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May 2017

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

This Technical Note on Stress Testing the Banking Sector and Systemic Risk Analysis on New Zealand was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in May 2017.

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TECHNICAL NOTE

STRESS TESTING THE BANKING SECTOR AND SYSTEMIC RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by Laura Valderrama, with contributions from Lucyna Gornicka (both IMF staff), in the context of the Financial Sector Assessment Program in New Zealand. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP program 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
BPS	Basis Points
BU	Bottom-up (stress test)
CAR	Capital adequacy ratio
CCB	Capital Conservation Buffer
CCR	Counterparty credit risk
CDS	Credit Default Swap
CET1	Common Equity Tier 1
CFR	Core Funding Ratio
CoVaR	Conditional Value at Risk
CRE	Commercial real estate
DSGE	Dynamic stochastic general equilibrium
EaD	Exposure at default
EDF	Expected default frequency
EL	Expected loss
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
HQLA	High-quality liquid assets
HTM	Held to maturity
IRB	Internal ratings-based (approach)
KgMS	Kilogram per Milk Solid
LCR	Liquidity coverage (ratio)
LGD	Loss-given default
LIBOR	London Interbank Offered Rate
LTV	Loan-to-value (ratio)
LVR	Loan-to-value ratio
NII	Net interest income
NIM	Net interest margin
NPL	Nonperforming loan
NSFR	Net-Stable Funding Ratio
NZD	New Zealand Dollar
OCR	Official Cash Rate
P&L	Profit and loss
PCA	Principal component analysis
PD	Probability of default

PiT	Point-in-time
pps	Percentage points
PTB	Price-to-book (ratio)
RAM	Risk Assessment Matrix
RBNZ	Reserve Bank of New Zealand
ROA	Return on assets
ROE	Return on equity
RWA	Risk-weighted assets
STA	Standardized (approach)
STeM	Stress test matrix (for FSAP stress tests)
TD	Top-down (stress test)
TTC	Through-the-cycle
VAR	Vector autoregression
VaR	Value at risk
VIX	Volatility index
WEO	World Economic Outlook
Yoy	Year-on-year
YTM	Yield to maturity

EXECUTIVE SUMMARY

Imbalances in the housing market, concentrated exposures to the dairy sector, and reliance on wholesale funding are the key macrofinancial risks in New Zealand. The banking sector, which dominates the financial system, has significant exposures to real estate and agriculture, is relatively dependent on foreign funding and is dominated by four Australian subsidiaries. A sharp decline in the real estate market, a prolonged period of low dairy prices, a deterioration in global economic conditions, and a tightening in financial markets would adversely impact the system.

Despite these risks, the banking system is resilient to severe shocks. Results of stress tests and sensitivity analysis indicate that the solvency and liquidity of the banking system can withstand adverse and severe shocks. In addition, there is a limited impact of solvency and liquidity contagion cascades from bank interlinkages and common transactional exposures to banks, nonbank financial institutions, and corporates. Given uncertainties around the impact of the potential implementation of Basel III LCR requirements, authorities are encouraged in their efforts to conduct the liquidity review and implement a more granular and conservatively calibrated liquidity tool.

While the risk of contagion through the interbank market appears to be limited, New Zealand banks are vulnerable to severe distress in G-SIBs. This is because interbank exposures are relatively small compared to banks' initial capital levels. A loss of the three largest bank exposures would lead to a default of one locally-incorporated bank. On the other hand, the analysis on cross-border spillovers at the consolidated level suggests that, on average, the risk that severe distress affecting G-SIBs is transmitted to the four largest New Zealand subsidiaries through equity markets is significant.

The authorities are encouraged to expand their stress testing capabilities to address systemic risk and feedback effects. Stress test results should be interpreted with caution. Stress test scenarios replicate historical events or express extreme "tail events" based on historical loss distributions, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance. The RBNZ is encouraged to expand its modeling capabilities to enhance credit risk assessment of CRE/SME and corporate exposures as well as to step up their analytical work to explore systemic interactions among financial institutions.

Table 1. New Zealand: Main Recommendations on Stress Testing		
Recommendations	**Time[1]**	**Institution**
Stress Testing Analysis		
Strengthen data infrastructure including data collection efforts over granular risk parameters for CRE and corporate/SME exposures.	Short-term	RBNZ
Expand modeling efforts to develop in-house structural models for CRE and corporate/SME exposures.	Short-term	RBNZ
Develop in-house models of funding risk to reflect liquidity and solvency interactions.	Medium-term	RBNZ
Expand analytical capabilities to capture bank behavioral reactions to stress, systemic interlinkages and feedback effects.	Medium-term	RBNZ
Step up the use of stress test results to inform system-wide prudential policy.	Medium-term	RBNZ
[1] Short-term is 1–3 years and Medium-term is 3.5 years.		

INTRODUCTION

A. Financial System Structure

1. **The financial sector in New Zealand is dominated by banks, which represent about 75 percent of total financial assets.** The New Zealand banking system was about NZD 500 billion in June 2016, around twice New Zealand annual GDP.[1] Among nonbank financial institutions, managed funds and trusts (including KiwiSaver and other superannuation funds) account for 50 percent of GDP while private insurance represents around 12 percent of GDP.

2. **The banking sector is characterized by the dominance of four Australian subsidiaries.** The banking sector is comprised of 24 registered banks, mostly locally incorporated banks.[2] The system is concentrated on four subsidiaries of the largest Australian banks, whose share in banking sector's total assets was 87 percent in June 2016 and represent a significant share of parents' assets ranging between 10 and 15 percent. The systemic importance of New Zealand subsidiaries for parent banks makes the New Zealand-Australian interdependence unique.[3] At the same time, the New Zealand subsidiaries have decreased their reliance on funding from Australian parents and affiliates. While during the GFC, Australian banks proved willing to provide significant liquidity support to their New Zealand subsidiaries through a range of channels, today intragroup liabilities comprise less than 4 percent of total liabilities for each bank, down from 15 percent in 2004. The intragroup funding relations are expected to decrease further in response to the new Australian bank regulation (APS 222).[4]

3. **While the four Australian subsidiaries have similar business models and corporate ownership, other New Zealand banks are active in specific market segments and present a diversity of ownership structures.** The four Australian subsidiaries have large exposures to

[1] This compares with a ratio of 10.0 in the United Kingdom, 8.8 in the Netherlands, 5.6 in Switzerland, 6.4 in Japan, and 3.9 in the United States.

[2] As of September 2016, there were 15 locally incorporated banks and 9 branches. Local incorporation policy introduced in 2003 required subsidiarization for systemically important banking institutions. Westpac New Zealand Limited (WNZL) was registered as a locally incorporated bank on October 31, 2006 and operates as a subsidiary of the Australian parent bank (WBC). WBC operates both a subsidiary and a branch in New Zealand, though the vast majority of banking activity is undertaken by WNZL. Australia and New Zealand Banking Group Limited was registered as a branch on January 5, 2009 as a special purpose vehicle to reduce funding pressures on ANZ Bank New Zealand Ltd. Its assets are RMBS transferred from the subsidiary. CBA was registered as a branch on 23 June 2000 (ASB Bank Ltd is the subsidiary of the Australian parent bank).

[3] The principles for cooperation between home and host regulators are set out in a Memorandum of Cooperation on Trans-Tasman Distress Management, agreed in September 2010. The path of dividend payout accommodates RBNZ's buffer ratio restrictions to payments on ordinary share dividends (see 3.4B of BS2B). In a stress event, New Zealand subsidiaries of Australian banks would stop paying dividends for the period of stress. In a severe stress, the parent is expected to provide some capital support to the subsidiary.

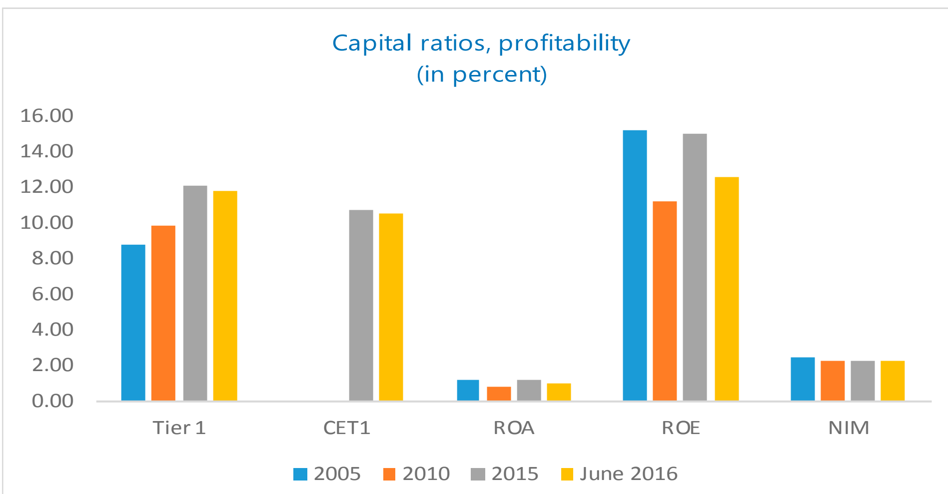
[4] Australian banks are required to limit their non-capital exposures to New Zealand banking subsidiaries, either directly or via New Zealand branches, to below 5 percent of the ultimate parent's Tier 1 capital by end-2020.

housing, property investment, and the agriculture sector.[5] They are 100 percent owned by their respective Australian parents. By contrast, the fifth largest bank (Kiwibank Ltd) is primarily a mortgage bank with around 90 percent exposure to housing and is jointly owned by New Zealand SuperFund, ACC, and New Zealand Post – and the sixth bank (Rabobank) is an agribusiness bank with mainly rural lending exposure owned by its Dutch parent.

4. **The New Zealand stress testing exercise took place against a backdrop of strong fundamentals in the banking sector** (Figure 1). The banking sector is characterized by robust capitalization and strong structural profitability, which provides a solid buffer to withstand severe macrofinancial stress. Profitability is supported by the traditional lending focus of banks and strong and net interest margins. Margins have been stable hovering around 2.3 percent since 2000, with an average 2.2 percent in the post-crisis period. Robust net interest margins are partly attributed to banks' capacity to pass-on funding cost shocks to borrowers supported by the contractual repricing schedule of loans with an average time to repricing of housing loans of around 11 months across banks. CET1 ratios have increased to around 12 percent in June 2016, while return on equity (ROE) reached over 12 percent and net interest margins hovered around 2.2 percent.

Figure 1. New Zealand: Banks Capital and Profitability

Aggregate Tier 1 ratios have increased in the wake of the GFC to around 12 percent while ROE is strong at above 12 percent.



Sources: RBNZ and IMF staff estimates.

5. **The New Zealand banking system has a traditional lending focus with net interest income as the key source of profitability** (Figure 2). For the major New Zealand banks, interest income dwarfs non-interest income (about eight times larger). Most interest income is sourced from loans. Interest income accrual from the securities portfolio accounted for only 5 percent of total income as of June 2016. The securities portfolio represents about 7.5 percent of banking system

[5] The average exposure to housing, property investment, and the agriculture sector was 57 percent, 19 percent, and 14 percent, respectively in May 2016.

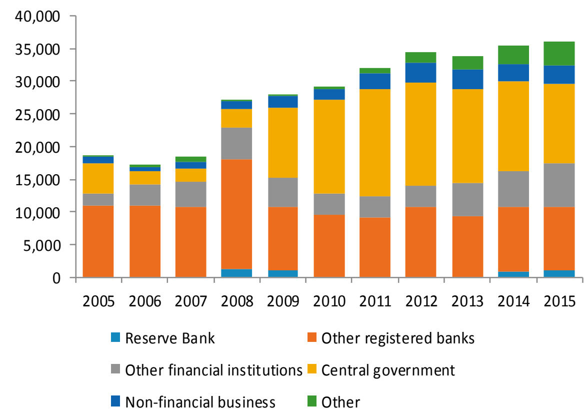
assets. Most securities are held as liquid buffers to comply with RBNZ's regulatory liquidity policy. By type of issuer, one third of securities are central government bonds, one fourth debt issued by other registered banks, and one fifth securities issued by other financial institutions. Holdings of Kauri bonds are significant, accounting for around one-fifth of total debt securities held in June 2016.[6]

Figure 2. New Zealand: Banks' Business Model

New Zealand banks have a traditional lending focus with net interest income as a key source of profitability and government securities as the main instrument held in their securities portfolio.

Net interest income exceeds non-interest income by over three times…

…while central government securities account for one third of debt securities holding and instruments issued by banks represent one fourth of total holdings.



Sources: RBNZ and IMF staff estimates.

B. Stress Testing Under the FSAP Program

6. **The aim of the FSAP stress test is to assess the resilience of the banking sector as a whole rather than the capital adequacy of individual institutions.** The FSAP approach to stress testing is essentially macroprudential: it focuses on the resilience of the broader financial system to adverse macrofinancial conditions rather than on the resilience of individual banks to specific shocks. The FSAP stress test ensures consistency in macroeconomic scenarios and metrics across firms to facilitate the assessment of the banking system as a whole. The stress test analysis is intended to help country authorities to identify key sources of systemic risk in the banking sector and inform macroprudential policies to enhance its resilience to absorb shocks.

7. **The FSAP stress tests of the New Zealand banking system should be seen in conjunction with the stress tests undertaken by the RBNZ for supervisory purposes.** Alongside the tests run internally by registered banks, the RBNZ has conducted several collective stress tests of the larger New Zealand banks in the last 5 years (and, in 2014, a test of several smaller incorporated institutions). As well as running periodic 'regulator initiated' stress tests, the RBNZ has also recently

[6] A Kauri bond is a New Zealand dollar denominated security, registered in New. Zealand and issued by a foreign issuer.

begun to work with APRA to provide common scenarios for use in the major banks' internal stress testing.[7] The most recent full macroeconomic stress tests conducted by RBNZ include the 2014 stress test run jointly with APRA and the 2015 ICAAP stress test on a common scenario.

8. In late 2015, the RBNZ conducted a dairy portfolio stress testing exercise on the five largest dairy lenders featuring low milk prices and sharp falls in dairy land values. The results were published in March 2016.[8] Simulating the effect of two stress scenarios, banks reported a material deterioration of credit quality of dairy customers. Although the scenarios generate significant increases in loss rates, they are manageable for the banking system as a whole.

9. The FSAP stress test results should be interpreted with caution. The FSAP stress test results on the New Zealand banking system are based on supervisory data as of June 2016. These data are complemented by publicly available data to support the calibration of quantitative projections undertaken by the FSAP team. Despite the best efforts of the FSAP team to build a consistent database, the matching and reconciliation of risk data extracted from multiple data sources is a complex exercise. More generally, stress test scenarios typically replicate historical events or express extreme "tail events" based on a historical distribution, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance. While some nonlinear effects can be captured in stress tests, it is always possible that unknown patterns emerge, especially if extreme shocks materialize.

C. Stress Testing Approach for the New Zealand FSAP

10. The resilience of the New Zealand banking system is assessed under a battery of stress tests (Figure 3):

- **Solvency stress tests:** The IMF and the RBNZ ran parallel solvency stress tests using their own in-house methodologies based on supervisory data and common macroeconomic scenarios. The IMF stress test includes the five largest New Zealand banks, representing around 90 percent of total banking system assets. The scope of the RBNZ test covers the four largest banks which are subject to regular macroeconomic stress test conducted jointly with APRA. The 5-year solvency test is conducted over 2017-2012 using end-June 2016 as the cut-off date.

- **Liquidity stress tests:** A suite of liquidity tests were performed jointly by the RBNZ and the IMF team based on commonly agreed assumptions. They help assess banks' short-term resilience to an abrupt and sudden withdrawal of funding as well as banks' structural exposure to liquidity risk. The perimeter includes all fifteen New Zealand locally incorporated banks. The liquidity

[7] The RBNZ expects to continue to run regulator initiated stress tests every 2–3 years. In years where there is no regulator initiated test, it plans to repeat the process of providing a mandatory scenario for ICAAP stress testing.

[8] Dunstan, A. (2016), "Summary of the dairy portfolio stress testing exercise", *Reserve Bank of New Zealand Bulletin* Vol. 79, No. 5, March.

stress tests are run using end-August 2016 data and are based on supervisory data from RBNZ's liquidity survey.

- **Network analysis:** This captures the potential for cascading defaults throughout the New Zealand interbank market. 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. The potential fire sales of assets in a stressed market are linked to the LCR prescribed haircuts for liquid assets. The analysis is based on RBNZ's large exposure data template.[9] The coverage of the network analysis includes all fifteen New Zealand locally incorporated banks. Large counterparty exposure data is provided as of end-June 2016.

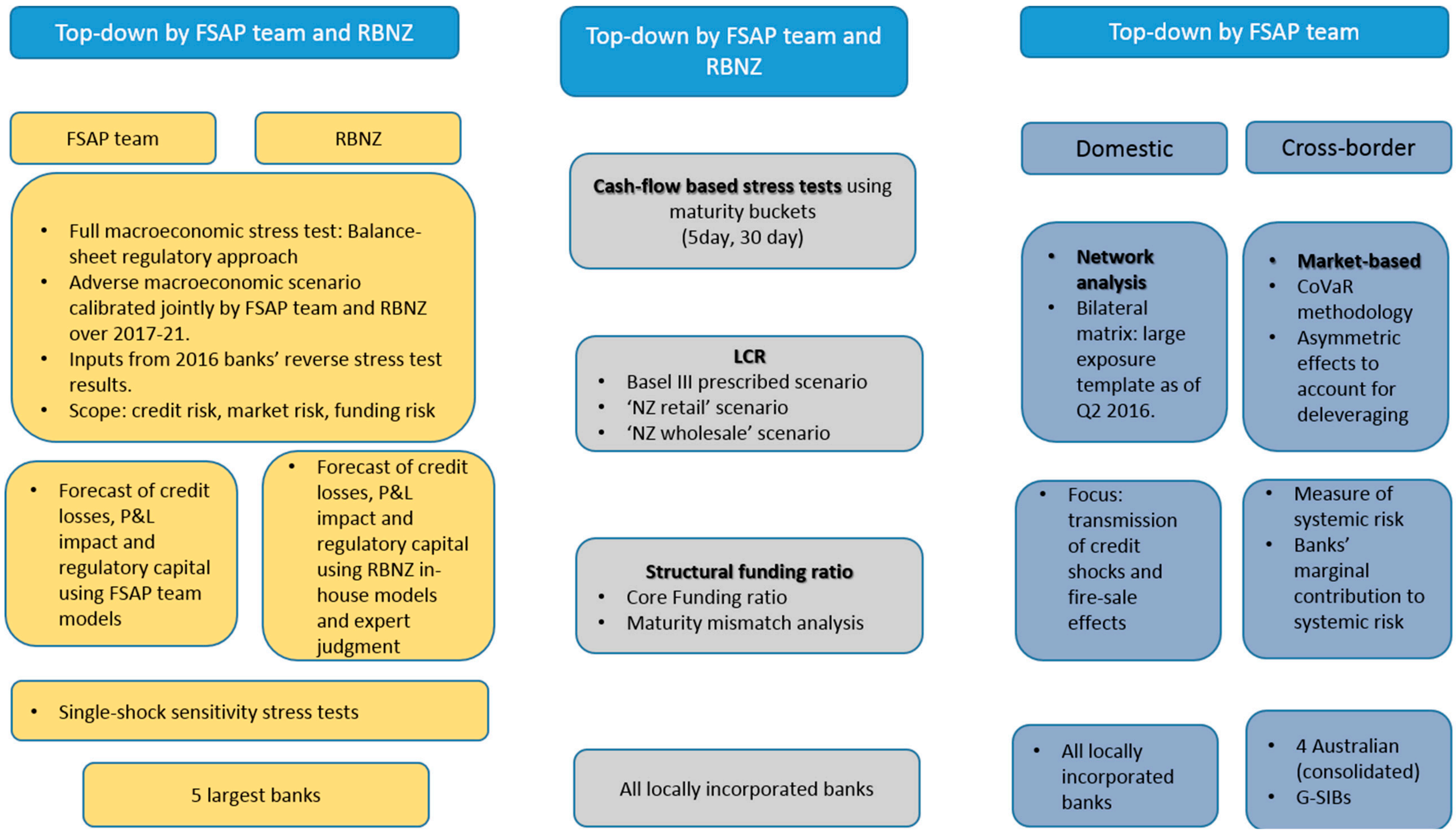
- **Market-based contagion:** This approach assesses market contagion through equity valuations triggered by direct transactional exposures to distressed banks, common exposures, or investors' correlated strategies. Given the active presence of Australian banks in offshore markets, the perimeter of the analysis includes all global systemically important banks identified jointly by the FSB and BCBS in November 2015.[10] The analysis is based on the *CoVaR* methodology and uses weekly data from November 2006 through October 2016.[11] The Australian parent bank share price data is used as the New Zealand subsidiaries are not publicly listed on equity markets. It is reasonable to presume that the way global stress affected the parent banks would be a reasonable proxy of how it would affect the local subsidiaries.

[9] The database covers the 10 largest bank and nonbank financial institution exposures, as well as the 10 largest other exposures and any exposure larger than 10 percent of CET1 capital. Thus, the network analysis captures any significant cross-sector exposures.

[10] The CoVaR analysis is conducted at the consolidated level of the banking group due to the lack of market-based indicators at the subsidiary level. By contrast, the stress test is conducted at the highest level of New Zealand consolidation.

[11] Lopez-Espinosa, Moreno, Rubia, and Valderrama, (2012) "Short-term wholesale funding and systemic risk: A global CoVaR approach", *Journal of Banking and Finance* 36, 3150–3162.

Figure 3. New Zealand: Overview of FSAP Stress Testing Exercise



KEY RISK FACTORS

11. Drawing on the assessment of key risks and vulnerabilities facing the New Zealand financial system, the analysis of resilience is linked to the four major macrofinancial risks that might challenge the solvency or liquidity position of the banking system:

- ***A collapse in the New Zealand real estate market*.** A key financial stability concern is related to housing lending. In particular, Auckland prices are still high relative to incomes and rents, and after a period of deceleration, indicators in the first half of 2016 suggested that pressures may be returning to the market. Concerns include the high share of new lending at high debt-to-income ratios for owner-occupiers and investors, and the high share of interest-only mortgages.[12] While risks in the commercial real estate sector are relatively contained, partly supported by conservative LTV ratios, credit growth remains strong in the sector.

- ***Depressed dairy prices*.** This may be triggered by a slowdown in China and/or increased competition from European producers—persisting over the medium-term. Low prices have already negatively affected indebted dairy farms. So far, the financial buffers of dairy producers have been sufficient to absorb the losses, with banks supporting these efforts via expansion of working capital lending.[13] Yet, a severe scenario featuring a slow recovery in dairy prices could trigger credit risk losses among debt-stretched farmers.

- ***A deterioration in global economic conditions*.** Global growth may decelerate as China's growth disappoints, disinflationary pressures build up further, and higher global macroeconomic risks undermine short-term growth triggering a rapid deterioration of market sentiment globally. The emergence of economic stress could be exacerbated in New Zealand due to trade linkages with Australia and China and confidence effects.

- ***Tight conditions in financial markets*.** Market disruptions could crystallize following a disorderly hike in policy rates in the U.S. A spike in risk premiums and more volatile conditions could contribute to a liquidity squeeze in funding markets, the disruption of FX and interest rate swap markets, and the steepening of the yield curve, rising wholesale funding spreads and hedging costs and pushing down asset valuations. Banks have traditionally managed to entirely pass through increases in funding costs effectively stabilizing their net interest margins, but this ability may be constrained in a system-wide tail event.[14]

[12] The interest-only share of new lending is above 30 percent for owner-occupier mortgages and above 50 percent for investor lending.

[13] Based on recent RBNZ's stress tests, assuming a milk payout of $4.00 in 2015–2016 and 2016–2017 and a fall in farm prices by around 40 percent by 2018–2019, the NPL ratio of banks' loans to dairy producers could increase up to 40 percent by 2018–2019.

[14] The lending spread over the 90-day benchmark money market rate widened by over 30 basis points during 2008 relative to the pre-crisis period. The weighted average time before a mortgage has to be repriced is around 12 months because most borrowers are still under floating or on short-term fixed rates.

12. Supervisory reverse stress tests conducted by the four major New Zealand banks yielded additional insights into scenarios that might threaten their viability. These bottom-up stress tests helped revealed business vulnerabilities and potential system-wide effects from correlated losses in the banking system. The scenarios, which would lead to a breach in minimum capital requirements, also helped inform the identification and calibration of sensitivity stress tests conducted by the IMF team, complementing the scenario-based stress testing exercise.

