MEMORANDUM FOR	FSO Committee
FROM	Financial Policy
MEETING DATE	12 September 2016 (date of corrected version)
SUBJECT	**An updated version of the Harrison model for calculating a bank capital ratio (corrected version)**
FOR YOUR	Information

Purpose

1. This paper is for your information. No decisions are sought. We caution against using the model results presented here to draw any conclusions about real-world capital ratios (a key conclusion is that this sort of modelling does not give certainty).

Background

2. The Reserve Bank has previously used a model to evaluate the costs and benefits of changing the minimum regulatory capital ratio for banks. This paper briefly describes the original model and the results of a "rebooted" version of the model.

3. A decision was taken early on not to try and build a new 'optimal' capital model. There have been developments in the literature, and newer approaches may well be superior to the Harrison model. However, it was felt that this would be too lengthy an undertaking for models that in any case are always going to be sensitive to underlying assumptions, and therefore are not going to deliver a precise answer to the question of 'what is the right level of capital for our system?'. In the event, it was quite a lengthy process to update the model and put it onto a more robust footing, including through formally writing the model up.

The Harrison model

4. The Harrison model was developed by Ian Harrison and others over from about 2011–2012, and its results were used in support of the adoption of (higher) "Basel III" capital requirements.

5. The model assesses the costs and benefits of changing the amount of regulatory capital, drawing on previous work of the Basel Committee on Banking Supervision and the Bank of England. The focus is on the costs and benefits *to New Zealand* (in a loose sense, social benefits).

6. In the original Harrison model there are two main benefits of higher capital:

   - the avoidance of GDP losses, because of fewer bank collapses; and
   - the avoidance of bailout costs paid to foreigners, also because of fewer bank collapses.

7. There is also a tax benefit, because of reduced tax deductions as banks replace tax-deductible debt with non-deductible equity. This benefit is a transfer of taxes paid by foreigners, from foreign treasuries to New Zealand's.

8. There are two costs in the original model:

   - lower GDP because of higher interest rates (the assumption here is that banks have to pay more for equity capital than debt, and that they pass the cost on to borrowers); and
   - more transfers to foreign shareholders (as the bank switches from debt funding, which is assumed to be cheap, to expensive equity funding).

9. The model suggested a tier one capital ratio of 13%.[1] This was sensitive to assumptions; sensitivity testing caused results to vary from 5.5% to 17%.

10. We have attempted to replicate the model and run it with updated data.

11. There have been some refinements to the model. For example, we have replaced the calculation of transfer costs and tax benefits with an approach which is internally coherent but different from the one originally used (see paragraph 17 below).

12. We note a number of simplifying assumptions in the model:

    - GDP losses (from banks charging higher interest rates) are assumed to be based on a constant level of banking-sector assets.

    - Banks' cost of debt finance is assumed to be constant.

    - The model assumes that banks are equity-financed only by foreigners, and that any changes in debt are due to bond issues to, or bond repurchases from, foreigners.

    - The model assumes that a bank fails when its capital ratio falls below 2% (not 0%).

13. In the original justification for higher capital ratios in 2012, Harrison wrote that:

    > We caution against taking the numerical results from the model too literally, given the uncertainties inherent in a cost-benefit study involving the incidence and impact of financial crises.

14. This advice still holds.

[1] The model is arguably not internally consistent. It purports to determine the level of tier 1 capital and in parts it explicitly assumes capital is tier 1, having an equity-like return of 15% with non-tax-deductible distributions. But in other parts the model does not make a distinction between different tiers of capital. It is therefore unclear whether to interpret the model output as a tier 1 capital ratio or a total capital ratio or, perhaps more sensibly, something in between. See paragraphs 48-50 of http://www.rbnz.govt.nz/-/media/ReserveBank/Files/regulation-and-supervision/banks/policy/4932427.pdf for a brief discussion of the issue at the time the model was first used.

The updated and revised model

15. As in the original Harrison model, the benefits and costs are:

- Reduced cost of bank failures, because banks are less likely to collapse when well capitalised (a benefit)
- Some lost GDP in normal times because of higher interest rates, assuming equity is "expensive" (a cost)
- Changes in taxes and other transfers to or from foreigners, as a result of changes in the cost of capital (this is expected to be a cost but could be a benefit for certain values of parameters).

