems.²⁹** An initial negative credit or funding shock to a country's financial system could be propagated through the network of bilateral claims across countries (as based on the BIS locational banking statistics), and could lead to distress in banking systems of other countries beyond the direct losses from the initial shocks. If any banking system incurs losses larger than their capital base, the system is deemed to "fail." This failure can subsequently cause other banking systems to fail, triggering domino effects across the network. Three sets of simulations are considered in the analysis: the first simulation applies to BIS reporting banks' exposure to foreign banks, the second to the individual cross-border exposures of the top 10 Australian banks and the third to the individual bank exposures to domestic counterparts.³⁰
- **Market Contagion:** Market participants' revise their expectations of the solvency of systemically important banks that have similar business models to the bank in distress. This channel is captured using equity prices of the banks, which reflect investors' perception of the transmission of risk through the global banking system.

²⁸ These channels have been highlighted by Daniel K. Tarullo, "Regulating Systemic Risk," Speech, 2011 Credit Markets Symposium, North Carolina, Charlotte, March 31, 2011, Board of Governors of the Federal Reserve System, available at <http://www.federalreserve.gov/newsevents/speech/tarullo20110331a.htm>. Note that three of the four channels mentioned in the report are analyzed in this section.

²⁹ The sample consists of 42 BIS reporting countries which have bilateral exposures with Australian banks. Cross-border banking exposure data are based on BIS locational statistics. Tier 1 regulatory data are taken from IMF's FSI Statistics. The analysis is based on Dec-2017 data.

³⁰ The first simulation uses BIS data, while the second and third use supervisory bank-level data from APRA.

- **Market-prices Approach: The spillover analysis using the Diebold and Yilmaz (2014) methodology involves deriving a pairwise directional interconnectedness measure to estimate the contribution to systemic risk among GSIBs and the biggest Australian banks.** A Vector Autoregression (VAR) model is used on market data of equity returns for the sample of systemically important global banks³¹ and the nine largest publicly traded Australian banks or banking groups. The interconnectedness measure is then derived from the Generalized Variance Decomposition (Pesaran and Shin, 1998) of the underlying VAR.³² On aggregate, the inward-spillover measure captures exposures of individual banks to systemic shocks from the network, while the outward-spillover measure captures contributions of individual banks to systemic network events. In addition, the net-degree measure (the difference between inward- and outward- measures) describes the relative contribution to systemic risks from each entity.

77. The FSAP simulations for the balance-sheet approach were carried out under the following assumptions for solvency and liquidity shocks:

- **Credit shock:** “Failure” of banking system A will transmit credit losses to system B that has claims against A. The credit loss rate assumption controls for the severity of credit costs incurred due to failure of the counterparty institution. Loss given default rates of 40 and 100 percent are assumed, to capture the impact of varying degrees of credit shocks.³³
- **Funding shock:** A ‘global funding shock scenario’ is assumed to replicate post-Lehman liquidity stresses, including a sharp rise in funding cost and credit market freezes. “Failure” of banking system A will force system B (that has claims against A) to find alternative sources of funding. The fraction of lost funding that is not replaceable is assumed to be 35 percent (65 percent rollover). This may result in the fire sale of liquid assets by system B to fill the funding gap and the haircut in the fire sale is assumed to be 50 percent.³⁴ Unsecured interbank, FX swap markets and capital markets are assumed to be closed, as is the access to emergency liquidity facilities. Banks that borrowed from the defaulted bank need to find new sources of funding or liquidate some assets, subject to market conditions described in Table 6 below.

³¹ The sample includes 25 of the 30 G-SIBs identified by the FSB in 2017. Five Chinese banks are not included due to unavailability of equity data for a longer time horizon. The nine Australian institutions include ANZ, CBA, WBC, NAB, BoQ, MQG, BEN, SUN and AMP Group. ING and HSBC, which have local subsidiaries in Australia) are part of the G-SIB sample, while AMP Group is included given it has a banking arm and is the largest asset manager in Australia.

³² Daily equity returns for the sample banks, constructed as the log difference of equity prices, are calculated from Bloomberg data. The sample time horizon for the analysis is from Jan 1, 2005 to July 23, 2018.

³³ A loss given default rate of 100 percent is assumed in Espinosa-Vega and Sole (2010), the Italy 2013 FSAP and the 2012 Japan FSAP. Espinosa-Vega and Sole (2010) and Wells (2004) argue that network studies should consider higher loss-given-default estimates than the 40 percent that is typically assumed, as banks tend to face substantial uncertainty over recovery rates in the short run. The simulation results should be interpreted as the maximum possible impact of systemic instability. Note that any collateral and hedging instruments are not taken into account in this analysis due to data limitations.

³⁴ The assumptions on the funding shock in Espinosa-Vega and Sole (2010) was for discount rate of 0.50, while other FSAPs have chosen 0.3 reflecting conditions during the Lehman crisis. While the final numerical results are sensitive to these assumptions, the relative importance of systemic countries remain the same.