SOLVENCY STRESS TESTS

13. The solvency stress test covered credit risk and market risk, as well as shocks to the profit and loss account and banks' balance sheets. The stress testing exercise examined the effect of shocks across all relevant risk factors taking into account interrelations among solvency and liquidity. In order to capture the compound effect of risk concentrations, the scenario covered balance sheet and off-balance sheet assets and addressed potential changes in market conditions that may affect banks' exposures to risk concentrations. To complement the scenario-based stress test, a range of single factor sensitivity tests were carried out to explore sensitivities around the calibration of key risk factors.[15]

A. Macroeconomic Scenarios

14. The macroeconomic scenario includes the path for fifteen variables for New Zealand and a core set of financial variables reflecting conditions in global markets (Figure 4):

- **The baseline scenario reflects the 2016 October IMF WEO macroeconomic projections.** Medium-term prospects are positive with output growth projected to stabilize around 2.6 percent by 2021. Inflation is forecast to rise from an estimated 0.4 percent in June 2016 to the mid-point of the 1–3 percent target range by 2018. The 90-day bank bill rate is projected to rise gradually from 2.4 percent to 3.8 percent by 2021, and Fonterra dairy payout is expected to stabilize from NZD 4.0 per kilogram of milk solids (kgMS) in June 2016 to NZD 5.1 per KgMS by end 2021. This is a conservative forecast in light of the recently revised Fonterra's forecast payout of around NZD 5.5 for June 2017.

- **The adverse scenario captures the key risks identified above using a stressed macroeconomic scenario and a funding shock module.[16]** The scenario simulates a balance sheet recession in New Zealand triggered by deteriorating global conditions from a sharper than expected global growth slowdown, tighter and more volatile financial conditions, a credit cycle

[15] This is in line with the 2009 BIS principles for sound stress testing practices and supervision.

[16] The macroeconomic scenario is based on the IMF in-house Global Macrofinancial Model (GMM) and includes RBNZ's overlays for the unemployment path and additional variables for farm land prices and dairy payout prices generated by the RBNZ. Bank-specific loan loss provisions are projected using FSAP team internal satellite models at the portfolio level (Section B) rather than relying on aggregate projections produced by the GMM model.

downturn in China, and persistently lower commodity prices.[17] This pushes down Fonterra's dairy payouts to NZD 3.5 per KgMS below the average estimated break-even payout of NZD 5.3 per KgMS, and below the low point of the 2015 RBNZ Dairy portfolio stress test of NZD 4.0 per KgMS (under scenario 2). The global downturn impacts directly Australia and New Zealand and creates additional spillovers in New Zealand through financial linkages with Australia and a sharp correction in the New Zealand property and equity market.[18] The funding shock module includes bank-specific stressed spreads over the projected benchmark rate for wholesale debt issuance.[19] In addition, it incorporates a 'systemic' funding shock component linking bank-specific funding costs to the stressed capital position of the rest of the banking system.[20]

15. The severity of the stress exceeds that of the GFC and or recent FSAPs. The adverse scenario projects six quarters of negative growth rates peaking at -2.6 percent in 2017 Q4, while the GFC featured four consecutive quarters of negative growth reaching -2.3 percent in 2009 Q1. Both the GFC and the stressed path for real GDP feature V-shaped recoveries (Figure 4). The stressed GDP path constitutes a 2.4 standard deviation move in the two-year cumulative real GDP growth rate by 2018, computed using historical data over 1990–2016. This is larger than the severity benchmark used in other FSAPs of shocks to real GDP that represent 2.0 standard deviations in terms of historical volatility.

[17] To assess the vulnerability of dairy farmers to adverse shocks, the scenario features a combination of a sustained 20 percent fall in dairy prices relative to June 2016 and a protracted recovery, representing a 60 percent fall from the peak observed in June 2014, with a 20 percent peak-to-trough drop in land prices.

[18] This triggers a private domestic demand-driven contraction in New Zealand, featuring a 12 percent reduction in private investment and a 3 percent decline in private consumption.

[19]The path of stressed funding costs under the adverse scenario exceeds the expected rise in funding costs for the Australian-owned New Zealand banks from changes to requirements imposed on parent banks to reduce non-capital exposures to their New Zealand operations in December 2015 (APS 222).

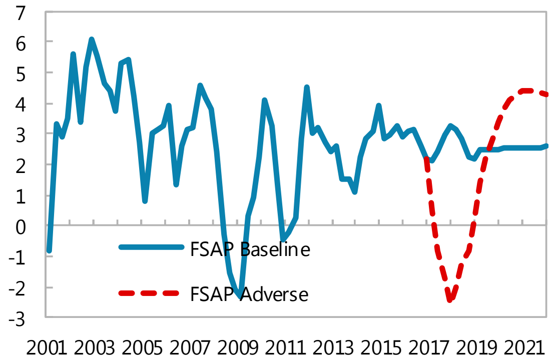
[20] This element captures a key amplification channel exposed during the global financial crisis, as the presence of weakly capitalized banks might prompt an increase in funding costs for all banks in the system.

Figure 4. New Zealand: FSAP Stress Test Adverse Scenario

The FSAP adverse scenario features a sharp contraction of GDP growth, sustained deflation, tightened money markets, a sharp correction of real estate prices and protracted low dairy prices.

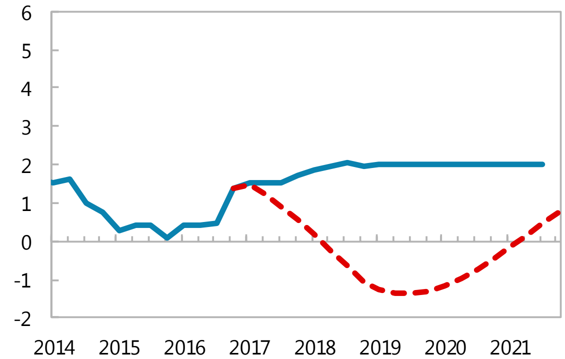
Under the severe scenario, real GDP growth declines sharply and is followed by a V-shaped recovery. The peak deviation from baseline reaches -7.5 percent by 2018.

Real GDP Growth
(Percent; year-on-year)



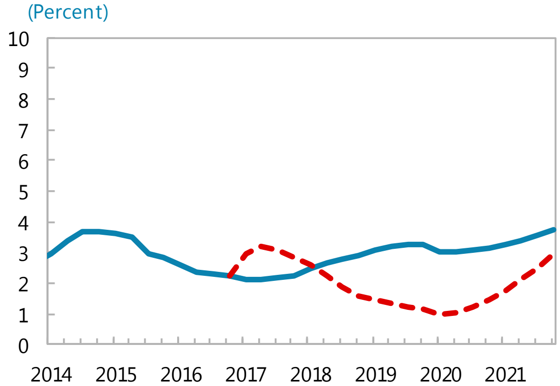
Inflation falls into negative territory, and remains below zero until the end of the stress period.

Inflation Rate
(Percent; year-on-year)



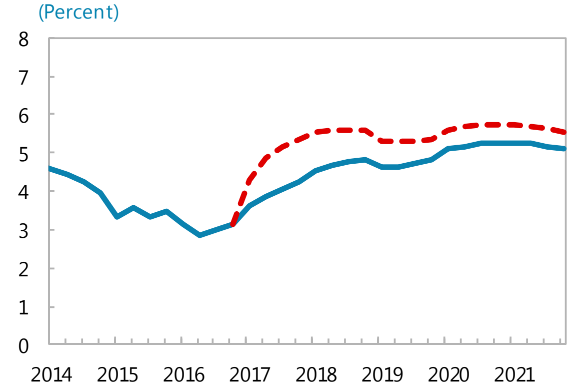
Money market conditions tighten initially, but relax later as credit risk premia softens and monetary policy remains accommodative.

90d Bank Bill Rate
(Percent)



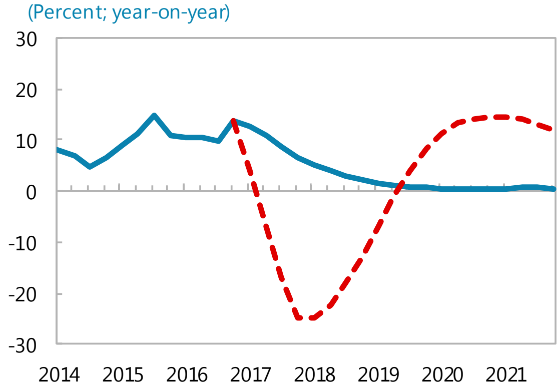
The yield curve steepens pushing down asset valuations.

10y Yield Rate
(Percent)



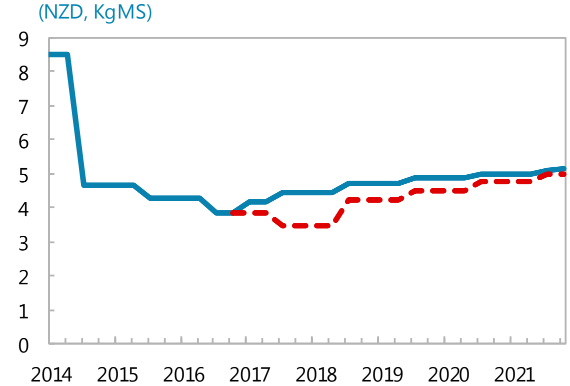
House prices fall by 35 percent by 2018, but recover to the pre-crisis levels by the end of the stress period.

Housing Prices
(Percent; year-on-year)



The dairy payout levels remain below the break-even of around NZD 5/KgMS. Projections are more severe than under the 2015 RBNZ dairy stress test scenario.

Dairy Payout Price
(NZD, KgMS)



Sources: RBNZ, IMF, and IMF staff estimates.

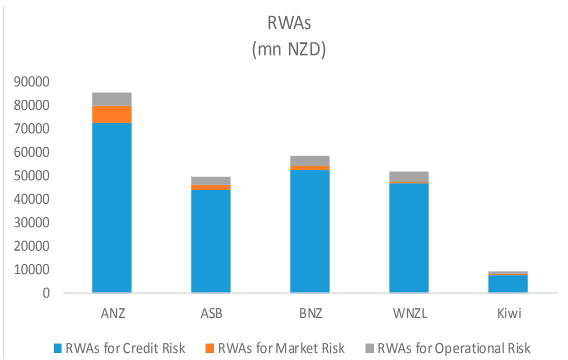
B. FSAP Team Modeling Approach

Credit Risk

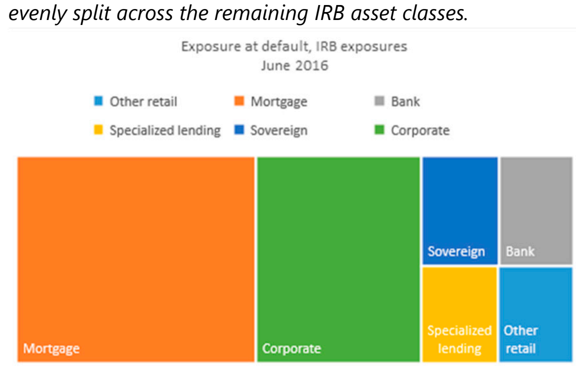
16. Credit risk accounts for the largest regulatory capital requirement of New Zealand banks (Figure 5). In June 2016, RWAs of the largest five New Zealand banking groups reached NZD 255 billion, of which 88 percent reflects credit risk, including counterparty credit risk (CRR). Capital requirements for market risk and operational risk are less material, accounting for around 5 percent, and 7 percent of risk weighted assets, respectively.[21]

Figure 5. New Zealand: Overview of Credit Risk

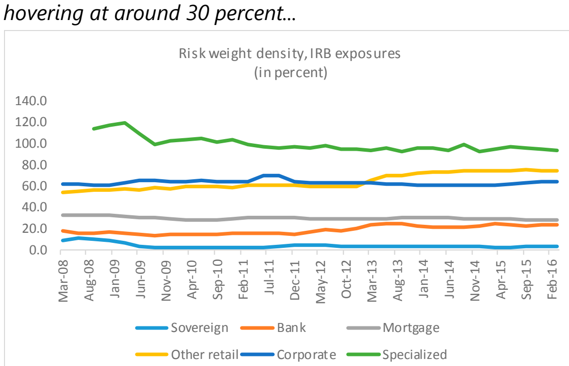
Credit risk represents the bulk of regulatory capital requirements for major New Zealand banks...



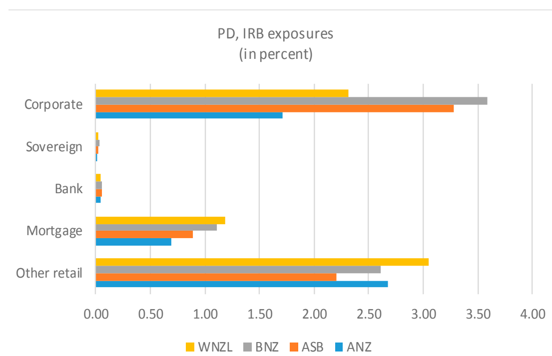
...with mortgage exposures accounting for about half of EaD under IRB, corporate exposure for one third, and the rest evenly split across the remaining IRB asset classes.



Average risk weight density has remained stable since 2008 with specialized lending, unsecured retail and corporate carrying the highest risk weights and mortgage risk density hovering at around 30 percent...



...despite certain dispersion in bank-estimated PDs reflecting the diversity in the risk profile of underlying exposures as well as differences in IRB models.



Sources: RBNZ, Banks' disclosure statements, and IMF staff estimates. The sample of banks includes the five major New Zealand locally incorporated banks. IRB banks include ANZ, ASB, BNZ, and WNZL. IRB exposures exclude specialized lending subject to the slotting approach.

17. While default drivers depend on the underlying risk profile of the portfolio, capital requirements depend on the regulatory treatment of credit exposures. Capital requirements vary by bank. The big four New Zealand banks are IRB accredited banks. RWAs for IRB exposures account for about 85 percent of RWA for credit risk. While exposures subject to the slotting

[21] IRB banks are subject to capital requirements floors for operational risk. The floors are binding for most banks.

approach represent 10 percent of RWAs, only 5 percent of RWAs are related to standardized exposures. By contrast, the largest domestic-owned lender is subject to standardized rating grades to compute capital requirements for credit risk.

18. Because IRB bank-estimated credit risk parameters have through-the-cycle (TTC) features, they are not suitable to project credit losses under stress. To estimate stressed expected losses using credit risk parameters, probability of default (PD) should represent point-in-time (PIT) estimates, using the defaults in the latest available period. Yet the available time series for IRB portfolios' PDs are through the cycle (TTC) PDs under RBNZ's IRB capital regulatory framework, as they reduce volatility of capital requirements over time.[22] However, TTC PDs should not be used for estimating losses under stress since these are just averages over the last years and do not necessarily reflect the actual risk at the time of projections.[23]

19. Credit losses are projected using a range of PD proxies. Using granular supervisory data from the RBNZ's asset quality survey broken down by bank and sectoral classification, the FSAP team projected credit risk losses using time series data on the following PD proxies: (i) the stock of collective and specific provisions; (ii) the stock of nonperforming loans (NPLs) and the coverage ratio for performing and nonperforming exposures;[24] (iii) the flow of impairment expense including collective and specific expense; and (iv) the flow of total impairment expense including direct write-offs and cures of NPLs.

20. The impact of credit risk on banks' capital ratios depends on the regulatory approach used by banks to book credit exposures. Scenario-based stress testing requires the projection of banks' loan loss provisions and stressed capital requirements as the level of credit risk rises. For exposures under the IRB approach, credit risk depends on stressed values for exposure at default (EaD), PDs and LGDs as set out in RBNZ's BS2B framework. For exposures under the STA approach, risk weights depend on stressed values for standardized rating grades in line with RBNZ's BS2A framework. Credit risk exposure is calculated by risk weighting on and off-balance sheet exposures to credit risk according to broad categories of relative credit risk. For residential mortgages the risk weighting categories take into account LTV ratios at time of origination and lender's mortgage insurance arrangements. For other types of exposure, credit ratings from independent credit rating agencies are used as a basis for determining risk weights.

[22] Under RBNZ's capital regulatory framework for IRB banks, PDs reflect long-run averages of one-year PD associated with the internal obligor grade of IRB exposures. Downward adjustments to LGDs are performed to take into account forced sale discounts in a downward market.

[23] For the purposes of determining the regulatory capital requirement the through-the-cycle PD is converted, using the Basel capital equation, into a 1-in-1000 year "bad" PD. For this reason, the use of a TTC PD does not imply that capital would be insufficient in a downturn. For stress-testing, neither the raw TTC PD (which is an average and so not reflective of a downturn) nor the resultant "bad" PD (which will be higher than almost all PiT PDs) is suitable; a PiT PD is what is wanted.

[24] NPLs are defined as loans past due over 90 days and impaired loans.

Credit Risk Models for Expected Losses

21. Credit loss modeling for expected losses is based on the sectoral categories shown in RBNZ's asset quality survey. We split gross loans into the following lending categories: Agriculture (dairy, sheep and beef, other rural); real estate/SME (investment property, property development, unallocated commercial property, secured by residential mortgages, other commercial and business lending); personal, housing, and corporate (corporate, asset-backed lending, and other lending). The data has monthly frequency and runs from September 2008 to June 2016.

22. For each sector, the number of explanatory variables is selected by applying the Forward-Stepwise Selection algorithm. For each number of regressors, the best models are selected in terms of their explained sum of squares. The core set of explanatory variables includes fifteen macroeconomic and financial variables for New Zealand and four global variables. For each variable, up to four quarterly lags are considered. Aggregate credit risk is driven by common variables across multiple sectors as well as by sector-specific variables. Common variables include, among others, growth, inflation, unemployment, interest rates, and the yield curve. Sector-specific variables include, for instance, dairy payout and farm land prices in the agriculture sector, residential prices and mortgage rates in the housing sector, and commercial real estate prices and corporate lending rates in the real estate sector. Global variables include world GDP growth, energy and non-energy commodity prices and 6-month LIBOR USD rates.

23. Forecasts of credit risk losses are based on three separate econometric strategies (Appendix II). The final specification of each equation was based on a specification search based on measures of overall model fit (adjusted R2) as well as statistical significance of the macroeconomic and financial variables in accordance with economic theory.[25]

- ***Strategy 1*:** The FSAP team ran a battery of individual econometric regressions on credit risk losses by bank and asset class. This strategy allows preserving individual slopes for the drivers of credit risk by bank and improves the overall fitness of the model.

- ***Strategy 2*:** The bank-specific approach was complemented by a set of panel regressions with fixed effects to exploit cross-sectional variation across banks while controlling for unobserved time-invariant heterogeneity. Each specification includes robust standard errors clustered by bank.

- ***Strategy 3*:** To account for feedback effects between variables, the FSAP team estimated a multivariate VAR for each bank, broken down by asset class. To reduce the dimensionality of the macroeconomic scenario, a factor model was built to reflect underlying conditions in three categories of variables (i.e., macroeconomic variables, financial variables, and real estate prices). Using the VAR estimated coefficients, the estimated credit losses were projected building a scenario using the variable paths projected in the stress test scenario.

[25] This strategy is in line with the Capital and Loss Assessment under Stress Scenarios (CLASS) Model used by the Federal Reserve Bank of New York to assess financial stability.

24. Based on selection criteria grounded on economic theory and statistical significance, the projected weighted average credit loss is significant at around 4 percent of starting loans (Figure 6).[26] Cumulative losses over the 5-year horizon masks diversity across portfolios with peak losses for corporate loans at 13 percent, moderate losses for rural loans at 7.0 percent, and small losses for housing loans at 1.4 percent. Given the different profile in the composition of credit books across banks, banks are affected differently by stress, with mortgage banks posting relatively lower loss rates.

25. Credit risk in housing loans peaks in 2018 at an estimated 1-year PD of 2.2 percent. Housing loans represent the bulk of gross loans for major New Zealand banks at close to 60 percent of the overall credit portfolio as of June 2016. While the exposure to the residential real estate sector varies across banks, credit losses are very sensitive to credit loss projections for housing loans. For the average bank, PDs rise to 2.2 percent in 2018, while NPL ratios increase to 4.2 percent and stressed loans loss provisions (both specific and collective) reach 2.1 percent.

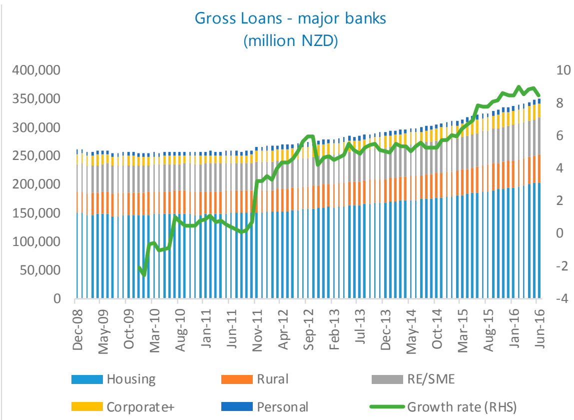
26. For bank exposures a market-based approach was used while for sovereign exposures a structural approach was followed. There are no sectoral categories in the asset quality survey for bank exposures and sovereign exposures. The proxy used to project implied PDs is based on Moody's EDF measure for New Zealand financial group while the proxy used to project PDs for sovereign bonds is based on the 10y yield for New Zealand government bonds.

[26] This chart shows credit losses using strategy 1 for housing loans, rural loans, real estate loans, and personal loans. Credit losses for corporate loans are projected using strategy 2.

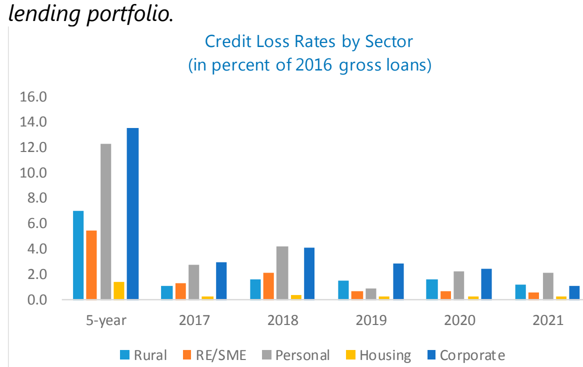
Figure 6. New Zealand: Credit Loss Projections – Adverse Scenario

Projected cumulative credit losses are significant at 4.0 percent across credit books. Aggregate credit risk in the mortgage book peaks at an estimated average 1-year PD of 2.2 percent in 2018 with loan loss provision ratio at 2.1 percent, and NPL ratio at 4.2 percent.

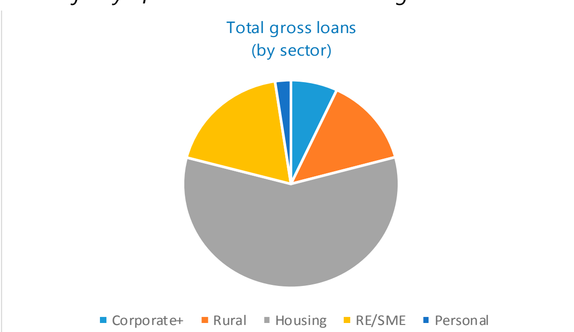
Gross loans have increased steadily since 2011 at an average growth rate of 5 percent.



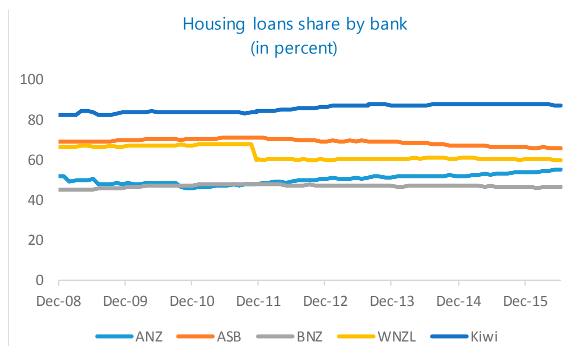
Under the adverse scenario cumulative credit loss rates are significant, particularly in the corporate and unsecured lending portfolio.



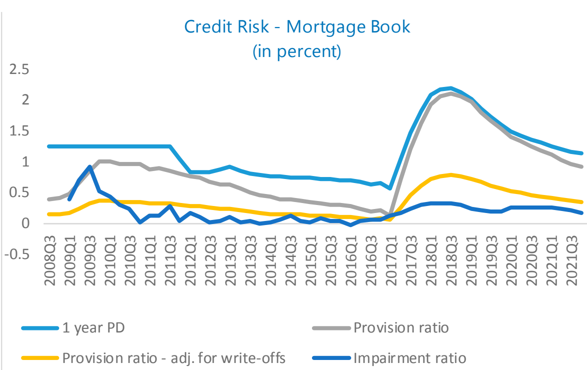
The majority of loans in 2016 are housing loans…



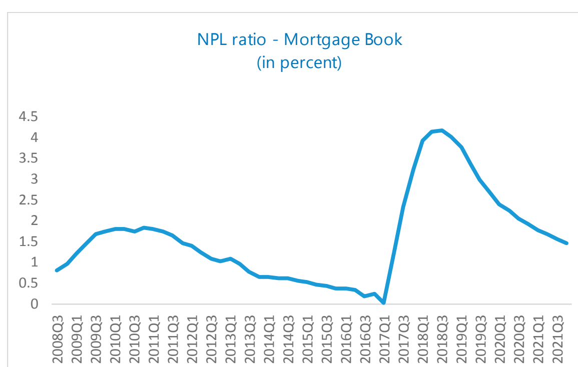
… with some variation across banks.



