Towards Putting a Price on the Risk of Bank Failure

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Abstract

This paper develops a new approach for conceptualizing and measuring the risk associated with bank failure. The price of this risk in risk-adjusted present-value terms is estimated at $170-340 million per annum (0.07-0.15% of GDP), representing the price of the financial risk that exists ex-ante (ie, before a bank fails). This can be interpreted as the cost that is either passed onto the banks via higher funding costs, or borne as an implicit risk on the government's balance sheet. Alternatively, one could think of this as a one-off cost, in the event that all major banks failed in a single crisis. If that were to happen, and if net losses were to be 5-10 per cent of bank liabilities the total cost could be $16-31 billion (7-13% of GDP). This can be interpreted as either the net cost of a government bail-out, or the total value of haircuts on wholesale and retail creditors that would be applied under an Open Bank Resolution (OBR) or a liquidation.

Bank bail-outs are not necessarily required or recommended in New Zealand given the existence of OBR. However, the major banks currently receive a one-notch uplift in their credit ratings specifically because of the expectation of government support. These ratings' uplifts are used to estimate the market-implied likelihood that the banks would be bailed out in the event of their failure, and therefore the size of the implicit guarantee banks that are seen to receive. This perceived implicit guarantee is estimated to be worth around $80-$230million per annum (0.04%-0.11% of GDP), equivalent to a 3-8 basis points subsidy on banks' total borrowing costs. This estimate is low by international standards, consistent with the current soundness of the major domestic banks and the relatively low perceived likelihood of government support.

JEL CLASSIFICATION

G21 - Banks; Other Depository Institutions; Mortgages
G38 - Government Policy and Regulation
H89 - Public Economics - Miscellaneous Issues - Other

KEYWORDS

Bank failure; contingent liabilities; implicit guarantee; financial crises; bail-out; bail-in; bank resolution.

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Towards Putting a Price on the Risk of Bank Failure

1 Introduction

The Global Financial Crisis illustrated all too well that major banking crises pose a significant threat to this fiscal and macroeconomic stability, even in developed economies. While the New Zealand banking system weathered the crisis relatively unscathed, this does not guarantee that New Zealand is immune to banking crises in the future. The severe impact that such a crisis could have on national living standards suggests that this is a risk that needs to be well understood and, crucially, well managed.

In general, bank failures can be seen as having two types of costs: direct costs and indirect costs. The direct costs refer to the financial losses associated with a bank that has become insolvent. In principle, these losses should be borne by a failed bank's creditors, who would receive less than what was owed to them as the bank is wound down. However, many cases in recent years have seen taxpayers bear these costs via government bail-outs, particularly for "too-big-to-fail" institutions whose disorderly wind-down would be extremely disruptive. In response, a number of jurisdictions have now introduced so-called 'bail-in' regimes that aim to eliminate too-big-to-fail by allowing for losses to be allocated to creditors in a more orderly fashion. In New Zealand, the Open Bank Resolution tool (OBR) has been developed for this purpose.

Bank failures can also involve indirect costs to the broader economy, which may be particularly large if the failure is of one or more major banks. Severe banking crises can result in a significant loss in confidence, heightened financial instability, tightening of credit conditions, and mounting pressures on household and government balance sheets. These effects can then have flow-on impacts throughout the economy, leading to sizable and potentially long-lasting overall declines in GDP, fiscal balances, and living standards.

While both types of costs are significant, this paper focuses on the direct costs of bank failure. To conceptualize the size of these costs, the paper develops two distinct but related ways of measuring them: as *ex-post* costs, and as *ex-ante* costs. As will become clear from the discussion throughout this paper, these two costs are linked by taking into account a measure of the risk-adjusted probability of failure.

The ex-post cost of bank failure measures the amount required to absorb the insolvency losses of a failed bank. In other words, it is the 'price' of resolving a bank *after* it has failed. On the other hand, the *ex-ante* cost measures the amount of risk associated with the fact that a bank may fail in a given period of time. In other words, it is the 'price' of the financial risk that exists *before* a bank fails, simply because its failure is possible. So while *ex-post* costs are contingent on a bank actually failing, *ex-ante* costs exist regardless of whether a bank actually fails. It is important to note that these two costs are not additive given that they reflect two ways of measuring the same financial risk.

When a bank fails, the *ex-post* cost is borne by whoever absorbs the bank's insolvency losses, whether that be bank creditors (under a bail-in), or taxpayers (under a bail-out). In either case, there is a cost that must be borne by somebody. Similarly, the *ex-ante* cost is borne by whoever is expected to bear the *ex-post* cost if a bank were to fail. If bank creditors expected to be bailed-in, they would bear the immediate *ex-ante* costs, but would transfer these costs to the bank by demanding a higher interest rate or yield on their investment. To the extent, however, that governments are expected to bail out particular banks, taxpayers bear the *ex-ante* costs on behalf of bank creditors, and an implicit guarantee is said to exist. Such an implicit guarantee reduces the *ex-ante* costs faced by creditors and therefore the compensation they demand from banks, potentially giving rise to moral hazard and other market distortions in the banking sector.

The main purpose of this paper is to assess the size of these *ex-post* and *ex-ante* costs and any associated implicit guarantee in the New Zealand context. To do this, a simple model is developed based on the observation that the financial risk associated with bank failure is analogous to that arising under a put option on a bank's assets. The binomial options pricing model of Cox and Rubenstein (1976) is used to value this option, and therefore to estimate both the *ex-post* and *ex-ante* costs for the major domestic banks. Finally, the model is extended to estimate the size of the implicit guarantee, using a market-based measure of the likelihood of a government bail-out.

The rest of this paper proceeds as follows. Section 2 develops a conceptual framework for assessing the costs of bank failure, and how these relate to the implicit guarantee. Section 3 develops an analytical framework for assessing these quantities. These are then estimated for the major New Zealand banks, with Section 4 describing the data used in the analysis, and Section 5 presenting the results. Finally, Section 6 offers some brief concluding remarks.

2 Conceptual framework

This section develops a simple conceptual framework for thinking about the direct costs of bank failure.

2.1 Defining bank failure

For simplicity, this paper assumes that bank failure only occurs when a bank is fundamentally balance-sheet insolvent. Balance-sheet insolvency represents the case where a bank faces losses large enough to mean that the market value of its assets is lower than its total financial liabilities. The idea here is that if the market value of assets was higher than total liabilities, there would be a price at which the bank could issue equity to a willing buyer in order to replenish its capital ratios and avert failure.

A caveat for the analysis below is that this is a (necessarily) over-simplistic assumption of how bank failure plays out. In reality it will be near impossible to know the true market value of a bank's assets, and therefore whether or not a bank is fundamentally balance-sheet solvent or not. This uncertainty means that insolvency and illiquidity are difficult to distinguish in practice. For example, a fundamentally balance-sheet insolvent bank could avoid failure if it could continue accessing market or central bank liquidity. Alternatively, a fundamentally balance-sheet solvent bank could fail if it is unable to remain liquid.

2.2 The *ex-post* cost of bank failure

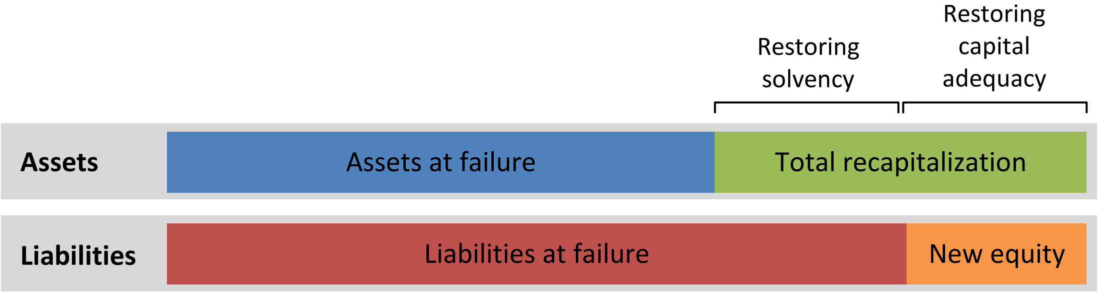
In general, a failed firm can be liquidated without significant disruption to the financial system or the real economy. However, this may not be the case for a failed bank, especially if the bank is highly financially interconnected and plays a significant role in providing payments services, credit intermediation, and other important banking functions in the economy. For this reason, when a bank becomes insolvent, it may be necessary to avoid a disorderly liquidation and prevent significant financial and economic disruption. But to do so, there is an immediate need to restore the balance-sheet solvency of the failed bank.

