Discussion Document: Stress-testing methodology for New Zealand incorporated banks.

1.   Introduction

The purpose of this paper is to provide advice to New Zealand incorporated banks on how to conduct macroeconomic stress tests, which are analyses of how their institution would be able to handle a severe macroeconomic downturn. To motivate that, we begin by describing the Reserve Bank's view on the purpose of macroeconomic stress testing, which can be divided into the use by participating banks, and the use by the Reserve Bank as prudential regulator.

Use of stress test by banks

In New Zealand, registered banks are required to conduct stress tests and report the results as part of their Internal Capital Adequacy Assessment Process (ICAAP). The Banking Supervision Handbook (BS12) sets out the need to conduct stress tests and also review the appropriateness of the severe loss estimates being used in those stress tests from time to time. As well as providing a benchmark for the adequacy of capital levels, stress tests should also be intrinsically useful information for bank boards and senior management, helping to understand the risks to their business and possible ways to mitigate those risks (e.g. through adjusting lending standards).

Larger banks in New Zealand use an internal-rating based (IRB) approach to computing risk weights on their assets. While stress testing may use some information that is also used in IRB modelling (e.g. estimated probabilities of default from IRB models), there are crucial differences between stress testing and IRB modelling (see table below)

IRB modelling	Stress testing
Models must be formally accredited by the Reserve Bank.	Models are not formally accredited and banks have more discretion.
Models measure downside default risks in a fairly mechanical way (using the 'Basel equation')	An actual downside scenario is designed, so the model needs to infer how that will impact on default risk.

We regard macroeconomic stress testing as important for most locally incorporated banks, but expect more sophisticated stress testing from larger banks. This document was prepared by evaluating stress testing practices at the 5 largest New Zealand banks. While not every aspect will apply to smaller locally incorporated banks it may also be of interest for those institutions.

Use of stress tests by the Reserve Bank

Stress tests also offer useful information to the Reserve Bank in its role as a prudential regulator. Firstly, the adequacy of capital and liquidity buffers held by banks may be called into question by the results of a stress test, leading to further investigation and potentially prudential response. Secondly, macroeconomic stress testing can help the Reserve Bank evaluate the importance of particular macroeconomic risks (e.g. sharp increases in interest rates) as drivers of banking system stress, which helps inform analysis such as the Financial Stability Report. For stress testing to be useful for these purposes, the scenarios need to be severe and represent the sorts of events that capital and liquidity buffers are held for. This motivates our views on scenario design (section 2).

Alongside the tests run internally by registered banks, the Reserve Bank has conducted several collective stress tests of the larger NZ banks in the last 5 years (and, in 2014, a test of a number of smaller NZ incorporated institutions). As well as running periodic 'regulator initiated' stress tests, the Reserve Bank has also recently begun to work with APRA to provide common scenarios for use in the major banks' internal stress testing. This allows

banks to work to their own timetables, while still facilitating comparison of results across banks. The Reserve Bank expects to continue to run regulator initiated stress tests every 2-3 years, and (in years where there is no regulator initiated test) repeat the process of providing a mandatory scenario for ICAAP stress testing. At times there may also be other stress tests of a different nature (e.g. examining a single loan type) but the full macroeconomic stress tests are expected to be the main emphasis of the Reserve Bank's stress test requests (and are the main topic of this paper).

Work described in this paper and key findings

After the 2014 test, the Reserve Bank initiated a review of the stress testing methodologies being used by the five largest banks. The participating banks responded to a questionnaire, and there were follow-up discussions with each participating bank. Concurrently with that review, the Reserve Bank also reviewed the ICAAP documents being produced by NZ banks (including the stress tests in those documents). After some further analysis and testing in late 2015, participating banks were invited to comment on a draft version of this document.

The primary purpose of this paper is to set out the Reserve Bank's view on how macroeconomic stress tests should be conducted and used within major NZ banks[1]. Having described our expectations for stress testing, the paper also discusses how the Reserve Bank intends to support the industry in making improvements along the lines discussed. Reflecting that evolution, the Reserve Bank will consider publishing a revised version of this document in the future.

Our most important finding concerns the way in which credit loss estimates (which are central to stress test results for New Zealand banks) are generated.
- No single statistical approach to modelling likely credit losses will produce results that are reliable enough to be used in isolation, creating a need for expert judgement (and making use of multiple models desirable).
- Expert judgement needs to be informed by looking at contexts. These should normally include losses in NZ in the last 20 years or longer in the relevant portfolio, but should also include some analysis of past severe downturns in other countries (given that Australasia's last major banking crisis was more than 20 years ago).
- This contextual information should be provided to boards and senior management to help them interpret the stress test results. For example, if losses in the Irish housing market were an order of magnitude larger than a New Zealand stress test suggests in a similar macroeconomic scenario, the board may wish to examine the explanations staff provide for this difference and decide if they are convincing.

We provide much more detail on all of these points in sections 3 and 4.