For the average bank, the estimated mortgage PDs peak at 2.2 percent in 2018…



…while the stressed projected NPL ratio peaks at 4.2 percent.

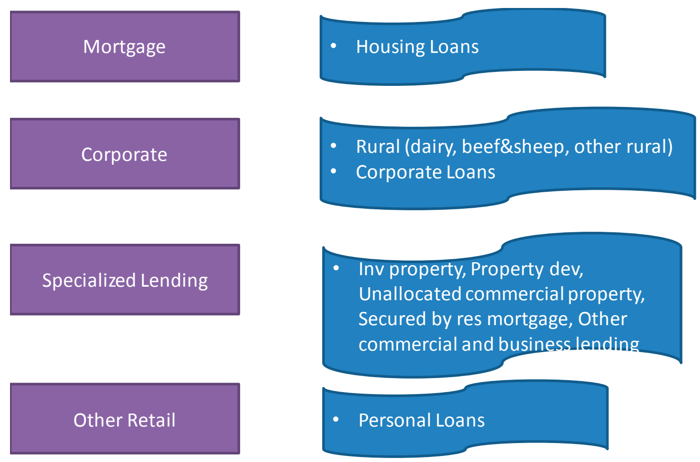


Source: IMF staff estimates.

Credit Risk Models for Unexpected Losses

27. The impact of stress on regulatory capital for IRB exposures depends on the projection of stressed PDs, LGDs and EaDs. The FSAP team estimated separate shifts to credit risk parameters by bank and Basel asset class. Credit risk in the specialized lending portfolio subject to the slotting approach under RBNZ's regulatory capital framework received a similar treatment than STA exposures.[27]

28. A sectoral mapping is required. This is because credit losses are based on New Zealand loan classification, while conditional PDs are estimated by Basel IRB risk grades. The reconciliation of mortgage-related amounts with housing loans is straightforward (with housing loans to other retail and corporate customers accounting for just around 6 percent), but other asset class reconciliations are more challenging. The reason is twofold. First, some IRB categories include different types of lending, i.e., corporate exposures include corporate loans and most rural loans, while only a subset of real estate loans are subject to the slotting approach for commercial real estate loans. Second, IRB amounts include on balance sheet exposures as well as off balance sheet exposures with prescribed credit conversion factors applied to carried amounts, while gross loans are net of lending commitments.



29. The FSAP team used a three-step process to project PDs over the stress test horizon. Rather than forecasting PDs using historical IRB-based bank-estimated PDs, the FSAP team projected credit loss estimates and extracted loss-implied PDs. The motivation is twofold. First, expected PDs from IRB models might differ from realized credit risk losses. Second, IRB models in New Zealand for material asset classes are TTC and thus are not designed to capture stress in the loan portfolio during a severe economic downturn.[28] At the same time, Basel III requires IRB banks to deduct from regulatory capital the excess of expected losses (using banks' IRB models) over provisions (using credit loss estimates).[29] In addition, the projection of stressed RWAs requires the forecast of IRB-based PDs in line with banks' approved internal models. To capture cyclical variation

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[27] The supervisory slotting approach applies to project finance, object finance, commodities finance, and income producing real estate exposures. By contrast with the IRB approach, internal obligor grades for those exposures are mapped to five supervisory slogging categories with each category being associated with a specific risk-weight. For stress testing purposes, RWAs are computed separately for performing and non-performing exposures assuming a migration matrix for internal obligor grates.

[28] As discussed in footnote 23, this has no particular implications for the adequacy of regulatory capital because the TTC PD is converted into a "bad" PD before use, but it does make the TTC PD inappropriate for use in stress testing.

[29] This means that banks will make provisions for an expected average loss of TTC PD x downturn LGD x EaD and also hold capital to meet the unexpected loss in the 1-in-1000 bad year.

for unexpected losses while at the same time smoothing the implied PD projections to capture TTC properties of IRB models, the FSAP team followed a three-pronged approach:

- A forecast of loan loss provisions by bank and economic sector was built based on RBNZ's asset quality survey data, using the variable paths for the set of core macrofinancial drivers of credit risk under the baseline/adverse scenario:

$$LR^{i}_{j,t} = \left(cp^{i}_{j,t+}sp^{i}_{j,t}\right)/\,l^{i}_{j,t}$$

- Implied conditional PDs were inferred from the estimated credit risk loss forecasts, assuming a bank-specific, portfolio-based LGD path based on banks' historical data.

- An econometric approach was used to forecast bank-specific IRB-based PDs using banks' disclosure statements as the dependent variable and the projected series of implied conditional PDs as the main driver. The final series is denoted by $\left\{PD^{j}_{it,s} \middle| s \in \{b,a\}\right\}$ at time *t*, for bank *j*, asset class *i*, and scenario *s*=*b* for baseline and *s*=*a* for adverse.

30. LGD projections were estimated using historical data for downturn-LGDs, taking into account of 2015 RBNZ's prescribed LGD floors for mortgage and farm loans. The time series of bank-specific IRB-based LGDs was used to forecast stressed LGDs under the scenario. As the historical series includes the estimation of a downturn LGD, it is considered adequate for stress testing purposes. The forecast was subject to the revised regulatory constraints implemented from 2008 to 2015 to include LGD floors for residential mortgage loans and farm lending exposures.[30] For residential mortgages, aggregate data on the split of mortgages between owner occupiers and investors by LTV bucket was used to compute bank-specific breakdowns between non property-investment and property investment, using bank-specific amounts by LTV bucket. Although loans at high LTV ratios are more prevalent for owner occupier mortgages, the higher prescribed LGD floors for investor mortgages by bucket results in a higher average LGD floor for investor mortgages at 22.6 percent relative to owner occupier mortgages at 20.1 percent as of June 2016. For farm lending, the average LTV ratio for the four IRB banks of 48 percent (disclosed in the 2015 results of the dairy portfolio stress test) was used to back out the prescribed LGD floor at an average 22.5 percent.

The Housing Sector

31. To test the performance of econometric results, two additional structural approaches were implemented to produce credit risk estimates in the housing sector. First, the TUI model developed by RBNZ was used by the team to build forecasts of bank-specific PDs and LGDs.[31] Second, a Merton option-based approach to compute the sensitivity of stressed LGDs to house price projections.

[30] LGD floors were introduced in 2008, though modified in 2015 to differentiate between investor and owner-occupier mortgages. LGD floors for farm lending were introduced in 2011.

[31] Harrison, I. and Mathew, C. (2008), "Project TUI: A Structural Approach to the Understanding and Measurement of Residential Mortgage Lending Risk", Reserve Bank of New Zealand.

32. Under the TUI model, default occurs if there is a distressed sale and the net value of the collateral, after disposable costs, is less than the value of the loan.

$$PD_t = PSS_t \cdot \left\{ \# L \middle| \widetilde{P}_T - C < L \right\} / (\# iterations)$$

Where the first term PSS_t denotes the borrower's capacity to service the annual debt service required on the loan, and the second term captures strategic defaults when the property has negative equity. As housing prices follow a stochastic process, 2,000 iterations are conducted to determine the frequency of defaults.

$$PSS_t = \beta_0 \cdot D + \beta_1 \cdot \Delta DSR_t^{\gamma} + \beta_3 \cdot \left(\beta_4 \cdot u_t + \beta_5 \cdot (\Delta u_t)^{\alpha} \right)$$

Borrower affordability tightens with income gearing -the debt service ratio ΔDSR_t^{γ} is expected to increase under stressed conditions (as lending rates go up and income declines)-, and the rise in unemployment u_t, with the exponential term allowing for the impact of non-linear effects.

33. To build conservative predictions we tighten the strategic default condition to add the net present value of future interest payments to the outstanding value of the loan in the behavioral equation:

$$PD_t = PSS_t \cdot \left\{ \# L \middle| \widetilde{P}_t - C < (1 - t\rho) \cdot L + \sum_{j=1,T-t} i_{t+j} \cdot (1 - (t+j) \cdot \rho) \cdot L / (1 + i_{t+j})^j \right\} / \# iterations$$

Strategic default occurs when the current value of the house net of transaction costs is lower than the outstanding face value of the loan (amortized at an annual rate ρ over t periods) and the present value of future interest payments until the maturity of the loan at time T.

34. The conditional LGD is driven by the discounted sale price of the house. The sale occurs at time *t+s* (where s denotes the time to sell the collateral) and the sale proceeds are net of transaction costs discounted at a rate reflecting the risk premium of the foreclosed asset:

$$LGD_t = (1 - \rho t)L + C - (1 - \delta)P_{t+s} / (1 + r_t + cs_t)^s$$

35. Bank-specific forecasts for stressed PDs and LGDs are built over 2016–2021. Constructing a matrix of ΔDSR_t^{γ} by LTV bucket (using historical data on mortgage rates, loan-to-income ratios, and the breakdown of mortgage loans by bank and LTV bucket), and vintage (under the assumption of 20 y mortgage loans), and using the parameters calibrated in the TUI model, we project cumulative forecasts of stressed PDs and LGDs by bank over 2016–2018 and 2019–2021.

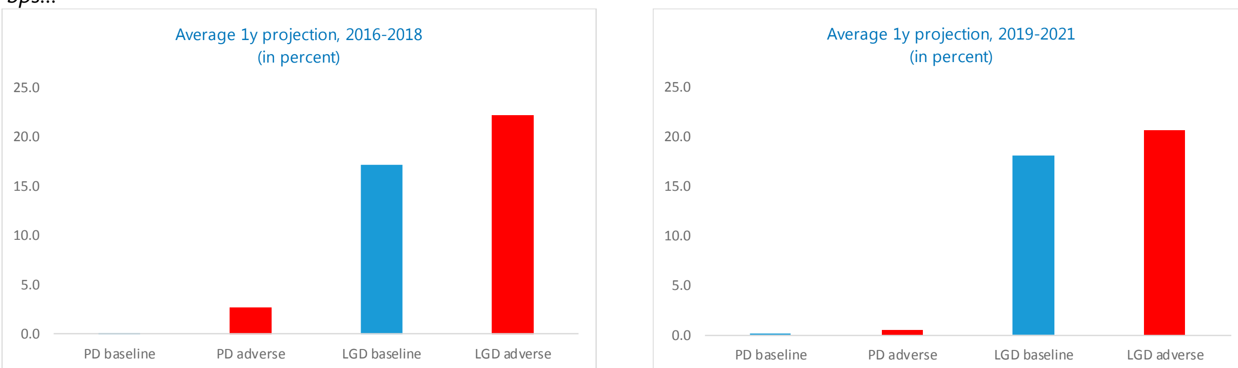
36. Results are consistent with econometric-based forecasts for stressed PDs. Over the stress test horizon, the average PD under the adverse scenario reached 1.6 percent. This is in line with an annualized stressed PDs of 1.9 percent using the TUI model (Figure 7). The PD path is, however, different with econometric-based PDs showing a gradual recovery throughout the outer years of the scenario by contrast to the sharper recovery using the TUI-based forecasts. This is partly due to the time frequency of the forecast. While quarterly projections are produced for the econometric approach, 3-year cumulative projections are performed under the TUI approach.

Figure 7. New Zealand: Credit Risk for Housing Loans – TUI Model-Based Projections

Stressed affordability of stretched borrowers and strategic defaults would lead to a deterioration of creditworthiness during the first two years of the adverse scenario with PDs reaching 2.7 percent and LGDs widening to 22 percent.

During the first two years of stress, PDs would widen by 260 bps on an annualized basis while LGDs would rise by 500 bps…

…this gap would tend to close towards the outer years of the horizon due to the V-shaped nature of the scenario.

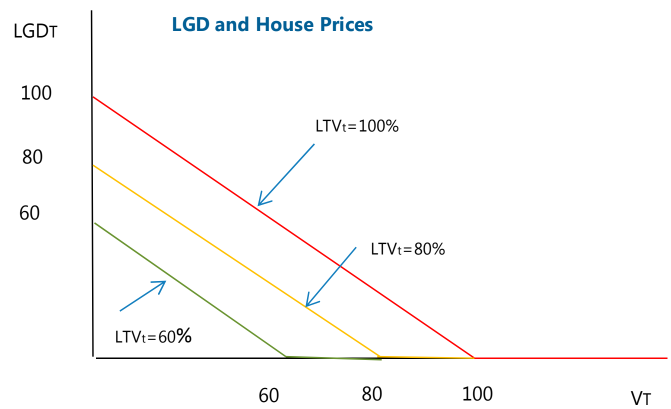


Source: IMF staff estimates.

37. **The Merton option-based approach is used to explore sensitivities of stressed LGDs to further house price declines.** The LGD on a loan secured by collateral has option-like features whereby the value of the defaulted asset is non-linear on the value of the posted collateral. Specifically, LGD is a nonlinear function of the house price at the time of default V_T and the original LTV_t ratio (priced at the time of mortgage origination t) (Figure 8). As house prices have evolved over time, this analysis requires the estimation of LGD by vintage repriced at stressed house prices.

Figure 8. New Zealand: LGD for Mortgage Loans and House Prices

LGD for mortgage loans is a highly non-linear function of house prices at the time of default.



LGD_T shows the LGD at the time of default T, LTV_t reflects the original LTV distribution at time t, and VT denotes the house price at the time of default T.

38. **LGD projections under the stress scenario depend on four key parameters:** (i) the distribution of original LTV ratios by vintage; (ii) the outstanding value of each loan vintage net of amortization; (iii) the house price fall assumed under the scenario; and (iv) the forced sales discount on the property's market price under foreclosure.

39. The distribution of LTV buckets has remained stable over the last two years with under 90 percent of loans originated below the 80 percent mark. Drawing on RBNZ data, the fraction of risky loans over 80 percent LTV stood at 12 percent in June 2016, down from 17 percent in September 2014. The volume of loans outstanding from each vintage depends on the principal rollover rate. We assume that the average loan has 20-year maturity with 5 percent per annum amortization rate. This is a very conservative estimate as the actual turnover of the mortgage book is close to 30 percent per annum, reflecting customers selling property or swapping banks.

40. The analysis explores the sensitivity of LGDs to a range of peak-to-trough declines in housing prices. While the adverse scenario assumes a peak-to-trough decline of 30 percent by March 2018, the analysis assumes further declines of up to 50 percent. Stressed prices are used to reprice LTV values at origination across vintages.

41. A conservative forced sales discount was set at 25 percent of fair-value residential property prices. There is wide evidence of price discounts relative to fair-market value in the case of fire sales during crisis periods. Empirical evidence varies across countries, LTV ratios, and home quality. A recent study in European countries found a price discount between 15 percent and 36 percent of the fair-market value.[32] The estimated marginal effect for losses at foreclosure in the U.S. post-crisis is 20 pps.[33] These loans may be associated with weaker underwriting, higher expenses, weaker markets, and longer time lines. Previous studies on U.S. foreclosure sales had documented fire sales discounts of about 25 percent.

42. To conduct the analysis, we assume that the LTV distribution of loans is priced at fair market values at the time of reporting. For the purpose of calculating regulatory capital requirements banks define the LVR ratio as the current loan exposure divided by the value of the property at origination. Yet banks regard some credit events, including the transfer of a loan to the watch list or a substantial refinancing of the loan, as creating a new origination triggering the revaluation of the property. To simplify the analysis, we assume that loans are repriced at fair value prices at the time of reporting.

43. The LGD estimate is extracted from the recovery rate of the loan at the time of selling the collateral. The recovery rate is the ratio of the stressed housing price, net of the foreclosure discount, to the outstanding value of the loan:

$$LGD_{t,i}^{b_j} = 1 - \min\left(1, \left(1 + \Delta P_{T,i}\right) \cdot \left(1 - D\right) / \left(b_j \cdot \left(1 - \left(t - i\right) \cdot (1/M)\right)\right)\right)$$

where t is the cut-off date of the stress (June 2016), i is the vintage of the loan, bj is the LTV bucket, T is the time at which the property is sold, and M is the maturity of the loan.

32 See Bardhan, et al. 2011 for evidence on forced sale discounts across countries.

33 Ross, E. J., and L. Shibut, 2015, "What Drives Loss Given Default? Evidence from Commercial Real Estate Loans at Failed Banks," FDIC CFR WP 2015–03.

44. The average LGD is the bucket-weighted sum of each LGD by vintage weighted by the outstanding amount of loans from each vintage as of June 2016. To calculate outstanding loans from vintage *t*, we use information on the aggregate stock of loans for the five banks over 2014-16 and assume that *1/M* is the annual amortization rate over the horizon.

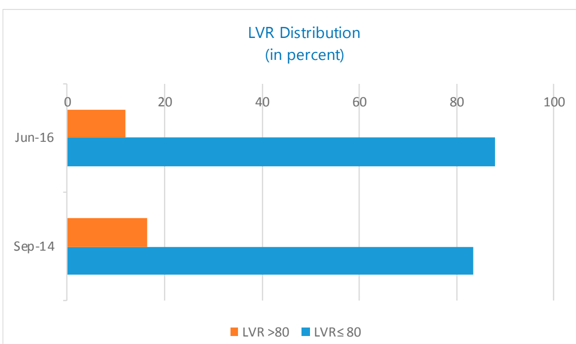
$$OL_{t,i} = L_i \cdot (1 - 1/M)^{(t-i)}$$

45. The results show that the highest LGD comes from most recent vintages due to the sharper housing price correction (Figure 9). While LGD from the most recent vintage is estimated at under 20 percent under the adverse scenario, the average LGD for loans weighted by vintage is around 10 percent. Under a most severe scenario assuming a peak-to-trough decline of 50 percent the average LGD would reach about 30 percent.

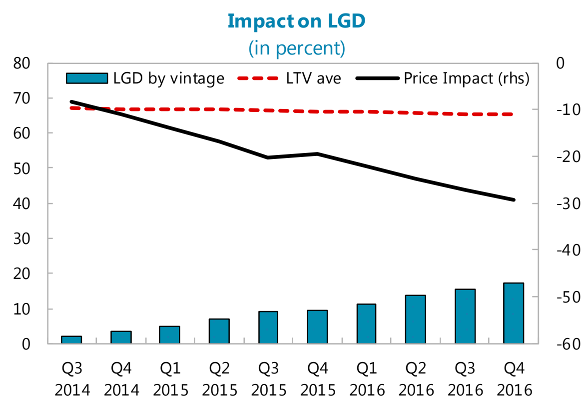
Figure 9. New Zealand: Credit Risk for Housing Loans – Merton Model-Based Projections

Using a structural approach, stressed LGDs for housing loans would rise from 10 percent under a 30 percent decline in housing prices to 30 percent under a 50 percent price correction. The impact is somewhat limited due to the sound distribution of LTVs across banks.

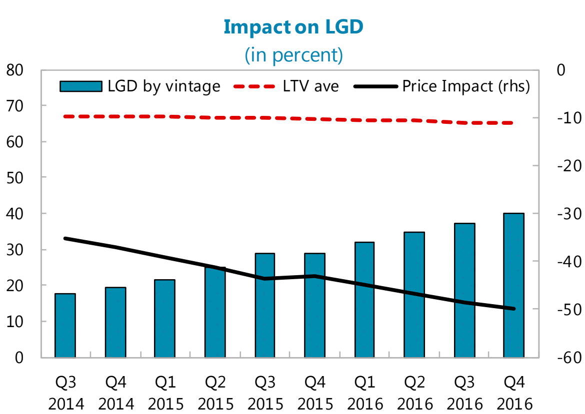
Most housing loans post LTV ratios under 60 percent, and only 12 percent are at risky LTV buckets over 80 percent.



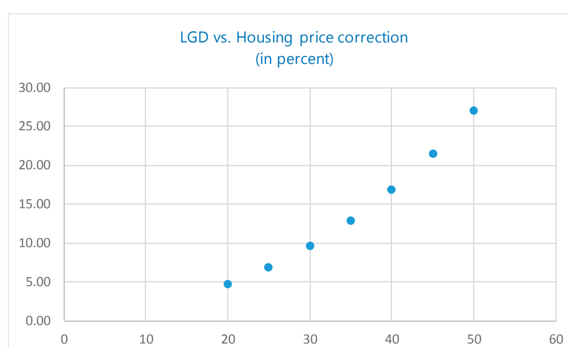
Under a 30 percent housing price decline the average LGD is projected at under 10 percent in line with Basel III regulatory floors.



The projected average LGD increases to under 30 percent under a peak-to-trough decline in housing prices of 50 percent.



LGD projections show an exponential trend in the underlying housing price correction.



Source: IMF staff estimates.

46. Beyond a threshold for price correction, further falls in housing prices affect average LGDs roughly linearly. This is partly due to the stability of LTV buckets over the 2014-2016 period with average LTV ratios fluctuating around two thirds, and to the lack of volatility in the assumed foreclosure discount.

47. The projection of EAD was driven by balance sheet growth rate assumptions and stressed credit conversion factors from undrawn credit lines and guarantees triggered under stress. The change in EAD across IRB bank portfolios is governed by:

$$EAD^{j}_{i,t} = EAD^{j}_{i,t-1} \cdot (1 + g_{i,t}) \cdot (1 - PD^{j}_{i,t-1}) + \Delta L^{j}_{i,t} \cdot UCL^{j}_{i,t-1}$$

where *i* denotes the bank, *j* denotes the asset class, and *t* is time, $g_{i,t}$ is the growth rate of the IRB portfolio, $(1 - PD^{j}_{i,t-1})$ represents the non-defaulted portfolio, $\Delta L^{j}_{i,t}$ is the shock to triggered credit lines and guarantees, and $UCL^{j}_{i,t-1}$ is the amount of undrawn guarantees at time *t-1*. The growth rate of the portfolio follows an iterative process. The initial growth rate is linked to the nominal GDP projection under each scenario. Balance sheet capacity to fund the assumed growth rate path depends on the organic generation of capital which is endogenously determined under the scenario. The remaining funding is sourced at stressed funding rates which further undermine capital retention. The fixed point between the growth rate and the motion of capital determines the final balance sheet growth projection.

48. To compute IRB capital requirements, regulatory risk parameters are considered and the Basel III formula for IRB exposures is applied, subject to RBNZ regulatory overlays on LGD floors and portfolio correlation parameters. The derivation of RWAs is dependent on estimates of PD, LGD, EAD, correlation assumptions, and effective maturity for each exposure. According to the Basel III framework, RWAs were computed after applying the scaling factor of 1.06 to credit RWAs. Also, a multiplier of 1.25 was applied to the correlation parameter of all exposures to large regulated financial institutions and to all unregulated financial institutions. RBNZ regulatory overlays over the Basel III IRB framework were applied. Specifically, these include LTV-linked LGD and 2.5-year maturity floors on farm lending as well as the disallowance of firm size adjustment, the prescribed correlations for housing exposures linked to LTV buckets, and the LGD floors on housing loans differentiated by LTV bucket and type of borrower (i.e., owner occupier and investor).

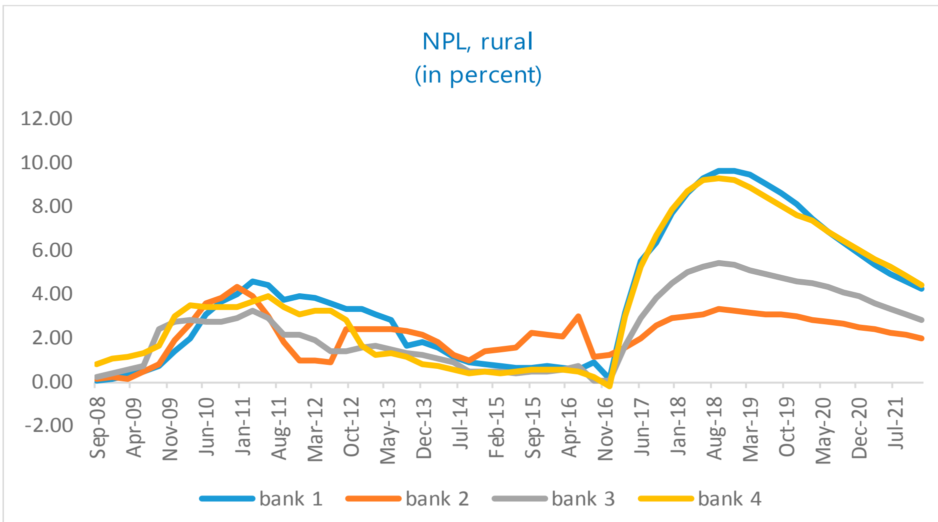
49. For STA exposures, required regulatory capital is determined by the projected credit downgrade of exposures. Exposures are downgraded due to the impact of credit risk migration from pass grades to nonperforming status, across rating categories within the NPL category (from special mention, to substandard, to doubtful), and across internal gradings for performing loans.