This paper considers the *ex-post* cost of bank failure to be the immediate cost that is required to return an insolvent bank to the point where the market value of its assets is at least equal to its total liabilities (ie, a zero net-asset position). In this case, the bank's assets will be just sufficient to ensure that the bank could meet all of its financial obligations as they fell due, provided it could access the necessary liquidity in the interim. In reality, uncertainty and variability in the value of the bank's assets mean that the bank will require additional loss absorbency (such as equity capital) to reduce the risk of subsequent insolvency and to facilitate access to market liquidity. However, if additional loss-absorbing capital is provided, one would expect this capital to have an equivalent economic value. This suggests that any capital corresponding to a positive net asset position does not contribute to the economic cost of restoring solvency.

Example 1: the *ex-post* cost in a bail-out

In a simple bail-out, the government bears the *ex-post* cost of bank failure by purchasing equity in the bank at above market value.[1] Governments will often purchase enough equity for the bank to meet its regulatory capital requirements going forward. In this situation, the total funds injected can be broken into two components: the cost of returning the bank to a zero net-asset position (ie, the cost of restoring solvency); and the cost of giving the bank a suitably positive net-asset position (ie, the cost of restoring capital adequacy). This breakdown is illustrated in Figure 1 below.

Figure 1: Evolution of a bank's balance sheet in a bail-out



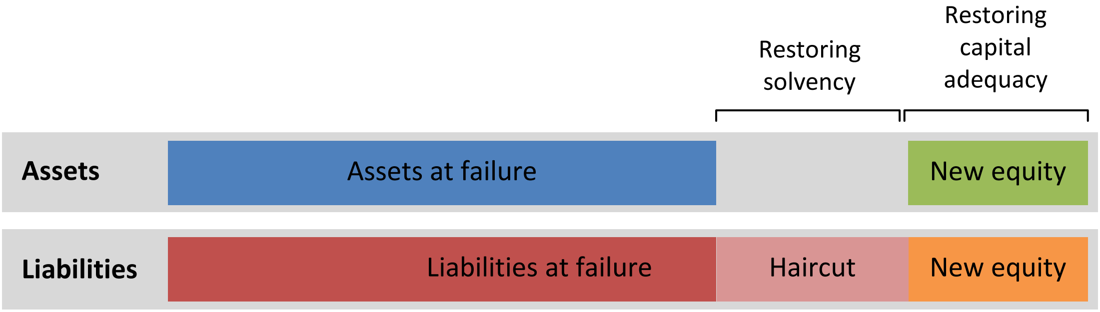
[1] Bail-out could occur in other forms. For example, the government could provide guarantees on loans held by the bank or on the borrowing of an insolvent bank. Alternatively, the government could purchase bank assets (including securitised assets) for more than their market value. However, the exact mechanism does not directly affect the size of the economic cost at the point of failure.

In this paper, the *ex-post* cost of bank failure only refers to the cost of restoring solvency. This reflects the fact that when the government recapitalizes a bank it receives bank shares that may have some value.[2] In fact, the cost of restoring capital adequacy once solvency has been restored is not really a cost – it is just a transaction of assets at market values (ie, 'cash' for bank equity) – and could equally be provided by a third party other than the government. This means that the *net* cost faced by taxpayers in a bail-out is potentially less than the total cost of the recapitalization. So while restoring solvency does imply a cost for the government, restoring capital adequacy does not, and is thus not considered part of the *ex-post* cost of bank failure.[3]

Example 2: the *ex-post* cost in OBR

The Open Bank Resolution (OBR) tool is intended as an alternative to bail-out that enables the costs of bank failure to be allocated to a bank's creditors without requiring a disorderly wind-down. It works by placing a bank into statutory management and freezing a portion of selected bank liabilities in line with a conservative estimate of the bank's insolvency losses and the hierarchy of claims. The bank would then open the next business day, giving depositors access to the unfrozen portions of their accounts. Any unfrozen amounts would be guaranteed by the government. When the value of the bank's assets is clearer, the frozen portion could be reduced to reflect a final write-down of bank liabilities. In order for the bank to operate as a going concern following OBR, it would also require an injection of new capital to buffer bank creditors from future losses and meet regulatory capital requirements. This is illustrated in Figure 2 below.

Figure 2: Evolution of a bank's balance sheet in an Open Bank Resolution



In OBR, the *ex-post* cost of bank failure is equivalent to the final haircut faced by the bank's creditors, plus any call on the government guarantee if losses are greater than the initial haircut. Again, the cost of any new equity injected into the bank following OBR is not part of this *ex-post* cost, given that this new equity has economic value. To the extent that OBR does not affect the value of the bank's assets, the size of the *ex-post* cost is the same irrespective of whether bail-out or OBR is used.[4] In other words, OBR alters the *incidence* but not the *magnitude* of the cost.

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[2] Significant uncertainty in the midst of a banking crisis will mean that valuing the equity received will not be straightforward in practice. Even once equity is sold it will be unclear what rate of return would have represented a fair compensation for holding risky bank equity throughout a crisis. Nonetheless, this breakdown is still a useful way to conceptualize the cost of bank bail-outs.

[3] That being said, there may be indirect costs to the government holding risky bank equity. For example, uncertainty around the value of the bank equity on the government balance sheet could be reflected in the government's borrowing costs.

[4] In reality one could expect that the costs would be different under OBR and bail-out if the choice of tool had feedback effects on the market value of the failed bank's assets. For instance, if the tools had different impacts on the performance of the real economy, one might expect this to affect the level non-performing loans going forward.

2.3 The *ex-ante* cost of systemic bank failure

An alternative way to think about the direct cost of systemic bank failure is to look at amount of financial risk associated with the fact that a bank might fail. This financial risk - like any financial risk - has an associated financial cost to whoever bears it (think of insurance). This cost can be referred to as the *ex-ante* cost of bank failure. It represents the fact that, even if failure does not occur in a given period, there is risk - and therefore a cost - that must be borne by somebody (either explicitly or implicitly).

2.3.1 The *ex-ante* costs when creditors face the risk of failure

When creditors face the financial risk of bank failure (given the existence of a credible bail-in mechanism), they may demand compensation for this risk via a higher interest rate or yield on their investment in a bank. When this happens, the *ex-ante* cost of failure is borne by creditors but passed onto banks through higher funding costs relative to the 'risk-free' rate in the economy. In this case, banks are like any other levered firm where funding costs are dependent on creditors' risk of facing default losses. Over the longer term, one would expect at least part of this cost to be passed onto bank customers via higher lending rates. These mechanisms ensure that those who create risk (ie, banks and their borrowers) face the cost of the risk they create, helping to promote efficient levels of risk-taking in the banking system.

2.3.2 The *ex-ante* costs when taxpayers face the risk of failure

On the other hand, if the government faces the financial risk of bank failure (ie, if it cannot credibly commit to not bailing out certain banks), the *ex-ante* cost is borne implicitly by taxpayers. In this case, the *ex-ante* costs are less tangible, but can be thought of as an implicit contingent liability on the government's balance sheet.[5] This contingent liability contributes to the overall riskiness of the government's balance sheet, which in turn has a marginal impact on government's borrowing costs, debt capacity, and the size of the net debt buffers that are desirable to ensure the resilience of the balance sheet to shocks. Collectively, this may have a marginal effect on the amount of goods and services the government can provide for a given level of taxation.