The international context

Running full macroeconomic scenario stress tests of key institutions has become an increasingly central part of prudential oversight of the banking system in many economies since the global financial crisis. A useful summary is provided in Bank of England (2013)[2]. In the US, EU and UK, regulators have required banks to provide substantial amounts of loan level data as well as stress test results. This has allowed regulators in those jurisdictions to

---

[1] While smaller banks are not expected to reach the same levels of technical sophistication as the major banks in stress testing, this document should still be of interest to smaller banks.

run stress testing models themselves on that harmonised data in order to evaluate the results provided by individual banks. As described by Byres (2014), these tests have been used to demonstrate the need to insist on capital raising by individual institutions, so that a heightened amount of transparency and result validation is required.

At the Reserve Bank of New Zealand, our approach is different (and closer to that of the Australian Prudential Regulation Authority (APRA)- see Byres (2014)). That is, we prefer to use stress testing as a component of supervisory assessment rather than directly tying supervisory action to stress test results. The Reserve Bank puts considerable effort into understanding the IRB modelling being done by banks to determine the risk weights assigned to loans for capital purposes. For example, in the current benchmarking project, IRB banks are providing the RBNZ with loan level data samples that will help the RBNZ test that the probability of default and risk weights banks are calculating for each loan are measured in a comparable way across banks. This will also provide confidence that risk weights are a useful summary measure of portfolio characteristics that can be used as an input to stress tests.

For the time being, the Reserve Bank has no plans to collect highly detailed loan level data as part of the stress testing process. However, there is likely to be value in further harmonization of data collected and provided by the banks in stress testing exercises. For example, standardising the calculation of 'total debt to income' for household mortgage customers would allow this to be used as a driver of different downturn default rates in the housing assets of banks in a regulator run stress test. There could also be value in producing additional harmonised data for parts of the rural and commercial property loan books. This illustrates that while the core of the stress test dataset will be the probability of default and risk weight data computed by banks, there will be additional data (in some cases private data) being provided to the Reserve Bank in order to help us validate stress test results. Information gathered in stress tests may also sometimes shed light on the validity of the risk weighting methodology being used by banks.

Many regulators have also embarked on an exercise similar in spirit to the one discussed in this guide, discussing with banks the methodologies being used by banks themselves to produce stress test results. The Basel Committee on Banking Supervision (2009) provided some baseline principles for sound stress testing and also recommended that regulators should make "comprehensive assessments" of stress testing methodology within banks. For example, besides the discussion in Bank of England (2013) and APRA publications (including Laker (2012) and Byres (2014)), there is also detailed discussion of methodological issues in Federal Reserve (2014). As noted further on within this text, there are considerable parallels between the issues raised by those supervisors and our findings in the New Zealand context.

Figure 1: Principal elements of a stress test

Scenario Creation (Sec 2)
Data gathering/validation (Sec 3&4)
Credit risk estimates (Sec 3)
Overall financial forecast (Sec 4)
Dialogue with key decision makers (Sec 4)

2. Scenario development and test frequency

Sometimes banks work with a stress test scenario provided by the regulator, as described in section 1. However, banks also need to be able to generate suitable scenarios to test key risks germane to their business (insofar as any regulator provided scenarios do not include them).

As described in section 1, the Reserve Bank considers that these should be severe multi-year downturns that may be considerably worse than seen in recent New Zealand history. A possible working concept would be to look for scenarios that approach the most severe seen in the last century in New Zealand (perhaps unemployment and asset price outcomes during the 1930s), and/or the worst seen in relevant comparator countries in the last 25 years. These ideas are elaborated on below.

The Reserve Bank considers that as a bare minimum, major NZ banks should aim to include at least two macroeconomic scenarios in their ICAAP. The following sources of scenario should all be important:
- In many years, one of these scenarios might be provided by the regulator (either specifically for use in ICAAP testing, or for use in a regulator-led test).
- It could also be useful to use updated versions of past scenarios, perhaps including those provided by the regulator. Repeating scenarios has advantages as it allows results to be compared with previous runs, and there is value in understanding the drivers of differences in results (which may include model changes as well as changing balance sheet characteristics).
- Other specific severe macroeconomic scenarios that are particularly relevant to the business of the institution should be considered and designed in house.

Besides macroeconomic scenarios (where there is a severe macroeconomic shock and most aspects of the banks business are affected, including trading books and funding as well as credit losses) there is likely to be value for banks in running simpler partial stress tests of individual portfolios or other risks (e.g. market risk). As discussed above, those partial stress tests are not a focus of this paper, but many of the methodological principles are likely to be useful in designing those tests as well.

> **Principle 1:** Major NZ banks should aim to include at least two macroeconomic scenarios in their ICAAP. Banks should seek to complement their macroeconomic stress testing with partial stress tests of key individual portfolios and other key risks.

> **Principle 2:** Macroeconomic scenarios should be of sufficient length and severity to enable most credit losses to fully eventuate. At a minimum, this should be a 3 year scenario, beginning with a sharp decline in asset prices and little or no recovery for two years or more. Running longer scenarios periodically is desirable.

If a formal statistical metric is used to identify a scenario it is important that it can pick up severe multi-year downturns. For example, in our judgement, it is not appropriate to define a severe scenario based on the measured largest single year declines in GDP. As noted above, we consider that scenarios should be multi-year (probably 5 years long, at least some of the time). The second issue is that the extent to which GDP can fall relative to baseline over a 5 year period is poorly approximated by just looking at year on year changes.