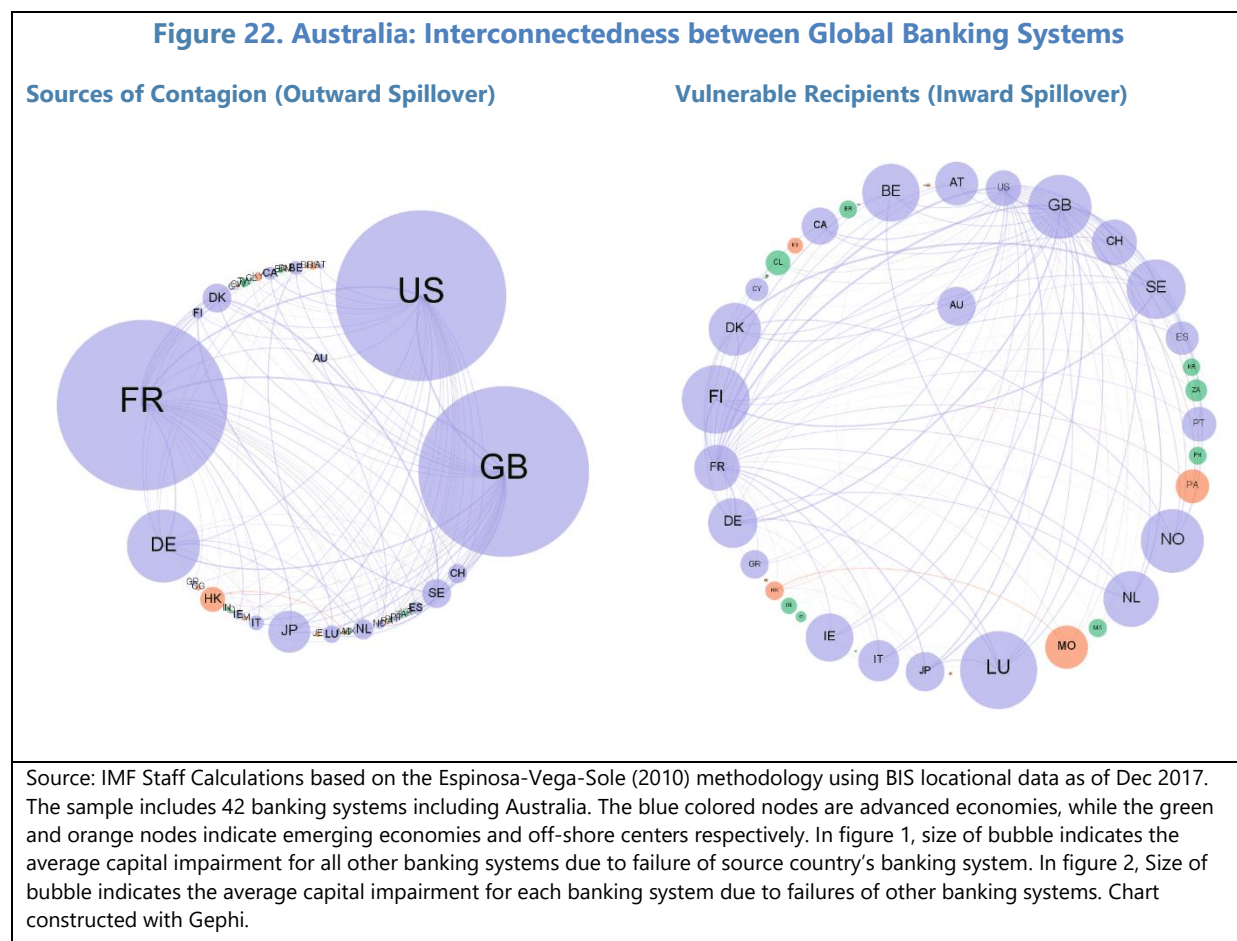
Table 6. Australia: Bank Network Analysis – Parameter Calibration

Parameter/variable	Description
$\lambda=0.4$ and 1.0	40 and 100 percent loss given default on exposures
$\rho=0.35$	Share of lost funding that is non-replaceable
$\delta=0.5$	50 percent discount on asset sales
capital	Tier 1 capital under Basel III
bank default	Tier 1 capital falls to 0 percent ³⁵

C. Results

78. The global bank network analysis using BIS data reveals that the main sources of contagion reside among a handful of large banking systems while the spillovers from these risks are distributed more broadly. Using the Espinosa-Vega-Sole model to assess the contagion (outward-spillover) and vulnerabilities (inward-spillover) for global banking systems, we find that the key sources of contagion are concentrated in the U.S, U.K, French banking systems, and to a lesser degree in Germany and Japan. New Zealand does not feature in the interbank spillover analysis as it is not a BIS reporting country. Meanwhile, the vulnerabilities are distributed globally, with no major banking system standing out as an outlier. From this sample of global banking systems, the Australian banking system neither appears as a significant source of contagion nor as a significant recipient of spillover risks (Figure 22).

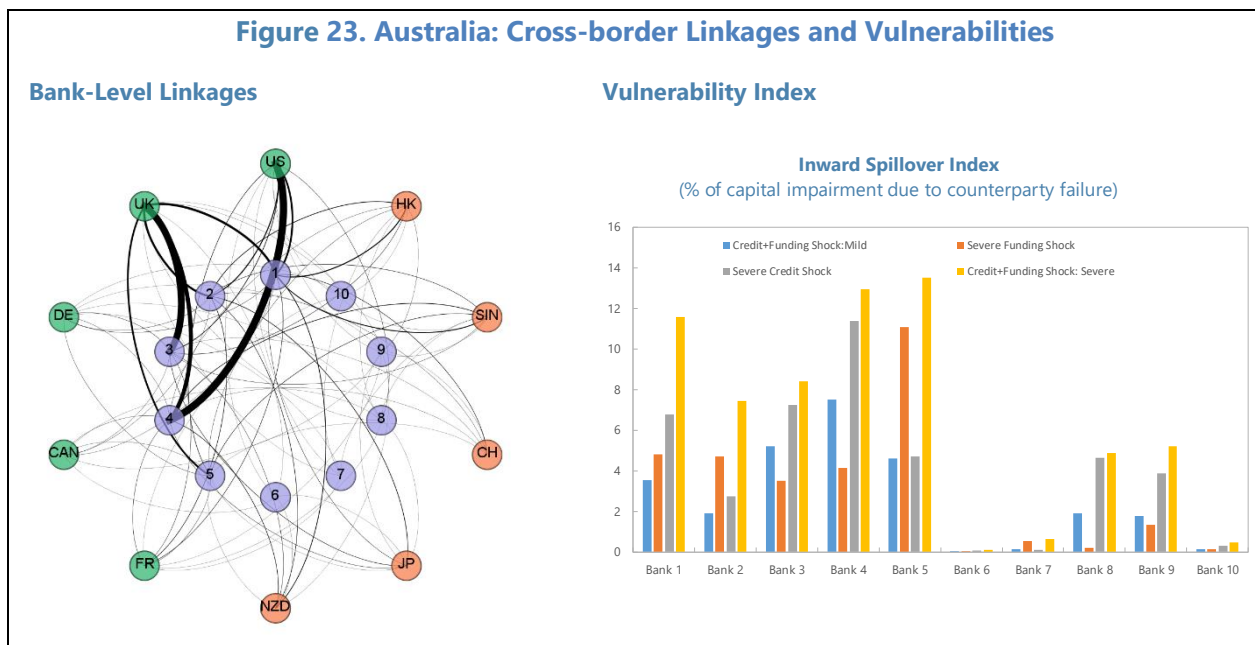
³⁵ Banks will typically fail the solvency test if their Tier 1 capital falls below the regulatory minimum. However, in this stylized exercise, the binary states of active and fail are assessed with a threshold of zero Tier 1 capital. Any variations in capital thresholds can instead be assessed by varying assumptions on LGDs.



