RESERVE BANK OF NEW ZEALAND

DP2009/11

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Paul Bedford and Chris Bloor

November 2009

JEL classification: E32, E44, G01

www.rbnz.govt.nz/research/discusspapers/

Discussion Paper Series

ISSN 1177-7567

DP2009/11

A cobweb model of financial stability in New Zealand*

Paul Bedford and Chris Bloor†

Abstract

Financial turbulence over the past two years has generated increased interest in the analysis of financial stability. However, such analysis often suffers from conceptual difficulties and a lack of measurability. This paper develops a 'cobweb model' for analysing financial stability in New Zealand. A key objective of this cobweb model is to depict the Reserve Bank of New Zealand's assessment of financial stability in a single diagram that will enable better communication of the main risks facing New Zealand's financial system. The results of this model are displayed using a cobweb-style diagram, with five dimensions constructed using a wide range of quantitative indicators, supplemented by expert judgement where necessary. It is anticipated that this cobweb diagram will become the focal point of the Reserve Bank's *Financial Stability Report*.

* The Reserve Bank of New Zealand's discussion paper series is externally refereed. The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. The authors would like to thank David Hargreaves for valuable contributions in constructing the model, seminar participants at the Reserve Bank of New Zealand, and two anonymous referees for providing comments on an earlier draft. All errors and omissions are ours and the views expressed are not necessarily those of the Reserve Bank of New Zealand.

† Address: Financial Markets Department, Reserve Bank of New Zealand, 2 The Terrace, PO Box 2498, Wellington, New Zealand. *email address:* Chris.Bloor@rbnz.govt.nz.

ISSN 1177-7567

1 Introduction

The analysis of risks to financial stability has grown in importance at central banks over recent years. Almost all major central banks now publish documents akin to the Reserve Bank of New Zealand's *Financial Stability Report* (under various names) on a regular basis (Cihák 2006).[1] The precise focus and structure of these publications vary across central banks, but they generally aim to outline recent developments affecting the financial sector and evaluate the extent of current risks to financial stability.

However, in contrast to the evaluation of monetary policy, financial stability analysis often suffers from conceptual issues and a lack of measurability. For example, there is no single accepted definition of exactly what constitutes a stable (or unstable) financial system. As a result, financial stability reports generally take a narrative approach, covering a broad range of areas considered relevant to financial stability. The limitations of this approach were summarised in Borio and Shim (2007). The authors argue that "central banks have developed an excessive tendency to look at everything, without a clear sense of how to look at everything".

To overcome this problem, and to try to create an anchor for discussion of financial stability issues, attention has been paid to developing quantitative indicators of financial stability. To this end, there are two broad categories of indicators that can be constructed. The first is an attempt to provide an early indicator of impending risk to financial stability, often focussing on emerging imbalances and vulnerabilities. However, in practice, early warning indicators have had limited success, with forecasting horizons generally short, and a high number of false warnings (Borio and Drehmann 2009). Their value in informing policy decisions remains debatable, although a concerted international effort, led by the International Monetary Fund (IMF) and Financial Stability Board, is currently underway to develop better analytical tools for detecting emerging threats to international financial stability.

The second approach is to provide a contemporaneous indicator of financial stability. This is likely to be easier to implement in practice, and serves as a useful communication device and tool for focussing policy discussion. One avenue in this regard has been to formulate indexes of financial stability. An example of this approach is the banking stress index developed at the Swiss National Bank (Hanschel and Monnin 2004). This index is a weighted average of a range of standardised banking indicators. A similar approach

[1] The major exception in this regard is the US Federal Reserve.

has been taken to construct a financial stress index for Canada (Illing and Liu 2003), and an aggregate financial stability index for the Dutch financial system (van den End 2006).

These three examples all seek to measure financial stability or an element thereof in a single index. The IMF has developed an alternative approach which measures financial stability along six dimensions (IMF 2007). This 'global financial stability map' measures financial stability over four risk dimensions, and two dimensions relating to current macroeconomic and financial market conditions. The score for each dimension is constructed by converting a range of indicators into percentile ranks based on the history of the series. This mechanical methodology is supplemented by judgement to achieve the desired positioning on the map. Scores on each of the six dimensions are then graphed on a cobweb-style diagram, which features prominently in the IMF's six-monthly *Global Financial Stability Reports*.

In this paper a quantitative measure of financial stability is developed for New Zealand. It is similar in design to the IMF global financial stability map, measuring financial stability over five dimensions: three relating to current macroeconomic and financial conditions; and, two capturing the health of domestic financial institutions. As with the IMF model, we visually represent our five-dimensional assessment of financial stability using a cobweb diagram – a 'cobweb model' of financial stability.