Furthermore, the government bearing the risk of bank failure 'on behalf of' creditors constitutes an *implicit guarantee*. In this case, the expectation of bail-out shelters creditors from the risk of bank failure, weakening their incentives to monitor and require compensation for this risk via higher interest rates. As a result, the implicit guarantee can implicitly subsidise certain banks' funding costs, and promote moral hazard and other market distortions in the banking sector. Indeed, a key motivation for the introduction of the OBR tool in New Zealand has been to reduce this distortionary implicit guarantee.

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5 For a more in depth discussion of implicit contingent liabilities see Polackova (1999)

2.4 Overview of the various direct costs associated with bank failure

To summarise, the table below illustrates how the financial costs of bank failure manifest when the risk is faced by either the creditors or the government. Note that in reality, risk may be borne by both of these parties if there is uncertainty around who will face the financial costs in the event of bank failure.

Table 1: The various manifestations of the ex-ante and ex-post costs of bank failure

Resolution approach	Manifestation of *ex-post* costs	Manifestation of *ex-ante* costs
OBR	Haircuts in OBR (plus any call on the government guarantee)	Higher funding costs for banks
Bail-out	Cost of bail-out, less the market value of bank equity received	Implicit contingent liability on the government balance sheet

2.5 The indirect costs of bank failure

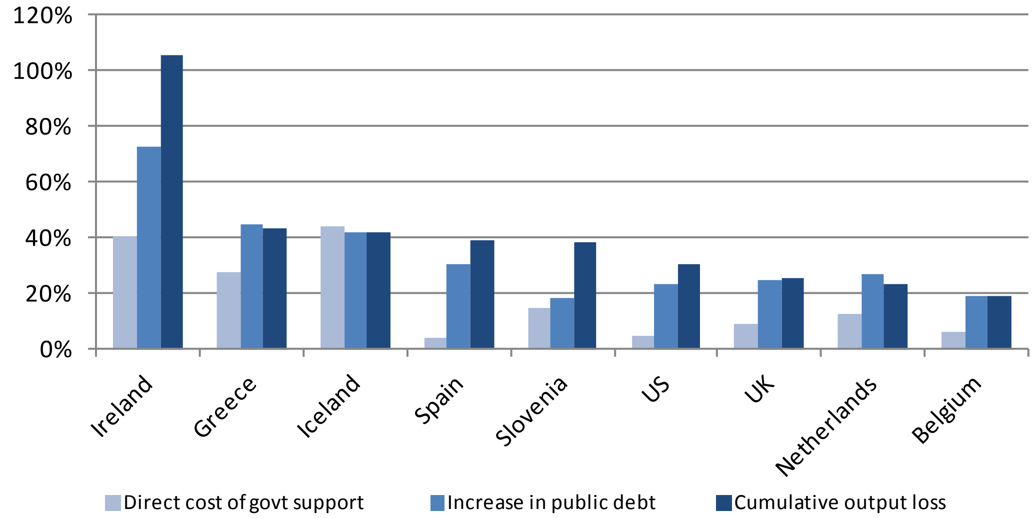
This paper focuses solely on the direct costs of bank failure. However, severe banking failures will likely be associated with significant indirect economic, fiscal, and social costs as well. These costs are inherently difficult to distinguish from those that would have arisen in the absence of bank failure, given that such failures are most likely to occur in severe economic downturns to begin with. Nonetheless, historical evidence does suggest that severe banking crises result in deeper downturns (Reinhart and Rogoff, 2009).

In general, these indirect costs arise because of the wide range of channels through which a banking crisis can impact on the real economy and the government balance sheet. For example, the immediate disruption to the banking sector and broader financial markets will impact on the cost and availability of capital in the economy, and on the supply of credit to households and businesses. Moreover, the flow-on impact on household wealth and consumer and business confidence would compound weakening demand in the economy. This would ultimately affect incomes, employment, and tax revenues. Larger fiscal deficits would add see public debt and debt servicing costs rise, potentially leading governments to cut spending, putting further downward pressure on aggregate demand. While lower interest rates and a weaker exchange rate would eventually help the economy rebalance, the cumulative impact on output could be sizeable - particularly if any of these effects were permanent or long-lasting.

To illustrate, the graph below gives examples of the costs of recent major banking crises from the IMF's *Systemic Banking Crises Database* (Laeven and Valencia, 2013). In advanced economies, the average bail-out cost, less recoveries, is 4.2% of pre-crisis GDP. By contrast, public debt increased by an average of 23.6% of GDP, and the cumulative loss in aggregate output was 32.4% of GDP.[6] As shown in Figure 3 below, these costs were significantly higher in more severe crisis situations, such as Ireland, where banking failures were more widespread. While these costs will not necessarily be entirely attributable to bank failure, they at least provide an idea of the economic and fiscal conditions that tend to be associated with major banking crises.

[6] These figures may actually understate the true impact given that the do not account for effects beyond 2011.

Figure 3: Direct and indirect costs of recent banking crises (% of pre-crisis GDP)



Source: Laeven and Valencia (2013)

3 Analytical framework

This section develops an analytical framework for contemplating the financial costs of bank failure based on the conceptual framework developed above.

3.1 A 'real-option' view of bank failure

The failure of a bank, as defined in this paper, is analogous to a situation where bank equityholders' option to default is in-the-money.[7] Equityholders' option to default is the 'real option' that allows them to walk away from a bank in the event of its insolvency, thereby giving effect to the limited liability nature of bank equity. This real option is considered by Merton (1977), who treats a firm's equity as a European[8] call option on the value of the firm's assets, A, with a strike price equal to the face value of the firm's debt, D. This debt is assumed to have a single maturity, T, at which point equityholders have the option (ie, the right but not the obligation) to pay debtholders D and receive A. Equityholders therefore exercise the option and receive the firm's net assets if $A - D > 0$, or choose not to exercise the option and receive nothing. Under this model, the value of equity is equivalent to the value of this call option:

$$E = C(A, D, T) \tag{1}$$

Instead of a call option, equity can also be seen as a long position in the firm's net assets ($A - PV(D)$) plus an option to default. The option to default is essentially a put option on the bank's assets with a strike price equal to the face value of its debt. This means that when a firm has negative net assets, equityholders can default on their liabilities, effectively selling the firm's assets to bondholder for $D > A$. Because of put-call parity, the value of equity is equal under both approaches.

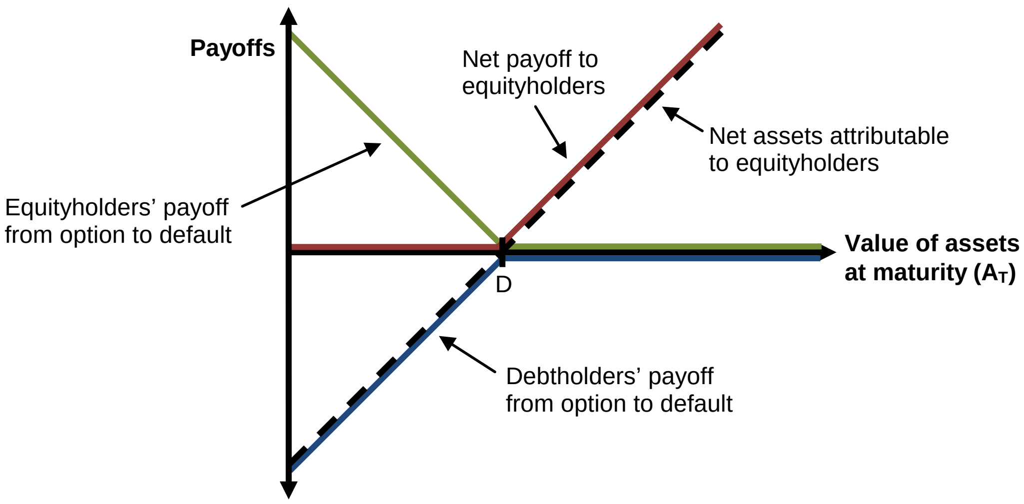
$$E = A - PV(D) + P(A, D, T) \tag{2}$$

7 An option is referred to as "in-the-money" at a given point of time if it would have a positive payoff if exercised.

8 A European option can only be exercised at maturity, whereas an American option can be exercised at any point prior to maturity.