79. Cross-border analysis using country-level and individual bank-level supervisory data corroborates the view that the Australian banks are particularly vulnerable to external funding shocks given their dependence on wholesale funding from overseas. Supervisory bank-level data as well as banking statistics from the BIS reveal that Australian banks have large asset exposures to New Zealand and, to a smaller degree, to China. Meanwhile, the four major banks as well as some mid-sized lenders have large liability positions vis-à-vis the United States and the United Kingdom, where they raise wholesale U.S. dollar funding (Figure 23). A stylized network analysis reveals notable vulnerabilities for Australian banks vis-à-vis their global counterparts. Specifically, under an adverse credit and funding shock,³⁶ the four major Australian banks appear particularly vulnerable to funding shocks emanating from banking systems in the United States and United Kingdom, and to a lesser degree from Singapore and Hong Kong. Under such a scenario, the four major banks with a higher dependence on overseas wholesale funding see a sharper deterioration in their capital positions, while some mid-sized banks, those with purely-domestic as well as those with global operations, also face significant erosion of their capital base. Anecdotal evidence suggests that funding from Singapore and Hong Kong banks reflects borrowing from international banks operating in these two regional financial centers.

³⁶ The adverse scenario assumes a loss given default of 1.0 on asset exposures to the failing institution and that none of the funding obtained from the failing counterparty is rolled over. Under this scenario, banks are forced to sell assets at large haircuts to offset the lost funding.

Figure 23. Australia: Cross-border Linkages and Vulnerabilities



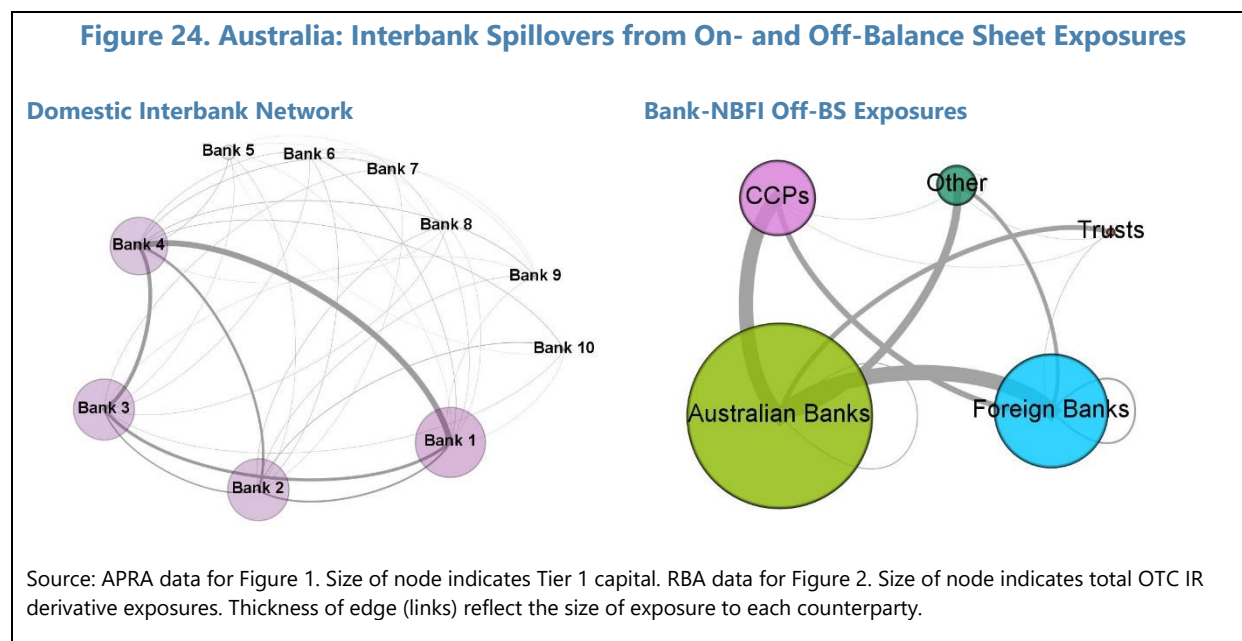
Source: IMF Staff Calculations based on the Espinosa-Vega-Sole (2010) methodology using APRA bank-level data as of June 2018. Note: The blue colored nodes represent the 10 largest Australian banks, while the green and orange nodes indicate advanced economies and Asia-Pacific countries respectively. Thickness of edges (links) reflect the size of gross asset exposures. Chart constructed with Gephi. Figure 2 presents the capital impairments estimated using the Espinosa-Vega-Sole (2010) methodology. The mild credit+funding shock scenario assumes LGD=0.4, 65 percent of funding is rolled over and haircuts on fire sale of assets is 50 percent. The severe funding shock scenario assumes no credit losses, but 0 percent of funding gets rolled over and the haircuts on the fire sale is 100 percent. The severe credit shock assumed LGD=1.0, with no funding shock. The severe credit+funding shock scenario assumes LGD=1.0, 0 percent of the funding gets rollover over and haircuts on the fire sale of assets is 100 percent. The results of the contagion analysis should be treated with caution. Fire-sale of assets are calibrated exogenously. The spiral effects from further declines in prices as a function of the aggregate increase in supply of assets are not modeled explicitly. Also, the mark-to-market effects from common exposures to stressed assets by banks holding similar assets are not computed. Second, contagion effects from a bear-market sentiment to banks following similar business models to the bank in distress are excluded.

80. Domestic interbank on-balance sheet exposures are relatively small. While the major Australian banks are very similar to each other in terms of exposures and business models, and less so with second-Tier banks, the size of their on-balance sheet exposures to each other amounts to around 5 percent of each institution’s total asset base.

81. However, off-balance sheet exposures between the four major Australian banks, and between the major banks, foreign banks and nonbanks (mainly CCPs), comprising primarily of derivative positions, appear to be sizeable. While the gross notional amount of Australian banks’ off-balance sheet assets have reportedly tripled in the past ten years, to around A\$36 trillion, the gross market value of the OTC derivative positions is estimated to be much smaller according to the RBA’s trade repository data.³⁷ The domestic interbank portion of these OTC exposures is estimated

³⁷ An RBA article published in June 2018 (<https://www.rba.gov.au/publications/bulletin/2018/jun/the-australian-otc-derivatives-market-insights-from-new-trade-repository-data.html>), estimates the gross market value of OTC IR derivatives traded in Australia at around A\$900 billion, with Australian banks being counterparties on A\$363 billion worth of these trades.

to be around A\$12 billion, while the gross market value of banks' derivative exposures to foreign banks and CCPs is estimated to be around A\$120 billion each (Figure 24).