50. The projection of the flow of NPLs was based on a battery of regressions. Following the strategy used to project expected losses, a suite of bank-specific regressions and panel regressions was performed on a core set of drivers. Projections were based on the core macrofinancial variables featuring in the scenario.

51. For the rural portfolio, the NPL peak under the adverse scenario is over three times the average NPL observed since 2008 (Figure 10). While the level and path of stressed NPL varies across banks, the average peak NPL across banks is reached at around 7 percent compared to 2 percent in the preceding period over 2008-June 2016. Econometric results suggest that NPL ratios rise with unemployment and the increase in money market rates, as banks pass on funding costs to borrowers, and the slope of the yield curve (Appendix II, Table 3). While land prices and dairy prices might be important drivers of nonperforming exposures at long lags (i.e., 8–12 quarters), there is no strong statistical significance at shorter lags. This may be partly due to distressed loans renegotiation practices with stretched borrowers when sectoral shocks are expected to be short-lived.

Figure 10. New Zealand: Projection of NPL Ratios for Rural Loans – Adverse Scenario

NPL loans peak at around 7 percent in 2018 from an average 2 percent in 2008–2016.



Source: IMF staff estimates.

52. To compute the impact of loan migration on capital requirements for STA exposures, the FSAP team used a two-prong approach:

- The risk weight of NPL was set at an average 100 percent, informed by banks' reported average risk weight on defaulted exposures. The difference between 100 percent and the average risk weight of each bank STA portfolio multiplied by the nominal amount of NPLs under the scenario (driven by the balance sheet dynamics and the forecast of the NPL ratio) represents the increase in risk weights attributed to the STA exposures in default. Bad debt expense for NPLs under the adverse scenario rise from the current loan loss coverage ratio to an estimated 60 percent due to the downward migration of NPLs across credit gradings.

- The non-defaulting portfolio is assumed to downgrade one notch under the adverse scenario. The major standardized bank is mostly exposed to residential mortgages. We assume that under stress, the residential mortgage portfolio migrates from the <80 percent LTV bucket to the 80–90 percent LTV bucket increasing standardized risk weights from 35 percent to 40 percent.

- Specialized Lending exposures subject to the supervisory slotting approach, with a current average risk-weight of 94 percent, migrated from a 'Good' rating grade to a 'Satisfactory' rating grade at an average risk weight of 115 percent.

53. Capital requirements for STA exposures were driven by changes in provisioning rates, growth of EAD, triggered credit lines and guarantees, and migration effects. Four main components drive the dynamics of RWAs in the STA portfolio. The first component reflects the motion of RWAs generated by the flow of provisions, and the growth rate of the portfolio. The second component shows the increase in risk weights resulting from triggered off-balance sheet credit lines and guarantees. The third component reflects the increase in risk density from the transition of loans from the performing to nonperforming category. Finally, the fourth component denotes the change in risk density from the transition matrix estimated for performing exposures:

Market Risk

54. The FSAP solvency stress test assesses the impact of market risk on regulatory capital from valuation losses in bond markets. The analysis covers the debt securities portfolio booked in the trading book (HFT) and available for sale book (AFS). While the impact of shocks to HFT securities impact regulatory capital through net profits, asset mark-downs from shocks to the AFS portfolio hit capital through other comprehensive income. The value of the securities portfolio among the five major banks amounts to around NZD 32 billion or 7 percent of total assets.

55. Shocks to the securities portfolio are consistent with the macroeconomic scenario and hit banks throughout the five-year stress test horizon. This is a particularly severe assumption, especially for the trading book, as rebalancing of the portfolio is disallowed. Shocks to risk factors impact the fair valuation of securities under both the baseline and the adverse scenario. The market shock is applied as an instantaneous shock to all the positions covered by the market risk analysis each year of the horizon, with losses fully recognized each year of the stress test:

56. The impact of traded risk stress test on profit and loss (P&L) differentiates between the general interest rate impact and the credit spread impact. The FSAP team calculated a haircut for each fixed income instrument under stressed conditions as the result of multiplying the modified duration for each security (assuming a 4-year average duration) by the change in stressed credit spreads:

$$-\frac{D}{\left(1+r_t^f+cs_t\right)}\cdot Sec_t\cdot\Delta cs_t$$

where D denotes average duration, Sec_t denotes the carrying value of the debt security portfolio in June 2016, r_t^f reflects the official cash rate (OCR) and Δcs_t the shock to credit spreads.

57. A similar approach was followed to compute the impact on asset valuations from repricing risk. Given the easing in risk free rates under the adverse scenario, the impact of changes in risk -free rates on mark-to-market valuations is typically positive mitigating the adverse effect from a sharp rise in credit spreads.

58. Market risk from shocks to other risk factors is negligible. New Zealand banks do not carry material open positions in foreign exchange, commodities or basis risk. Therefore, market risk is confined to fair-valuation effects on the securities portfolio from the combined effect of credit risk premium shocks and term premium shocks across debt markets.

Funding Costs

59. The stress test included a contagion module from the presence of weaker peer banks in funding markets as well as a solvency-funding cost module from the interaction between solvency risk and funding costs. The projection of bank funding costs followed an iterative process:

- ***Initial Projection of Funding Costs (Stage 1)*:** The initial projection of bank-specific funding costs was informed taking into account aggregate projections for the reference rate in debt markets, bank-specific stressed spreads for wholesale issuance benchmarked against the behavior of their bond spreads during the GFC, and bank-specific structure of liabilities as of June 2016. Stressed funding costs were used to project stressed Tier 1 ratios at the bank level.

- ***Solvency-Funding Cost Module (Stage 2)*:** The forecast of individual bank funding costs is driven by macroeconomic variables (under each scenario), bank-specific variables (including stressed Tier 1 ratios from stage 1, asset quality, and funding structure), global variables (including world GDP, commodity prices, and USD LIBOR). A revised path of funding costs is projected for each bank and each scenario.

- ***Contagion Module (Stage 3)*:** A contagion risk factor by bank is constructed to capture the effect of rising funding costs in peer banks. This factor reflects the average funding cost of the rest of the New Zealand banking system which is unexplained by systematic risk factors. This component captures the 'systemic funding risk' shock from idiosyncratic shocks in peer banks to each individual bank.

- ***Final Funding Cost Projection (Stage 4)*:** The revised forecast of funding costs from stage 3 is combined with other risk factors (i.e., credit risk, market risk, regulatory capital) to project the final path of bank capital ratios.

Initial Projection of Funding Costs

60. Funding costs are projected for each bank using the aggregate paths under each scenario and banks specific spreads. For each scenario, the 90-day bank bill rate is projected based on the endogenous behavior of the official cash rate (OCR) and the 100 bps credit shock spread over 2017Q1–2018Q4 under the adverse scenario. Bank funding spreads over the money market rate depend on the composition of bank liabilities as well as on the projection of yield to maturity (ytm) spreads for wholesale liabilities. The amount of outstanding wholesale debt across banks is significant at around 20 percent of liabilities as of June 2016 (Figure 11).

61. Stressed bank-specific spreads were benchmarked against the behavior of capital instruments' ytm spreads during the GFC. For each bank, the face value-weighted average spread of all outstanding bonds' ytm (issued under own name by major banks) relative to bank bill rate that were active during the GFC was calculated. Stressed ytm spreads during 2008–2009 were used to inform projections during the first two years of the adverse scenario. For baseline projections, the weighted average of ytm spreads during 2014–2016 of all bank bonds issued after 2011 was used to inform bank-specific spreads.

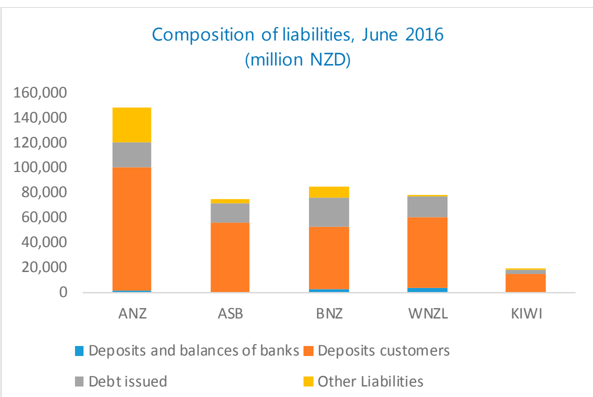
62. Shocks to deposit spreads over the bill rate were informed by historical experience. For baseline projections, the long-run average spread of deposit rates over the bill rate during January 2000–June 2016 was used. By contrast, the behavior of spreads during the GFC helped inform stressed spreads under adverse conditions.

63. A bank-specific blended spread was projected as a function of banks' liability structure in June 2016 and banks' path for funding shocks. Figure 10 shows that spreads relative to starting funding costs rise substantially under stress over the first two years of the horizon and recover in the outer years. This is consistent across banks suggesting correlated behavior of spreads in wholesale debt markets, and a similar structure of interest-bearing liabilities.

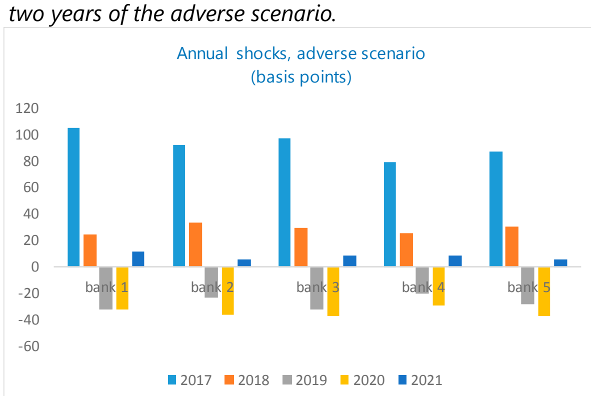
Figure 11. New Zealand: Funding Shock Projections – Stage 1

Major New Zealand banks' wholesale liabilities represent around one fifth of interest-bearing liabilities. Stressed spreads in wholesale markets drive most of the widening in funding costs in the adverse scenario.

While deposits from customers represent the higher funding source of major banks, outstanding debt is significant…



…shocks to spreads in wholesale markets are the main contributing factor to the rise in funding costs over the first two years of the adverse scenario.



Sources: Banks' disclosure statements and IMF staff estimates.

Solvency-Funding Cost Module

64. A VAR-based econometric approach is used to explore linkages between funding costs and bank solvency ratios. Using Tier 1 capital projections from stage 1, and funding cost projections from stage 2, a VAR econometric approach is used to explore endogeneities between banks' solvency position and funding costs. This analysis is particularly relevant for major New Zealand banks as wholesale investors are typically more credit-sensitive than retail depositors.

65. Results suggest that the two-way interaction between solvency and funding costs is significant. A 100 bps shock in funding costs pushes down Tier 1 capital between 10 and 20 bps across banks. Conversely, a 100 bps shock in Tier 1 capital increases funding rates on bank liabilities by an average of 15 bps.

Contagion Module

66. This module incorporates explicitly contagion from peer banks' funding pressures. Contagion in funding markets can occur if funding stress in a New Zealand bank is a signal to creditors that other banks in the banking system are likely to be in financial trouble. It can also be triggered by competitive pressures in funding markets that may result in a restriction of liquidity as counterparties shy away. To capture contagion, a two-pronged approach is followed:

- For each major bank, a peer group was defined as the rest of the New Zealand banking system, excluding each bank in turn. The average funding costs for the peer group is regressed against the set of explanatory variables for each individual bank that are expected to drive bank funding costs i.e., bank-specific variables, country-specific variables, and global variables.

- The orthogonal residuals of the aforementioned regression are identified as a proxy of contagion from funding pressures in other New Zealand banks and used as an explanatory variable in the model of the funding cost of the bank being examined.[34] As a result, the value of the contagion variable differs across banks.

67. The main model defines funding costs as the implicit interest rate paid in interest-bearing liabilities, and uses a battery of bank-specific and panel regressions. A key challenge is to identify a proxy for bank funding costs. The key reference variable used for the main model is effective interest paid on interest-bearing liabilities. The effective interest rate reflects the P&L impact of funding stress, taking into account banks' funding structure. The data is sourced from the quarterly RBNZ GDS database from 2000 through June 2016. The econometric analysis is based on a set of individual-based regressions to capture heterogeneity across banks and a panel model with fixed effects and robust standard errors clustered by bank. Interest payments are computed on an annualized basis.

[34] This approach builds on Longstaff, F., J. Pan, L.H. Pedersen, and K.J. Singleton, 2011, "How Sovereign is Sovereign Credit Risk?" *American Economic Journal: Macroeconomics 3,* April 2011: 75–103.

68. The results of regressing New Zealand banks' funding costs on a broad range of determinants suggest that (Appendix III, Table 1):

- ***The most significant macroeconomic variables are growth and unemployment.*** Under the panel-based approach, a drop in GDP growth by 1 pp leads to an increase of funding costs of around 15 bps. The effect of unemployment is significant for some banks with coefficient estimates between 0.3 and 0.4.
- **Money market conditions are key determinants of bank effective interest payments.** The 90-day bank bill rate is always significant across specifications with an elasticity revolving around 0.8. This points at the benchmark role played by the 90-day bank bill rate in New Zealand onshore funding markets. Also, the impact of the 90-day USD LIBOR is a significant driver of funding costs highlighting the relevance of offshore funding for New Zealand banks.
- **Contagion is a significant driver of effective interest rates across banks.** For the average bank, a 100 bps widening of funding costs in the rest of the New Zealand banking system is associated with a rise in individual funding costs of around 80 bps. The elasticity of funding costs to peer banks' funding pressures varies across banks with estimates ranging between 0.25 and 0.95, after controlling for bank-specific, country-specific and global drivers of funding costs. This result is consistent with the existence of common factors that affect all banks' credit spreads, but are not captured by the other explanatory variables, including bilateral counterparty exposures. This finding might also point at the relative concentration of the New Zealand banking system.

Funding Cost Projection

69. The final path of funding cost projections incorporates the forecast of funding shocks as well as the composition of bank liabilities (Appendix III, Figure 1). For the average bank, funding cost rates widen by around 130 bps by 2018 under the adverse scenario, despite accommodative monetary policy, driven by a combination of credit risk premia shocks and contagion shocks.

70. The impact of funding costs on NIMs (P&L impact) is somewhat mitigated by banks' interest rate repricing schedule. Bank lending rates are projected using a constrained pass-through cap of 50 percent of funding cost increases. Banks' interest rate repricing schedule on interest-bearing assets and liabilities as of June 2016, categorized by the earlier of contractual repricing or maturity dates, is applied to the carrying amounts projected under the stress test scenario. Results show that the ultimate impact of an increase in funding costs on banks' P&L is somewhat mitigated by the contractual repricing schedule of loans with an average time to repricing of housing loans of around 11 months across banks.

$$income_{i,t} = \sum_b gap_{i,t}^b \cdot \left(\frac{365 - mid^b}{365} \right) \cdot \Delta i_t^f$$

Other Assumptions

71. The path of dividend payouts accommodates RBNZ's buffer ratio restrictions. Under the baseline scenario a benchmark rate of 50 percent payout is applied. Under the adverse scenario, the assumed payout ratio declines to 30 percent provided profits are positive and subject to RBNZ's buffer ratio restrictions:[35]

$$D_{i,t} = \begin{cases} \max(0, 0.3 \cdot \pi_{i,t}) & \text{if Buffer Ratio}_{i,t} > 1.25 \\ \max(0, 0.2 \cdot \pi_{i,t}) & 0.625 < \text{if Buffer Ratio}_{i,t} \leq 1.25 \\ 0 & \text{if Buffer Ratio}_{i,t} < 0.625 \end{cases}$$

C. Solvency Stress Test Results

72. The IMF stress test results suggest that major New Zealand banks are resilient to a severe global economic downturn. The IMF stress test results are broadly comparable to the stress test results produced by RBNZ using the commonly agreed scenario and RBNZ's in-house credit risk models in combination with expert judgment.

- ***Under the baseline scenario, the capital of all banks is above minimum requirements and the capital conservation buffer*** (Figure 12). Aggregate CET1 ratios stabilize at around 10.5 percent by 2021 as capital buffers grow in line with risk-weighted assets, well above fully loaded Basel III regulatory minima of 7 percent. While the RBNZ has not implemented the Basel III regulatory leverage ratio, this was projected for stress testing purposes. The aggregate Tier 1 leverage ratio is expected to settle at around 7.2 percent under baseline conditions. Tier 1 capital is projected to decline slightly to 11.7 percent by end-2021 due to the phase-out of additional Tier 1 instruments non-compliant with Basel III.[36] The aggregate capital ratio is projected to hover around 12.4 percent by 2021.

- **Under the adverse scenario, all banks would still meet minimum requirements but most banks would breach their capital conservation buffer at the low point of the stress** (Figure 13). Aggregate CET1 ratios fall from 10.4 percent in June 2016 to a low point of 7.7 percent in 2018, exceeding the regulatory minimum of 4.5 percent,[37] before trending back to 10.5 percent

[35] It is worth noting that these buffer ratio restrictions also apply to payments (whether interest or dividends) on AT1 instruments. This restriction is likely to be more binding than a restriction on ordinary share dividends, because an AT1 holder will generally be expecting an interest-like return.

[36] Under RBNZ's implementation of Basel III regulatory framework, non-compliant capital will be fully phased-out by January 1, 2018, ahead of Basel III transitional schedule.

[37] The RBNZ capital regulatory framework does not include additional capital buffers for systemic banks. Instead, capital standards are tighter than those prescribed by Basel III. Examples of the conservative implementation of Basel standards include LGD floors, maturity floors, and no firm size adjustment on farm lending, LGD floors and higher correlations for housing exposures, the creation of a new asset class for retail investor mortgages with higher LGD floors and correlations, and the introduction of a reverse residential mortgage asset class with high prescribed risk weights. APRA has estimated that under the international implementation of Basel, CET1 ratios would be boosted by around 300 bps.

by 2021. While stressed CET1 and Tier 1 ratios are above the capital requirements plus capital conservation buffer throughout the stress test horizon, the total capital aggregate ratio is projected at 9.4 percent at the low point of the stress, breaching the capital conservation buffer by around 110 bps. Bank-by-bank results reveal that all banks pass the 7 percent mark for CET1. The capital conservation buffer for Tier 1 capital is breached by two banks by 10 bps and 20 bps, respectively. Four banks breach the capital conservation buffer for total regulatory capital by between 70 bps and 130 bps in 2018. In the outer years of the horizon, CET1 ratios improve supported by stable net interest income, lower risk premia implying higher prices of liquid buffers, and lower risk weight density in line with improved credit risk profiles of underlying portfolios.[38]

73. The shortfall in aggregate capital ratios under the stress test is mainly driven by stressed risk weighted assets (RWAs), credit losses, and funding costs (Figure 14). At the low point of the stress, the overall 2-year cumulative impact on aggregate capital ratios relative to June 2016 is around 400 bps. This impact can be broken-down by contributing factor with shifts to RWAs accounting for 400 bps, 200 bps from credit loss provisions, and 100 bps from stressed funding costs. The impact of full implementation of Basel III accounts for further 40 bps of the aggregate capital shortfall. On the other hand, banks are able to retain capital through profitability despite the erosion in margins, supporting capital ratios during the downturn.

RBNZ Stress Test Results

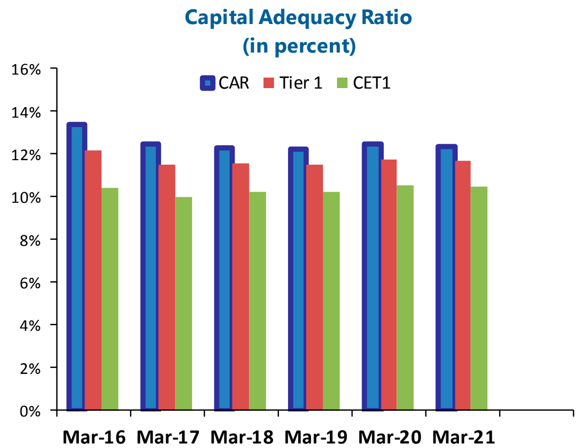
74. RBNZ conducted a top-down (TD) stress test on the downturn scenario agreed with the FSAP team. RBNZ used its own analytical models and judgment to produce projections for credit loss estimates, balance sheet financials, and regulatory capital ratios. Results were produced using in-house structural credit risk models, namely the TUI model for housing loans and the farm model for rural exposures.

[38] This is consistent with the post-GFC experience. While the average Tier 1 capital ratio in March 2008 stood at 7.9 percent, it improved in the post-crisis period to 9.0 percent in June 2009 and to 12 percent in 2016.

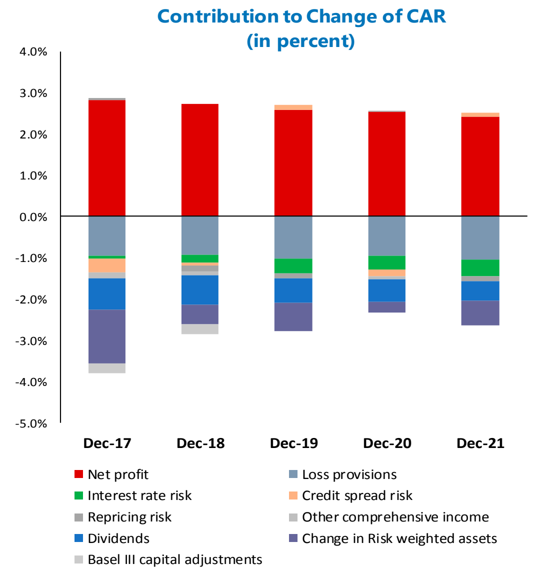
Figure 12. New Zealand: Results of the FSAP Solvency Stress Test – Baseline Scenario

Under the baseline scenario, all banks are able to build capital buffers through the generation of retained earnings.

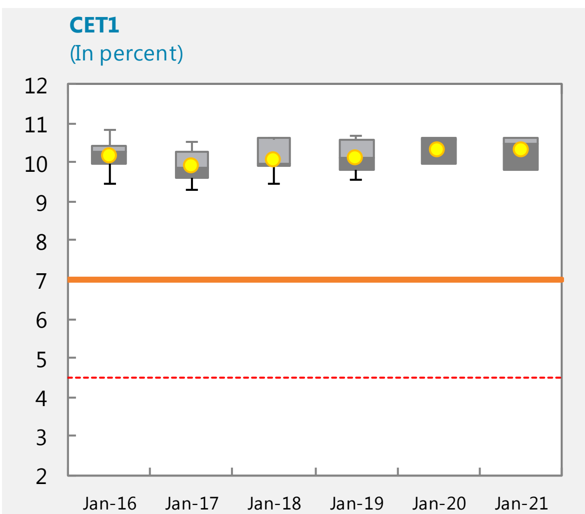
Aggregate bank capital ratios are sustained throughout the horizon. While CET1 ratios edge up driven by retained earnings. CAR tilts down slightly due to the phase-out of non-qualifying Basel III instruments.



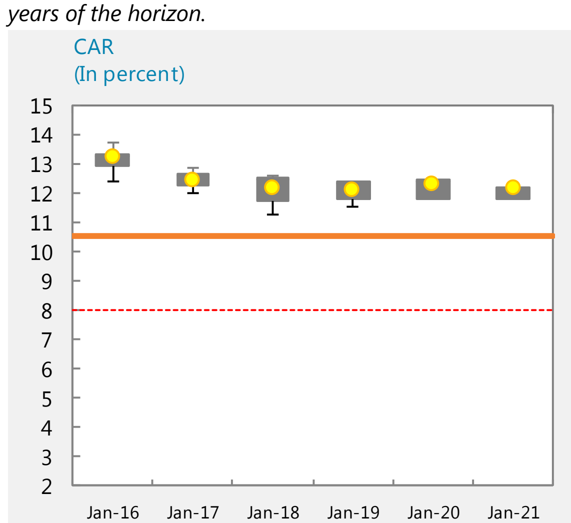
Strong profitability is the key contributor to strong capital ratios.



All banks have strong capital buffers over the stress test horizon…



…with the dispersion in CAR ratios narrowing in the outer years of the horizon.



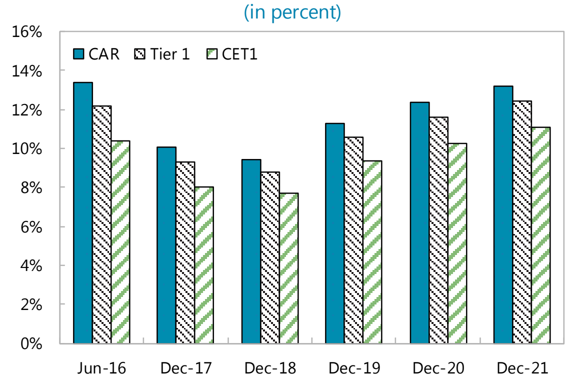
Source: IMF Staff Estimates. The sample of banks included the five major New Zealand locally incorporated banks. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers). The dashed line indicates the minimum capital regulatory ratio. The solid line includes the capital conservation buffer.