While the model incorporates some forward looking information, it is intended to provide an indication of current financial stability conditions in New Zealand, and should not be interpreted as an early warning indicator. While there are a number of financial stability concepts that could be measured, the intention is to capture the factors affecting the soundness and resiliency of New Zealand financial institutions. The cobweb model aims to provide a focal point for the Reserve Bank's analysis of financial stability, and also establish a communication device that can frame both internal policy discussions and external communications on financial stability conditions, notably in the context of recent changes to the Reserve Bank Act.[2]

The remainder of the paper proceeds as follows. Section 2 outlines the design and dimensions of the cobweb model. Section 3 outlines the data and discusses the methodology for constructing the model. Section 4 discusses the

[2] Section 165A(2) of the Reserve Bank Act states that the *Financial Stability Report* must report on the soundness and efficiency of the financial system. The cobweb diagram of financial stability will be included for the first time in the November 2009 edition of the Reserve Bank's *Financial Stability Report*.

results from the model. Section 5 demonstrates a graphical representation of the results while section 6 concludes.

2 Design of the cobweb model

The purpose of the cobweb model is to give an indication of the risk that one or more major New Zealand financial institutions experience a shock of sufficient magnitude to make failure a realistic possibility in the absence of official support. While in theory this could be achieved through a single indicator, measurement problems abound and we prefer to distinguish risks and vulnerabilities across five different dimensions. Three of these dimensions are designed to pick up the major shocks and underlying macroeconomic vulnerabilities that would trigger major difficulties for domestic financial institutions. These are captured through the domestic environment, financial market conditions, and the global environment. The remaining two dimensions reflect the capacity of financial institutions to absorb a shock to either side of their balance sheets, measured through their capital and profitability, and their funding and liquidity.

A score across each of these dimensions is calculated as a weighted average of a range of different data sources. In total 78 data series are used to construct the five dimensions of the cobweb (see Appendix A for a full list of data in the model).

There are a number of considerations for selecting the data series to represent each of the five dimensions. In general, data that enters into the cobweb should be free from trends that are unrelated to financial stability. Some variables in the model, such as household debt servicing ratios, have displayed significant trends over the sample period considered. However, these trends are indicative of rising vulnerabilities within that sector of the economy.

In principle it is desirable for indicators to be monotonically related to financial stability risks. However, in some cases it is difficult to find suitable indicators which fulfill this property. For example, rapidly rising house prices, low risk aversion and credit spreads, low real interest rates and strongly rising equity markets are all consistent with the imminent risks to financial stability being low. However, and as recent global events clearly demonstrate, these developments may create imbalances which sow the seeds for future episodes of financial instability. In these cases we have chosen indicators that best reflect current financial stability conditions, even if these indicators may have different long-run implications. For this and other reasons, we envisage that the list of indicators used to construct the cobweb diagram will evolve over time.

Beyond these two conceptual requirements, series have been chosen based on the availability of time series data at quarterly frequency, and the extent to which they correspond to the underlying concept the cobweb is trying to measure. Forecast variables and data with leading information have been preferred to purely backward looking information. In addition, we wish to include enough data in each dimension so that it is not unduly affected by individual data series or idiosyncratic developments unrelated to broader macro-financial stability.

The following sub-sections describe each of the five dimensions in more detail, and the choice of data for each of these dimensions.

2.1 Domestic environment

The domestic environment dimension primarily captures the risk that economic developments will combine with existing imbalances and debt burdens to result in a material rise in default rates, leading to substantial losses for financial institutions. This dimension is a weighted average of the overall macroeconomic situation (25 percent), including New Zealand's aggregate indebtedness vis-*à*-vis the rest of the world, and the outlook for the four main (non-financial) sectors of the economy: household (25 percent), ex-farm business (20 percent), agriculture (20 percent), and government (10 percent). For each sector, we use indicators of the debt burden within that sector to measure its vulnerability to shocks. Data measuring the drivers of stress within that sector, as well as direct indicators of current stress are also included. For example, for the household sector, the debt burden is captured with the aggregate loan-to-value ratio, debt servicing ratios, and the proportion of credit card debt bearing interest. Effective interest rates, changes in house prices, and the unemployment rate measure the drivers of stress within the household sector. The number of personal bankruptcies is a direct indicator of current stress within the sector.

From the choice of indicators it is clear that this dimension is unlikely to provide much of an early warning of an impending deterioration in financial stability. High scores on this dimension are likely to be recorded at roughly the same time as debt default rates are rising.

2.2 Financial market conditions

The financial market conditions dimension measures the risk of sharp movements in asset prices or drops in market liquidity exposing domestic financial institutions to market and liquidity risks. This dimension reflects the fact that financial markets can be a key source of shock to financial stability, and also an early indicator of shocks that have originated in other parts of the economy. This dimension is split between international (40 percent) and domestic (60 percent) financial market developments. The international dimension incorporates equity prices and volatility along with a range of credit spreads to measure perceptions of credit quality and market risk appetite. The domestic indicator is similar, but also incorporates market bid/ask spreads as a measure of liquidity in New Zealand's financial markets.

2.3 Global environment

The global environment dimension captures the risk that external shocks, such as a sharp downturn in the world economy, translates into credit losses for New Zealand financial institutions. Reflecting the important effect of Australia on the New Zealand economy and financial system, this indicator is a 30/70 split between Australia and the rest of the world. The international dimension primarily captures the international economic cycle, although average current account balances and real commodity prices are also included as indicators of imbalances in the world economy. The Australian sub-dimension is similar to (but less granular than) the aggregate domestic environment indicator in that it combines headline indicators of indebtedness, current economic conditions and the sovereign risk premium.