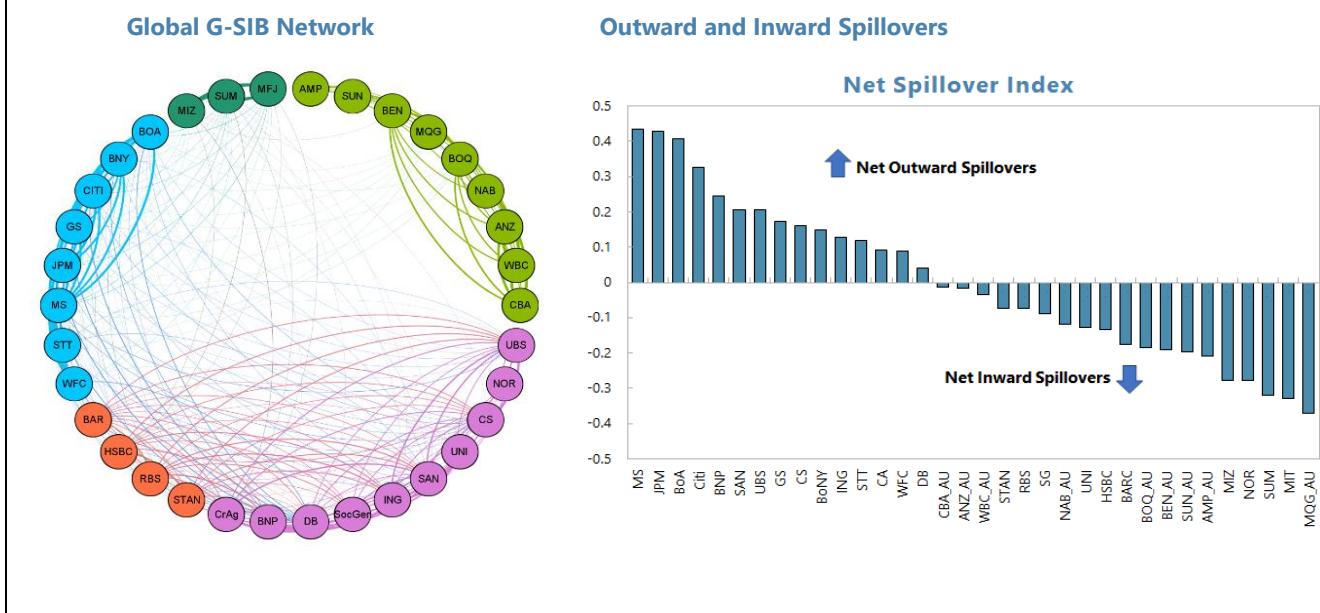


82. Network analysis using the Diebold-Yilmaz (DY) approach suggests a relatively low degree of interconnectedness between major Australian banks and G-SIBs. Both outward and inward spillovers,³⁸ from and to the Australian banking sector respectively, appear to be relatively moderate vis-à-vis the G-SIBs (Figure 25). Among the sample set of global banks studied, the U.S., French, and German banks have the highest degree of contagion (outward spillover), as also evidenced by the analysis using direct exposures (Vega-Sole), while Asian banks appear to be net recipients of spillovers. Australian banks' net contribution to global systemic risk³⁹ appears to be negligible, with their vulnerability metric relatively moderate compared to global peers. However, the mid-sized Australian banks reveal net inward spillover risk, reflecting their increased vulnerability to external shocks. One institution stands out as an outlier given its larger exposure to the global financial system.

³⁸ The interconnectedness measure (outward and inward spillover) is derived from the variance decomposition of the underlying vector autoregression (VAR). The inward spillover measure captures exposures of individual firms to systemic shocks from the network. The outward spillover measure captures contributions of individual firms to systemic network events. In addition, the net-spillover measure (the difference between inward- and outward-measures) describes the relative contribution to systemic risks from each financial firm. See references for more details on the methodology.

³⁹ The net contribution to global systemic risk is captured by the difference between the outward spillover to the system from the bank and the inward spillover to the bank from the system based on forecast error variance decomposition.

Figure 25. Australia: Interconnectedness between Major Australian Banks and GSIBs



Source: IMF Staff Calculations based on the Diebold and Yilmaz (2014) methodology using daily equity returns from Bloomberg (January 1, 2003 to July 23, 2018).
 Left panel: The sample includes 25 of the 30 G-SIBs identified by the FSB in 2017. Five Chinese banks are not included due to unavailability of equity data for a longer time horizon. The nine Australian institutions include ANZ, CBA, WBC, NAB, BoQ, MQG, BEN, SUN, and AMP Group. The blue, orange, purple and dark green nodes denote U.S., U.K, European and Asian banks, respectively, while light green nodes denote Australian banks. The thickness of the edges captures total linkages (both inward and outward). Chart constructed with Gephi. Right panel: The Net Spillover Index (the difference between inward- and outward- spillovers) describes the relative contribution to systemic risks from each entity.

CORPORATE SECTOR ANALYSIS

A. Recent Developments

83. The nonfinancial corporate sector (NFC) has been resilient in recent years, recovering strongly from the commodity market slump in 2015, but faces strong headwinds in the wake of a China slowdown and tighter global financial conditions. Surveys reveal that business confidence across industries have been slowly deteriorating since January 2018, though the sub-index for business conditions is still hovering above long-term averages.⁴⁰