For example, considering the global financial crisis, the level of real GDP declined by around 10 percent relative to expectations, and the gap relative to expectations appeared to persist.

This sort of weakness relative to baseline is much more severe than a single year decline followed by a rapid recovery. And much worse outcomes are possible: it is important to recognise that other aspects of the New Zealand crisis experience were for various reasons milder in many ways than seen in certain other countries (including Ireland, Iceland, Spain, and the United States).

Figure 2: New Zealand GDP (2007 forecasts compared to RBNZ view in 2014)
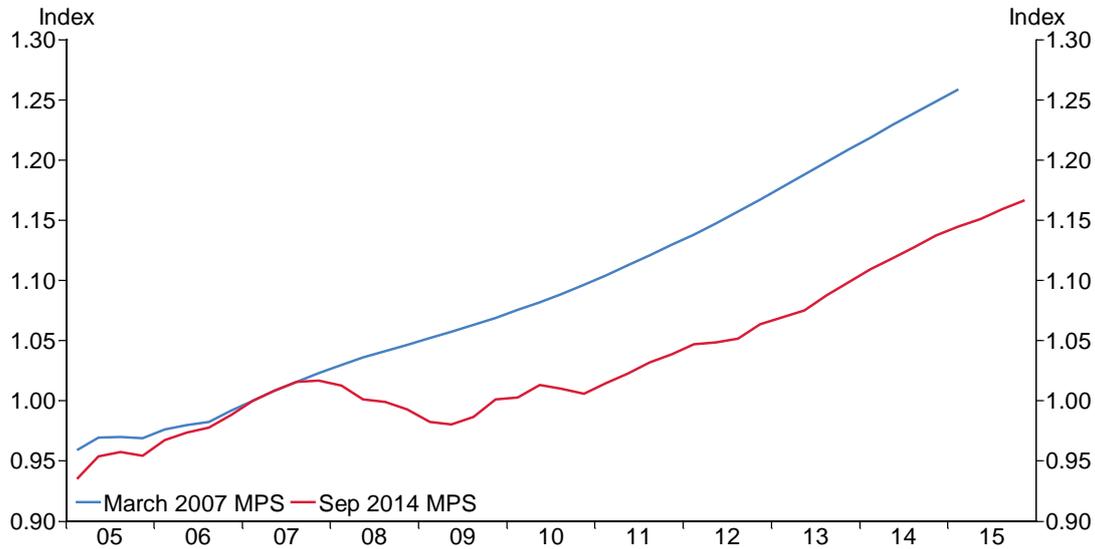
Taking all of these factors into account and settling on a reasonable 'severe' event is difficult to do precisely, but we consider that excessive reliance on the time series properties actually observed in New Zealand over the last 25 years is potentially misleading, particularly if the focus is on a reduced form metric like largest single year falls. Laker (2012) raises similar issues.


Principle 3: Macroeconomic scenarios should not be built purely based on recent New Zealand time series data given the relatively mild macroeconomic conditions seen in the last 25 years. Scenario design should also incorporate the more severe crisis experience seen in other advanced economies during the GFC period, and prolonged declines in output relative to baseline expectations.

---

3. Modelling credit risk

New Zealand banks typically have loan books comprising 80% or more of their assets. Banks do not have large trading books or take substantial interest or exchange rate risk. For example, while they have foreign currency funding books, the funding is hedged into New Zealand dollars. So the key risk of losses in most macroeconomic downturns will typically be credit risks relating to their loan portfolios, and determining likely credit losses will be a key activity in most stress tests.

There are a number of steps to forecast all of the credit variables required to complete a stress test, with a number of intermediate variables required. Figure 3 summarises the typical interactions between all of these intermediate variables. In some banks, things are done in a slightly different order.