Figure 4 below provides a visual illustration of this model. When a bank is insolvent (ie, $A < D$), equityholders' negative equity position $(D - A < 0)$ is offset by the amount they receive from exercising their option to default $(A - D)$. This puts a zero lower bound on the value of equity, thereby giving effect to equityholders' limited liability. Note that the net payoff to equityholders (illustrated by the red line) is equivalent to the payoff of a call option on the value of assets with a strike price of D.

Figure 4: Payoffs to equityholders and bondholders under the Merton model



Using this analogy, we can see that the *ex-post* cost of bank failure is equivalent to the payoff from the option to default (the blue line) when it is in-the-money $(A - D < 0)$, given this amount corresponds to the insolvency losses of a failed bank (and therefore the cost of restoring its solvency). This also means that the *ex-ante* cost for a given bank is equal to the value of the option to default, given that the financial risk of bank failure is equivalent to the financial risk arising from a short position in this option.

3.2 Pricing the risk of bank failure

There are three well-established ways to price financial options, each of which could be used to estimate the *ex-ante* cost of bank failure.

3.2.1 Black-Scholes model

The Black-Scholes equation is a structural-form model for valuing financial options, and is used by Merton (1977) to value the option to default described above. The value of a European put option using Black-Scholes is:

$$P(A,D,T) = N(-d_2)De^{-rT} - N(-d_1)A$$

$$where \quad d_1 = \frac{1}{\sigma\sqrt{T}}\left[\ln\left(\frac{A}{D}\right) + T\left(r + \frac{\sigma^2}{2}\right)\right], \qquad d_2 = d_1 - \sigma\sqrt{T} \tag{3}$$

In this model r is the constantly compounding risk-adjusted drift rate of bank assets (typically assumed to be the risk free rate over time-to-maturity T), σ is the standard deviation in the growth rate of bank assets over the period T, and $N(\cdot)$ is the standard normal distribution. Typically, this model can be parameterised using readily available information. For example, σ is often derived from the return volatility of listed equities.[9] This approach is used by Noss and Sowerbutts (2012) who value this put option using both historical equity volatility and implied volatility from banks' traded equity options.

However, there are several weaknesses of the Black-Scholes approach in this context. The main weakness is that it assumes that changes in value of bank assets are normally distributed - a condition that understates the probability of large swings in asset values that can be observed in reality. Furthermore, the option to default is American, not European, in nature, as it can be exercised at any point in time where a bank has principal or interest payments due. A structural-form model is unlikely to be the best way to do account for these factors.

3.2.2 Monte-Carlo simulations

One way to circumvent the shortcomings of the Black-Scholes method is to use Monte-Carlo simulations. This approach would provide greater flexibility than structural-form models. Simulations allow for deviations from the normally-distributed changes in the value of bank assets, meaning that more accurate probability distributions could be used.[10] Simulations could be calibrated to better reflect the 'American' nature of the option to default. However, this approach would still be difficult to calibrate accurately, particularly as it would require significant assumptions around how the value of bank assets changes over time.

3.2.3 Binomial pricing model

A simpler way to apply Black-Scholes is the binomial model developed by Cox and Rubenstein (1979). This model has the same theoretical underpinnings as Black-Scholes, but relies on simpler assumptions around the probability distribution of changes in the value of bank assets. The model is based on the observation that the term $N(-d_2)$ represents the risk-neutral probability that the option is exercised, $p(A_T < D)$[11], and that the term $N(-d_1)A$ represents the discounted expected value of assets given that the option is exercised, $e^{-rT}E(A_T|A_T < D) \cdot p(A_T < D)$. These insights allow for the Black-Scholes equation above to be restated as follows:

$$P(A,D,T) = e^{-rT}p(A_T < D)D - e^{-rT}p(A_T < D)E(A_T|A_T < D) \quad (4)$$

$$= e^{-rT}p(A_T < D) \cdot [D - E(A_T|A_T < D)] \quad (5)$$

In this case, the term $D - E(A_t|A_t < D)$ represents the expected payoff from the option if exercised: the strike price received less the expected value of the assets sold under the put. The term $e^{-rT} \cdot p(A_T < D)$ then transforms this expected payoff at exercise into an expected present value based on the *risk-neutral* probability that the option is exercised. In other words, the value of the option is equal to the risk-neutral expectation of the option's future payoff. This is analogous to a two-state world (hence binomial) where the option is either: a) not exercised, paying off nothing; or b) exercised, paying off its expected payoff given exercise.

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9 Note that estimating asset volatility from equity volatility addresses the fact that a firm's debt is not constant over time. This feature is particularly useful in the context of banks where liabilities are highly variable and often highly correlated with assets

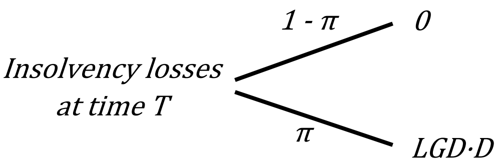
10 For example, loan-loss models developed by banking regulators or the risk-weighted asset model of Miles et al. (2010) that includes a low-probability, large-shock component based on historical movements in GDP per capita.

11 Risk-neutral probabilities are discussed in detail in the next section.

The terms in the expression above have intuitive interpretations in the case of bank equityholders' option to default. Firstly, $p(A_T < D)$ is equivalent to the bank's risk-neutral probability of default, hereafter denoted π. Secondly, $E(A_t|A_t < D)$, is the expected value of the bank's assets given default, equivalent to $D(1\text{-}LGD)$, where LGD denotes expected loss-given-default on the bank's total liabilities. Using these terms, the equation above can be restated as follows:

$$P(A, D, T) = \pi e^{-rT}[D - D(1 - LGD)] = \pi e^{-rT} LGD \cdot D \tag{6}$$

This equation is equivalent to a binomial pricing model for the option to default based on the following two-state world:



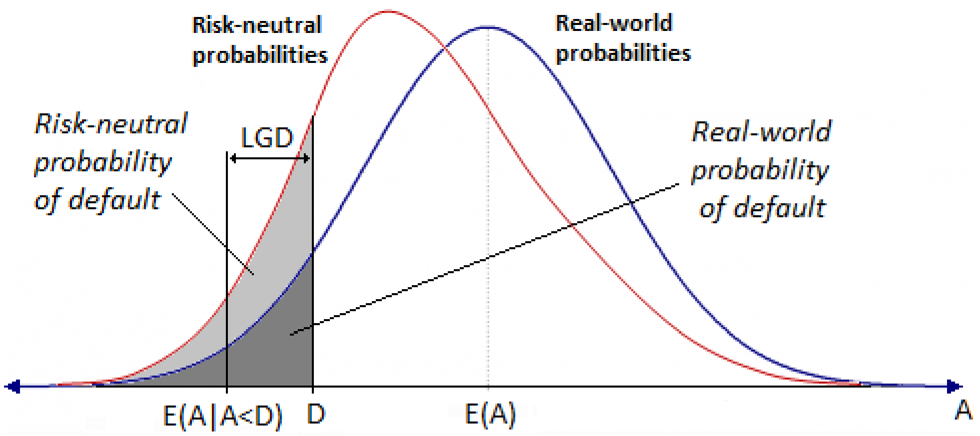
In this case, $LGD{\cdot}D$ is equal to the expected insolvency losses of a failed bank, and can therefore be used to measure the expected *ex-post* cost of bank failure when it does occur. Multiplying this amount by πe^{-rT} then translates this value into a risk-adjusted present value, which can be used to assess the *ex-ante* cost of bank failure.