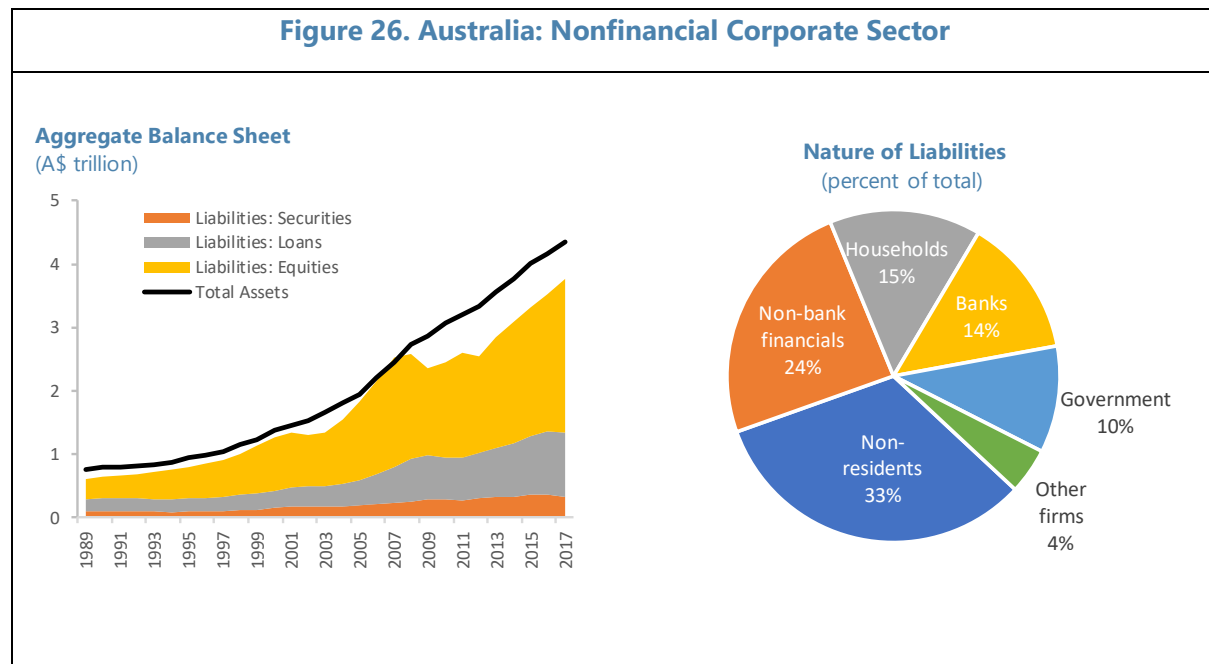
84. Firm insolvencies rose nearly 30 percent during the global financial crisis and have stabilized in recent years albeit at higher levels. The average annual growth rate in corporate insolvencies has been negative over the past five years, compared to double-digit increases during the GFC. Some regions (e.g., Western Australia) continue to see a rising trend in business insolvencies, while others (e.g., Queensland, Victoria) are yet to see insolvencies return to pre-GFC levels. The construction sector has among the highest number of insolvencies and looks particularly vulnerable in the event of a correction in the property markets. Meanwhile, the mining sector saw a sharp rise in

⁴⁰ The NAB business confidence index is the benchmark index for business sentiment in Australia.

insolvencies during the commodity slump in 2014–2015, with the Queensland region seeing the largest share of these failures. Investment into mining has declined sharply since, potentially hampering the recovery in the sector.

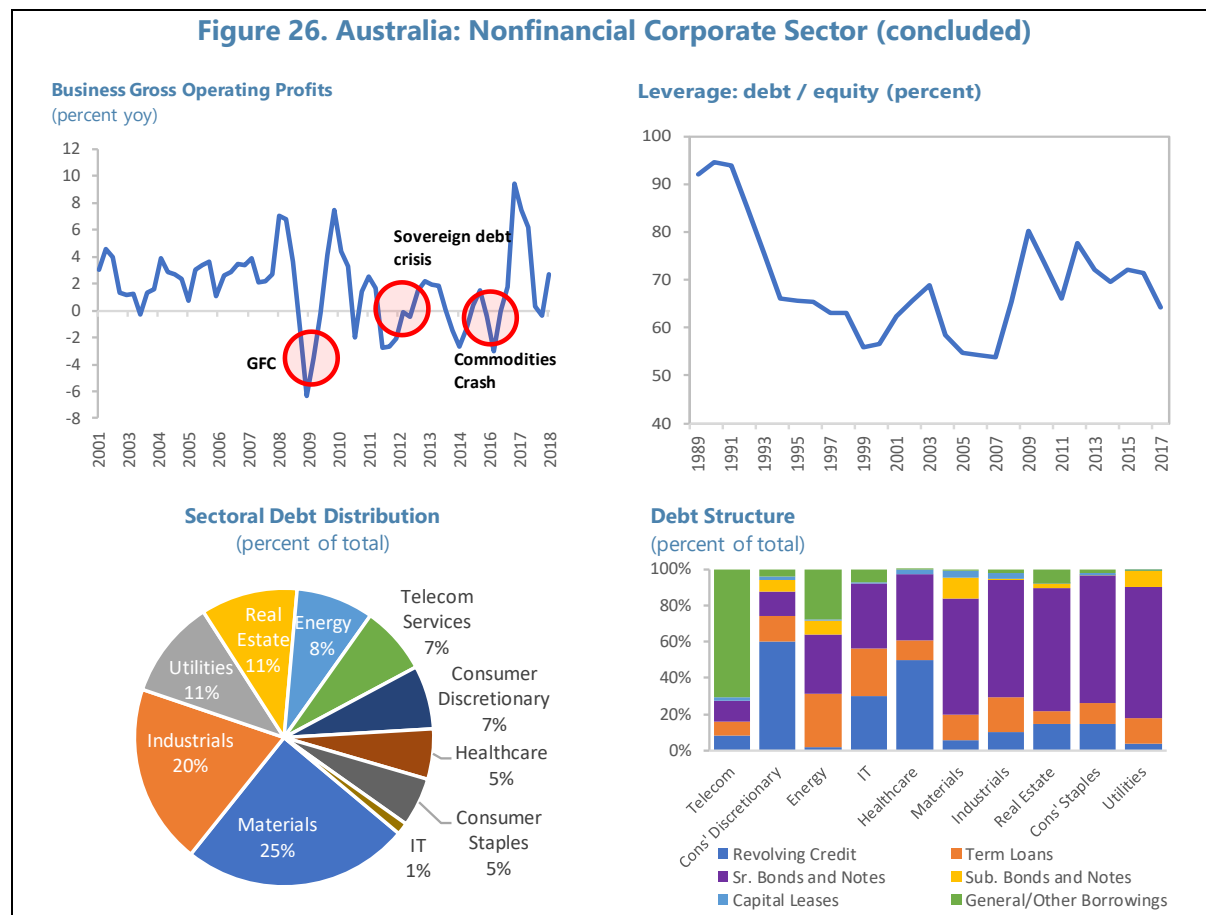
B. Key Vulnerabilities and Risks

85. While banks are an important source of financing for companies, bank loans comprise only around 15 percent of aggregate liabilities, with the bulk of debt and equity financing coming from nonbank financials and nonresidents. The NFC sector has assets totaling around 250 percent of GDP (Figure 26), with the bulk of the debt residing in cyclical sectors such as industrials, materials, energy and real estate.⁴¹ Gross operating profits have been relatively strong in recent years, following volatile earnings during the GFC, the European sovereign debt crisis and the slump in global commodities. Firm leverage trends appear generally benign, though debt servicing capacity for some levered sectors, such as real estate and materials, necessitate closer monitoring given high exposures to the housing market and China respectively.