2.4 Capital and profitability

The capital and profitability dimension is intended to capture the ability of the banking sector to absorb shocks to the asset side of their balance sheet, and to generate or obtain enough capital to withstand credit losses if necessary. Data for New Zealand banks is obtained from their quarterly general disclosure statements, and captures capital and leverage ratios, asset quality, and interest margins. Since the four largest New Zealand banks are Australian owned, this dimension also includes capital and leverage ratios, and asset quality of the parent banks, as well as their equity prices.

At present, both the capital and profitability, and the funding and liquidity dimensions only capture data on the banking system. In principle, it would be preferable to include data on a wider range of financial institutions. Currently there is little data available on the health of non-bank financial institutions. However, with the Reserve Bank recently commencing regulation of non-bank deposit takers, it is likely that data availability will improve over time.

2.5 Funding and liquidity

The funding and liquidity dimension measures the ability of New Zealand financial institutions to absorb a shock to the liability side of the balance sheet through higher costs or reduced availability of funding. This dimension uses data on the source of banks funding, and the availability of liquid assets to assess the likelihood that the banking sector has difficulty securing funding. As with the capital and profitability dimension, data on the Australian parent banks' funding capacity are also included.

3 Data and construction of the indicators

The model is constructed on a quarterly frequency, using data from 1990 onwards. In some cases there is no suitable data series spanning the entire time period. In these cases we use the longest available data series.

Prior to constructing the indicators a few transformations need to take place. Data that is not already at quarterly frequency is either averaged or (in a handful of cases) interpolated to produce this frequency. A problem that arises in constructing the indicators in real time is that there will often be some data missing at the end of history. For example, if the cobweb is updated at the end of October, a whole range of financial market data will be readily available for the September quarter, but most macroeconomic data for the quarter will not have been released yet. Where there is missing data at the end of history we take the last observed outturn to construct the cobweb. Because of this, the results of the model are likely to change throughout the quarter as new data becomes available.

A number of data series in the model exhibit heavy positive skew, which creates some difficulties in constructing the indicators. Where applicable we log transform series to remove this skew.

There are a number of ways that the data can be combined to produce financial stability scores across each dimension. For presentational purposes, we wish to create ordinal rankings on a 1–9 scale. The IMF (2007) approach is to convert each series into a percentile rank based on the history of that series, and then combine these percentiles. This approach has a number of advantages. Foremost among these is that it is not necessary to make strong distributional assumptions about the data – particularly when some input data is unlikely to follow a normal distribution. However, with relatively short samples, this methodology is unlikely to generate accurate estimates of the 'true' distribution of data. In particular, this methodology will have particular difficulty in estimating the probability of tail events – the region of most interest for financial stability analysis.

We use an alternative approach here. Data is first standardised into z-scores. In some cases we impose judgement on the mean and standard deviation of a series if we believe that the observed sample of data is not reflective of the full underlying distribution. Our judgementally adjusted z-scores are thus:

$$z = \frac{x - \mu * \mu_{jud}}{\sigma * \sigma_{jud}} \tag{1}$$

where x is the data point, μ is the mean of the series, μ_{jud} is the judgemental adjustment made to the mean, σ is the standard deviation of the series, and σ_{jud} is the judgemental adjustment to the standard deviation. If we believe the data sample reveals the underlying distribution in its entirety, no adjustment is necessary and $\mu_{jud} = \sigma_{jud} = 1$.

Weighted averages of these z-scores are taken for each dimension and sub-dimension. There are a range of methodologies that can be taken to select these weights. For example, Illing and Liu (2003) investigate weighting schemes based on equal weights, factor model based weights, or weights based on the credit weights in the economy. They find that an equally weighted scheme produces the best results for their model. However, we want our weights to provide some reflection of the relative importance of that particular indicator. There is no obvious methodology to select the weights in our model. We therefore set them judgementally to reflect the perceived importance of each data series to the underlying concept, while at the same time seeking to minimise the influence of individual series on the

Table 1
Jacques-Bera normality tests

	Normality test			
	test statistic	p-value	skewness	kurtosis
Domestic environment	5.27	0.05	0.63	3.01
Financial market conditions	14.96	0.01	0.42	5.19
Global environment	20.58	0.00	1.18	3.86
Capital & profitability	0.05	0.5	0.05	2.95
Funding & liquidity	3.86	0.07	-0.66	3.58

The normal distribution has skewness of 0 and kurtosis of 3. Higher numbers on each of these measures represent positive skew, and fatter tails than the normal distribution respectively.

aggregate indicator.[3]

The next step is to convert these standardised indicators into cumulative probability distributions. This step requires an assumption to be made about the underlying distribution that has generated each of the indicators. Jacques-Bera tests reject the null hypothesis of normality at the 5 percent level for two of the five indicators, while normality can be rejected at the 10 percent level for a further two indicators (see table 1).