Figure 13. New Zealand: Results of the FSAP Solvency Stress Test – Adverse Scenario

Under the severe scenario, all banks would still meet minimum requirements but most banks would draw down their conservation buffer.

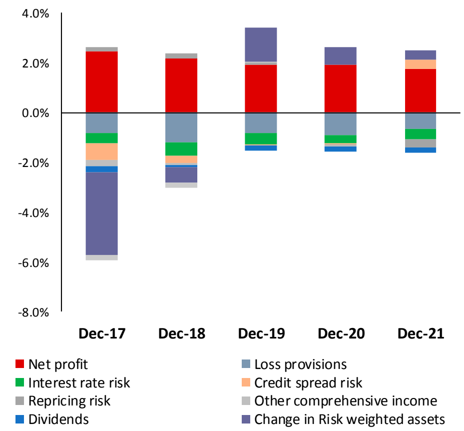
Aggregate bank capital ratios decline in the first two years of the severe scenario and recover afterwards. The recovery is less pronounced for CAR due to the full phase-out of non-qualifying Basel III capital instruments.

Capital Adequacy Ratio
(in percent)



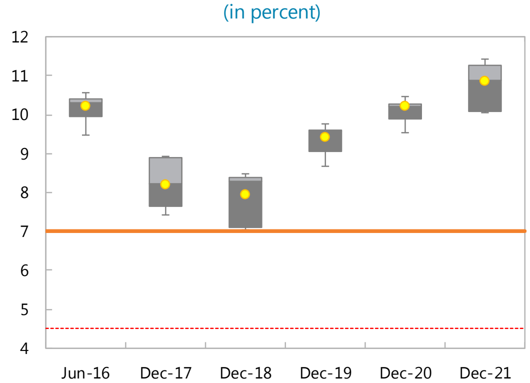
Increased risk weighted assets contribute the most to the fall in capital ratios.

Contribution to Change of CAR
(in percent)



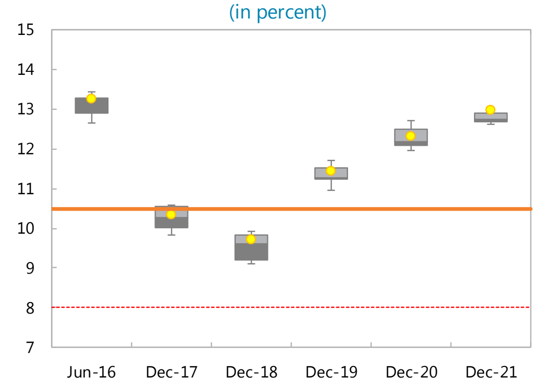
No bank breaches the CET1 minimum ratio or the capital conservation buffer over the stress test horizon…

CET1
(in percent)



…but most banks breach their capital conservation buffer for total regulatory capital at the low point of the stress.

CAR
(in percent)

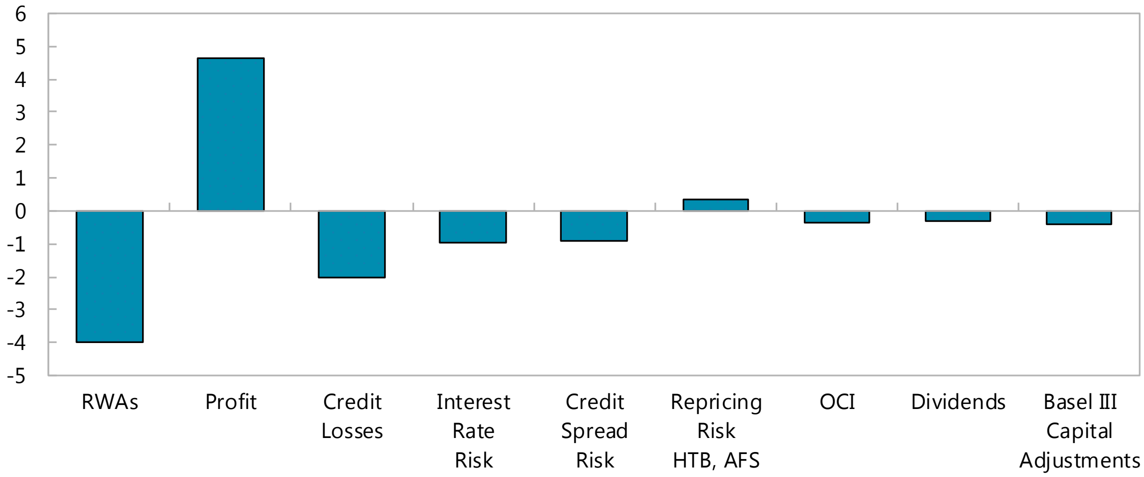


Source: IMF staff estimates. The sample of banks included the five major New Zealand locally incorporated banks. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers). The dashed line indicates the minimum capital regulatory ratio. The solid line includes the capital conservation buffer.

Figure 14. New Zealand: Results of the FSAP Solvency Stress Test – Cumulative Impact on CAR

(in percent; first two years of the stress test, cumulative)

The shortfall of 400 bps in aggregate capital ratios relative to June 2016 levels is mainly driven by increased RWAs (due to stress and drawdown of limits), significant credit losses, and higher funding costs.



Source: IMF staff estimates.

75. RBNZ stress test results are broadly comparable to IMF stress test results using the commonly agreed scenario. Under the RBNZ test, results are computed for the aggregate balance sheet of the big four banks. Under the adverse scenario, aggregate Tier 1 capital is projected at around 8.4 percent at the low point, and total capital ratios reaching about halfway through the conservation buffer at the worse point. This is broadly comparable to the IMF aggregate results discussed above.

- Credit risk losses are substantial with a weighted-average cumulative bad expense over the 5-year horizon of around 4 percent relative to starting loans under the IMF test and 3.6 percent of starting assets under the RBNZ test. The aggregate projection masks some dispersion in loss rates across credit portfolios, ranging between 1.4 percent of bad debt expense for housing loans, 5.4 percent for real estate and SMEs, 7 percent for the rural portfolio, and 12.3 percent for personal loans under the IMF test, relative to projected loss rates of 2.1 percent for housing loans, 6 percent for CRE, 9 percent for the rural portfolio, and 10 percent for personal loans under the RBNZ test.

- Market risk losses are larger under the IMF stress test as trading securities and AFS securities suffer marked-to-market losses. This is driven by a widening in money market spreads due to credit risk shocks and the steepening of the yield curve triggered by term premium shocks across debt markets. Given the composition of banks' securities portfolio as of June 2016, market shocks lead to an accumulated asset valuation loss of around 10 percent. This is a very conservative estimate as hedges are assumed not to operate effectively under stressed market conditions. By contrast, liquid assets were treated as HTM securities under the RBNZ test and were hit by an accumulated loss rate of 0.3 percent.

- Interest risk losses are material as bank funding costs increase under stressed money market conditions and banks' ability to pass-through funding shocks to borrowers is capped at 50 percent. The sharp rise in funding costs is driven by the combined effect of a shock to the reference rate, credit risk concerns over bank debt as capital buffers are eroded under stress, and system-wide contagion from weaker banks. However, the impact of funding shocks on banks' capital buffers is somewhat mitigated by thin maturity gaps in the banking book and sound interest rate repricing schedules.[39] Overall, net interest margins compress by around 60 bps at the low point of the stress from 2.2 percent in June 2016.

76. Separate reverse stress tests conducted recently by the four large banks reveal that bank capital ratios are robust to a severe macroeconomic downturn but are exposed to a compression of margins and a spike in operational risk. This exercise involved the large banks determining the most plausible scenario that would lead to a breach of their capital requirements. While scenarios chosen varied significantly across banks, a common theme was that additional risk factors would need to coincide with a severe macroeconomic downturn. For example, net profits at some banks are further hit by an assumed compression of margins of around 100 bps over the 3-year scenario, and capital buffers are also eroded by an increase in operational risk losses reaching an average 11 percent of credit losses, and rising risk weights.[40]

Sensitivity Tests

77. In addition to scenario-based solvency tests, a range of sensitivity tests were conducted to further explore bank vulnerabilities to wider shifts to risk factors (Figure 15). The adverse scenario already includes margin compression on new lending from a sharp rise in funding costs and constrained pass-through. Drawing on insights from the reverse stress tests, the direct impact on capital ratios from pressures on effective margins is significant with a compression of 150 bps on margin pushing down CET1 ratios by around 400 bps. More limited is the impact from a sharp hike in risk-free rates pushing down asset valuations. A hike of 300 bps in the policy rate would depress capital buffers by about 150 bps. This is consistent with the lending focus of New Zealand banks and their limited securities holdings.

78. A separate sensitivity test on credit concentration risk suggests this risk is moderate. Credit concentration risk was assessed by simulating the default of the largest counterparties of each of the 5 largest banks, including banks, other financial institutions, and corporates.[41] This test assesses imperfect diversification from large exposures to specific obligors (single name

[39]For residential mortgage loans, the average number of months to rate reset stands at around 11 months.

[40] Certain categories of risks affecting financial institutions, such as operational or legal risk, or risk related to fraud, are not covered in FSAPs. However, in the context of reverse stress tests, some New Zealand banks decide to include non-credit risk events such as operational risk events to challenge the viability of the bank, given the strong structural profitability of New Zealand banks.

[41] Only bank exposures to supranationals and the New Zealand government were excluded from the analysis.

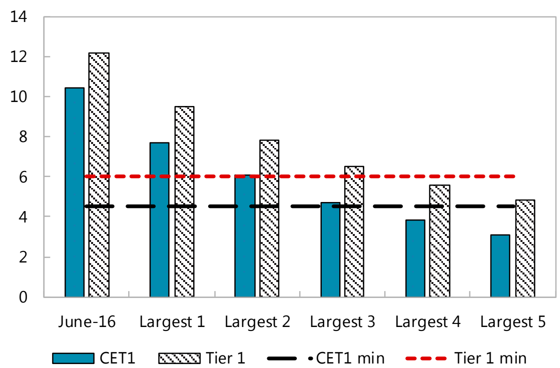
concentration).[42] Credit concentration in key New Zealand banks' portfolios is moderate. Banks would be able to meet their regulatory capital ratios following the default of their three largest counterparties.

Figure 15. New Zealand: Sensitivity Tests

Bank capital ratios are relatively more sensitive to pressures on net interest margins and concentration risk.

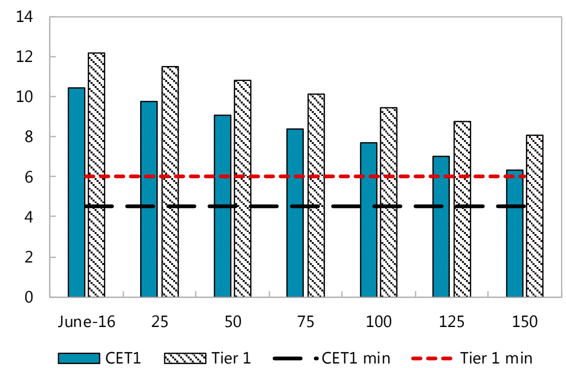
The simultaneous failure of the three largest counterparties would push capital ratios toward their regulatory minimum.

Credit Concentration Test
(in percent of capital)



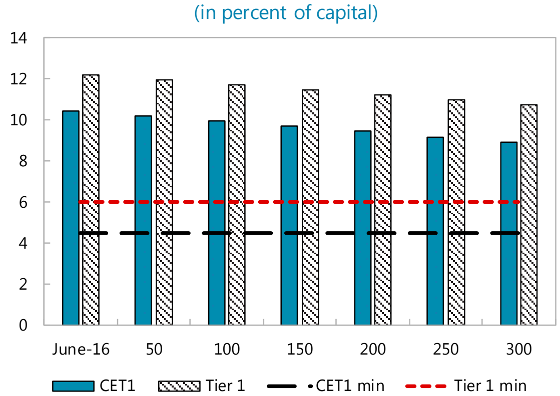
A compression of net interest margins by 150 bps would erode capital buffers by around 400 bps.

NIM Compression
(in percent of capital)



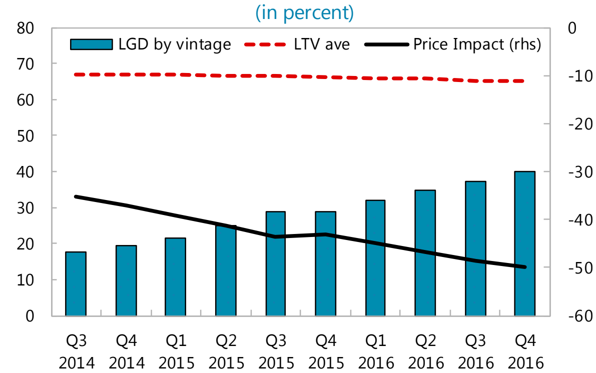
Capital ratios are resilient to sharp increases in policy rates.

Repricing Risk
(in percent of capital)



A 50 percent fall in residential real estate prices combined with a forced sale discount of 25 percent, would widen average LGD ratios to under 30 percent despite improved LTV ratios.

Impact on LGD
(in percent)



Source: IMF staff estimates.

79. **Stress test results should be interpreted with caution.** Stress test scenarios replicate historical events or express extreme "tail events" based on historical loss distributions, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected

[42] Concentration risks from imperfect diversification to economic sectors (e.g., the residential real estate sector and the rural sector) are addressed by using conservative assumptions on LGD floors, maturity floors, no firm size adjustment, and higher correlation factors than those prescribed by the Basel III regulatory framework.

interrelationships where the past offers limited guidance. While some nonlinear effects can be captured in stress tests, it is always possible that that unknown patterns emerge, especially if extreme shocks materialize. The RBNZ is encouraged to expand its modeling capabilities to model ways in which systemic interactions could crystallize to form judgments on banks' behavioral reactions and feedback effects.

LIQUIDITY STRESS TESTS

A. Liquidity Stress Test Scenarios

80. **While all locally incorporated banks are required to comply with RBNZ liquidity policy, Basel III liquidity requirements have not been implemented in New Zealand.** The RBNZ adopted quantitative liquidity requirements in April 2010. The one-month mismatch ratio is broadly aligned with Basel III liquidity coverage ratio (LCR) whereas the CFR has a similar structure to the Basel III net-stable funding ratio (NSFR). RBNZ is currently conducting a liquidity review to identify the appropriate liquidity regulation framework in New Zealand.

81. **The top-down liquidity stress tests were undertaken using the current RBNZ' regulatory framework and a framework similar to Basel III.** The liquidity stress tests under the RBNZ's liquidity regulatory policy framework included: (i) one-month mismatch ratio to assess banks' resilience to a withdrawal of funding; and (ii) the CFR to evaluate banks' reliance on short-term wholesale funding. The team also conducted a range of Basel III quasi-LCR tests over 2 different horizons (30-day quasi-LCR test, and 5-day quasi-LCR) and 3 separate scenarios (Appendix IV).[43] These scenarios included the 2013 LCR scenario ("LCR scenario") with standard prescribed haircuts, rollover rates and run-off rates, and two additional scenarios tailored to New Zealand banks which are more severe than those prescribed by the Basel III regulatory framework: a "New Zealand retail" scenario, and a "New Zealand wholesale" scenario.[44]

[43] To populate the data in the LCR liquidity stress testing tool, the RBNZ's liquidity survey was used to compute the 30-day and 1-week maturity mismatch ratio. RBNZ conducted a mapping of LCR categories for level 1 and level 2 of High Quality Liquid Assets (HQLA), various categories or types of liabilities and off-balance sheet for cash-outflows and several categories of contractual receivables for cash-inflows. The mapping was conducted on a best effort basis, but in some categories the matching might not be perfect.

[44] The "New Zealand retail" scenario features run-off rates for stable (unstable) deposits of 10 percent (15 percent) rather than 5 percent (10 percent) under Basel LCR. The run-off rate for undrawn but committed credit and liquidity facilities for retail and SMEs (corporates) rises from 5 percent (20 percent) to 10 percent (40 percent), among other shifts to draw-down rates. Under the "New Zealand wholesale" scenario, the run-off rate for uninsured corporate deposits increases from 40 percent to 100 percent, operational deposits generated by clearing and custody are drawdown at a 75 percent rate rather than 25 percent, and secured funding backed by Level 2B assets runs at a rate of 100 percent over the Basel 50 percent mark, among other changes to Basel rollover rates.

B. Liquidity Stress Test Results

82. New Zealand banks are resilient to sizable withdrawals of funding (Figure 16). In particular:

- **Under the current liquidity regulatory regime, banks have sufficient liquid buffers to withstand a 1-week and 30-day liquidity stress scenario.** The mismatch ratio, which is defined as primary liquid assets minus stressed net cash outflows (as a share of total funding), stood at 4.4 percent at one-week horizon and 4.9 percent at one-month horizon in August 2016, well above the zero percent regulatory minimum.

- ***The short-term resilience of the liquidity risk profile of banks is supported by quasi-LCR stress test results.*** Under Basel III prescribed assumptions, the 30-day weighted average LCR ratio stood at 113 percent in August 2016. The LCR ratio fell below the Basel III transitional 80 percent mark only in one bank, with an aggregate liquidity shortfall of 0.2 percent in total assets. Under more stressed conditions captured by the "New Zealand retail" scenario, the aggregate LCR ratio fell to 73 percent with 6 banks falling under the threshold. While the aggregate LCR ratio improves somewhat under the "New Zealand wholesale" scenario to 78 percent, the aggregate liquidity shortfall is larger at 2.8 percent of total assets as this scenario hits the major banks harder. Results improve somewhat under the 5-day scenario, with the average LCR ratio standing at 147 percent and all banks passing the test under Basel III assumptions, and a liquidity shortfall of 0.7 percent of assets (1.3 percent of assets), under the "New Zealand retail" ("New Zealand wholesale") scenario.

83. New Zealand banks' funding structure appears resilient despite significant reliance on wholesale funding. To ensure that banks have sufficient stable funding to meet their funding needs all locally incorporated banks are required to have at least 75 percent of their loan portfolio financed using core funding. The weighted average CFR for the banking system as a whole stood at 85 percent in August 2016, in excess of the hurdle rate under RBNZ liquidity regime.

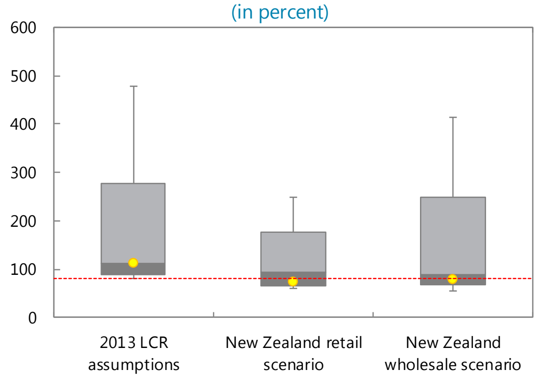
84. This resilience reflects an improvement in the liquidity position of New Zealand banks, which can be attributed to strengthened regulatory and supervisory standards since the last FSAP. The CFR was initially set in 2010 at 65 percent to reflect the then existing mix of funding. The RBNZ increased the requirement in mid-2011 to 70 percent and to 75 percent in early 2013 (Figure 17). In response, banks increased the proportion of retail deposits and long-term funding. The regulatory changes were designed to provide a sound minimum funding base for the banks and are meant to be permanent.

Figure 16. New Zealand: Results of the FSAP Liquidity Stress Test

New Zealand banks are resilient to sizable withdrawals of funding – both using NZ-specific metrics, as well as when applying a quasi-LCR stress test.

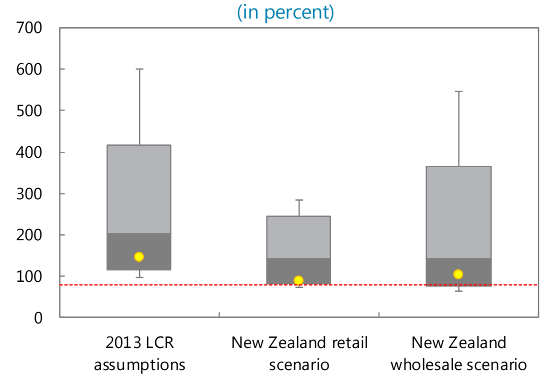
The majority of banks would comply with the transitional 80 percent 30d LCR threshold under Basel III, but the size-weighted average quasi-LCR falls below this mark under the retail and the wholesale scenarios.

30d Quasi-LCR Test
(in percent)



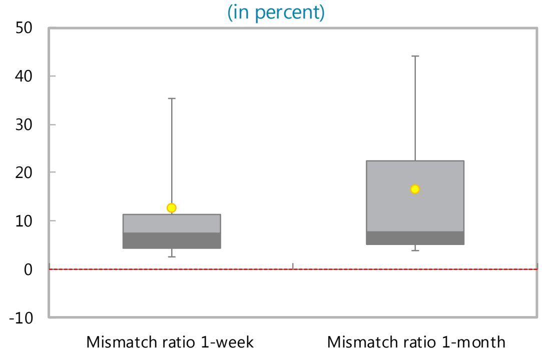
Results improve under the 5d quasi-LCR test, with no bank falling below the 80 percent threshold, and just a small liquidity shortfall of 1.3 percent of assets under the wholesale scenario.

5d Quasi-LCR Test
(in percent)



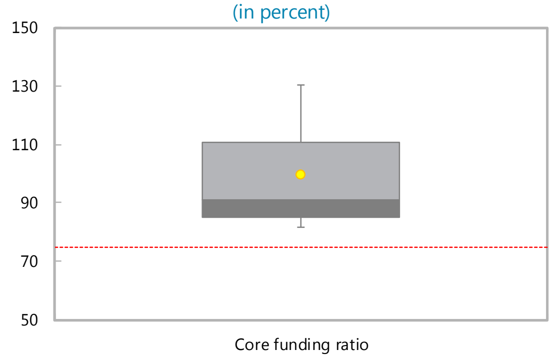
All banks comply with the RBNZ's liquidity requirements, i.e., the 1-week and 1-month mismatch ratios…

RBNZ Mismatch Ratio
(in percent)



…as well as the core funding ratio.

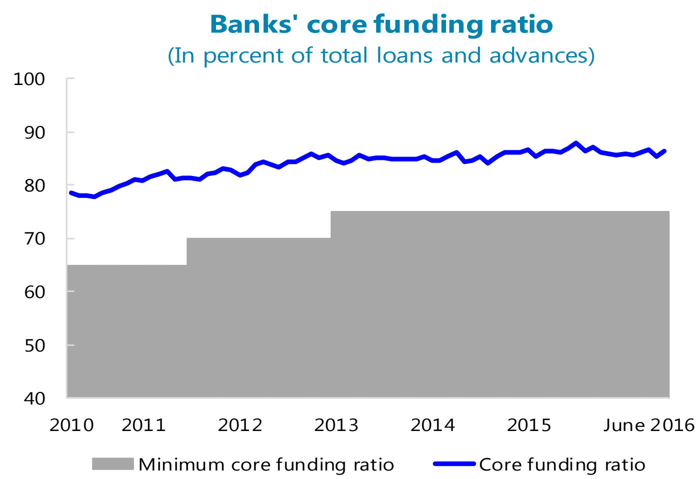
RBNZ Core Ratio
(in percent)



Source: RBNZ and IMF staff estimates. Note: The sample of banks included in the liquidity stress test includes all fifteen New Zealand locally incorporated banks. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 80th percentiles (whiskers) for the quasi-LCR ratios, and the 10th and 90th percentiles for RBNZ liquidity regulatory ratios. The red line indicates the lowest acceptable ratio value (hurdle rate).

Figure 17. New Zealand: Banks' Core Funding Ratio

The improvements in the liquidity position of New Zealand banks can be attributed to strengthened regulatory and supervisory standards.



Source: RBNZ and IMF staff estimates.

CONTAGION ANALYSIS

85. A contagion module assessed the potential for distress in a financial firm to create risks to overall financial stability. For the simulation of the scenarios, two separate initial conditioning events (shocks) were considered:

- **Rising funding pressures:** A 'global funding scenario' was laid out to replicate the post-Lehman liquidity strains including a sharp rise in funding cost and credit market freezes. A bank facing a liquidity squeeze engages in fire sales to obtain liquidity. In a first step, this reaction erodes the banks' capital buffer. In a second step, the post-shock capital base is combined with a network model to simulate cascading defaults in the New Zealand interbank market.

- **A drop in market value:** A repricing of market risk factors causes portfolio/credit losses pushing a bank's financial returns to the left tail of the distribution. The bank reaches its VaR returns in the market-implied value of assets.