Note that the term πLGD is commonly used to determine credit spreads, such as the spread by which the yield on risky bonds exceeds the risk-free rate, or the annual premium for credit default swaps on risky debt. In theory, one could actually measure the *ex-ante* cost of failure using observed credit spreads. However, this approach may not be suitable as, in reality, credit spreads comprise more than just compensation for default risk. For example, Amoto and Remolona (2003) find that only 1-6% of credit spreads for A-rated corporate bonds relates to expected losses. Even when accounting for default-related risk premiums, Longstaff, Mithal and Neis (2005) find that default risk accounts for only 56% of credit spreads. A commonly cited non-default factor in credit spreads is liquidity. For example, Hull, Predescu and White (2004) find that, on average, roughly 43bps of corporate bond spreads can be attributed to a liquidity premium. For these reasons, it seems inappropriate to measure the *ex-ante* costs of bank failure using observed credit spreads alone.

3.2.4 What are risk-neutral probabilities?

Risk-neutral probabilities are widely used in financial economics to assess risk-adjusted expectations. They are the hypothetical probabilities that would make a risk-averse agent value a risky security at its expected value (ie, as if he/she were risk-neutral). The idea is that, if economic agents were not risk-averse, then they would simply value a risky payoff at its expected value, but that risk aversion means that agents value payoffs in bad states of the world more highly than they value payoffs in good states of the world. This is analogous to the case where a risk-averse agent places higher probabilities on bad outcomes, and lower probabilities on good outcome relative to actual or "real-world" probabilities. This is illustrated in Figure 5 below.

Figure 5: The difference between risk-neutral and real-world probabilities



In general, one would expect bank failure to be highly correlated with overall market conditions. Therefore, there is most likely a significant degree of non-diversifiable risk associated with the possibility of bank failure. This suggests that the binomial pricing equation above would understate the *ex-ante* cost of failure if it used 'real-world' probabilities of default. This is because it would not be taking into account society's aversion to non-diversifiable risk. Using risk-neutral probabilities, on the other hand, would account for aversion to non-diversifiable risk, and would therefore more accurately capture the *ex-ante* cost of bank failure to a risk-averse society.

3.3 Valuing the perceived implicit guarantee

There are a number of possible approaches to valuing the implicit government guarantee that certain banks may be seen to receive. The most common approach is to directly estimate the size of the funding cost subsidy received by systemically important banks. This can be done either by directly comparing average funding costs across controlled samples (ie, banks with and without an implicit guarantee), or by regressing bank funding cost against a measure of a bank's implicit guarantee and a range of control variables.

A key element of these approaches is determining which banks benefit from an implicit guarantee, and how strong this guarantee is. For example, Baker and McArthur (2009) assume that for US banks, all banks with total assets above US$100billion would receive government support in the event of their failure. Alternatively, Araten and Turner (2011) use a SIFI dummy variable based on the Financial Stability Board's classification of Globally-Systemically Important Banks (G-SIBs). Perhaps the most common approach, though, is to use the uplift for government support contained in bank credit ratings. For example, Schich and Lindh (2012) estimate the saving for wholesale debt by comparing interest rates on bonds with the same standalone credit rating of the bank, and the saving for deposits by comparing interest rates for systemic banks and smaller banks. Haldane (2010) and Ueda and di Mauro (2012) also use credit rating uplift in their models.

This paper takes a different approach to valuing the implicit guarantee based on the idea that the implicit guarantee arises from the expectation that the government will bear the cost (and risk) of bank failure on behalf of creditors. In this sense, the value of an implicit guarantee can be seen as the difference between the *ex-ante* cost that should theoretically be borne by creditors, and the *ex-ante* cost that is actually borne by creditors given the possibility of a taxpayer-funded bail-out. Equivalently:

$$implicit\ guarantee = \pi e^{-rT} LGD \cdot D - [1 - p(bailout)\,\pi e^{-rT} LGD \cdot D] \quad (7)$$

$$= p(bailout) \cdot \pi e^{-rT} LGD \cdot D \quad (8)$$

where $p(bailout)$ denotes the market's perceived probability that the government will bail out a given bank in the event of its failure.

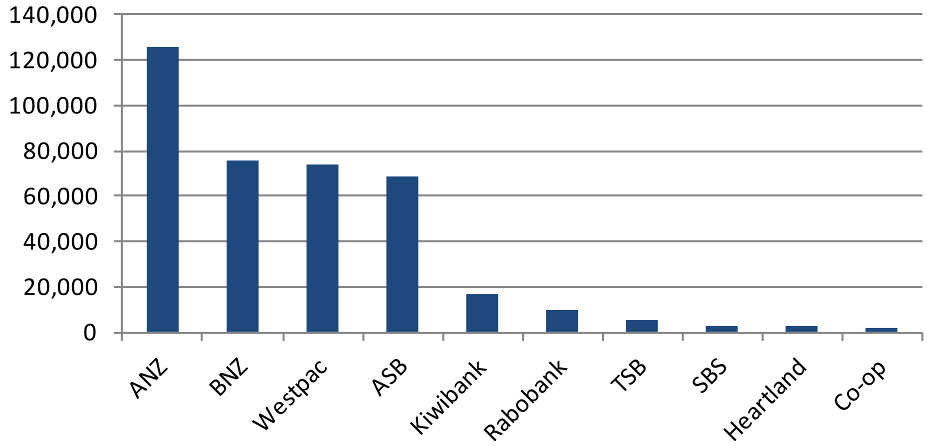
4 Data

This section describes the data used in applying the binomial pricing model developed in the previous section to estimate the financial costs of major bank failures in New Zealand. The binomial model is preferred for simplicity reasons, but also because it is not possible to observe the equity volatility of the major New Zealand banks given they do not have separately listed shares.

4.1 Banks in New Zealand

As shown in Figure 6 below, the New Zealand banking system is highly concentrated. The big-four Australian-owned banks (ANZ, ASB, BNZ and Westpac) collectively hold over 85% of total banking assets. Given the dominance of these banks in the domestic banking sector, the analysis that follows will focus exclusively on these four banks. Note that while Kiwibank has grown rapidly in recent years (especially in terms of customer numbers), it still accounts for only a small portion of total banking assets.

Figure 6: Total assets of domestically incorporated banks, June 2014 ($millions)



Source: RBNZ

4.2 Bank debt

In the model outlined above, banks are assumed to have a single pure-discount bond with a face value of D and maturity T. This is obviously quite different from banks' actual funding profiles. As a proxy, the face value of debt is measured as the future value of the bank's total liabilities (Le^{rT}) assuming that banks' weighted average borrowing cost is equal to the risk-free rate. Equation (6) can then be restated as:

$$P(A,D,T) = \pi e^{-rT} LGD \cdot D \approx \pi e^{-rT} LGD \cdot Le^{rT} = \pi LGD \cdot L \quad (9)$$

This proxy has the advantage of making the *ex-ante* cost independent on the hypothetical time-to-maturity of bank debt. In reality, a bank's funding spread over the risk-free rate is likely to be positive. However, the estimation error that would arise from this assumption is likely to be small, especially given banks receive a portion of their funding from zero-interest or low-interest deposits. Bank liabilities as at June 2014 are taken from the Reserve Bank of New Zealand website.