While there is some evidence of skewness in each of these dimensions, the primary departure from normality appears to be significant excess kurtosis, where kurtosis is measured by:

$$k = \frac{E(x-\mu)^4}{\sigma^4} \tag{2}$$

and k=3 corresponds with the normal distribution. In particular, the financial market conditions and global environment dimensions appear to have significantly fatter tails than the normal distribution. Given that most of the dimensions show signs of non-normality, we use t-distributions to convert these indicators to cumulative probability distributions. Specifically, the degrees of freedom for the t-distribution are chosen indicator by indicator

[3] While it would be possible to use a factor model to estimate the weights, this technique is more suited to applications where there are a range of indicators which are all related to a single underlying concept. However, financial stability is a multi-faceted concept so a factor model is unlikely to choose weights that best reflect the relative importance of each variable to financial stability.

Table 2
Probability distribution of ordinal rankings

	1	2	3	4	5	6	7	8	9
Theoretical	.067	.132	.207	.229	.183	.108	.049	.019	.007
Observed	.013	.082	.280	.241	.154	.056	.039	.015	0

to achieve the same degree of kurtosis exhibited by that particular series.[4] The degrees of freedom υ can be chosen with the following formula:

$$\upsilon = \frac{4k - 6}{k - 3} \tag{3}$$

Thus we use a t-distribution with seven degrees of freedom for the financial market conditions indicator, and the t-distribution with eleven degrees of freedom for the global environment indicator.

The final step is to convert these cumulative probability scores into ordinal rankings on a 1–9 scale. There is no obvious way to choose the cutoffs for each of the ordinal rankings. For presentational purposes we want the median ranking on each dimension to be four, and for scores of one, eight or nine to represent very unusual conditions. We could achieve this by arbitrarily choosing cutoffs for each ordinal ranking. However, an average of the binomial distribution with n=9 and p=$\frac{4}{9}$, and the poisson distribution with λ=4 fits the desired properties.[5] With these cutoffs the mean and median of each indicator will be equal to four, and there will be a positive skew to the distribution of rankings. Almost 86 percent of rankings will fall between two and six, and a ranking of 9 will occur on average approximately one quarter every 35 years. Table 2 shows the probability bands for assigning these rankings, along with the realised outcomes of these rankings across the five dimensions over our sample period.

As shown in table 2, the realised probability of extreme outcomes is somewhat lower than implied by the theoretical distributions. The low incidence of very low outcomes may in part be due to the residual positive skew that is evident in our indicators. The low incidence of high scores is likely to have

[4] For series with estimated kurtosis of less than 3 we use the normal distribution

[5] There is no theoretical reason to favour these particular distributions. However, a Poisson distribution with λ=4 produced extreme scores a little less frequently than desired, while a binomial distribution with n=9 and p=$\frac{4}{9}$ sees extreme values occurring too often.

been influenced by the judgemental adjustment that is applied to the mean and standard deviation of each series.

3.1 Judgemental adjustment to the model

This model has been designed to give as accurate as possible indicator of the current state of financial stability. However, for various reasons the model may not always capture the Reserve Bank's best judgement about current conditions. This may reflect lags in the data, or aspects of the current situation may not be well captured in time series data. An example in this regard would be the sharp drops in liquidity in international capital markets in late 2008 and early 2009. For this reason judgement may need to be applied to determine the final placing of an indicator on the diagram, so that the diagram reflects the best judgement of policymakers.

4 Results

Figure 1 shows the time series pattern of the resulting ordinal rankings for each of the five dimensions which make up the cobweb model.[6] It should be noted that not all data series in our model are available for the entire time period. As a result, results for earlier periods are often based on smaller samples of data.