Figure 3: Summary of typical process for modelling non-retail credit default risk
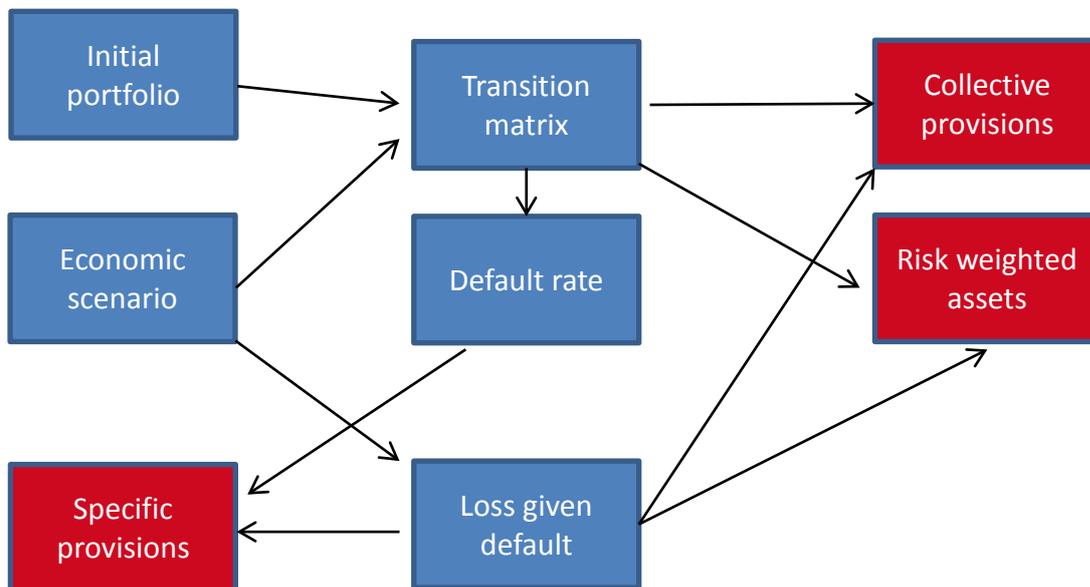
A crucial question for modelling is how to parsimoniously describe the portfolio characteristics that matter for loan default (the 'initial portfolio' above). IRB banks model the probability of default (PD) of each exposure when creating risk weights. It is possible to then run a stress test using a 'transition matrix' to define the extent to which the credit quality of a portfolio of exposures deteriorates as a result of the economic scenario. For example, the transition matrix would show how many A-rated exposures would default in an extreme stress scenario, and how many would deteriorate in credit quality down to the BB grade. For defaulted exposures, likely loss given default (LGD) is often then calculated based on estimates of likely exposure at default (EAD) relative to the value of collateral in the scenario.

The key modelling challenge then becomes finding a way to produce transition matrices as a plausible function of the degree of macroeconomic stress. It is possible to use an econometric model to directly estimate transition matrices as a function of the degree of macroeconomic stress. However, it is more typical to estimate or impose expected default rates and then identify a plausible transition matrix that gives that default rate and provides the details about the deterioration in the credit quality of non-defaulted exposures. If working

this way, the default rate should be analysed in a way that takes changing portfolio characteristics over time into account (see below).

The Reserve Bank (see box 1) has considered downturn credit risks for key portfolios such as housing and dairy farm lending using internally built default risk models. Based on that work, we have drawn some observations about desirable practice in modelling default risk, which we list below:

- Historical data from severe downturn periods should be taken into account. Because severe downturns occur infrequently, some of this downturn experience will probably need to come either from the distant past, or from other countries. RBNZ's work on farm risk had reference to macroeconomic data from the US in the 1980s and New Zealand in the 1930s. More recently, we have looked at residential mortgage defaults during the GFC in the US and Ireland.

- When using historical data, it is necessary to consider how portfolio characteristics have changed. For example, if LVRs are significantly higher than during the last severe downturn, a similar downturn today would probably result in higher residential mortgage losses.

- These approaches may not be suited to formal regression modelling (as sufficiently long spans of comparable data are not available). Formal regression modelling on shorter spans of data may also be useful, but should be seen as one lens into potential risk rather than as an authoritative answer.

- More generally, it will be desirable to have multiple ways of estimating potential credit risks in a given scenario (challenger models), and then a well-documented judgement process for deciding on a credible central estimate for credit risk. Other regulators including Bank of England (2013) and Federal Reserve (2014) have discussed the desirability of having multiple models and well considered judgement. There are analogies to the inflation forecasting process employed by the Reserve Bank and other central banks, where a range of models use different techniques to forecast inflation. The final published inflation forecast is based on the consensus judgement of the monetary policy committee, and the results of multiple models help to give a sense of the relevant uncertainties.

- For some sorts of mortgage lending (especially larger farms, and portfolios of residential or commercial rental property), a model which directly forecasts the evolution of the borrower's financial position (e.g. updated LVR, based on estimated cashflows and evolving collateral value in a scenario) may be a more plausible way of estimating default risk than measures based on reduced form information like PD grades. Some more discussion of this sort of model is contained in box 1 below.

Principle 4: Stress testing models of credit risk should be built with reference to data from severe downturns (if necessary using data from the distant past or other countries), but also account for changing portfolio characteristics over time.

Principle 5: Rather than relying on a single model, it is preferable to have multiple ways of estimating stress test credit risk for key portfolios. Final results should then be a conservative and well-documented judgement.

Principle 6: For mortgage lending in particular, it is desirable to have a stress testing model that directly forecasts the financial position of the underlying borrowers based on macroeconomic assumptions, and uses that information to forecast defaults and loss given default.

We recognise that assembling the relevant data and models necessary to fulfil the guidelines above is a time consuming and challenging task. The Reserve Bank may be able to assist to

some degree by publishing further work such as the TUI and farm default modelling work it has conducted. In the future, we hope to update the TUI model based on our analysis of recent residential mortgage default experience (including new insights such as the relatively high risks of default on investor lending observed in severe downturns internationally). The Reserve Bank can also run our internally built credit risk models on the data supplied by the banks during regulator-led stress tests and produce phase 2 loss rates (and data on the range of phase 1 estimates supplied by the banks). These should provide a useful benchmark for the banks to use in considering whether the loss rate judgements they have come to are reasonable.