4.3 Loss given default

Markets typically use 60% as a rule-of-thumb rate for LGD in practice. But this LGD may reflect a number of factors that are not relevant to this analysis. Firstly, a 60% LGD may be based on losses in liquidation, which could involve fire sales of assets, quite likely in times of suppressed asset prices. In more orderly failure scenarios, like a bail-out or OBR, it is likely that losses would be smaller. Secondly, a 60% LGD may incorporate compensation for factors other than those which relate directly to the bank's underlying credit risk, such as liquidity (as discussed above).

4.3.1 LGDs in FDIC resolutions

Historical loss rates for banks resolved by the FDIC (the US Federal Deposit Insurance Corporation) reinforce that 60% is not an appropriate estimate for LGD in the orderly resolution of a failed bank. Laeven (2008) finds the average final LGD on FDIC interventions from 1934-2001 to be 25% overall, or 8% for banks with over US$5billion in assets. The average FDIC loss rate for the 102 institutions that failed in the height of the GFC was 35% due to higher loan loss rates. However, it is questionable how appropriate these loss rates are, given that the FDIC very rarely resolves larger institutions. In the few cases where it has resolved large banks (eg, Washington Mutual, Continental Illinois), wholesale creditors buffer the FDIC from losses because of depositor preference. For example, the FDIC suffered no losses in the resolution of Washington Mutual, whereas CDS settlements 30 days after failure suggested that wholesale creditors faced an overall LGD of 43%. This implies an LGD on total liabilities of around 16%.[12]

4.3.2 LGDs in other recent bank resolutions

Estimating LGD's for non-FDIC bank resolutions is more difficult given that it requires knowing the true post-resolution value of bank equity. Accurate data on the fair value of equity immediately following resolution is rarely available, whereas data on the value of equity once markets have recovered do not account for the economic cost of holding risky

[12] Based on total liabilities of $307billion, including $188billion in (preferred) deposits, and post-failure equity of $2billion.

bank equity through the depths of a crisis. For this reason, the following examples estimate the *gross* cost of significant bank failures in recent years, and therefore overstate the true costs in cases where post-resolution equity has some value.

- Royal Bank of Scotland (RBS) was bailed out at a cost of £45.5 billion, equivalent to roughly 2% of around £2.3 trillion in assets. Some of this cost has been recovered through subsequent sales of equity by the UK government.

- Anglo-Irish bank was bailed out at a cost of €29.3 billion, equivalent to roughly 30% of around €100 billion in assets. The bank is currently being wound down.

- Allied Irish Banks was bailed out at a cost of €19.8 billion, equivalent to roughly 11% of around €180 billion in assets. The bank remains 99% state-owned.

- Spanish banking group Bankia received a total of €22.4 billion in capital from the state, with a further €4.8 billion in write-downs for junior bondholders. Together, this was equivalent to roughly 9% of around €300 billion in assets. The bank continues to operate and is listed on the Madrid Stock Exchange.

- Bank of Cyprus was recapitalized by the conversion of roughly €8billion in deposits to equity (based on a 47.5% haircut of uninsured deposits), equivalent to roughly 21% of around €38 billion in assets. The bank's shares relisted in December 2014 with a market capitalization of around €2billion.

- Dutch bank SNS Reaal faced a total resolution cost of €4.7 billion through equity injections and the write-down of subordinated debt. This was equivalent to roughly 6% of around €83 billion in assets. The bank remains nationalized.

- Banco Espirito Santo was resolved through the conversion of €1.3 billion in junior debt into equity and a €4.9 billion equity injection from the state, amounting to 7.8% of its €80 billion in assets. Share trading is currently suspended.

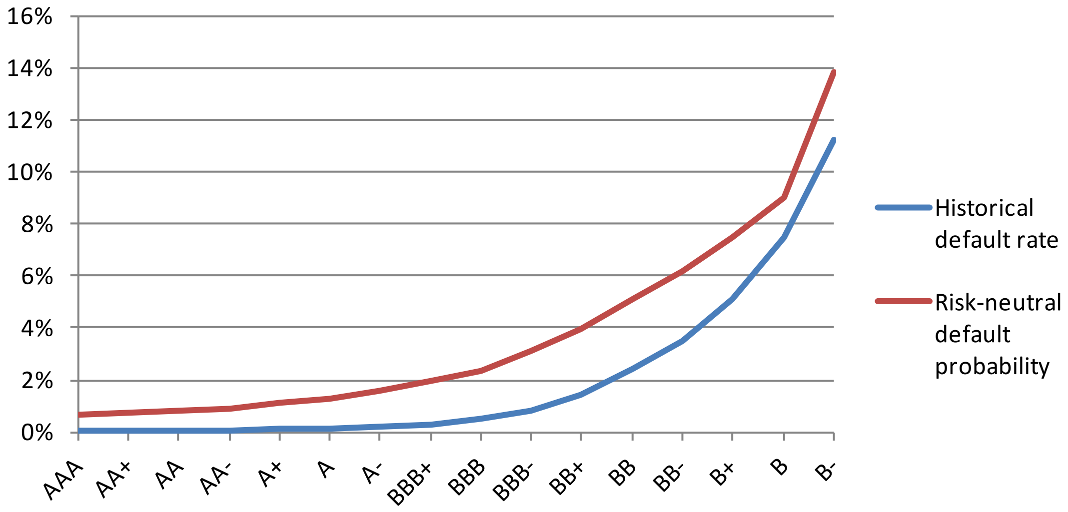
On the whole, however, international comparisons only have limited applicability to the New Zealand context. In general, the losses faced by a bank will depend on a number of specific factors. The severity of the particular crisis, the size and diversification of the bank's balance sheet, the riskiness of the bank's assets (including whether loans are made on a recourse or non-recourse basis), and the bank's pre-crisis capital ratios will all affect LGD. In New Zealand, we see that major banks are better capitalized on average than those banks that failed during the GFC, and have relatively 'vanilla' portfolios. But we also see a high concentration of lending in property and agricultural loans, contributing to a significant overall exposure to the performance of the New Zealand economy. Taking these factors into account, as well as the size of the major New Zealand banks, this paper uses 5-10% *expected* LGDs as a base-case. Admittedly, actual losses may be higher than this amount, though this situation could be somewhat less likely.

4.4 Default probabilities

Unfortunately, New Zealand-specific data on default probabilities is not available. Instead, the default probabilities used in this paper are based on data from Hull, Predescu and White (2005). In this study, annual "real-world" probabilities are estimated using Moody's data for corporate bond defaults over the period 1970-2003, based on the observed frequency with which a bond issuer with a given credit rating defaults in the next seven years.[13] Risk-neutral default probabilities are estimated by taking average bond spreads less the estimated 43 basis point liquidity premium, and dividing the result by the 60% rule-of-thumb LGD that is typically used in corporate bond pricing.

Figure 7 below shows that the differences between observed and risk-neutral probabilities of default can be large. This difference suggests that investors' exposure to systematic risk from holding risky bonds is substantial relative to their exposure to expected default losses in a given year. The ratio of risk-neutral to real-world probabilities is particularly high for investment grade bonds, where default is only likely to occur in very severe economic conditions. For speculative grade bonds, this ratio is lower, reflecting the pattern that defaults of these bonds tend to be less correlated with the economic cycle.

Figure 7: Historical and risk-neutral corporate default rates by credit rating



Source: Hull et al. (2005)

The four largest banks in New Zealand all currently receive AA-/Aa3 credit ratings from the major ratings agencies. This suggests a 0.92% annual risk neutral probability of default based on the Hull et al. data. There is a risk that using data based on corporate bond spreads over 1970-2003 does not accurately reflect the relationship between credit ratings and risk-neutral default probabilities for New Zealand banks. So to assess this risk, I use the method in Hull et al. (2005) to estimate the banks' risk-neutral default probability based on their average T-bill spreads as at February 2014. This estimate implies a risk-neutral annual default probability of 0.97%, suggesting that the Hull et al. probabilities probably provide a reasonable estimate.