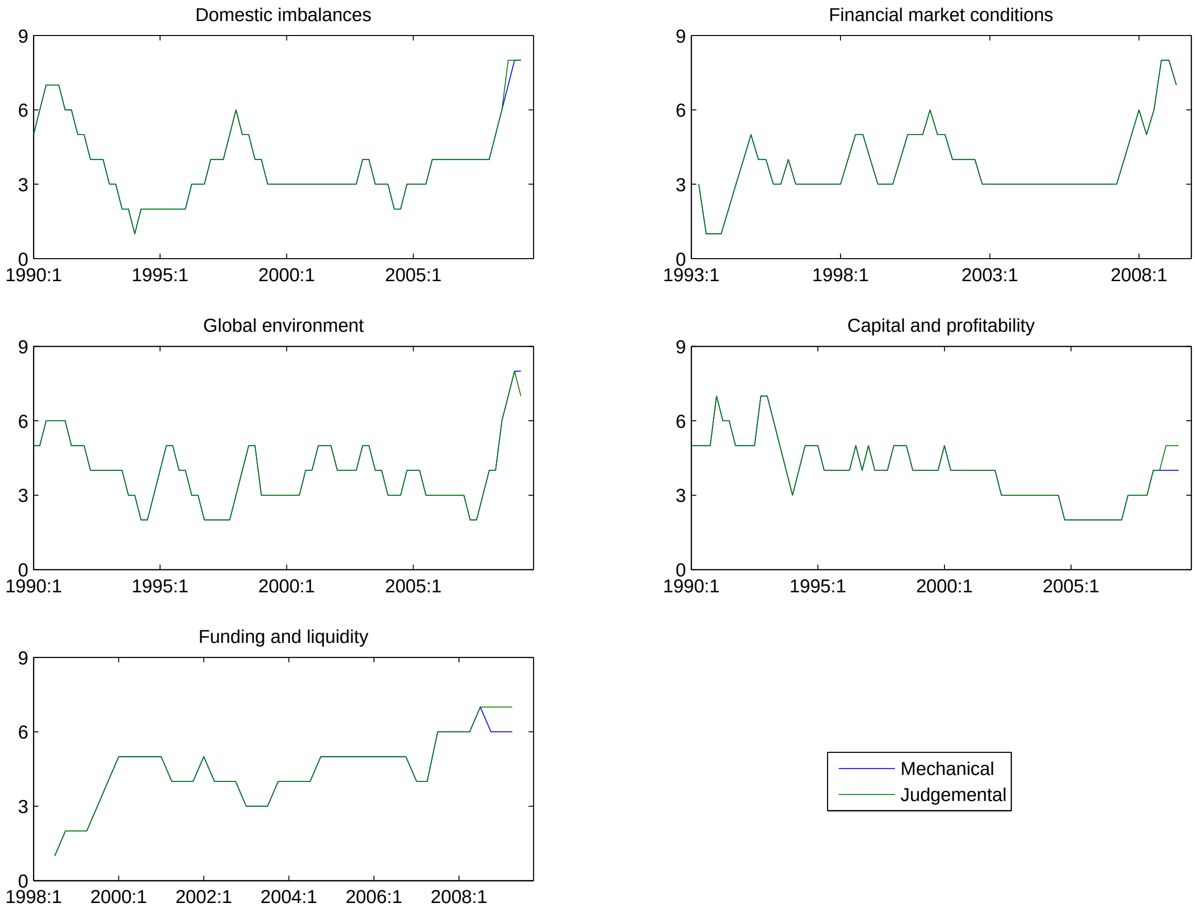
While van den End (2006) evaluates his model by correlating his results with interest rate spreads, bank credit ratings and financial institution failures, there are no clear metrics to evaluate the performance of our model against.

We therefore follow Illing and Liu (2003) and Hanschel and Monnin (2004) in employing expert judgement to compare the results of the model with subjective experience.

Prior to the most recent experience, the most severe episode of financial instability during our sample period occurred in the early 1990s, with a severe domestic recession and an enduring hangover from a share market and commercial property market bust in the late 1980s. Accordingly, the three dimensions for which we have data all recorded elevated readings during that period. The Asian financial crisis in the late 1990s is reflected in elevated

[6] Judgemental adjustment of the results has only been performed for the period from 2008Q4 to 2009Q2. No attempt has been made to adjust results from previous periods.

Figure 1
Five dimensions of the cobweb model



readings on the domestic environment and financial market conditions, although there was little discernable impact on the global environment as a whole or on banks' capital and profitability.

Reflecting the period known as the great moderation, most dimensions recorded fairly low scores for the majority of this decade, before rising sharply at the onset of the global financial crisis. Reflecting the unusual nature of this event, the three risk dimensions have all recorded their highest levels during the crisis. However, the New Zealand financial system has remained relatively resilient through this period, with bank capital and profitability in particular remaining stronger than in the early 1990s.

5 A graphical representation

There are a number of ways that the results of the model could be displayed. However, what is desired is a simple diagram that can clearly display scores across all five dimensions of the model, and thus feature prominently in the Reserve Bank's financial stability communications. In addition the diagram should be able to give an indication of how the indicators have changed over time.