However, as described above, banks have freedom to build their own models and generate their own stress-testing results. The Reserve Bank expects to see innovation and improvement in stress test modelling over time, and for us to obtain additional insights into risks from the modelling done by banks. Where a risk is quantified by analytical work in one bank, the Reserve Bank will be mindful that this does not mean risk has risen – it is just being better measured. Also, the newly modelled risk will be discussed with all banks to which it is potentially relevant. In these ways, stress testers within the banks should be able to innovate without being concerned that the results will place their bank at a competitive disadvantage.

> **Principle 7:** Banks should seek to improve stress testing models over time, including with reference to international practices.

Box 1: Key lessons from history for stress test modelling

In 2007, the Reserve Bank developed a calibrated model of housing loss based on international crisis experience including the UK in the 1990s (see Harrison and Matthew, 2008). Similar work was later conducted on risks to the dairy farming industry (Hargreaves and Williamson 2011).

Since that work, there have been further examples of substantial default experience in a number of countries. One useful summary is Kragh-Sorenson and Solheim (2014). That paper demonstrates that typical crisis losses are disproportionately related to commercial property/construction lending, with losses on residential mortgage lending typically much lower. Two important exceptions are the GFC experience of the United States and Ireland, where housing credit related losses were also quite significant.

The Reserve Bank is currently reconsidering the calibration of the TUI model in light of the recent default experiences in the US and Ireland. We intend to publish a survey article that summarises the evidence on the determinants of default in those crises. This should be of use in building stress test methodologies and thinking about the relevance of international experience to New Zealand. Some of the questions we expect to answer include the following:

a.   Are default rates higher for high LVR loans and/or loans that are a large proportion of borrower income?

b.   Do default rates for investor lending tend to be higher than owner occupier lending during severe downturns?

c.   How do the macroeconomic circumstances in countries that have experienced severe defaults differ from those in countries that have had severe downturns but much lower mortgage defaults?

d.   How important are institutional framework factors (e.g. the ease of foreclosure and ability of lender to recover post foreclosure shortfalls from the borrower) to loss experience?

As an example of the potential value of international experience, it is interesting to consider whether mortgage rates can be expected to always fall during severe economic downturns. While policy interest rates fell sharply in the US during the GFC, and eventually the ECB cash rate fell to low levels as well, various factors meant some mortgage borrowers were paying interest rates that fell much less or even rose. Some US borrowers were unable to refinance and adjust their interest rates because of reduced equity in the property. In Ireland, the banking system was paying substantially higher funding costs (relative to ECB benchmark rates) and loading that onto the interest rates available to new borrowers. In New Zealand, while interest rates have tended to fall in economic downturns since the inflation targeting regime has become embedded, this need not always be the case. With a floating exchange rate and an inflation target it is possible to imagine circumstances where international investors wanting to exit NZD positions push the currency down to levels where (despite economic weakness) the RBNZ is unwilling to reduce the OCR. This was the idea behind scenario 2 in the 2014 stress tests (where interest rates rose despite economic weakness).

The treatment of Residential Mortgage loans

Credit grades (as described above when talking about the non-retail portfolios) represent probability of default in a reduced form manner. A more structural model of default risk could look at the forecast income of a borrower relative to required interest rate servicing. These are particularly likely to be examined in the context of residential mortgages. For example, many IRB credit risk models include some sort of income servicing variable such as required debt servicing as a proportion of income or DSR. DSR (and LVR) can be stressed in a downturn scenario to understand what proportion of borrowers will have difficulty servicing the mortgage and what proportion of those in turn are likely to be in negative equity (since it is the combination of both of these things that will often drive residential mortgage losses).

In some regulator led-stress tests RBNZ has requested a breakdown of the mortgage portfolio by LVR and a DSR metric. One challenge this creates is that the concept of DSR or debt to income (DTI) is not particularly well harmonised across the banks (unlike LVR). The Reserve Bank has been working with some larger banks on debt to income reporting and expects to discuss this with the rest of the industry shortly. Having this data available should make differences between banks in stress test results easier to understand and interpret.

Because residential mortgages are often modelled with a more structural set of drivers, it is possible to model default risk more structurally (stressing interest rates and borrower income and determining if the loan is still serviceable, for example). The risk of default can either be a calibrated function that rises steeply when the loan becomes hard to service (as in the RBNZ's TUI model (Harrison and Matthew 2008) and other 'microsimulation models') or an empirically estimated hazard function. One somewhat similar vendor example we have seen is described in Stein et al (2011).

Risk weighted asset growth

When banks have settled on default rate estimates, banks (especially IRB banks) also need to decide how much RWA expansion occurs because of the deterioration in condition of non-defaulted customers (for example, a decline in the value of collateral raising loan to value ratios). RBNZ's preference for through the cycle modelling of default risk (in the residential mortgage book) means that economic deterioration should not always lead to risk weights rising. For example, it is not appropriate to use automated valuation models to write down residential collateral values and then use those new values to calculate increased LVRs and risk weights. Customers that request additional funds or undergo other credit events may need to have collateral revalued, so some residential mortgage customers are likely to have rising risk weights during a severe downturn, but not all.

Two different transition matrices (coupled with assumptions about likely LGD) can give identical default rates but very different results for RWA expansion, and the extent of RWA expansion is a crucial driver of the capital ratios reported by banks during a stress test. We think banks should consider designing their models to give realistic amounts of credit grade deterioration for non-defaulted exposures reflecting how their IRB models would be likely to be perform in a stress scenario. This may lead to useful discussions about any procyclicality in capital models and the economic implications of that.