However, for the purpose of this analysis, it is important to consider banks' credit rating *without* any ratings uplift that banks receive because of potential government support in the event of their distress. This is because banks can fail without default occurring if the government steps in to bail them out. Moody's currently assigns each of the four major banks a one-notch uplift for government support, suggesting that - from the New Zealand economy's point of view - the four major banks are effectively A+ rated. This implies a 1.09% risk-neutral probability of failure for the major banks.

[13] Where annual $PD = -ln(1-d)/7$, where d is the relative default frequency of firms with a given credit rating.

4.5 Perceived probability of government support

Bank bail-outs are not necessarily required or recommended in New Zealand given the existence of OBR. However, the fact that these credit ratings include one-notch uplifts for government support suggests that markets perceive this probability to be greater than 0%. That being said, the fact that banks' credit ratings are currently below the New Zealand sovereign rating[14] suggests that *p(bail-out)* is less than 100% - though it is very difficult to know exactly what probability the market does perceive.

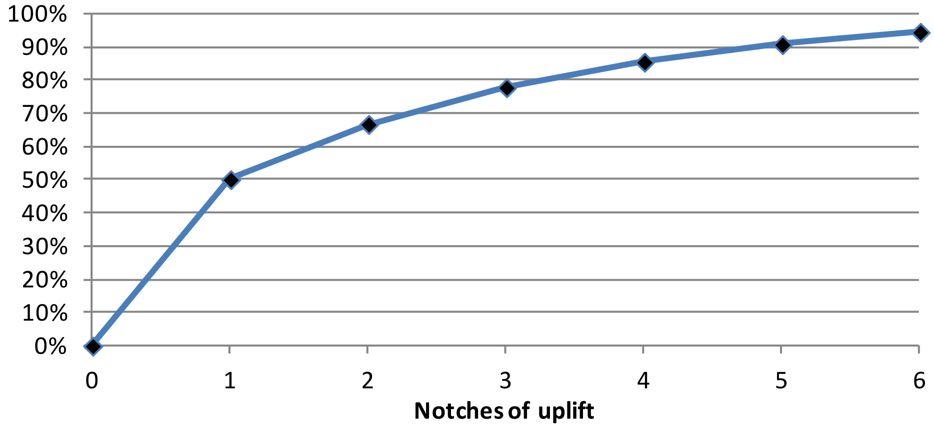
The methodology used here to estimate the perceived probability of government support is based solely on the uplift in banks' credit ratings, though there are possibly other ways to make this estimate. At any given credit rating, the implied probability of default is equivalent to the probability of failure multiplied by the conditional probability the bank is not bailed out if it fails: $p(default) = [1 - p(bail\text{-}out)]\cdot p(failure)$. The implied conditional probability of bail-out at a given credit rating can therefore be estimated as: $p(bail\text{-}out) = 1 - p(default)/p(failure)$. However, given that default is more likely to occur at lower credit ratings, a weighted average of conditional bail-out probabilities across credit ratings may provide a more accurate estimate of the actual probability of bailout. This can be calculated as follows:

$$p(bailout) \approx \sum_{i=1}^{N-u} \frac{PD_i}{\sum_{j=1}^{N-u} PD_j}\left(1 - \frac{PD_i}{PD_{i+u}}\right) \tag{10}$$

In this expression, PD_i denotes the real-world probability of default implied by credit rating i (where $i = 1$ corresponds to AAA/Aaa, $i = 2$ corresponds to AA+/Aa1, and so on), and u denotes the credit-rating uplift for government support in notches.

Figure 8 below displays perceived bail-out probabilities estimated using this method based on historical default probabilities from Hull et al. (2005). On this basis, the current one-notch uplifts received by the four major banks correspond to a conditional bailout probability of approximately 50%. Note that this figure is based solely on market-based information, and does not represent a judgment of the author around the likelihood that the government would bail-out any of these banks in the event of failure.

Figure 8: Implied bailout probability from bank credit rating uplifts



Source: Hull et al. (2005), author's calculations

14 At the date of publication the New Zealand government was rated Aaa by Moody's, and AA by Fitch and Standard and Poor's.

5 Results

5.1 *Ex-post* cost of failure

Table 2 below displays the expected *ex-post* cost of failure summed across the four major New Zealand banks across a range of LGD estimates. Note that these values represent either the total expected losses that would be attributable to creditors under OBR, or the net cost of bail-out for the government, if all of the major banks were to become insolvent.

Table 2: Estimated total ex-post costs of major bank failures

	Total Liabilities	**Total expected *ex-post* cost of failure**				
		5% LGD	**10% LGD**	**15% LGD**	**20% LGD**	**25% LGD**
$ billions	314.9	15.7	31.5	47.2	63.0	78.7
% of GDP	135	6.7	13.5	20.2	26.9	33.6

Summing across banks, the total *ex-post* costs could be expected to amount to around $16-31 billion, or 7-13% of GDP, though actual costs would depend on the size of the losses that banks face. This number gives an indication of the total direct costs that could materialise in a crisis where all four major banks were to fail (assuming that the average LGD across banks was equal to the expected LGD for each individual bank)[15]. This is obviously a particularly severe scenario, and it will not always be the case that all four banks will fail in a major crisis. In the event of an individual bank failure, expected costs would be smaller than the totals reported above, but would still be sizable. On the other hand, the total cost could even exceed this estimate if losses were particularly high, or if the total liabilities of major banks had grown as a percentage of GDP.

This figure is larger than the average fiscal cost of systemic banking crises in advanced economies, 4.8% of GDP, as reported in Laeven and Valencia (2013). However, very few past banking crises have involved the failure of all major banks. For more widespread banking crises, such as those in Ireland and Iceland, the direct cost of bank failure was upwards of 40% of GDP (though these countries also had much larger banking sectors relative GDP). Finally, it should be noted that this figure does not taken into account the wider economic and fiscal costs that would likely arise in a severe banking crisis.

[15] In theory, if banks assets are less-than-perfectly correlated, the variance of the big-four's total assets will be less than the sum of individual asset variances. This would mean that the expected total insolvency losses in a systemic crisis will be less than the sum of individual expected losses. That said, bank assets values may become highly correlated in periods of crisis.

5.2 *Ex-ante* cost of failure

Estimates of the *ex-ante* costs of failure are produced by multiplying the *ex-post* costs shown above by the risk-neutral probability of failure at a given credit rating. These estimates across different credit ratings and LGDs are presented in Table 3 below.

Table 3: Estimated total ex-ante costs of major bank failures

	Estimated total *ex-ante* costs				
	5% LGD	**10% LGD**	**15% LGD**	**20% LGD**	**25% LGD**
$ millions	170.9	341.7	512.6	683.5	854.3
% of GDP	0.07	0.15	0.22	0.29	0.36
% of total liabilities	0.05	0.11	0.16	0.22	0.27

The banks' current standalone credit ratings and ratings uplifts puts the total *ex-ante* cost of systemic banks at approximately $170-340 million per annum (or 0.07-0.15% of GDP) for the base-case assumption of a 5-10% LGD. This cost can be seen as the dollar value of the financial risk that is associated with the possibility of major banking failures in New Zealand. Alternatively, it could be viewed as an annualized expression of the *ex-post* costs of failure that is adjusted for risk aversion and the relatively low likelihood of failure in New Zealand's current banking environment.

Table 4 below shows that these *ex-ante* cost estimates increases exponentially if bank credit ratings were to decline and bank failure became more likely. For example, the *ex-ante* costs estimates would more than double if banks' standalone ratings were downgraded to BBB. These changes in *ex-ante* costs provide a useful illustration of the benefit of prudential measures that help reduce the probability of bank failure.