86. The transmission of each separate initial shock from an individual bank to the broader banking sector is spread through the following channels:[45]

- **Bilateral Exposures:** Counterparties with a significant exposure to the failing firm may suffer material losses resulting in their inability to satisfy their obligations thus transmitting distress to

[45] 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.

other parts of the financial system down the credit chain in the form of cascading defaults.

- **Market Contagion:** Market participants' revise their expectations on the solvency of other firms following similar business models than the firm in distress, conditional on the broader economic environment.

87. The bilateral exposure channel is captured by a network analysis conducted by the FSAP team drawing on New Zealand banks' bilateral matrix of exposures. The stress test assesses the solvency impact of liquidity strains from fire sales and rising funding costs and the potential for indirect default cascades through the New Zealand interbank market.

88. The contagion channel is examined by the FSAP team using a combined market and balance sheet-based approach. Given the lack of market equity data for New Zealand subsidiaries, the analysis was performed on consolidated Australian banks. Contagion effects from Australian banks' left tail co-movement in balance sheet dynamics and equity returns with G-SIBs are assessed using the CoVaR methodology.

A. The Network Analysis

89. The network analysis tries to address two missing links of the traditional solvency stress test. First, the solvency effects from a negative liquidity gap in banks facing funding pressures. Second, the potential for default cascades triggered by an insolvent firm on its creditors, leading in turn, to severe strains on the latter counterparties, transmitting distress throughout the entire banking sector.

90. The FSAP Network Model examines whether the failure of an individual institution may pose broad-based financial stability risks.[46] For the purposes of analyzing the New Zealand banking system, the model has been calibrated to mimic the market conditions following the Lehman liquidity shock. In particular:

- **New issuance:** unsecured interbank, FX swap markets and capital markets close. For the very strong banks, markets reopen gradually allowing up to 65 percent of banks' expected issuance after the first quarter of liquidity stress. The remaining amount has to be raised via a sale of assets, where assets are sold at a loss to their book value.

- **Counterbalancing capacity:** liquid assets suffer from sharp price declines driving up haircuts across asset classes. Banks that borrowed from the defaulted bank need to find new sources of funding for maturing liabilities or draw down their liquid buffers to meet their funding shortfall. The share of lost funding that is non-replaceable under stressed conditions is 35 percent, and the discount rate on liquid buffers that are sold at a discount is 32 percent, in light of the composition of banks' asset buffers as of June 2016 and Basel III prescribed haircuts for liquid

[46] Based on Espinosa, M., and Sole. J. (2010).

assets under the LCR standard.[47] Banks that become illiquid during the stress test horizon incur asset fire sales losses up to the depletion of their counterbalancing capacity.

91. We allow a bank default to transmit into the banking system through two channels. First, a default of a given bank translates into losses of other banks that were its creditors (through interbank lending, bond holdings, etc.) – with a LGD of 40 percent. Secondly, 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 2.

Table 2. New Zealand: Network Analysis – Parameter Calibration

Parameter/variable	Description
λ=0.4	40 percent loss given default for exposures
ρ=0.35	Share of lost funding that is non-replaceable
δ=0.3	30 percent discount on asset sales
capital	CET1 capital under Basel III
bank default	CET1 capital falls below 4.5 percent

92. The risk of contagion from a bank default through the interbank exposures in New Zealand is limited (Box 1). This is because interbank exposures are relatively small compared to banks' initial capital levels. Under standard assumptions there are no banks whose default would lead to consecutive defaults of other institutions (scenario 1). A loss of the three largest bank exposures leads to a default of one locally-incorporated bank (scenario 2). In the case of corporate and nonbank financial exposures (scenario 3), two banks default as a result of loss of three largest exposures, while two other banks default due to holdings of exposures common to other banks' largest exposures. However, if the LGD increases to 90 percent – reflecting a larger short-term loss of cash flows from the defaulted exposures – the default of one bank leads to the cascade default of one more bank, while five institutions default following the loss of their three largest exposures. Finally, while the results are sensitive to changes in the LGD assumptions, they are robust to changes of the discount on asset sales and of the share of non-replaceable funding.

93. The results of the contagion analysis should be interpreted with caution. First, fire-sale 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.

[47] In the funding shock simulation, the failure of a lending institution triggers a funding-shortfall induced loss to the borrowing institution. A share of lost funding is non-replaceable under stressed conditions, forcing the borrower to draw down on its liquid buffers at fire sales. The calibration of the discount rate is linked to the haircuts prescribed by Basel LCR applied to the composition of banks' liquid assets at the date of the simulation (June 2016) which amounts to an aggregate discount rate of 32 percent.

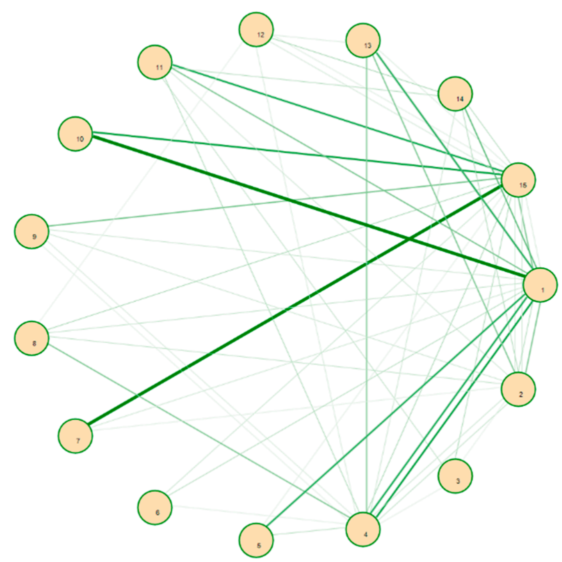
Box 1. Overview of the FSAP Network Model

The analysis examines whether the failure of an individual institution may pose a risk to financial stability. We assess the contagion risk in three hypothetical scenarios:

- *Default of a single bank*. We allow a bank default to transmit into the banking system through two channels: i) direct interbank exposures, ii) funding gap channel, where defaulting bank's borrowers need to find new sources of funding.

- *Default of three largest exposures to other financial institutions in a bank's portfolio* (exposures to parent companies are not taken into account). In the first step, direct portfolio losses decrease bank's capital. If the losses are large enough to cause the bank's default, then in the second step the bank's default can further transmit into the banking system.

- Default of three largest corporate and financial exposures, other than exposures to the banks covered by the large exposure database. In this scenario we also account for the common exposures across banks. For example, when simulating the impact of default of three largest exposures of a bank A, we account for losses for other banks if they hold exposures against any of the three defaulting counterparties in bank A's portfolio.



For each bank, three scenarios are examined using the RBNZ's large exposure database, which covers 15 largest locally incorporated banks, as well as their 10 largest exposures against other financial institutions, and their top corporate exposures. Scenario 1 simulates the default of each bank in turn. Scenario 2 simulates the default of the top 3 bank exposures. Scenario 3 simulates the default of the top 3 nonbank financial and corporate exposures. The network analysis thus captures the impact of any significant exposure. The chart in this box summarizes the interbank exposures between locally-incorporated banks in New Zealand based on the large exposure database as of June 2016. The nodes in the chart represent different banks. The lines between the nodes represent gross exposures between the banks. A thicker line between the nodes implies a larger bilateral exposure.

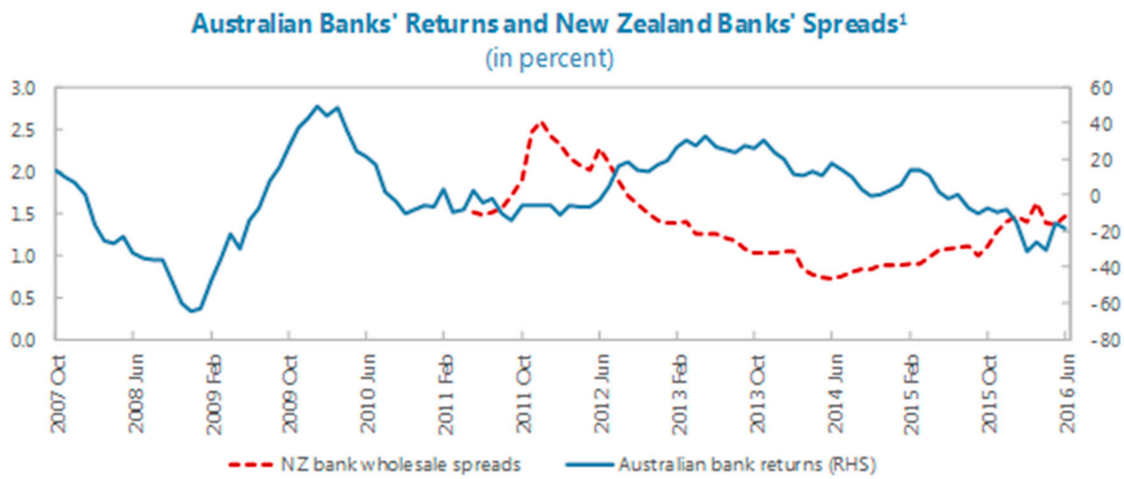
B. The CoVaR Analysis

94. The analysis of market contagion is complementary to the network analysis. It addresses two limitations of the network analysis. First, contagion effects are measured using market-implied asset returns capturing spillovers that might be unrelated to credit exposures (i.e., due to common exposures or driven by banks with similar business models). Second, systemic contagion can be transmitted by internationally active banks. For the large Australian banks, instability can spread from their global counterparts, given their active presence in offshore debt markets and derivative markets.

95. While the analysis is conducted at the consolidated level, distress can be expected to impact at the subsidiary level due to the tight correlation between Australian banks' equity returns and New Zealand banks' funding spreads. The analysis is performed for Australian banks due to the lack of market data for New Zealand subsidiaries. Yet Figure 18 shows that lower equity returns at the consolidated level are associated with widening funding spreads for New Zealand banks in wholesale markets. The analysis was performed on weekly bank equity price data and quarterly balance sheet data over the period November 2006–October 2016.[48]

Figure 18. New Zealand: Intra-group Spillovers

There is high negative correlation between Australian banks' equity returns and their New Zealand subsidiaries' wholesale funding spreads.



Sources: Bloomberg, RBNZ data, IMF staff estimates.

[1] The blue line shows monthly average weekly equity returns of the four big Australian banks weighted by their asset size. The red line shows the monthly average wholesale funding spreads in domestic and offshore markets for New Zealand banks.

96. The CoVaR framework is used to assess whether individual distress could pose a material risk to financial stability (Appendix V).[49] Although there is not a unique definition of financial distress, a firm is assumed to be in distress when it reaches its VaR. The contribution of an institution to left tail risk returns of the whole financial system is measured by its time-varying ΔCoVaR which measures the difference in asset-implied returns of the global system when the institution is in distress relative to when the institution is on its median returns.[50] The quantification of contagion effects depends on the definition of the financial system and the financial conditions under which a firm's failure arises.

[48] The starting point of the analysis is determined by the listing of Industrial and Commercial Bank of China.

[49] Lopez-Espinosa, Moreno, Rubia, and Valderrama, (2012) "Short-term wholesale funding and systemic risk: A global CoVaR approach", *Journal of Banking and Finance* 36, 3150–3162.

[50] We expect the sign of the ΔCoVaR to be negative as global system returns tend to decline with the distress of systemic institutions.

97. To assess the transmission of systemic risk two relevant peer groups of banks are constructed and a set of conditioning financial variables is identified. Two financial systems are considered: (i) a global banking system covering the 30 G-SIBs as of November 2015 (Appendix V, Table 1),[51] and (ii) an Australian banking system including the four largest Australian banks. The set of conditioning state variables is guided by their role in affecting global returns in financial markets.

98. Under the standard specification,[52] the analysis shows that market contagion from distressed banks is significant (Appendix V, Table 2). Among the different state variables used as control variables of market-implied asset returns, market volatility and liquidity spreads exhibit the strongest predictive power in statistical terms. The coefficient related to the dynamics of the lagged returns of distressed banks is highly significant with an average elasticity of around 0.6.

99. Allowing for non-linear effects in the response of VaR global system returns to individual distressed returns increases the significance of contagion when bank returns are negative (Appendix V, Figure 1). The median average elasticity increases from 0.6 under the standard specification to 0.9 under the non-linear specification. This may be due to the additional effect of fire sales of assets when banks are forced to deleverage their balance sheet at a discount.

100. Outward cross-border spillovers to G-SIBs appear relatively contained (Figure 19). Given the systemic importance of New Zealand subsidiaries for the parent banks, distress at the subsidiary level might impact market returns at the consolidated level. The results suggest that, on average, the risk that severe distress in consolidated returns is transmitted to G-SIBs is not negligible, but is less than the systemic risk transmitted by distressed G-SIBs to global bank returns.

101. Inward cross-border spillovers from distressed G-SIBs to New Zealand banks are significant. The CoVaR analysis suggests that European banks have become recently more systemic for Australian banks. While their New Zealand subsidiaries are not listed, Figure 18 suggests that wholesale funding spreads would widen as equity returns of their Australian parent plummet. The transmission of distress is more severe to tail equity returns than to market-implied asset returns during stressed times due to fire sales effects and contagion in funding costs, but the reverse is true during calm periods suggesting certain rebalancing of investors' portfolio away from distressed institutions into sound banks.

[51] Calculations are performed over 28 G-SIBs due to data limitations. Group BCPE is not listed and Agricultural Bank of China market-based data starts only in July 2010.

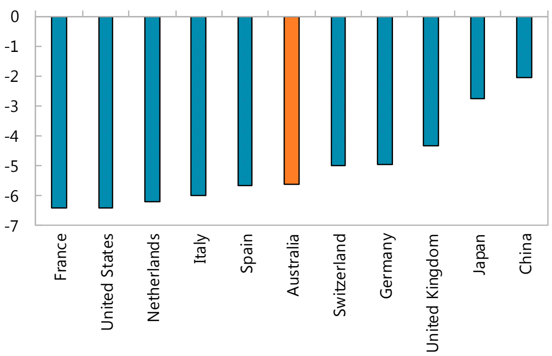
[52] Standard assumptions include a symmetric specification for the transmission of distress on the sign of bank returns, a 1 percent confidence level, and market-valued asset returns as the dependent variable.

Figure 19. New Zealand: CoVaR Analysis: Cross-Border Spillovers of New Zealand Banks

The systemic importance of New Zealand subsidiaries for the parent banks suggests that distress can be transmitted through intragroup exposures. The analysis of cross-border spillovers of New Zealand banks at the consolidated level shows that, while their contribution to global systemic risk appears relatively contained, these banks have been increasingly vulnerable to distress in European banks.

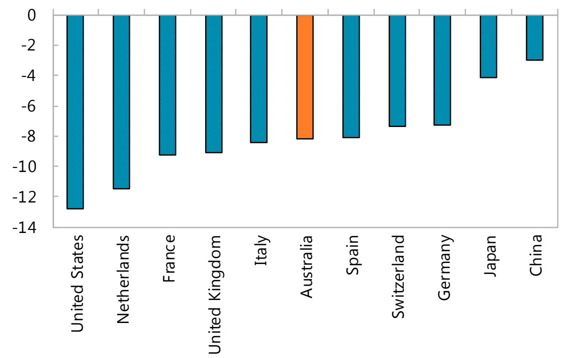
The contribution of Australian banks' distress to the 1 percent quantile of system returns is around -5.6 percent compared to -6.1 percent for the top 5 systemic jurisdictions over 2006–2016....

Contribution to systemic risk
(in percent)



...while the absolute contribution of Australian distress increases during July 2007–December 2008, the gap relative to the top 5 systemic jurisdictions widens from 50 bps to 200 bps.

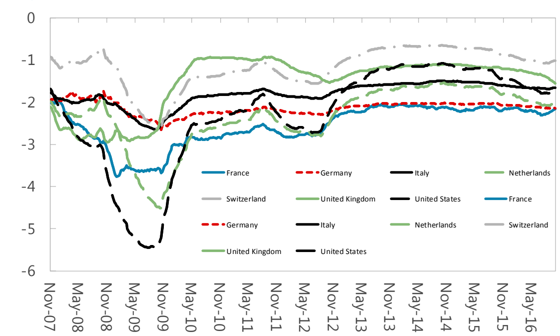
Contribution to systemic risk - Crisis Period
(in percent)



Crisis: July 2007-Dec 2008

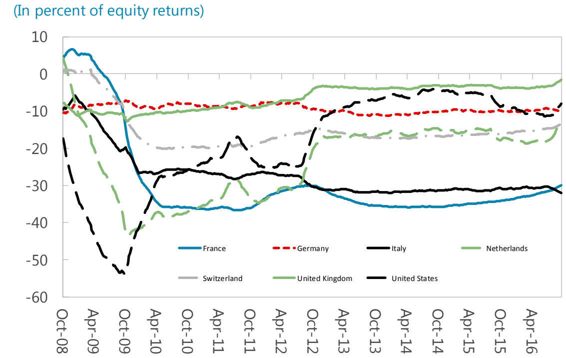
European banks have become recently more systemic to Australian banks...

Contribution to Systemic Risk in Australia
(In percent of asset returns)



...this result is confirmed when systemic risk is measured by the contribution to global equity returns rather than to market-implied global asset returns.

Contribution to Systemic Risk in Australia
(In percent of equity returns)



Source: Bloomberg, RBNZ data, and IMF staff estimates.

102. The analysis provides some evidence for the need to combine a micro-prudential and macro-prudential perspective in the regulation of systemic institutions. The results from the CoVaR analysis suggest that there is a weak link between individual and systemic risk. There is no correlation between banks' risk in isolation, measured by the CDS, and banks' contribution to systemic risk, measured by their ΔCoVaR (Appendix V, Figure 2). This suggests that any add-on on regulatory capital requirements designed to contain spillover effects needs to be calibrated drawing on both individual and systemic risk analysis.[53]

[53] Notwithstanding the merits to enhance systemic risk monitoring through equity markets, a caveat of the analysis is that the market-based assessment is conducted at the consolidated level of New Zealand subsidiaries of Australian banks.

CONCLUSIONS AND RECOMMENDATIONS

103. Stress test results suggest that the New Zealand banking system is adequately capitalized against adverse macroeconomic shocks. Under the adverse scenario, all banks would still meet minimum requirements but most banks would breach their capital conservation buffer for Tier I and CAR at the low point of the stress. Aggregate CET1 ratios fall from 10.4 percent in June 2016 to a low point of 7.7 percent in 2018 exceeding the regulatory minimum of 4.5 percent, before trending back to 10.5 percent by 2021. While stressed CET1 and Tier 1 ratios are above the capital requirements plus capital conservation buffer throughout the stress test horizon, the total capital aggregate ratio is projected at 9.4 percent at the low point of the stress, breaching the capital conservation buffer by around 110 basis points.

104. A range of sensitivity tests suggest that while credit concentration risk is moderate, banks are relatively exposed to shocks to net interest margins. Credit concentration risk was assessed by simulating the default of a large number of exposures to specific obligors, including banks, other financial institutions, and corporates. Although banks would be able to meet their regulatory capital ratios following the default of their three largest counterparties, their capital buffers would be further eroded in the extreme event of additional counterparty defaults. Drawing on insights from reverse stress tests, the direct impact on capital ratios from pressures on effective margins is significant, with a prolonged compression of 150 bps pushing down CET1 ratios by around 400 bps. The effect of a sharper decline in residential housing prices on mortgage LGD rates is somewhat mitigated by improved LTV ratios. A severe collapse of real estate prices by 50 percent would push up bank LGD ratios on mortgage loans to over 30 percent.

105. The funding contagion module suggests the existence of two-way solvency-funding cost interlinkages and contagion in funding costs from weaker banks. VAR modeling suggests a 100 bps shock in funding costs pushes down Tier 1 capital between 10 and 20 bps across banks. Conversely, a 100 bps shock in Tier 1 capital appears to increase funding rates on bank liabilities by an average of 15 bps. The analysis provides evidence of contagion effects in funding markets. Results also suggest that peer banks' funding pressures have a significant impact on individual bank funding costs, after controlling for bank-specific, country-specific and global determinants of interest-linked expenses. These findings might also point at the relative concentration of the New Zealand banking system.

106. The risk of contagion from a bank default through interbank exposures in New Zealand appears to be limited. This is because interbank exposures are relatively small compared to banks' capital levels. Under the baseline calibration there are no banks whose default would lead to consecutive defaults of other institutions. A loss of the 3 largest cross-bank exposures leads to the default of one locally-incorporated bank under standard assumptions, while a loss of three largest exposures (cross-bank or corporate) results in defaults of four banks.

107. While outward cross-border spillovers from New Zealand banks to G-SIBs appear relatively contained, inward cross-border spillovers from distressed G-SIBs to New Zealand banks are significant. The systemic importance of New Zealand subsidiaries for the parent banks suggests that distress can be transmitted through intragroup exposures. The analysis on cross-border spillovers at the consolidated level suggests that, on average, the risk that severe distress affecting the four largest New Zealand subsidiaries is transmitted to G-SIBs is less than the systemic risk transmitted by distressed G-SIBs to global bank returns. On the other hand, European banks have become recently more systemic for New Zealand subsidiaries.

108. Authorities are encouraged to expand their data collection efforts and modeling toolkit to enhance systemic risk analysis. The GFC showed that risk characteristics can change rapidly as financial institutions' reactions to stress may trigger feedback effects and set off adverse system-wide dynamics. This is confirmed by the contagion module on funding costs. Strengthening the data infrastructure over granular risk parameters and expanding analytical capabilities to capture systemic interlinkages would help upgrade the stress testing toolkit.

Appendix I. Risk Assessment Matrix

Source of risk	Overall Level of Concern	
	Likelihood of severe realization in 1–3 years	**Expected impact on financial stability**
Persistently lower dairy prices, triggered by supply and demand factors, reversing only gradually.	***High*** • While recent reduction in global supply has helped reduce the imbalance between demand and supply, markets have remained volatile and supply might readjust more gradually than expected, keeping dairy prices low in a downturn.	***Medium*** • The estimated payout would be well below the break-even payout of $5.25 per KgMS, resulting in a third consecutive season of negative cash flow for many farms. • Low milk prices would put the dairy sector under material stress, with debt relative to trend income increasing over 350 percent. • This could result in a sharp increase in NPLs.
A significant China downturn leading to a global growth slowdown and further declines in commodity prices.	***Medium*** • The China downturn would weaken New Zealand export demand directly (as China is New Zealand's second largest trading partner), and indirectly (as Australia is New Zealand's largest trading partner and Australia's largest export market is China). • The global growth slowdown would impact New Zealand through broad-based falls in export demand, low commodity prices, and confidence effects.	***Medium*** • A global recession would adversely affect bank earnings. Borrowers' creditworthiness would be affected (including through falling property prices, leading to greater than expected defaults, write-offs, and loan impairment charges. • The adverse effect on net income from a sharp slowdown could be amplified by large currency fluctuations and disruptions in capital flows. • Australian-owned New Zealand banks would be particularly exposed to a sharp slowdown in China, with potential spillover effects from Australian parents.
Dislocations in offshore wholesale funding markets.	***Medium*** • The trigger could be related to various sources, including disorderly and/or accelerated monetary policy normalization in the U.S., low market liquidity, or funding pressures for the Australian-owned New Zealand banks prompted by regulatory changes. • The cost of long-term wholesale funding would increase if heightened market volatility returns.	***Medium*** • Higher funding costs would erode banks' net interest margins weighing down on profits which could be also affected by lower securities valuations. • Banks' ability to borrow cross-border would be hampered by market disruptions, exacerbating funding and liquidity risk. • New Zealand banks' reliance on wholesale funding remains large, especially when just over half of this funding is sourced offshore. • RBNZ would be able to provide liquidity support.
A large correction in property markets, including both residential and commercial real estate (CRE) segments. This may be triggered by deteriorating global conditions, including from a significant downturn in China.	***Medium*** • Auckland house prices remain elevated relative to fundamentals and market pressures are increasing. • Price pressures are spreading to the rest of the country further stretching household balance sheets. • CRE prices continue to increase with prices relative to rents returning to pre-crisis peaks, while supply factors point at the risk of oversupply in the medium-term.	***Medium*** • The banking system would be affected by a generalized and substantial fall in property prices in New Zealand. • A fall in real estate prices would lead to higher credit impairment losses in portfolios secured by real estate assets. • If the correction triggers an economic recession, rising unemployment and lower corporate profits could lead to higher impairments across other asset classes. Credit risk would be exacerbated by high household debt-to-income ratios.

Appendix II. IMF Credit Risk Model

1. To project expected losses and credit loss-implied PDs, the FSAP team used a battery of individual-bank and panel regressions by sector. Bank-specific regressions outperform panel regressions with fixed effects and robust standard errors due to the diversity in provisioning and write-off practices across banks. Loan loss provisions for housing loans are driven by rising unemployment, stress in money markets, a steepening of the yield curve, and low residential housing prices (Appendix II, Table 1). Similar drivers underlie the projection of total impairment expense for housing loans though the performance of regressions decreases due to the noise inherent in bad expense data introduced by direct write-offs and cures of NPLs (Appendix II. Table 2).