> **Principle 8:** It is important to carefully model the extent to which portfolio risk weights will change in a downturn. This depends on whether the risk weights are set in a 'through the cycle' manner, as with IRB treatment of residential mortgages in New Zealand.

4. Structure of stress test team and management/board involvement

As noted in section 3, for a stress test it is necessary to gather useful information about the starting assets of the bank and their risk characteristics. It will also be necessary to prepare a baseline financial forecast (showing expected margins, profitability and the like if the stress scenario does not occur), and then prepare an analysis of how the aspects of this forecast unrelated to credit loss would change in a stress scenario.

Figure 4: Stylised depiction of stress test calculations
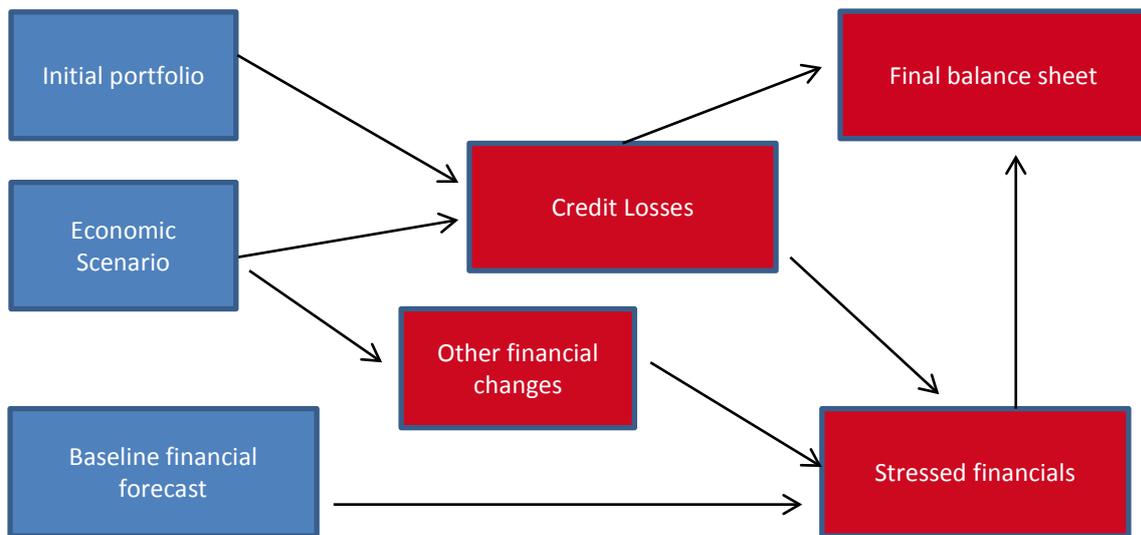
Clearly there are multiple ways to organise this work within a bank. For most larger NZ banks, we understand that stress tests are primary run out of the risk function, drawing on significant resources from finance, treasury, capital planning and credit teams. Generally there appears to be a strong delineation between the credit side of the stress tests which are generally developed by the risk function, and the resulting profit and loss and balance sheet which are done by finance and/or Treasury. This can mean some complexities and manual work is involved in production of overall results, which can make it harder to test alternative assumptions. It is also important that someone is in overall charge of result production and coordinating quality assurance.

Principle 9: A system that allows results to be generated quickly is desirable even if that means some simplified calculations in less crucial areas. It is also desirable for the test to have a 'champion' who is able to check results, organise internal critique, and work with other areas to obtain needed assumptions.

Some banks work with the relevant experts in their parent banks when producing and running credit default models. But the judgemental adjustment and financial forecasting (balance sheet/PLA after credit migration is determined) is generally being conducted locally. We consider cooperation on modelling to be useful as long as the resulting models are well understood within the local banks, so that the results can be interpreted and judgementally adjusted where necessary.

Principle 10: Using models from external vendors or parents is acceptable, but in order to use the model and communicate risks and limitations to stress test users, it is important that the model and its limitations are well understood by staff within the local bank.

Mitigating actions

In a stress scenario, banks may be able to bolster balance sheets in a number of ways, principally including raising capital, reducing expected asset growth, and containing costs. If senior management and boards consider these potential responses to a severe downturn in detail, that is a useful outcome of a stress test. However, it is important that the potential pitfalls of any mitigating actions that are proposed are considered. For example, if all banks are trying to reduce exposures in a particular sector such as housing, that could sharply worsen the economic deterioration in that sector (since it will be hard for prospective house buyers to fund desired purchases). Similarly, capital raising in a downturn can have a significant impact on the share price and so existing shareholders may not be in favour of capital raising. For these reasons, and as stated elsewhere, e.g. box 1 in the November 2014 FSR, it is important to report and emphasise stress test results prior to the application of mitigating actions and consider any proposed mitigating actions carefully.

Principle 11: Proposed mitigating actions should be carefully scrutinised by staff and board to ensure they would be realistic in the context of the stressed scenario.