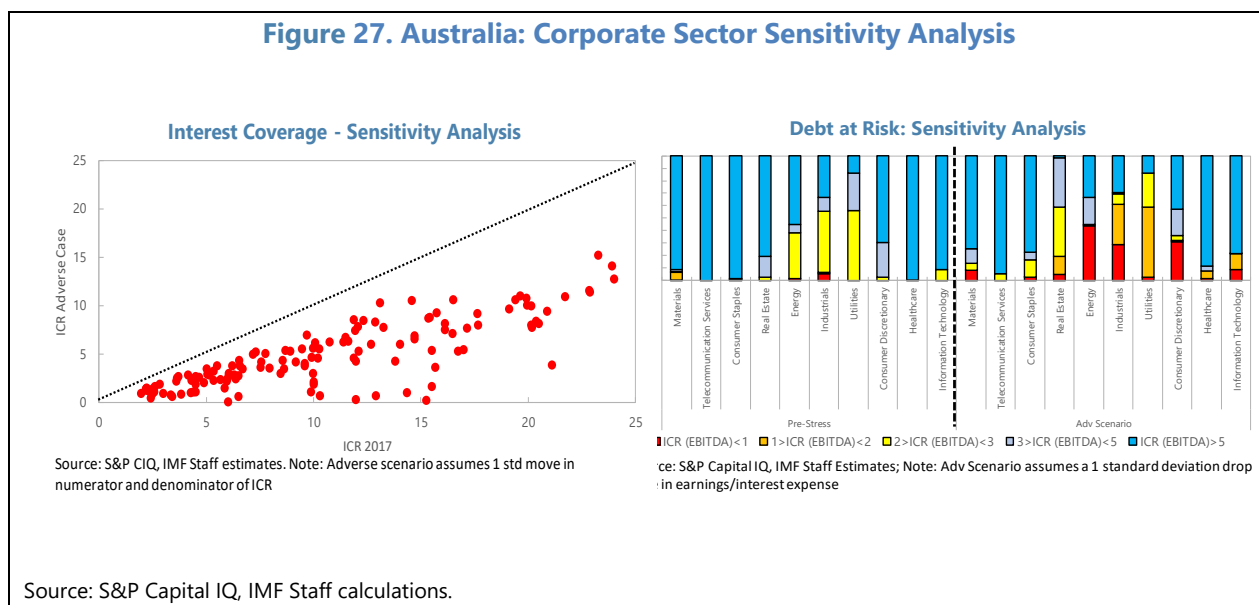
⁴¹ Based on a sample of 250 firms from S&P Capital IQ, the 4 sectors have a combined debt of over 65 percent of total debt among NFCs.

Figure 26. Australia: Nonfinancial Corporate Sector (concluded)



86. Corporates are increasingly borrowing from global capital markets or foreign banks, on the back of cheaper funding options offshore and as domestic banks are pulling back from some markets and divesting out of auxiliary business lines. Larger firms, particularly those in the materials, industrial and real estate sectors with strong ratings, typically access international debt capital markets to raise U.S. dollar financing and swap these proceeds into Australian dollars. Anecdotal evidence suggests these firms have ample natural and synthetic hedges for their currency exposures and have built large cash reserves to meet their liquidity needs. Corporate leverage has risen somewhat since the GFC but remains low with debt of only about 60 percent of equity. Meanwhile, balance sheets of foreign banks have grown nearly 50 percent over the past five years, albeit from a small base, compared to a growth rate of 25 percent for the major lenders. While foreign subsidiaries and branches only comprise around 15 percent of total banking system assets, anecdotal evidence suggest they are more aggressively expanding their balance sheets, particularly across the more riskier loan segments such as corporate loans and commercial real estate.

Figure 27. Australia: Corporate Sector Sensitivity Analysis



C. Sensitivity Analysis

87. The FSAP assessed the vulnerabilities of the nonfinancial corporate sector to an adverse shock that negatively impacts earnings and funding costs. The scenario envisaged includes a macroeconomic shock that would hurt corporate earnings, combined with a tightening in global financial markets which would raise funding costs for banks and corporates alike. The magnitude of the shock to earnings and interest expense is assumed to be one standard deviation,⁴² which is expected to have a differentiated response from the various sectors, depending on the sector’s fundamentals. Under such an adverse scenario, there is a wide dispersion in interest coverage ratios (ICR) across the sample of companies.⁴³ Interestingly, several firms with relatively high starting ICRs witness a steep deterioration in debt repayment capacity (Figure 27), possibly reflecting higher leverage and sensitivity to interest rates. Estimates of firms’ debt-at-risk under this adverse scenario reveal that debt repayment capacity is particularly weak for those sectors exposed to China and the domestic real estate market. Energy, Industrials, Utilities and Real estate sectors are among those that see the most deterioration in debt-at-risk, while the Materials sector appears relatively resilient given the sector has been through a phase of deleveraging following the global commodity slump. The sharp deterioration in ICRs for some of the above sectors reflects the relatively higher leverage and increased sensitivity to interest rate shocks.

POLICY RECOMMENDATIONS

88. Additional investment in data and analytical tools would strengthen financial supervision and systemic risk oversight. Relative to international experience, the assessment

⁴² The one standard deviation move is estimated over a 10-year time horizon for the variables shocked.

⁴³ Based on a sample of 250 firms from S&P Capital IQ, which have a combined debt of around A\$1 tn.

identified shortfalls in the granularity and consistency of data to support analysis of supervisory and systemic risks and the formulation of policy. The CFR agencies are recommended to conduct a major review of potential data needs and implement improvements, publishing the results where feasible. Improved data would also facilitate further enhancements in stress testing and support closer integration of the results into prudential supervision and policy discussions. It would also provide a platform to better harness the collective expertise of the RBA and APRA in the analysis and evaluation of policy options.