2. Individual- and panel-based regressions are complemented by bilateral and multivariate vector autoregressive (VAR) estimation techniques and nonlinear principal component analysis (PCA) was used. The simultaneous behavior of credit risk, macroeconomic conditions, financial conditions, and real estate conditions was modeled explicitly in the econometric specification. In addition, global conditions were included as driver of credit risk, given the significant exposure of New Zealand farmers to developments in international markets.

3. VAR modeling is a useful approach to estimate and evaluate economic-wide models. It provides a flexible forecasting tool, it forms the basis of Granger causality testing, and it can be used to compute impulse responses. The key characteristics of this system of equations is that each equation is expressed as a function of its own lags, and other lags including lagged values of all the other variables of the system. For a multivariate VAR consisting of K variables $\{Y_{1,t,} Y_{2,t}, \ldots, Y_{K,t}\}$, the VAR is given by:

$$
\begin{aligned}
Y_{1,t} &= f_1\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{1,t} \\
Y_{2,t} &= f_2\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{2,t} \\
&\ldots \\
&\ldots \\
&\ldots \\
Y_{K,t} &= f_K\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{K,t}
\end{aligned}
$$

Where $\{e_{1,t,} e_{2,t}, \ldots, e_{K,t}\}$ is a vector of non-correlated error terms with zero mean and covariance matrix Ω.

4. The factor model approach allows extracting systematic risk factors from major macrofinancial variables and incorporates them into the VAR specification. To reduce the dimensionality of the multivariate VAR, the first factor of each principal component is included as an endogenous driver. The first factor explains about 60-70 percent of each factor. The composition of individual factors is informed by the following set of variables: (i) The macro factor is linked to macroeconomic developments related to GDP growth, inflation, and unemployment; (ii) the financial factor captures financial conditions related to money markets (90-day bank bill rate), public debt markets (term structure of the yield curve), equity markets (NZX 50), and FX markets (NZD/USD), and (iii) the real estate factor includes developments in residential housing (QVNZ house price index), commercial real estate (commercial property index), and farm land prices (REINZ dairy farm price). In addition, global conditions are captured in world GDP growth, USD LIBOR markets, and Fonterra dairy payout for dairy farmers.

5. The set of variables feeding into each principal component can be regarded as a system containing N variables $v_t = \{v_{1,t}, v_{2,t}, \ldots, v_{N,t}\}$ and $K \leq N$ factors $s_t = \{s_{1,t}, s_{2,t}, \ldots, s_{K,t}\}$, with:

$$v_t - \mu = \beta \cdot s_t + u_t$$

Where μ_{it} is the mean of v_{it}, and the vector of factors (s_t) and the vector of disturbances (u_t) have the properties $E[u_t] = 0$, $E[u_t u_t^{'}] = \Omega$, $E[s_t] = 0$, $E[s_t s_t^{'}] = I$. The equation shows that $v_t - \mu$ can be decomposed into a systematic component $\beta \cdot s_t$ and an idiosyncratic component (u_t). Given the properties of s_t and u_t, the covariance structure of v_t can be decomposed as $\text{cov}(v_t) = \beta\beta' + \Omega$ where $\beta\beta'$ captures the systematic factors.

6. For each asset class, a separate factor analysis is performed using sectoral specific drivers. Determinants of credit losses are expected to vary across sectors. While financial conditions affecting credit risk in corporate exposures are likely to include business rates and rates for overdraft loans for SMEs, default in mortgages are more likely to be explained by fixed rates in mortgages and house price developments. Global conditions affecting Fonterra payout ratios for dairy farmers and farm land prices are more likely to affect credit losses in the rural portfolio.

Table 1. Housing Loans – Key Drivers of Loss Provisions

	Bank specific regressions								Panel regressions	
	Bank 1		Bank 2		Bank 3		Bank 4			
Provision Rate	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Model 1	Model 2
u	0.268***		-0.761		0.116***		0.083***		0.070	
	(0.037)		(0.718)		(0.020)		(0.017)		(0.178)	
st	0.110***		0.511		-0.005		0.038***		0.213	
	(0.025)		(0.572)		(0.015)		(0.012)		(0.136)	
slope	0.122***		1.395***		-0.006		0.054***		0.372	
	(0.032)		(0.437)		(0.014)		(0.014)		(0.314)	
house prices	-0.011**		0.103		-0.008***		-0.006***		0.022	
	(0.004)		(0.086)		(0.002)		(0.002)		(0.025)	
L.u		0.206***		-1.438		0.107***		0.078***		-0.301
		(0.031)		(0.914)		(0.023)		(0.017)		(0.512)
L.st		0.090***		-0.453		0.014		0.057***		-0.095
		(0.018)		(0.794)		(0.015)		(0.010)		(0.185)
L.slope		0.138***		0.748		0.013		0.066***		0.224
		(0.026)		(0.523)		(0.013)		(0.012)		(0.150)
L.house prices		-0.017***		-0.055		-0.008***		-0.006***		-0.028
		(0.003)		(0.085)		(0.002)		(0.002)		(0.022)
Constant	-1.495***	-1.046***	3.229	12.058	-0.463***	-0.492***	-0.387***	-0.437***	-0.766	2.755
	(0.220)	(0.163)	(6.040)	(8.222)	(0.150)	(0.165)	(0.115)	(0.107)	(0.493)	(3.425)
Obs.	32	31	32	31	32	31	32	31	128	124
R-squared	0.897	0.916	0.329	0.222	0.768	0.773	0.881	0.900	0.120	0.086

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2. Housing Loans – Key Drivers of Asset Impairment Expense

	Bank Specific Regressions										Panel Regressions	
	Bank 1		Bank 2		Bank 3		Bank 4		Bank 5			
Loss rates	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2
u	-0.090		0.014		-0.049		0.045		-0.040		-0.022	
	(0.054)		(0.024)		(0.046)		(0.049)		(0.050)		(0.027)	
st	0.036		0.015		0.075		0.103*		0.005		0.048*	
	(0.066)		(0.044)		(0.054)		(0.055)		(0.036)		(0.019)	
slope	0.146***		0.061**		0.052**		0.124***		0.023		0.081**	
	(0.043)		(0.023)		(0.024)		(0.036)		(0.022)		(0.023)	
house prices	-0.009		-0.012***		-0.004		-0.002		-0.002		-0.006*	
	(0.006)		(0.003)		(0.004)		(0.006)		(0.005)		(0.002)	
L.u		-0.158*		-0.019		-0.035		-0.003		0.007		-0.053
		(0.081)		(0.038)		(0.043)		(0.033)		(0.062)		(0.032)
L.st		-0.056		0.003		0.101**		0.068***		0.019		0.021
		(0.080)		(0.030)		(0.038)		(0.020)		(0.039)		(0.030)
L.slope		0.080**		0.043*		0.071***		0.104***		0.024		0.065**
		(0.037)		(0.023)		(0.020)		(0.030)		(0.020)		(0.014)
L.house price		-0.024**		-0.016***		0.000		-0.008***		-0.000		-0.010*
		(0.009)		(0.004)		(0.004)		(0.003)		(0.003)		(0.005)
Constant	0.456	1.309	-0.054	0.221	0.028	-0.197	-0.632	-0.180	0.211	-0.118	-0.013	0.290
	(0.489)	(0.772)	(0.262)	(0.285)	(0.335)	(0.357)	(0.463)	(0.184)	(0.359)	(0.437)	(0.202)	(0.290)
Observations	30	30	30	30	30	30	30	30	30	30	150	150
R-squared	0.496	0.570	0.650	0.674	0.346	0.491	0.686	0.600	0.074	0.064	0.380	0.400

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3. Rural Loans – Key Drivers of NPLs

	Bank specific regressions								Panel regressions	
	Bank 1		Bank 2		Bank 3		Bank 4			
NPL rural	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Model 1	Model 2
u	2.077***		0.373		0.807***		1.677***		1.233*	
	(0.303)		(0.453)		(0.198)		(0.304)		(0.398)	
st	0.146		-0.169		0.428***		0.753***		0.289	
	(0.220)		(0.219)		(0.093)		(0.164)		(0.201)	
slope	-0.033		-0.048		0.529***		0.635***		0.271	
	(0.190)		(0.251)		(0.177)		(0.199)		(0.185)	
payout	0.144		0.239		0.069		-0.114		0.085	
	(0.155)		(0.163)		(0.108)		(0.140)		(0.076)	
land	0.029**		-0.011		-0.002		0.012		0.007	
	(0.013)		(0.016)		(0.007)		(0.014)		(0.009)	
L.u		2.162***		0.665		0.825***		1.559***		1.303**
		(0.360)		(0.437)		(0.153)		(0.327)		(0.354)
L.st		0.469*		0.039		0.597***		0.979***		0.521*
		(0.234)		(0.199)		(0.092)		(0.149)		(0.198)
L.slope		0.360		0.109		0.759***		0.967***		0.549*
		(0.220)		(0.260)		(0.076)		(0.202)		(0.197)
L.payout		0.019		0.023		-0.084		-0.213		-0.064
		(0.151)		(0.158)		(0.061)		(0.142)		(0.057)
L.land		0.030**		-0.012		-0.001		0.013		0.008
		(0.013)		(0.016)		(0.005)		(0.012)		(0.009)
Constant	-11.933***	-13.261***	-1.211	-2.515	-5.942***	-5.970***	-10.977***	-10.853***	-7.516*	-8.150**
	(2.123)	(2.636)	(3.070)	(3.114)	(1.466)	(1.138)	(2.032)	(2.269)	(2.554)	(2.505)
Observation:	32	31	32	31	32	31	32	31	128	124
R-squared	0.703	0.720	0.343	0.363	0.809	0.883	0.712	0.759	0.527	0.567

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

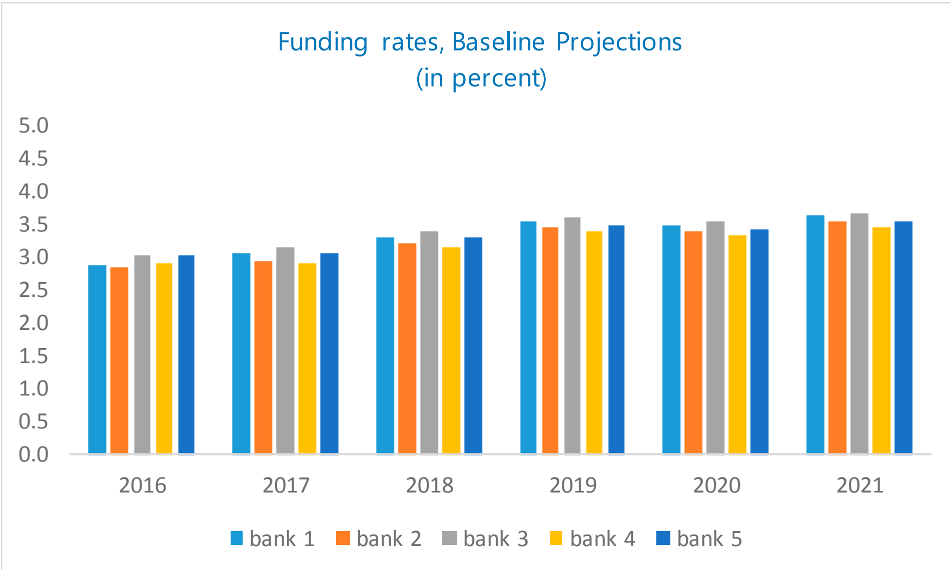
Table 1. Key Determinants of Funding Costs

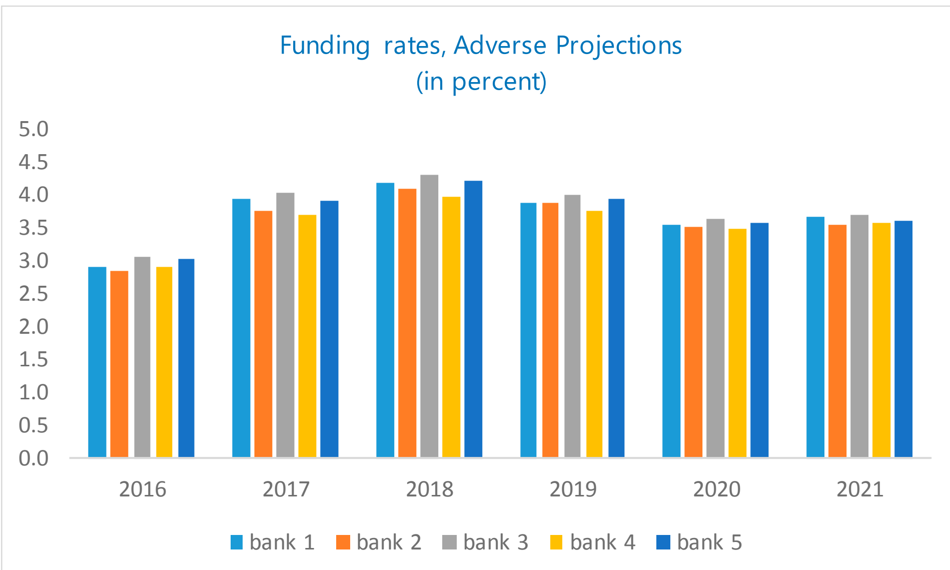
	Bank specific regressions										Panel regressions	
	Bank 1		Bank 2		Bank 3		Bank 4		Bank 4			
Funding Costs	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2	Spec. 1	Spec. 2
prov	1.089**	0.947*	0.896	-0.159	-0.041	-0.102	1.880***	1.888***	0.710**	0.263	0.578	0.630
	(0.416)	(0.537)	(2.222)	(2.005)	(0.330)	(0.316)	(0.288)	(0.336)	(0.311)	(0.394)	(0.306)	(0.385)
lev	0.056*	0.026	0.360***	0.472***	0.085**	0.051	-0.005	-0.048	0.070***	0.070***	0.047***	0.057***
	(0.031)	(0.036)	(0.095)	(0.069)	(0.040)	(0.040)	(0.084)	(0.084)	(0.014)	(0.017)	(0.006)	(0.009)
g	-0.132***		-0.130**		-0.044*		-0.005		-0.086**		-0.149**	
	(0.021)		(0.060)		(0.023)		(0.032)		(0.035)		(0.041)	
u		0.172		-0.075		0.278***		-0.096		0.450***		0.160
		(0.108)		(0.172)		(0.094)		(0.126)		(0.149)		(0.132)
st	0.783***	0.770***	0.903***	0.795***	0.559***	0.572***	0.710***	0.646***	0.674***	0.826***	0.678***	0.704***
	(0.124)	(0.119)	(0.148)	(0.169)	(0.099)	(0.117)	(0.162)	(0.170)	(0.075)	(0.103)	(0.060)	(0.078)
slope	0.063	0.011	0.256	0.212	-0.037	-0.161	0.227**	0.233**	0.042	-0.029	0.153	0.108
	(0.080)	(0.082)	(0.187)	(0.166)	(0.091)	(0.100)	(0.099)	(0.106)	(0.079)	(0.064)	(0.079)	(0.084)
libor	0.231***	0.237***	0.153	0.203*	0.051	0.045	0.345*	0.323	-0.074	-0.088	0.084	0.095
	(0.067)	(0.078)	(0.110)	(0.104)	(0.048)	(0.043)	(0.199)	(0.210)	(0.091)	(0.079)	(0.045)	(0.051)
contagion	0.632***	0.789***	0.328	0.836**	0.263***	0.248**	0.956***	0.896***	0.473**	0.554***	0.154	0.492*
	(0.109)	(0.079)	(0.393)	(0.382)	(0.096)	(0.100)	(0.224)	(0.195)	(0.231)	(0.160)	(0.122)	(0.205)
Constant	-2.435	-2.486	-15.573***	-18.987***	3.194*	3.170*	-2.955	-0.728	0.223	-2.775***	0.905*	-0.595
	(2.795)	(2.808)	(3.749)	(2.735)	(1.752)	(1.613)	(3.088)	(3.110)	(0.423)	(0.873)	(0.384)	(0.469)
Observations	62	62	62	62	62	62	39	39	56	56	281	281
R-squared	0.955	0.954	0.853	0.856	0.977	0.979	0.943	0.943	0.940	0.948	0.868	0.855

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 1. New Zealand: IMF Funding Cost Projections





Source: IMF staff estimates.

Appendix IV. Basel III LCR Scenario – Outflows

	LCR	Outflow scenario 2	Outflow scenario 3
Retail Deposits			
Demand deposits			
Stable deposits	5%	10%	5%
Less stable retail deposits	10%	15%	10%
Term deposits, residual maturity > 30d	0%	0%	0%
Unsecured Wholesale Funding			
Demand and term deposits, residual maturity < 30d, small business			
Stable deposits	5%	10%	5%
Less stable deposits	10%	15%	10%
Operational deposits generated by clearing, custody, and cash management activities	25%	50%	75%
Portion covered by deposit insurance	5%	5%	50%
Cooperative banks in an institutional network	25%	25%	100%
Nonfinancial corporates, sovereigns, central banks, multilat development banks, PSEs			
Fully covered by deposit insurance	20%	20%	50%
Not fully covered by deposit insurance	40%	60%	100%
Other legal entity customers	100%	100%	100%
Secured Funding			
Secured funding with a central bank, or backed by Level 1 assets	0%	0%	0%
Secured funding backed by Level 2A assets	15%	15%	15%
Secured funding backed by non-Level 1 or non-Level 2A asset, with domestic sovereigr	25%	25%	50%
Funding backed by RMBS eligible for Level 2B	25%	25%	50%
Funding backed by other Level 2B assets	50%	50%	100%
Other secured funding transactions	100%	100%	100%
Additional Requirements			
Valuation changes on non-Level 1 posted collateral securing derivatives	20%	20%	20%
Excess collateral held by bank related to derivate transactions that could be called anyt	100%	100%	100%
Liquidity needs related to collateral contractually due on derivatives transactions	100%	100%	100%
Increased liquidity needs related to derivative transactions allowing collateral substitu	100%	100%	100%
ABCP, SIVs, conduits, SPVs, or similar			
Liabilities from maturing	100%	100%	100%
Asset backed securities	100%	100%	100%
Undrawn but committed credit and liquidity facilities			
Retail and small business	5%	10%	5%
Nonfinancial corporates, sovereigns, central banks, multilat dev. banks, PSEs			
Credit facilities	10%	30%	10%
Liquidity facilities	30%	50%	30%
Supervised banks	40%	50%	50%
Other financial institutions			
Credit facilities	40%	50%	50%
Liquidity facilities	100%	100%	100%
Other legal entity customers, credit and liquidity facilities	100%	100%	100%
Other contingent funding liabilities			
Trade finance	5%	10%	5%
Customer short positions covered by customers' collateral	50%	75%	75%
Additional contractual outflows	100%	100%	100%
Net derivative cash outflows	100%	100%	100%
Any other contractual cash outflows (not listed above)	100%	100%	100%

Appendix V. CoVaR Approach to Assess Market Contagion

1. **The CoVaR methodology is applied to evaluate the potential for individual bank stress to propagate throughout the financial system.** The channel of propagation of financial distress is contagion through financial markets as price-to-book ratios change and banks' balance sheets evolve. The quantification of contagion effects depends on: (i) the definition of the financial system; (ii) the economic and financial circumstances in which a firm's failure arises.

2. **A bank is distressed when it reaches its VaR returns.** We proxy weekly bank returns by the estimated growth rate of the market-implied value of assets. This measure captures individual distress generated by: (i) a decline in asset prices, and/or (ii) balance sheet deleveraging. We apply the market-to-book equity ratio to transform book-valued total assets into market-valued total assets. Since balance sheet data is reported quarterly or semi-annually, we use a cubic spline interpolation to smooth accounting data to weekly frequency.

3. **The relevant financial system is defined as the set of globally active banks** (Appendix V. Table 1). The list of banking institutions draws from the 2015 FSB update of the list of systemically important banks (G-SIBs).[1] The analysis runs over November 2006 through October 2016. Balance sheet data and equity data is sourced from Bloomberg and Thomson Reuters.

4. **The time-series estimation of extreme returns is enhanced by using a set of macrofinancial state variables.** The choice of variables is guided by their role in affecting expected returns in financial markets. We use the set of state variables sampled from the U.S. market as common conditioning variables to characterize the time-varying conditional VaR and CoVaR dynamics of both individual banks and the financial system: (i) Volatility Index (VIX) of the Chicago Board Options Exchange (CBOE); (ii) liquidity spread defined as the difference between the 3-month LIBOR rate and the 3-month US T-bill rate; (iii) the weekly change in the US 3-month T-bill rate, (iv) the change in the slope of the US yield curve defined as the spread between the 10-year generic bond yield and the 3-m T-bill yield; (v) .the S&P 500 Equity Index weekly return, and (vi) a global financial crisis dummy over July 2007-December 2008.

5. **The CoVaR approach measures the marginal contribution of an individual financial institution distress to the risk of the financial system.** The contribution of each institution to left tail risk of the whole financial system is measured by its time-varying Δ CoVaR (Appendix V. Box 1).

6. **The baseline specification consists of**: (i) a symmetric specification in the co-dependence structure of tail returns, (ii) bank return defined as the growth rate of the implied-market valued of assets, (iii) a quantile approach to the estimation of VaR dynamics, and (iv) a confidence level defined by the 99th percentile of the loss distribution.

7. **We conduct a battery of robustness checks including**: (i), an asymmetric model allowing for a differential contribution to systemic risk across states of balance sheet growth and

[1] All the 30 G-SIBs are included in the analysis except for BCPE Groupe as it is not listed in the stock market.

deleveraging (ii) a CoVaR analysis applied to bank equity returns, (iii) the characterization of individual VaR dynamics using a GARCH (1,1) approach on conditionally demeaned returns, and (iv) the analysis at the 95th percentile of the loss distribution.

Table 1. List of Global Banks

Country	Bank	Bloomberg Ticker
Australia	AUST AND NZ BANKING GROUP	ANZ AU Equity
Australia	COMMONWEALTH BANK OF AUSTRAL	CBA AU Equity
Australia	NATIONAL AUSTRALIA BANK LTD	NAB AU Equity
Australia	WESTPAC BANKING CORP	WBC AU Equity
China	Agricultural Bank of China	1288 HK Equity
China	Bank of China	3988 HK Equity
China	China Construction Bank	939 HK Equity
China	Industrial and Commercial Bank of China Limit	1398 HK Equity
France	BNP PARIBAS	BNP FP Equity
France	CREDIT AGRICOLE SA	ACA FP Equity
France	SOCIETE GENERALE	GLE FP Equity
Germany	DEUTSCHE BANK AG-REGISTERED	DBK GR Equity
Italy	UNICREDIT SPA	UCG IM Equity
Japan	MITSUBISHI UFJ FINANCIAL GRO	8306 JP Equity
Japan	MIZUHO FINANCIAL GROUP INC	8411 JP Equity
Japan	SUMITOMO MITSUI FINANCIAL GR	8316 JP Equity
Netherlands	ING GROEP NV-CVA	INGA NA Equity
Spain	BANCO SANTANDER SA	SAN SM Equity
Sweden	NORDEA BANK AB	NDA SS Equity
Switzerland	Credit Suisse Group AG	CSGN VX Equity
Switzerland	UBS Group AG	UBSG VX Equity
UK	BARCLAYS PLC	BARC LN Equity
UK	HSBC HOLDINGS PLC	HSBA LN Equity
UK	Standard Chartered	STAN LN Equity
UK	ROYAL BANK OF SCOTLAND GROUP	RBS LN Equity
United States	BANK OF AMERICA CORP	BAC US Equity
United States	BANK OF NEW YORK MELLON CORP	BK US Equity
United States	CITIGROUP INC	C US Equity
United States	GOLDMAN SACHS GROUP INC	GS US Equity
United States	JPMORGAN CHASE & CO	JPM US Equity
United States	MORGAN STANLEY	MS US Equity
United States	STATE STREET CORP	STT US Equity
United States	WELLS FARGO & CO	WFC US Equity

Note: This table shows the four Australian banks and the list of 29 G-SIBs designated by FSB as of Nov 2015. G-SIBs are required to hold additional capital buffers contingent on their risk bucket category (2.5 percent RWAs for banks highlighted in red; 2.0 percent RWAs in orange; 1.5 percent RWAs in blue; and 1.0 percent RWAs in green). Groupe BCPE is excluded because it not listed.