How stress testing results are used

One of the focuses of our review was the extent of management and board engagement in stress tests, and how results fed into the determination of capital triggers and risk appetite.

All major banks consider stress tests as part of their Internal Capital Adequacy Assessment Process (ICAAP). Stress tests are used to form a view on capital adequacy and to help to inform the setting of management and board capital targets. Most banks did not have an explicit link between capital targets and the stress test results, but considered that the bank having survived an adverse scenario in a stress test provided additional assurance that the capital targets being proposed were prudent.

We saw some examples of reporting, which tended to focus on documenting the scenario being examined and providing the estimated results. As discussed earlier, we consider that it would be useful for more discussion of the assumptions and risks associated with the results to be included. For example, a more detailed presentation could include
- results from multiple models for key assumptions along with an explanation of the reasoning for the final judgement
- comparison of phase 1 (bank led) and phase 2 (regulator imposed loss rates) results and an explanation for the difference
- benchmarking of the results against key stress episodes from recent severe downturns (in other countries if no recent NZ downturn is sufficiently severe).

A prototypical example of how this material could be presented is shown in the box below.

Principle 12: The methodologies and assumptions used in providing stress test results should be explained to senior staff and boards, and they should receive other contextual information (e.g. sensitivity analyses) that will help them decide whether they consider the results reasonable.

Box 2: Potential reporting to senior management
(The text below provides a stylised example of how results for a particular portfolio (residential mortgages) can be provided in a way that gives substantial context. The text illustrates the uncertain nature of the results (by providing multiple estimates), shows how results from one model have changed over time, provides international context, and justifies the final decision taken.)

Estimated loss on residential mortgages over 5 years:
2.1% (Using benchmark model)
3.1% (Judgement based estimate)
3.7% (RBNZ estimate)

Estimated loss from a similar stress test in 2010
2.4% (Using benchmark model)

Estimated loss in 2 recent crisis episodes internationally
8.5% (Ireland)
3% (United States)

Commentary:
- The loss estimates created using our benchmark model were considered to be too mild by our internal oversight committee, largely because the committee considered that the benchmark model is not calibrated to deal with a rise in interest rates of the severity assumed in the scenario.
- In providing phase 2 loss rates, the Reserve Bank also emphasised this issue.
- The decline in high-LVR lending since the advent of LVR restrictions has reduced average LVR across our book and this leads to a lower loss rate than when a similar scenario was analysed in 2010.
- The higher loss rate experienced in Ireland in the GFC has been analysed using our benchmark model. Our benchmark model suggests we would have losses around 4 percent if economic conditions were that severe. We consider that actual Irish losses were higher predominately because the pre-GFC loan originations in Ireland were substantially higher LVR on average.

Aside from capital setting, we would hope that granular stress test results would be used in the setting of risk limits and strategy[3]. For example, stress test results showing that mortgage loans with LVRs above 90 percent tend to perform very poorly in a severe housing downturn could prompt a review of this lending. In order for stress tests to achieve this, they probably need to use quite detailed models that show the implications of changing portfolio structure (some aggregate models do not).

Principle 13: A desirable feature of the stress testing framework is that the models are able to deliver risk information that is valuable to business units and potentially useful for adjusting lending policy.

---

[3] This is also discussed as a priority by other regulators including Laker (2012) and BCBS (2009).

5. The role of the Reserve Bank in stress testing

The Reserve Bank has a number of roles in the running and evaluation of stress tests.

- For regulator led stress tests, the Reserve Bank provides the macroeconomic scenario.
- The Reserve Bank then obtains results from banks (based on their own internal loss estimates, often called "Phase 1" results).
- These individual results are compared, and benchmarked to results from the Reserve Bank's own risk modelling and other comparative material like loss estimates from similar downturns in other countries. Often the Reserve Bank then provides harmonised "Phase 2" loss estimates to banks.
- The results (using bank's own loss estimates or imposing the Reserve Bank's view) can also be aggregated to give a view of the overall impact of the scenario on the banking system. The Reserve Bank can also check at this point that the macroeconomic scenario remains consistent with how banks suggest they would behave in the scenario. For example, if banks intend to rapidly attempt to liquidate overdue loans in a sector through mortgagee sales, that may imply that the actual fall in asset prices in that sector will be worse than initially assumed.
- Results from stress tests that indicate that banks (individually or collectively) would exhaust their capital or liquidity buffers could lead to supervisory discussions (for example around provisioning or risk weights). However, it is important to note that we do not regard tests as a 'pass/fail' exercise. For example, a sufficiently severe scenario could lead banks to exhaust certain buffers, but it may be that the scenario is so severe it is unlikely. Conversely, if banks have surprisingly severe results in a relatively mild scenario, that could lead to supervisory action even if banks do not breach any regulatory minima.

The Reserve Bank also recognises that the sort of modelling and benchmarking that we have described above as ideal best practice can impose significant resource requirements on banks. These requirements can potentially be reduced through the provision of analytical material by the Reserve Bank. For example, these could include models of potential default drivers in a key sector (such as the Housing and farm default models referred to above) or literature reviews on the drivers of default in a major relevant downturn (e.g. the mortgage loss experience in the most severe housing downturns that occurred in the GFC). However, as described above, the Reserve Bank does not expect to be the key source of information on how to stress test for larger NZ banks, who we expect will drive most innovations in this area themselves.