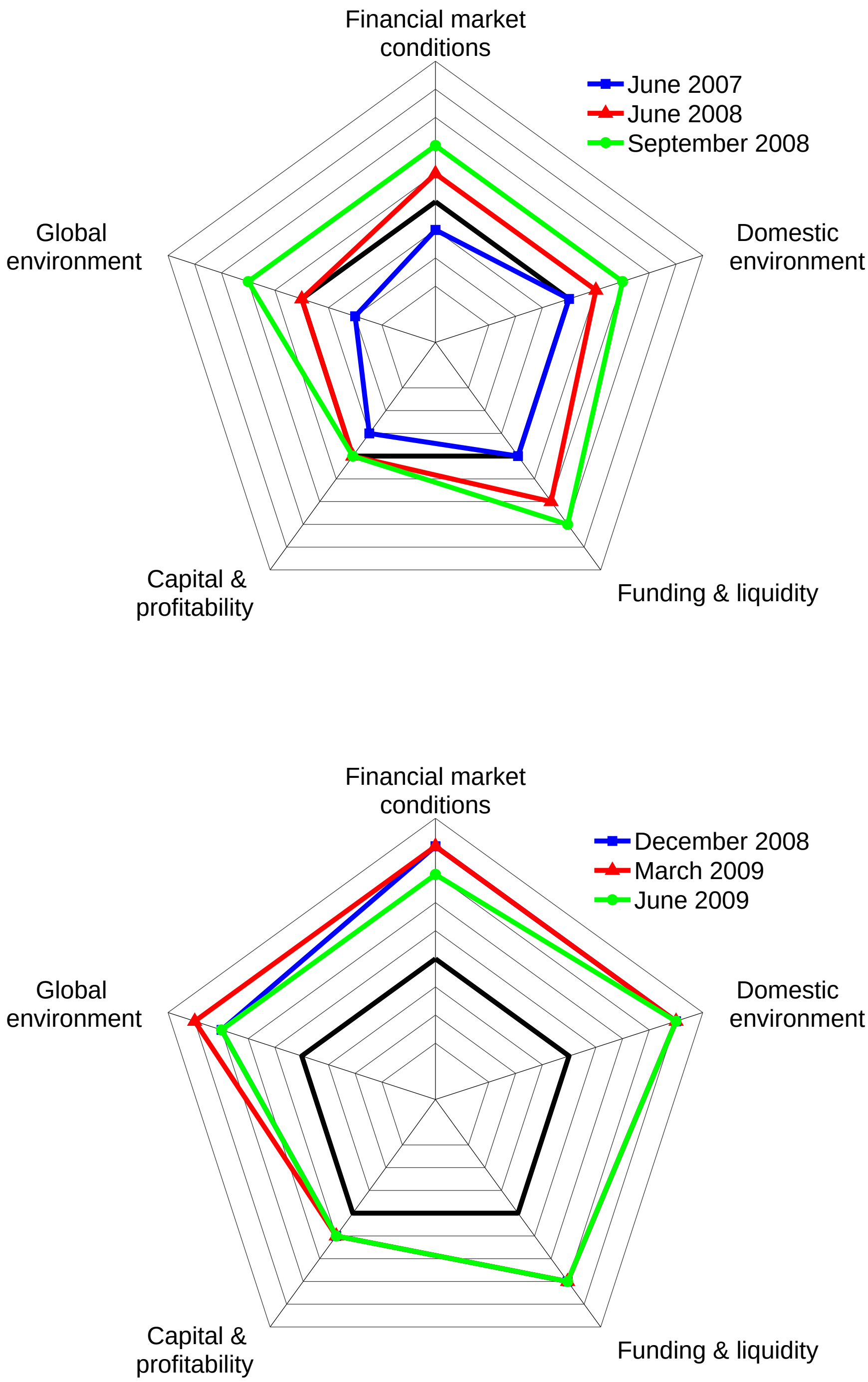
We follow the lead of the IMF in using a cobweb, or radar, style diagram to display the results of our model. This approach has the advantage of being able to display all five dimensions, while also being able to compare results from a few different points of time. Figure 2 shows how the cobweb diagram evolved during the course of the financial crisis.

The solid black ring in the diagram represents the historical median outcome, and gives the reader a sense of where financial stability conditions sit relative to history.

At the advent of the financial crisis in June 2007, financial stability risks were estimated to be below normal. Over the following 18 months there were sharp increases in all five dimensions of the cobweb. In particular, between June 2008 and December 2008 most dimensions moved from a position of slightly elevated risk to extreme risk. However, reflecting the relative resilience of New Zealand's financial institutions, the capital and profitability dimension remained relatively close to its normal position throughout the crisis.

In retrospect, the cobweb model appears to have been slow to capture emerging financial stability risks. In part this is likely to reflect the cyclically

Figure 2
Cobweb diagram



Note: Black band represents the historical median outturn. Movements away from the centre of the diagram represent an increase in financial stability risks strong position of the global and domestic economy in the lead up to the crisis. However, it also appears that financial market variables were underpricing the degree of risk, causing the cobweb model to give a misleading indication of the financial stability position. This period highlights that the model will not generally provide an early warning of impending financial stability risks. Had the model been in use over this period, it is likely that the results would have been judgementally adjusted to reflect a greater degree of risk than was captured by the raw cobweb model output.

The diagram is not intended to provide an explicit demarcation between financial stability and financial instability. So while outward movements on the diagram represent a relative deterioration in financial stability, no ex-ante judgement has been made about what configuration of scores on the cobweb would cause significant concerns.

In practice, financial instability is likely to be reflected in high scores across a number of dimensions. For example, simultaneous high scores on both the financial market conditions, and funding and liquidity dimensions would likely reflect significant funding difficulties for domestic financial institutions, possibly requiring official liquidity support. Likewise, high scores on both the domestic environment, and capital and profitability dimensions would indicate an elevated risk of insolvency for New Zealand financial institutions.

6 Conclusion

The cobweb model is an attempt to provide a graphical representation of financial stability for New Zealand. The results of the model can be displayed in an easily interpretable way.

The results from this model will be included for the first time in the November 2009 *Financial Stability Report*. The key benefit of including quantitative indicators of this form is that it should serve to anchor discussion, and will focus readers attention to what are seen as the most significant risks to financial stability.