Table 2. Drivers of Global System Returns

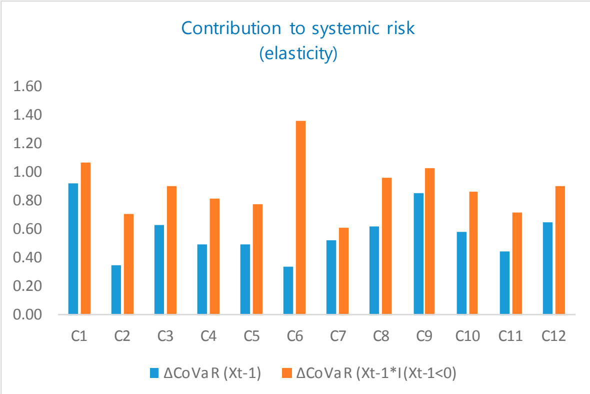
	Constant	VIX	liquidity spread	change US 3m Tbill	change US slope	return S&P500	Crisis Dummy	CoVaR Slope	Pseudo R2
Australia	0.09	-0.17	-7.32	-6.36	-2.34	0.00	4.86	0.92	0.38
	(0.13)	(-5.1)	(-11.)	(-2.5)	(-1.2)	(0.02)	(5.89)	(9.61)	
China	1.28	-0.24	-10.17	-1.92	-2.01	-0.02	7.52	0.35	0.27
	(1.73)	(-6.1)	(-10.)	(-0.4)	(-0.9)	(-0.1)	(4.84)	(3.09)	
France	0.13	-0.12	-3.52	-10.35	-2.24	-0.25	0.80	0.63	0.56
	(0.34)	(-5.7)	(-8.1)	(-6.2)	(-2.3)	(-4.0)	(1.23)	(19.2)	
Germany	1.13	-0.20	-3.71	0.60	1.90	-0.06	3.21	0.49	0.49
	(2.26)	(-7.1)	(-5.3)	(0.21)	(1.13)	(-0.7)	(2.70)	(11.0)	
Italy	-0.67	-0.11	-3.23	-5.50	1.72	-0.23	1.39	0.49	0.44
	(-1.2)	(-4.0)	(-4.8)	(-1.7)	(0.97)	(-2.3)	(1.43)	(10.3)	
Japan	0.27	-0.21	-6.40	-6.47	-1.67	-0.18	1.44	0.34	0.29
	(0.32)	(-4.5)	(-6.2)	(-1.5)	(-0.6)	(-1.1)	(1.14)	(3.02)	
Netherlands	-1.59	-0.06	-1.44	-6.84	-1.09	-0.14	-1.13	0.52	0.59
	(-4.1)	(-2.8)	(-2.7)	(-2.6)	(-0.9)	(-2.0)	(-1.3)	(13.8)	
Spain	1.45	-0.20	-4.77	-1.19	0.55	-0.20	3.61	0.61	0.53
	(3.88)	(-10.)	(-8.8)	(-0.4)	(0.36)	(-3.2)	(4.23)	(14.8)	
Sweden	-1.03	-0.12	-1.87	2.81	-0.40	0.07	1.01	0.86	0.53
	(-2.2)	(-4.7)	(-3.4)	(1.03)	(-0.2)	(0.92)	(1.11)	(14.9)	
Switzerland	0.13	-0.09	-4.52	-5.08	-2.15	0.08	2.57	0.58	0.50
	(0.32)	(-3.8)	(-7.2)	(-3.0)	(-2.0)	(1.38)	(2.93)	(11.0)	
United Kingdom	0.87	-0.22	-0.73	-4.42	1.11	-0.34	-1.75	0.44	0.51
	(1.80)	(-8.0)	(-1.1)	(-1.7)	(0.64)	(-4.2)	(-1.9)	(8.77)	
United States	-1.13	-0.08	-3.48	-1.70	-3.65	0.13	1.13	0.64	0.48
	(-2.7)	(-3.5)	(-7.1)	(-0.9)	(-2.4)	(1.95)	(1.44)	(12.0)	

Note: This table shows the estimated coefficients and t-statistics and pseudo-R2 in 1% quantile regressions of global system returns on a set of state variables and the market-implied asset returns of each country (CoVaR slope) when banks headquartered in this country are in distress. These results are based on weekly data from the week of November 10, 2006 to the week of October 14, 2016.

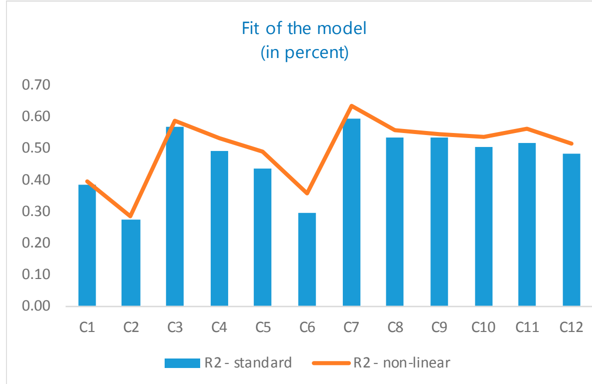
Figure 1. Linear and Non-linear Specification of CoVaR

The significance of tail individual returns to explain tail global system returns increases under a non-linear specification. The overall fitness of the model also increases.

Across the 12 countries of the analysis, the median elasticity of returns increases from 0.55 to 0.88...



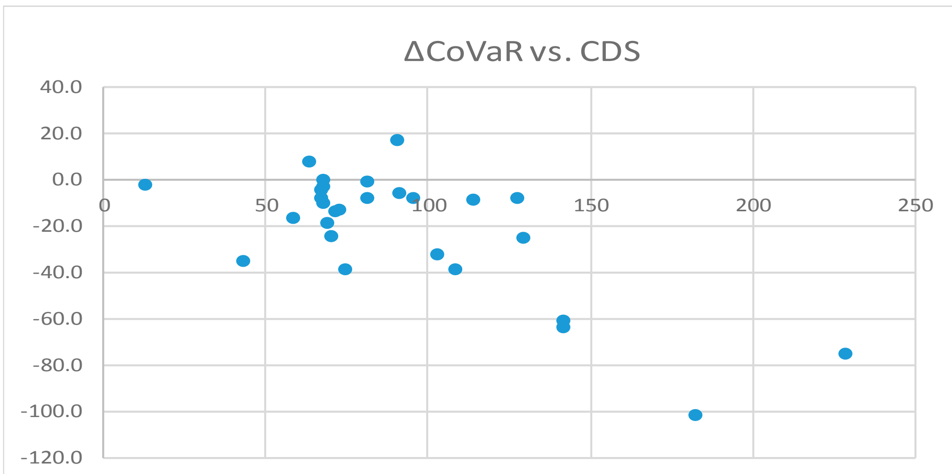
...while the pseudo-R2 of the specification increases.



Source: IMF staff estimates.

Figure 2. Individual Risk vs. Systemic Risk

There is no clear link between systemic risk (measured by ΔCoVaR) and individual risk (measured by CDS).



Note: The chart includes data for the 4 Australian banks and 25 G-SIBs for which data is available, as of October 14, 2016. *ΔCoVaR is measured in terms of contribution to equity returns.*

Source: IMF staff estimates.

Box 1. Overview of the CoVaR Methodology

The CoVaR is defined as the maximum expected loss in the banking system for a given confidence level and time horizon, conditional on the maximum expected loss of an individual bank at a specific confidence level and time horizon. More formally, the $(1-\lambda)\%$ CoVaR of system j given the $(1-\lambda)\%$ VaR of bank *i*, denoted $CoVaR_{\lambda,t}^{j|i}$, is defined as the λ quantile of the conditional loss function:

$$\Pr\left(X_t^j \leq CoVaR^{j|\Phi\left(X_t^i\right)} \middle| \Phi\left(X_t^i\right)\right) \tag{1}$$

where X_t^j and X_t^i denote system and individual bank returns.

A bank's individual contribution to systemic risk can be approximated by its Δ CoVaR:

$$\Delta CoVaR_{\lambda,t}^{i} = CoVaR_{\lambda,t}^{j|i} - VaR_{\lambda,t}^{j} \tag{2}$$

which captures how much risk bank i adds to overall systemic risk when it reaches its VaR.

For each conditioning event, we construct a different banking system to avoid spurious correlation. The banking system is defined as the weighted average returns of the remaining banks in the sample, once we exclude the bank in distress. In particular, the returns of the banking system given bank *i*'s distress are constructed as:

$$X_t^{S,i} = \sum_{j=1,\, j\neq i}^{n} \omega_{t,j} X_t^j, \quad \omega_{t,j} = W_t^j \left(\sum_{j=1,\, j\neq i}^{n} W_t^j\right)^{-1} \tag{3}$$

where X_t^j refers to the returns of the *j*-th bank and W_t^j is the book value of total assets.

The existence of risk spillovers is captured through the estimates of the $\delta_{\lambda,i}$ parameter. The left tail of the banking system can be predicted by observing the distribution of bank i's returns. The symmetric specification can be approximated by:

$$X_t^{S,i} = Z_{t-1}^{'}\beta_\lambda + \delta_{\lambda,i} X_t^i + u_{\lambda,t} \tag{4}$$

We check for possible asymmetries in the specification. Since the interest of our analysis is clearly on the behaviour of the left tail, for which 5% VaR is expected to be a negative value, the basic specification (4) neglects an important feature of the conditioning: the final prediction is constructed on a negative value. If we factor in the reinforcing effects from credit constraints in a downward market, the model is likely to yield parameter estimates of $\delta_{\lambda,i}$ which can significantly underestimate the impact on the system of a negative shock in the balance sheet of a bank. We estimate the asymmetric specification:

$$X_t^{S,i} = Z_{t-1}^{'}\beta_\lambda + \delta^{-}{}_{\lambda,i} X_t^i I_{\left(X_t^i<0\right)} + \delta^{+}{}_{\lambda,i} X_t^i I_{\left(X_t^i\geq 0\right)} + u_{\lambda,t} \tag{5}$$

The econometric specification of the contribution of bank *i*'s distress to the distress of the banking system is approached by:

$$\Delta CoVaR_{\lambda,t}^{i} = \hat{\delta}_{\lambda,i}\left(VaR_i^t(\lambda) - VaR_i^t(50\%)\right) \tag{6}$$

See Adrian and Brunnermeier (2016), and Lopez-Espinosa, Moreno, Rubia and Valderrama (2012, 2015).

Appendix VI. Stress Testing Matrix (STeM): Solvency and Liquidity Risks

Banking Sector: Solvency Test			
Domain		Framework	
		TD by Authorities	TD by FSAP Team
1. Institutional perimeter	Institutions included	Four major banks: ANZ Bank New Zealand Ltd; ASB Bank Ltd; Bank of New Zealand, and Westpac New Zealand Ltd. The criteria used to determine the institutional perimeter include: firms' balance sheet, firms' share in the lending market, and firms' role in the New Zealand payment system	Five major banks: ANZ Bank New Zealand Ltd; ASB Bank Ltd; Bank of New Zealand, Westpac New Zealand Ltd., and Kiwibank Ltd. The criteria used to determine the institutional perimeter include: firms' balance sheet, firms' share in the lending market, and firms' role in the New Zealand payment system
	Market share	About 85 percent of total banking sector assets.	About 90 percent of total banking sector assets.
	Data	Effective date: June 2016. Effective date for market risk: June, 2016. Data: Supervisory data, publicly available data. Scope of consolidation: Consolidated group basis. Insurance activities are excluded, but firms have to assess the impact of the scenario on insurance activities and model the impact on dividends, holdings of minority interests, capital deductions, and risk weightings.	Effective date: June 2016. Effective date for market risk: June, 2016. Data: Supervisory data, publicly available data (bank disclosures, Bloomberg, Thomson Reuters, Dealogic, Markit, Haver Analytics, Moody's KMV, Bankscope, SNL, International Financial Statistics (IFS), IMF Global Assumptions (GAS), and IMF WEO). Scope of consolidation: Consolidated group basis. Insurance activities are excluded, but firms have to assess the impact of the scenario on insurance activities and model the impact on dividends, holdings of minority interests, capital deductions, and risk weightings.
	Stress testing process	The RBNZ conducts its own TD macroprudential stress test based on the WEO/RBNZ forecast (baseline) and IMF's Global Macrofinancial Model with inputs from the RBNZ (adverse). RBNZ uses its own structural models for real estate exposures (TUI model) and the dairy stress portfolio (model for defaults on dairy lending). The results aggregation process includes adjustments based on expert judgment, including losses for other portfolios.	The FSAP team conducts its own TD macroprudential stress test based on the WEO/RBNZ forecast (baseline) and the IMF's Global Macrofinancial Model with inputs from the RBNZ (adverse). For expected losses, a separate credit risk model is calibrated for 5 economic sectors (drawing on RBNZ supervisory data) and core industry sectors (drawing on market-based data). For unexpected losses in IRB portfolios, PDs are estimated from stressed loan loss provision ratios linked to IRB models and allowing for RBNZ regulatory overlays on farming lending and mortgage exposures.

Banking Sector: Solvency Test			
Domain		Framework	
		TD by FSAP Team	TD by Authorities
			For STA exposures and specialized lending subject to the slotting approach, stressed NPL ratios, stressed coverage ratios, and a stressed transition matrix for performing exposures are projected. For robustness, the TD stress test includes projections using RBNZ's structural TUI model on borrowers' balance sheets and a detailed stress test of banks' mortgage book by LTV vintage using a Merton-based option-value approach. For market risk, stress to major sovereign issuers is modeled.
2. Channels of risk propagation	Methodology	Risks are projected using a variety of structural models (based on borrowers' stressed financials), macro models (based on stressed projections for key macroeconomic and financial variables) and expert judgment. RBNZ models the impact of a sharp rise in wholesale and retail funding costs, and how the increase in funding costs is passed on to customers drawing on banks' BU stress test results and expert judgment.	A comprehensive battery of econometric and structural models is specifically developed and calibrated for the 2017 New Zealand FSAP. Over 100 credit risk models are estimated for PDs based on bank-level regressions, panel-based regressions, and multivariate vector autoregressive models (VAR) with principal component analysis (PCA). Over 25 models are estimated to project solvency and funding cost interactions and contagion from peer banks. Lending rates are linked to shocks to deposit rates and wholesale funding spreads, projected in line with the macro scenario, bank-specific solvency ratios and funding stress in peer banks. Shocks to NIMs are modeled as a function of RBNZ's Official Cash Rate, money market shocks, and the slope of the yield curve, with pass-through effects estimated empirically, and linked to the interest repricing schedule for each bank as of June 2016. Bank specific wholesale spreads are linked to the behavior of ytm spreads of active bonds at the peak of the GFC under the adverse scenario and over the last two years under the baseline scenario. Mark-to-market losses from full revaluation of sovereign securities, excluding balance sheet hedges.

Banking Sector: Solvency Test			
Domain		**Framework**	
		TD by FSAP Team	**TD by Authorities**
3. Tail shocks	Scenario analysis	The adverse scenario is calibrated using the IMF's Global Macrofinancial Model and auxiliary models estimated by the RBNZ drawing on historical crisis-episodes in New Zealand, Australia, and the United Kingdom. This scenario is characterized by deteriorating global conditions from a sharper than expected global growth slowdown, tighter and more volatile conditions, a credit cycle downturn in China, and persistently lower commodity prices. The global downturn impacts directly Australia and New Zealand. Additional spillovers hit New Zealand through financial linkages with Australia, autonomous confidence effects, and a sharp correction in the New Zealand real estate market and equity market. This scenario constitutes a 2.4 standard deviation move in two-year cumulative real GDP growth rate by 2018, calculated over 1990–2016. New Zealand GDP growth contracts by - 1.4 percent in 2017 relative to a baseline projection of 2.5 percent growth rate. Real GDP reaches a peak deviation from baseline levels at -7.1 percent in 2018–19, which is higher than the 4.1 percent assumed in the 2014 joint stress test undertaken by APRA and RBNZ. Unemployment peaks at over 10 percent by end-2018 and there is persistent disinflation over 12 quarters. There is a sharp real estate market correction, with a peak-to-trough decline of 40 percent for residential prices, and 30 percent for commercial real estate. In addition, the real equity price index falls by 30 percent by end-2018. The deep recession increases banks' credit risk with money market peaking in 2017, and bank credit falling by 20 percent relative to baseline levels by 2021._This is accompanied by the steepening of the yield curve induced by a rebound in the term premium driven by internationally correlated duration risk premium shocks, pushing up long-term lending rates. The scenario includes an additional idiosyncratic and system-wide funding risk shock triggered by dislocation of money markets and linked to banks' capital ratios under stress and contagion from other New Zealand banks.	
	Sensitivity analysis		Concentration risk. Shocks to NZL residential house prices impacting stressed LGDs. Shocks to the NZD swap curve. Shocks to net interest margins. Additional calibration informed by 2016Q3 banks' reverse stress test exercise.
4. Risks and buffers	Positions/risk factors assessed	<u>Credit risk</u> Mortgage loans credit risk losses projected using the TUI model, a structural approach to the understanding and measurement of residential mortgage lending risk. Rural portfolio credit risk losses projected using the dairy portfolio model that incorporates cross-sectional data and considers behavioral assumptions of the drivers of default.	<u>Credit risk</u> IRB and Standardized exposure. Positions include retail exposures, corporate exposures, sovereign/public sector exposures, and exposures to financial institutions. Covered bonds and securitization exposures are included. Off-balance sheet exposures using baseline and stressed Credit Conversion Factors (CCFs) are included.

Banking Sector: Solvency Test			
Domain		Framework	
		TD by FSAP Team	TD by Authorities
		Other sectoral categories in the credit book include: SME/corporate lending, CRE lending, consumer lending, sovereign/bank lending ("liquid bonds"). <u>Operational and market risk</u> Driven by mark-to-market losses of the liquid asset portfolio. Losses are reversed as bonds mature. <u>Profits</u> Margin compression as banks push down lending margins to alleviate customer distress. Also, they are unable to pass higher funding spreads on to fixed term mortgage customers. <u>Regulatory impact</u> Phase-out of Tier 1 and Tier 2 instruments according to transitional rules.	<u>Sovereign risk</u> Mark-to-market valuation of securities (from shocks to interest rates and credit spreads) in trading book and AFS/FVO linked to macro scenario. <u>Market risk other than sovereign risk</u> Market stress from shocks to changes in interest rates and credit spreads. <u>Profits</u> Income from loans and non-loan activities. Interest income declines for the amount of lost income from defaulted loans. Interest income from non-defaulting loans is estimated according to satellite models. Interest expenses increase due to rising funding costs linked to the macroeconomic scenario with empirically estimated pass-through, stressed capital ratios and contagion from peer banks. Net fee and commission income and other income evolve with macroeconomic conditions and banks' balance sheets. No change in business models (no rebalancing of portfolio). Balance sheets evolve over the stress horizon according to the scenario. <u>Regulatory impact</u> The effects of the phase-out of no-longer-eligible additional Tier 1 and Tier 2 capital are included. No conversion of additional Tier 1 capital is assumed during the stress horizon.
	Behavioral adjustments	<u>Dynamic balance sheets</u> Credit supply effects are disallowed to calibrate credit risk projections. Balance sheets evolve with key macroeconomic aggregates adjusting for credit demand effects.	

Banking Sector: Solvency Test			
Domain		Framework	
		TD by FSAP Team	TD by Authorities
		EAD under stress from off-balance sheet exposures increases about 5-10 percent on average, reflecting higher use of undrawn credit and liquidity facilities. As a conservative assumption, all facilities are assumed to be contractually irrevocable ("committed") to extend funds in the future. Maturing assets are replaced by exposures of the same type and risk. Dividends are linked to banks' net profits. Under positive profits, the dividend payout floor is set at 30 percent subject to dividend restrictions if banks breach their capital conservation buffer. Otherwise, no dividend payout is assumed. The effective tax rate evolves with the macro scenario. Losses are recognized in the same year that a shock hits. If banks' capital ratio falls below regulatory minimum during the stress test horizon, no prompt corrective action is assumed.	
5. Regulatory and market-based standards and parameters	Calibration of risk parameters	Parameter definition PiT credit loss rates for expected losses and TTC PDs and LGDs for regulatory capital requirements (RWAs). Parameter calibration For IRB exposures, shifts to RWAs are informed by banks' BU stress test results, historical experience during the GFC and expert judgment.	Parameter definition PiT, PDs and LGDs for expected losses. PiT TTC-adjusted PDs and TTC LGDs for regulatory capital requirements (RWAs). PDs are blended PDs (i.e., include both defaulted and non-defaulted counterparties) by asset class. LGDs are calculated post credit risk mitigation by asset class. Parameter calibration For IRB exposures, shifts to PDs are informed by shocks to credit risk losses and banks' estimated PDs calculated in historical stressed episodes. Shocks to LGDs are projected using a Merton-based approach for mortgage exposures, shocks to unemployment for retail unsecured exposures, and shocks to GDP for corporate exposures. PDs and LGDs evolve with the macroeconomic and financial variables of the scenario. For STA exposures and specialized lending subject to the slotting approach, inflows into NPL categories are based on a panel regression, including risk migration for performing exposures, and stressed coverage ratios.

Banking Sector: Solvency Test (Concluded)			
Domain		Framework	
		TD by FSAP Team	TD by Authorities
	Regulatory standards	Capital definition according to Basel III/RBNZ rulebook, including CET1, Tier 1, and total CAR. The CET1 ratio is computed using Basel III end-point definition. Capital components that are no longer eligible for additional Tier 1 and Tier 2 capital components follow a front-loaded Basel III transitional path according to RBNZ's regulatory capital framework with complete phase-out by January 1, 2018. CET1/Tier 1/CAR ratio hurdle rate at 4.5/6.0/8.0 percent of RWAs for regulatory minimum capital breach with an additional 2.5 percent hurdle rate for capital buffer breach. Leverage ratio (3 percent hurdle rate met with Tier 1 capital) using the Basel III definition, notwithstanding the fact that the NZ liquidity regulatory framework does not include a leverage metric.	
6. Reporting format for results	Output presentation	Evolution of CET1, Tier 1, CAR for the aggregate banking system. Distribution of individual CET1, Tier 1, CAR in the banking system. Contribution of key drivers to aggregate net profits and aggregate CET1 capital ratios. Number of banks and share of total assets below hurdle rates. Capital shortfall in terms of nominal GDP.	

Liquidity Stress Testing Matrix		
Domain		**IMF designed stress test conducted jointly with the RBNZ**
1. Institutional perimeter	Institutions	Selection criteria: RBNZ liquidity returns under BS13.
	Market share	All fifteen locally incorporate banking institutions.
	Data and base date	The one-week and one-month maturity mismatch is based on supervisory data as of August 31 2016, under the RBNZ liquidity policy framework (BS13). The one-week and one-month quasi-LCR test is based on supervisory data as of August 31 2016. The definition of HQLA is stricter than under APRA's Basel III LCR implementation under APRA's *Prudential Standard APS 210 Liquidity* given the lack of a fee-paying contingent credit line facility.
2. Channels of risk propagation	Methodology	Basel III measures of liquidity risk—the quasi-LCR conducted on three calibrated scenarios. A cash-flow analysis based on RBNZ's mismatch ratio. A general maturity mismatch analysis by maturity bucket based on RBNZ's core funding ratio.
3. Risks and buffers	Risks	Funding liquidity risk, rollover risk, and market liquidity risk.
	Buffers	HQLA securities assessed at market values net of haircut on a security-by-security basis.
4. Tail shocks	Size of the shock	A range of adverse scenarios LCR Scenario under standard assumptions calibrated by BCBS. An LCR "New Zealand retail stress" scenario. The calibration of this deposit run-off scenario replicates the peak stress observed in relevant comparator jurisdictions during the GFC. An LCR "New Zealand wholesale stress" scenario. This scenario replicates the liquidity stress observed during the GFC. It is characterized by: (i) a freeze of wholesale funding on the interbank market, secured funding market via repo and covered bonds, and the commercial paper market (with run-off rate for operational deposits of 75 percent and for not-fully covered corporate deposits of 100 percent), and (ii) liquidity risk from shocks to secured funding backed by RMBS to 50 percent and shocks to undrawn but committed credit and liquidity facilities with run-off rates of 50 percent for supervised banks and other financial institutions. Implied cash flow assumptions include haircuts of up to 60 percent for securities and bank loans that can be mobilized in repos, no issuance of new unsecured funding and freeze of securitization markets, call-back rates of up to 100 percent, and cash outflows of up to 75 percent.

Liquidity Stress Testing Matrix (Concluded)		
Domain		**IMF designed stress test conducted jointly with the RBNZ**
5. Regulatory standards	Regulatory standards	Counterbalancing capacity above net cash outflows under stress scenario. Basel III transitional arrangement for the LCR ratio at 80 percent. CFR above RBNZ's regulatory 75 percent threshold.
6. Reporting format for results	Output presentation	Changes in average liquidity position and counterbalancing capacity for each scenario. Distribution of banks' liquidity position under each scenario. Number of banks with counterbalancing capacity below net cash outflows. Banks' post-shock net liquidity position. Liquidity shortfall in terms of banking system total liabilities.

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