At times, there will be other interfaces between stress testing and other supervisory activities. For example, the Reserve Bank is currently undertaking an IRB model benchmarking exercise which obtains some sample data from banks that use IRB capital approaches, in order to evaluate whether the dispersion in risk weights across banks is an appropriate depiction of the relative riskiness of their assets. Stress testing models can potentially help inform this process, and the data obtained in this process will also potentially help us construct revised stress testing models of the sectors under study. Loan characteristics that appear to be key risk drivers for a particular portfolio could also be incorporated into disclosure requirements.

6. Conclusions

Stress testing is difficult, but in the Reserve Bank's view it helps banks (and the Reserve Bank) understand key downturn risks and plan for them. The process in New Zealand gives substantial freedom for banks to design their own stress testing models and practices, and the Reserve Bank will also seek to avoid mechanistic policy responses to stress test results.

We think this should allow banks to innovate in designing stress testing tools that take a considered view of the potential consequences of adverse scenarios, rather than stress testing being seen as a pass/fail 'compliance' activity. We also hope this approach allows banks to build tools that incorporate the insights of the key credit decision makers within their institution, and are genuinely useful for understanding the risk impact of changing portfolio characteristics and the key downturn risks faced by the bank.

The Reserve Bank will continue to engage with banks as stress testing practices develop, and may periodically reissue this document as additional insights come to light.

Appendix: Summary of Principles

Principle 1: Major NZ banks should aim to include at least two macroeconomic scenarios in their ICAAP. Banks should seek to complement their macroeconomic stress testing with partial stress tests of key individual portfolios and other key risks.

Principle 2: Macroeconomic scenarios should be of sufficient length and severity to enable most credit losses to fully eventuate. At a minimum, this should be a 3 year scenario, beginning with a sharp decline in asset prices and little or no recovery for two years or more. Running longer scenarios periodically is desirable.

Principle 3: Macroeconomic scenarios should not be built purely based on recent New Zealand time series data given the relatively mild macroeconomic conditions seen in the last 25 years. Scenario design should also incorporate the more severe crisis experience seen in other advanced economies during the GFC period, and prolonged declines in output relative to baseline expectations.

Principle 4: Stress testing models of credit risk should be built with reference to data from severe downturns (if necessary using data from the distant past or other countries), but also account for changing portfolio characteristics over time.

Principle 5: Rather than relying on a single model, it is preferable to have multiple ways of estimating stress test credit risk for key portfolios. Final results should then be a conservative and well-documented judgement.

Principle 6: For mortgage lending in particular, it is desirable to have a stress testing model that directly forecasts the balance sheet of the underlying borrowers based on macroeconomic assumptions, and uses that information to forecast defaults and loss given default.

Principle 7: Banks should seek to improve stress testing models over time, including with reference to international practices.

Principle 8: It is important to carefully model the extent to which portfolio risk weights will change in a downturn. This depends on whether the risk weights are set in a 'through the cycle' manner, as with IRB treatment of residential mortgages in New Zealand.

Principle 9: A system that allows results to be generated quickly is desirable even if that means some simplified calculations in less crucial areas. It is also desirable for the test to have a 'champion' who is able to check results, organise internal critique, and work with other areas to obtain needed assumptions.

Principle 10: Using models from external vendors or parents is acceptable, but in order to use the model and communicate risks and limitations to stress test users, it is important that the model and its limitations are well understood by staff within the local bank.

Principle 11: Proposed mitigating actions should be carefully scrutinised by staff and board to ensure they would be realistic in the context of the stressed scenario.

Principle 12: The methodologies and assumptions used in providing stress test results should be explained to senior staff and boards, and they should receive other contextual information (e.g. sensitivity analyses) that will help them decide whether they consider the results reasonable.

Principle 13: A desirable feature of the stress testing framework is that the models are able to deliver risk information that is valuable to business units and potentially useful for adjusting lending policy.

Bibliography

Bank of England, (2013) "A Framework for stress testing the UK Banking System"

Basel Committee on Banking Supervision (2009), "Principles for sound stress testing practices and supervision", Final version May 2009

Byres, W (2014), "Seeking strength in adversity: Lessons from APRA's 2014 stress test on Australia's largest banks", Australia Prudential Regulation Authority

Federal Reserve (2014), "CCAR 2015: Summary Instructions and Guidance"

Harrison, I and Matthew, C (2008) "Project Tui: A structural approach to the understanding and measurement of residential mortgage lending risk", mimeo, Reserve Bank of New Zealand

Hargreaves, D and Williamson, G (2011) "Stress testing New Zealand banks' dairy portfolios", Reserve Bank of New Zealand Bulletin 74/2.

Kragh-Sorenson K and Solheim, H (2014) "What do banks lose money on during crises", Norges Bank staff memo 03/14

Laker, J (2012) "The Australian Banking System under stress, again?", Australia Prudential Regulation Authority

Stein, R et al (2011) "Mortgage Portfolio Analyzer: A quasi-structural model of mortgage portfolio losses", Moody's Research Labs