However, the model is only one of many factors that are considered in the Reserve Bank's assessment of financial stability. In this regard the cobweb diagram should not be interpreted as giving a binary indicator of whether the financial system is currently stable or unstable. It does, however, provide a starting point for a more detailed discussion of the current risks to financial system stability.

It is likely that this model will evolve over time as new indicators and of financial stability become available. A possible avenue for future work is to try to explicitly capture some of the longer-term indicators of evolving imbalances which may create the preconditions for future crises.

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Appendices

A List of indicators in cobweb model

	Weight	Inverted	Start date	Source(s)	Transformation
DOMESTIC ENVIRONMENT					
AGGREGATE	0.25				
Current output gap	0.3	yes	1990	RBNZ	RBNZ measure
Forecast output gap	0.3	yes	1990	RBNZ	Average over next four quarters
External debt sustainability	0.1	no	2000	Stats NZ & Reuters	Net international debt/GDP ratio, multiplied by 5-year swap rate
External financing requirement	0.1	no	2000	Stats NZ	Current account deficit plus short-term (< 1 yr) external debt, relative to current receipts
Terms of trade	0.1	no	1990	Stats NZ	
Sovereign risk premium	0.1	no	1990	Reuters	Yield differential between US and NZ 10-year government bonds
HOUSEHOLD SECTOR	0.25				
Aggregate household LVR	0.25	no	1990	QV & RBNZ	Total housing credit, relative to value of housing stock. Log transformed
Aggregate household DSR	0.25	no	1990	RBNZ	Sum of housing and other credit servicing costs, relative to household disposable income. Log transformed
Forecast change in 90-day interest rate	0.1	no	1990	RBNZ	Change over 12-month horizon
Forecast change in residential property prices	0.1	yes	1990	RBNZ	Change over 12-month horizon
Current unemployment rate	0.1	no	1990	Stats NZ	Log transformed
Forecast change in unemployment rate	0.1	no	2000	RBNZ	Change over 12-month horizon
Proportion of credit card debt bearing interest	0.05	no	2000	RBNZ	
Personal bankruptcies	0.05	no	1990	MED & Stats NZ	Number per thousand of NZ resident population
BUSINESS SECTOR	0.2				
Aggregate debt burden	0.3	no	2000	RBNZ & Stats NZ	Stock of business debt, relative to ex-agriculture production GDP
Related party debt	0.15	yes	2000	RBNZ & Stats NZ	Proportion of total business debt from overseas related parties
Equity market capitalisation	0.1	yes	1990	Datastream	Total market value of NZX, relative to annual GDP
Real interest rate	0.2	no	1990	Reuters & Stats NZ	Ex post measure, based on 90-day bank bill yield and GDP deflator
QSBO Expectations - Domestic trading activity	0.1	yes	1990	NZIER	
QSBO Expectations - Profitability	0.05	yes	1990	NZIER	
QSBO Expectations - Overdue debtors	0.05	no	1990	NZIER	Unweighted average across builders, manufacturers and merchants
Company liquidations	0.05	no	1990	MED	Log transformed
AGRICULTURAL SECTOR	0.2				
Aggregate debt burden	0.25	no	1991	RBNZ & Stats NZ	Stock of agricultural debt from banks, relative to nominal agriculture GDP. Log transformed
Approximate aggregate farm LVR	0.25	no	1996	RBNZ & REINZ	Stock of agricultural debt relative to aggregate farm value
Real NZD commodity prices	0.2	yes	1990	ANZ & Stats NZ	Nominal ANZ series deflated by farm expenses index
Forecast change in export price index	0.2	yes	1990	RBNZ	Change over 12-month horizon
Farm sales	0.05	yes	1996	REINZ	Quarterly sum of monthly data
Soil moisture deficit	0.05	no	1990	MAF	Four-quarter moving average
GOVERNMENT SECTOR	0.1				
Crown debt sustainability	0.25	no	1990	Treasury & Reuters	Net Crown debt/GDP ratio, multiplied by 10-year government bond yield
Crown financing requirement	0.25	no	1990	Treasury & RBNZ	OBEGAL plus short-term (< 1 year) debt, measured relative to current tax receipts
Forecast change in OBEGAL/GDP ratio	0.25	yes	1990	Treasury	Change over three-year horizon
Forecast change in net Crown debt/GDP ratio	0.25	no	1990	Treasury	Change over three-year horizon
GLOBAL ECONOMIC ENVIRONMENT					
INTERNATIONAL	0.7				
Trading partner real GDP growth	0.2	yes	1991	RBNZ	Export-weighted GDP16 measure, annual percent change
Forecast trading partner real GDP growth	0.2	yes	1990	RBNZ	Growth over next twelve months
OECD leading indicator	0.1	yes	1990	OECD	Amplitude-adjusted measure for all OECD countries
Real international commodity prices	0.1	no	1990	Datastream	CRB index (in USD), deflated by US core PCE deflator