Table 4: Estimated total ex-ante costs for all banks across different credit ratings

Credit rating (no uplift)	**Estimated total *ex-ante* costs**				
	5% LGD	**10% LGD**	**15% LGD**	**20% LGD**	**25% LGD**
AAA	$0.11	$0.21	$0.32	$0.42	$0.53
AA	$0.12	$0.25	$0.37	$0.49	$0.61
A+	$0.17	$0.34	$0.51	$0.68	$0.85
A	$0.20	$0.40	$0.60	$0.81	$1.01
BBB	$0.37	$0.75	$1.12	$1.50	$1.87
BB	$0.80	$1.60	$2.39	$3.19	$3.99
B	$1.42	$2.84	$4.26	$5.68	$7.10
C	$3.35	$6.71	$10.06	$13.41	$16.77

Note that using risk-neutral probabilities based on long-run historical averages means that these estimates represent a long-run average. In reality, risk aversion may fluctuate over time, meaning that the *ex-ante* cost of bank failure will fluctuate over time as well, even if the probability and *ex-post* cost of systemic bank failure remains constant. Estimating risk-neutral default probabilities based on current credit spreads could be one way to account for this variability, though current credit spreads for New Zealand banks suggest that risk aversion is around its long-term average at present.

5.3 The value of the perceived implicit guarantee

Using these estimates of *ex-ante* costs and a market-implied bail-out probability of 50%, the value of the perceived implicit guarantee in New Zealand is estimated at approximately $85-170 million per annum, equivalent to a 3-5 basis point saving on banks' weighted average funding cost. This amount represents the value of the financial risk that taxpayers could be seen to bear on behalf of bank creditors each year given the perceived likelihood of the government choosing to bail banks out in the future.

Note that this estimate of the implicit guarantee does not necessarily correspond to the amount that banks save in funding costs because of the guarantee. This funding-cost saving depends on how bank creditors price the risk that they face when they invest in bank deposits or debt securities. There are several reasons why this subsidy may differ from the value of the guarantee estimated here:

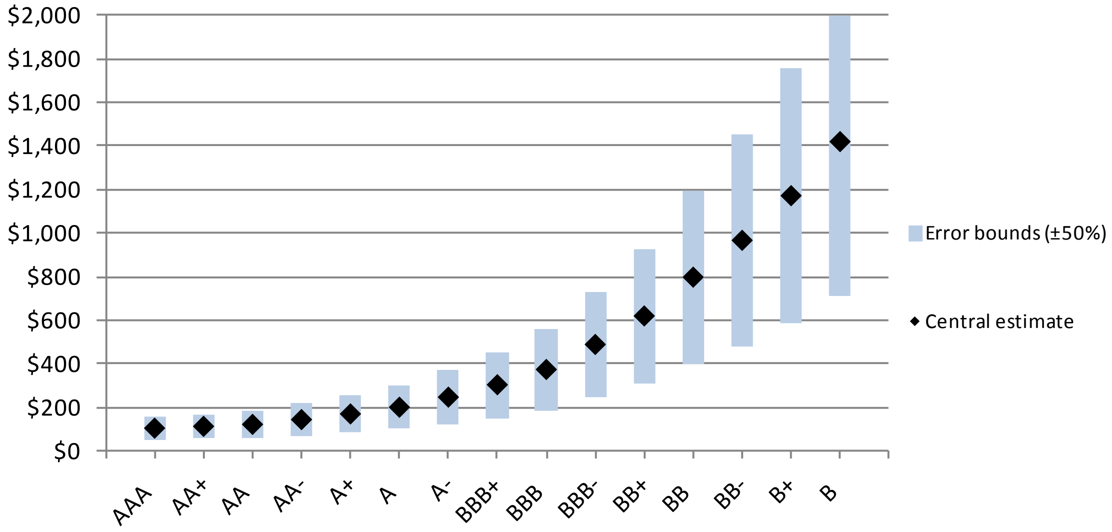
- Creditors of New Zealand banks may have different levels of risk aversion than that which is implied by the risk-neutral probabilities from Hull et al. (2005). For example, small depositors may be relatively risk-averse if they have lower wealth and less-diversified portfolios. This could imply a larger funding-cost saving.

- Uncertainty around the level of haircuts in OBR could encourage creditors to make conservative assumptions about expected haircuts. This could result from uncertainty around the size of any 'buffer' in the initial freeze, the expected insolvency losses of a failed bank, or the funding structure of the bank at the point of failure. Overall, this conservatism could also imply a larger funding-cost saving for banks.

- Finally, creditors may be more sceptical or more optimistic about the likelihood of government support than is suggested by the estimate used here. For example, uncertainty around the government's willingness or ability to bail out a failed bank could result in creditors pricing in a lower probability of bail-out. This would result in a lower funding-cost saving for banks.

To account for these uncertainties, Figure 9 below displays estimates of the total implicit guarantee across credit ratings based on a 10% LGD and error bounds of ±50%. The lower bound corresponds to the case of either a 5% expected LGD, or a 25% perceived probability of bail-out. The upper bound corresponds to either a 15% expected LGD, or a 75% perceived probability of bail-out. At current credit ratings, the estimated funding-cost saving resulting from the implicit guarantee is in the vicinity of $85-$260million per annum, equivalent to 3-8 basis points of total liabilities, or 0.04-0.11% of GDP.

Figure 9: Estimated value of total bank funding-cost savings ($millions p.a.)



Source: Author's calculations

By comparison, one can value the perceived implicit guarantee by estimating the direct benefit that a credit-rating uplift has on funding costs, along the lines of Schich and Lindh (2012) and Haldane (2010). Data from Hull et al. (2005) shows that an increase in credit ratings from A+ to AA- results in a funding-cost saving of 10 basis points, suggesting a total perceived implicit guarantee of approximately $300 million per annum. This estimate is slightly higher than the upper bound of the estimates presented above. This difference, at least in part, reflects the fact that the average value of uplift for all corporate bonds does not account for the lower LGDs that tend to arise during orderly resolutions of failed banks. Indeed, a key advantage of the method used here is that it can account for bank-specific LGDs. A further advantage of this method is that the implied probability of bail-out given failure is independent of a bank's credit rating, which is not necessarily the case when using a simple uplift approach.

Comparison with international evidence suggests that the perceived implicit guarantee estimate for New Zealand is relatively low. For example, Schich and Lindh (2012) estimate that implicit guarantees are worth between 0.02% and 1.0% of GDP for major banks in a range of European countries (excluding subsidiaries). The New Zealand estimates are at the low end of this range, alongside countries such as Belgium and Finland. This appears consistent with the relatively high credit ratings of the major New Zealand banks and the relatively low credit-rating uplifts that these banks receive, as both of these factors imply a lower implicit guarantee under the Schich and Lindh method.

6 Concluding remarks

This paper has developed conceptual and theoretical frameworks for pricing the financial risk of bank failure, and has used these to generate estimates of the size and incidence of this risk in the New Zealand context. By doing so, it provides policymakers a valuable quantitative assessment of the issues at hand, as well as a useful tool for evaluating the costs and benefits of policies aimed at managing the cost of risk of bank failure in New Zealand. These frameworks could usefully be applied in other countries as well.

It should be noted though that the approach taken in this paper is just one of many potential approaches, and that the results presented here are intended to be indicative only. These results rely on a number of assumptions and are subject to significant uncertainty. So while this paper has attempted to provide the best estimates it could with the information available, results should be used and interpreted with an appropriate degree of caution. Further analysis using alternative methodologies or data to estimate expected LGDs, risk-neutral default probabilities, or the probability of government support could be desirable to test the robustness of the results presented here.

Finally, this paper has stopped short of examining the various indirect costs that would result in the event of a major banking crisis. Overseas evidence shows that these costs can be very large, suggesting that they are an essential component of any analysis of the costs and risks of bank failure. However, a detailed examination of these indirect costs is left to future work.

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