89. Enhancing the existing stress testing framework would also further improve the authorities' ability to monitor and identify systemic risks and their policy formulation process.

Carrying out stress tests based on uniform data source across all banks would enhance the comparability of risks. Expanding the modeling process to develop in-house models to estimate potential losses would enhance the authorities' ability to cross-validate banks' bottom-up loss estimates. The authorities could also enhance monitoring of banks' exposures in major foreign jurisdictions and carry out network analysis on a regular basis. This would help identify potential channels of cross-border spillovers for the banking system. Performing liquidity risk analysis based on cash flows at various maturities would also complement the existing liquidity risk monitoring processes and allow for a more comprehensive assessment of risks.

90. Although it has declined in recent years, banks' continued reliance on wholesale funding is source of some vulnerability. Further extending banks' funding maturity profile and reducing their reliance on wholesale funding would further reduce structural funding risks.

Annex I. Risk Assessment Matrix (RAM)

Nature/Source of Main Threats	Overall Level of Concern	
	Likelihood of Severe Realization of Threat in the Next 1–3 Years (high, medium, or low)	Expected Impact on Financial Stability if Threat is Realized (high, medium, or low)
1. Severe real estate market downturn.	<p>Low / Medium</p> <ul style="list-style-type: none"> • Rising interest rates and low housing affordability reduce demand for additional housing purchases. • Nationally falling housing and commercial real estate prices lead to a dramatic increase in risk aversion in both these real estate markets. • Reversion of capital flows as international buyers leave the market. • Sharp price declines in domestic equity and bond markets. 	<p>High</p> <ul style="list-style-type: none"> • A sharp real estate market correction would lower residential and corporate investment and private consumption and thereby growth. • A vicious feedback loop of falling house and commercial real estate prices, higher non-performing loans, tighter bank credit, and lower activity could amplify the downturn. • The impact on banks would be largely through higher credit losses on mortgage and commercial real estate loans, but also on their broader loan portfolios due to the overall decline in economic activity and increasing unemployment.
2. Significant China slowdown and weaker-than-expected global growth.¹	<p>Low / Medium</p> <ul style="list-style-type: none"> • This shock could affect Australia via both trade and financial channels. • Lower export revenue for Australia would lead to lower growth and consumption, leading to lower profits for the corporate sector and lower investment, higher structural unemployment, and lower foreign direct investment (FDI), with reduced tax revenues for the government. • There would be a negative feedback for broad economic growth from reduced credit growth from banks. 	<p>Medium / High</p> <ul style="list-style-type: none"> • A China slowdown would lead to a sustained decline in commodity prices and a downturn in Australia. Could be exacerbated by a trade dispute with the United States. • Banks would face higher credit losses on corporate loans, and also on their broader loan portfolio due to the overall decline in economic activity. • Rising losses on loan portfolios might induce banks to cut back lending.

¹ In line with Risks #1 and 4 of the July 2018 Global Risk Assessment Matrix (G-RAM).

Overall Level of Concern		
Nature/Source of Main Threats	Likelihood of Severe Realization of Threat in the Next 1–3 Years (high, medium, or low)	Expected Impact on Financial Stability if Threat is Realized (high, medium, or low)
<p>3. Sharp tightening of global financial conditions.²</p>	<p style="text-align: center;">High</p> <ul style="list-style-type: none"> This shock would be accompanied by a spike in risk premiums, disorderly correction in asset prices, heightened volatility, and a sharp depreciation of the Australian dollar. Tighter financial conditions would lead to capital outflows from Australia and could put pressure on government bond yields. 	<p style="text-align: center;">Medium</p> <ul style="list-style-type: none"> The impact on banks would be largely through market risk (via the repricing of banks’ financial assets and the impact of a weaker Australian dollar on their net open position) and through higher funding costs, which would be exacerbated by the higher credit losses caused by this shock. Banks could experience a significant decline in wholesale funding available from abroad. Banks’ asset quality could also deteriorate as their customers would face rising borrowing rates on variable-interest rate loans (the bulk of banks’ lending).

²In line with Risk #3.

Annex II. Banking Sector Stress Testing Matrix (STeM)

Domain		Top-own Stress Test by FSAP Team: Assumptions
Banking Sector: Solvency Risk		
1. Institutional Perimeter	Market share of institutions included	<ul style="list-style-type: none"> • Largest 10 banks (largest five banks subject to the Major Bank Levy and five mid-sized banks) which hold approximately 88 percent of the domestic banking sector assets.
	Data Source and Baseline Date	<ul style="list-style-type: none"> • Data Source: Supervisory and publicly-available data • Baseline date: End-2017. • Scope of Consolidation: Level 2 consolidated data (banking business data for banks that have their headquarters in Australia and subsidiary level data for the foreign subsidiaries).
2. Channels of Risk Propagation	Methodology	<ul style="list-style-type: none"> • Balance sheet-based approach.
	Satellite models for macro-financial linkages	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Three years (2018–2020).
3. Tail Shocks	Scenario analysis	<ul style="list-style-type: none"> • Scenario-based tests, that assess the impacts on the entire portfolio including the loans and, if applicable, the trading book. • Variables in the scenarios include domestic macrofinancial variables (e.g., GDP, inflation, exchange rate, interest rates, unemployment rate, exchange rate, equity, and house prices), and global variables (the United States and China GDP, USD interest rates, and commodity prices). • Baseline scenario based on the April 2018 WEO projections. • The Adverse Scenario is simulated using IMF's Flexible System of Global Models. • The Adverse Scenario is driven by a combination of external shocks amplified by domestic characteristics, including existing vulnerabilities and policy constraints, see RAM. The three major drivers of the Adverse Scenario are: <ul style="list-style-type: none"> - Shock 1: Significant slowdown in China and weak growth in advanced economies. - Shock 2: Tightening of global financial conditions due to