– continued from previous page

	Weight	Inverted	Start date	Source(s)	Transformation
G7 current account imbalance	0.1	no	1996	OECD	Absolute current account balances of G7 countries, scaled by G7 nominal GDP
OECD unemployment rate	0.1	no	1990	OECD	
Forecast global corporate default rate	0.1	no	1990	Datastream	Moody's global default rate on corporate bonds (issuer weighted). Log transformed
EMBI Global spread	0.1	no	2000	Bloomberg	Log transformed
AUSTRALIA	0.3				
Real GDP growth	0.2	yes	1990	Datastream	Annual percent change
Forecast real GDP growth	0.2	yes	1990	RBNZ	Growth over next twelve months
External debt sustainability	0.1	no	1991	RBA, Datastream & Reuters	Net international debt/GDP ratio, multiplied by 5-year swap rate
Aggregate internal DSR	0.1	no	1990	Datastream & Reuters	Private sector credit/GDP ratio, multiplied by 90-day bank bill rate. Log transformed
Sovereign risk premium	0.1	no	1990	Reuters	Yield differential between US and AU 10-year government bonds. Log transformed
Unemployment rate	0.1	no	1990	Datastream	Log transformed
Benchmark credit spreads	0.1	no	2004	Bloomberg	iTraxx Australia Generic 5yr - Investment Grade. Log transformed
Terms of trade	0.1	yes	1990	Datastream	
FINANCIAL MARKET CONDITIONS					
INTERNATIONAL	0.6				
Global equity prices	0.1	yes	1990	Bloomberg	Annual percent change in MSCI Global index
Equity market implied volatility	0.1	no	1990	Bloomberg	VIX index (option-implied volatility of S&P500). Log transformed
FX market implied volatility	0.1	no	1999	Bloomberg	Average of 3-month option-implied volatilies in EUR, JPY, GBP & AUD against USD. Log transformed
TED spread	0.2	no	1991	Bloomberg	Yield differential between 3-month eurodollar and 3-month T-Bills. Log transformed
US benchmark credit spread	0.1	no	1990	Bloomberg	Yield diffential between corporate debt (Moody's average) and 30-year US Treasuries. Log transformed
Europe benchmark credit spread	0.1	no	2004	Bloomberg	iTraxx Europe cross-over index. Log transformed
Median LCFI 5-year senior CDS spread	0.1	no	2002	Bloomberg	LCFI population as per BoE FSR (ex-Lehman from Sept 2008). Log transformed
Net new commercial paper issuance	0.2	yes	1992	Bloomberg	Quarterly percent change in financial issuers' commercial paper outstanding
DOMESTIC	0.4				
New Zealand equity prices	0.15	yes	1993	Bloomberg	Annual percent change in NZX All-Share index
NZD implied volatility	0.3	no	1997	Bloomberg	3-month option-implied volatility against USD. Log transformed
Bid/ask spread in FX market	0.05	no	2007	Reuters	Expressed relative to mid-price. Log transformed
3-month Bank Bill-OIS spread	0.3	no	2002	Bloomberg	Log transformed
Bid/ask spread in BB futures market	0.05	no	2007	Reuters	Expressed relative to mid-price. Log transformed
Commercial paper benchmark spread	0.15	no	2002	Reuters	Spread to 3-month Bank Bills for A1+ issuance
CAPITAL AND PROFITABILITY					
Local banks' tier 1 capital ratio	0.2	yes	1990	RBNZ	
Local banks' leverage ratio	0.2	no	1990	RBNZ	Inverse of shareholder funds to assets ratio. Log transformed
Local banks' asset quality	0.2	no	1991	RBNZ	Ratio of gross impaired assets to total lending. Log transformed
Local banks' net interest margin	0.05	yes	1990	RBNZ	12-month running total. Log transformed
Australia tier 1 capital ratio	0.1	yes	1990	RBA	
Australia leverage	0.1	no	1990	RBA	Inverse of equity capital to assets ratio. Log transformed
Australia asset quality	0.05	no	1994	RBA	Ratio of gross impaired assets to total assets. Log transformed
Parent banks' equity prices	0.1	yes	1990	Bloomberg	Annual percent change in average share price across major parent banks
FUNDING AND LIQUIDITY					
Deposit/loans ratio	0.2	yes	1998	RBNZ	Ratio of NZD retail funding to total domestic lending (excluding M3 insitutions)
Retail deposit growth	0.05	yes	1999	RBNZ	Annual percent change
Non-resident funding	0.2	no	1998	RBNZ	Ratio of non-resident funding to total funding
Associate funding	0.05	no	1998	RBNZ	Ratio of associate funding to total funding

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	Weight	Inverted	Start date	Source(s)	Transformation
Liquidity cover	0.1	yes	1998	RBNZ	Ratio of liquid assets to total short-term funding (< 1 year)
Approximate core funding ratio	0.1	yes	1998	RBNZ	Approximate version of metric embedded in prudential liquidity policy
Uridashi/Eurokiwi coverage	0.1	yes	1998	Reuters & RBNZ	Ratio of stock of offshore NZD bonds outstanding to banks' total FX funding
Parent banks' median CDS spread	0.2	no	2003	Bloomberg	Median across four major parent banks. Log transformed