Domain	Top-own Stress Test by FSAP Team: Assumptions	
Banking Sector: Solvency Risk		
		<p>an abrupt change in risk appetite.</p> <ul style="list-style-type: none"> - Shock 3: A sharp housing market correction. <ul style="list-style-type: none"> • Under the Adverse Scenario, the Australian economy goes through a V-shaped growth path, with annual GDP growth shocks of -5.5 percent, -3.6 percent, and -1.3 percent. These shocks correspond to a cumulative deviation of real GDP growth of close to 9 percentage points over the first two years compared to the Baseline path (more than 4 standard deviations). • This economic slowdown is accompanied by unemployment shocks of 3.5 percent, 4.7 percent, and 4.7 percent. The cumulative house price decline reaches 31 percent. • The AU\$ depreciates by 25 percent in the first year, which only partially reverses in the second and third years leading to a cumulative depreciation of 16 percent at the end of the third year.
	Sensitivity analysis	<ul style="list-style-type: none"> • Sensitivity analyses conducted to supplement the scenario analysis. • They evaluate impacts of three different single risk factors on the existing capital buffers as of end-2017: <ul style="list-style-type: none"> - Interest rate risk - Spread increase for securities portfolios - Concentration risk.
4. Risks and Buffers	Risks/factors assessed	<ul style="list-style-type: none"> • Credit loss from banks' loan portfolios and sovereign 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. • Increase in funding costs.
	Behavioral adjustments	<ul style="list-style-type: none"> • Passive balance sheet assumption: <ul style="list-style-type: none"> - the balance sheet growth is identical to the overall credit growth, which is linked to nominal GDP growth (with a 0-floor); - the balance sheet composition remains constant throughout the stress test horizon; - banks build capital only through retained earnings; and - maturing capital instruments are not renewed.

Domain		Top-own Stress Test by FSAP Team: Assumptions
Banking Sector: Solvency Risk		
		<ul style="list-style-type: none"> Dividends are paid out by banks that remain adequately capitalized throughout the stress period. The dividend payout ratio is assumed to be 50 percent.
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	<ul style="list-style-type: none"> Projected losses distributed across different asset classes. Point-in-time credit risk proxies and parameters calibrated by the FSAP team and provided by APRA Phase 2 Stress test results.
	Regulatory/ accounting and market-based standards	<ul style="list-style-type: none"> National regulatory framework. Basel III approach.
6. Reporting Format for Results	Output presentation	<ul style="list-style-type: none"> System-wide capital shortfall. 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.
Banking Sector: Liquidity Risk		
1. Institutional Perimeter	Market share of institutions included	<ul style="list-style-type: none"> Largest 10 banks (largest five banks subject to the Major Bank Levy and five mid-sized banks) which hold approximately 88 percent of the domestic banking sector assets.
	Data Source and Baseline Date	<ul style="list-style-type: none"> Data Source: Supervisory and publicly-available data Baseline date: End-2017. Scope of Consolidation: Level 2 consolidated data (banking business data for banks that have their headquarters in Australia and subsidiary level data for the foreign subsidiaries).
2. Channels of Risk Propagation	Methodology	<ul style="list-style-type: none"> Cash-flow based liquidity stress test using maturity buckets. Basel III-LCR and NSFR ratios. Analyses carried out separately for AUD and USD, based on availability of data.
3. Risks and Buffers	Risks	<ul style="list-style-type: none"> Funding liquidity (liquidity outflows). Market liquidity (price shocks) and haircuts.
	Buffers	<ul style="list-style-type: none"> Counterbalancing capacity (HQLA). Central bank facilities.
4. Tail shocks	Size of the shock	<ul style="list-style-type: none"> Simulated run-off rates benchmarked against LCR/NSFR assumptions. Bank run and dry up of wholesale funding markets, taking into account haircuts to liquid assets.

Domain		Top-own Stress Test by FSAP Team: Assumptions
Banking Sector: Liquidity Risk		
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards	<ul style="list-style-type: none"> National regulatory framework. LCR: 100 percent. NSFR: Basel Committee on Banking Supervision (2014), "Basel III: The Net Stable funding ratio" Basel, October 2014.
6. Reporting Format for Results	Output presentation	<ul style="list-style-type: none"> System-wide liquidity gaps. Survival period by bank, number of banks that can still meet their obligations.
Banking Sector: Interconnectedness		
1. Institutional Perimeter	Institutions included	<ul style="list-style-type: none"> Largest 10 banks (largest five banks subject to the Major Bank Levy and five mid-sized banks) which hold approximately 88 percent of the domestic banking sector assets. Major nonbank FIs.
	Data Source and Baseline Date	<ul style="list-style-type: none"> Source: Supervisory data. Baseline date: End-2017. Scope of Consolidation: Level 2 consolidated data (banking business data for banks that have their headquarters in Australia and subsidiary level data for the foreign subsidiaries).
2. Channels of Risk Propagation	Methodology	<ul style="list-style-type: none"> Balance sheet-based interbank model by Espinosa-Vega and Solé (2010). Market price-based spillover model by Diebold and Yilmaz (2014). Cross-border network model by Espinosa-Vega and Solé (2010).
3. Risks and Buffers	Risks	<ul style="list-style-type: none"> Credit and funding losses related to interbank cross-exposures (and cross-border banking exposures).
	Buffers	<ul style="list-style-type: none"> Banks' own capital and liquidity buffers.
4. Tail shocks	Size of the shock	<ul style="list-style-type: none"> Pure contagion: Assumed failure of institutions.
6. Reporting Format for Results	Output presentation	<ul style="list-style-type: none"> Network analyses with supervisory data. <ul style="list-style-type: none"> System-wide capital shortfall. Number of undercapitalized and failed institutions, and their shares of assets in the system. Evolution and direction of spillovers.

Annex III. Key Macroeconomic Variables Under Baseline and Adverse Scenarios

(In percent, unless noted otherwise)

	Baseline				Adverse		
	2017	2018	2019	2020	2018	2019	2020
Australia Real GDP growth	2.3	3.0	3.1	2.9	-2.5	-0.5	1.6
China Real GDP growth	6.9	6.6	6.4	6.3	2.9	3.1	3.8
Unemployment rate	5.6	5.3	5.2	5.0	8.8	9.8	9.7
USD Exchange rate (level)	1.31	1.32	1.32	1.32	1.75	1.63	1.55
House price index (2017=100)	100	106	112	117	85	77	69
RBA cash rate	1.50	1.75	2.25	2.75	0.50	0.25	0.25
Bank Bill Rate/Cash Rate Spread	0.30	0.30	0.30	0.30	1.30	0.70	0.50
3-mo Bank Bill Rate	1.80	2.05	2.55	3.05	1.80	0.95	0.75
5-yr A Corporate bond/AGS Spread widening					2.57	2.01	1.33
5-yr BBB Corporate bond/AGS Spread widening					4.23	2.97	1.78
CPI inflation	1.9	2.1	2.2	2.3	0.6	1.2	1.3

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