16. The model itself is largely unchanged, apart from the treatment of tax and transfer costs.

17. The effects of tax and other transfers are modelled by assuming that bank shareholders and debtholders require a certain rate of return and discount their returns accordingly. Two scenarios are considered. In the first, bank shareholders respond as suggested by economic theory and so that switching from debt to equity is not costly, except for a minor tax effect. In the second, bank shareholders do not respond as suggested by theory and demand the same rate of return regardless of the capital ratio, so that switching to equity is costly. The final result of the model is a weighted average: 85% of the costless scenario, and 15% of the costly one. The tax and transfer effects are affected by changes in the stock of bank assets, if any.

18. The results of the model for a base scenario are presented, along with changes in the results if parameters are varied, below. The base case gives a capital ratio of about 18%, but there is considerable variation across the scenarios.

19. We note particularly the sensitivity to assumptions about:

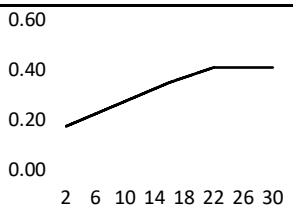
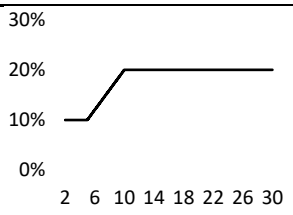
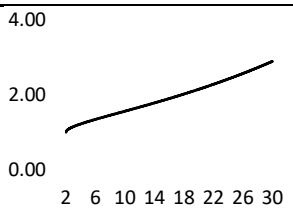
    - the applicability of the Modigliani-Miller theorems;
    - how much banking sector assets change when interest rates change; and
    - the extent of GDP losses in financial crises.

    We are especially uncertain about the value of these parameters.

20. A key conclusion of this modelling exercise is that with various choices of parameters, it is possible to produce a wide range of capital outcomes.

Base scenario settings

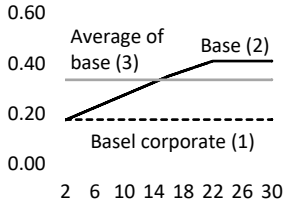
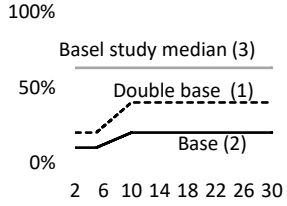
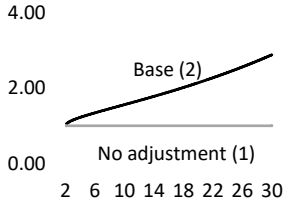
Setting	Value	Source
Basel equation parameters		
Average maturity	2.5 years	Harrison Model
Average risk weight	50%	Harrison Model
Average loss given default	30%	Harrison Model
Average probability of default	1.5%	Harrison Model
Variables affecting the net cost / benefit due to changes in transfers		
Bank borrowing rate (e.g. mortgage)	5.67%	Floating mortgage rate, RBNZ Table B3, July 2016.
Average interest rate paid by bank	2.63%	Ratio of interest expense to total liabilities, RBNZ Table S20, March 2016.
After-tax required return on unlevered equity	2.57%	Set so that the return on *levered* equity, calculated using Modigliani-Miller II, matches the observed value (below).
After-tax required return on bank debt	1.85%	Yield on bond ANB090 × (1 – tax rate on debt returns) (NZDX quote as at 24/8/16 for ANZ bond maturing on 18/9/17)
After-tax required return on (levered) bank equity	10.89%	NPAT ÷ Average equity × (1 – tax rate on equity returns) (ISS.MIMD3 and ISS.MIYF2, locally incorporated banks, year ended July 16). (In scenarios this term is calculated from the required return on unlevered equity, the required rate of return on debt, tax rates, and the capital structure of the bank, according to Modigliani-Miller II).
Corporate tax rate (NZ)	28%	Statutory rate.
Tax rate on debt returns (foreign)	30%	Hypothetical shareholder tax rate.
Tax rate on equity returns (foreign)	15%	Hypothetical shareholder tax rate.
Sensitivity of bank assets to changes in the retail interest rate	1.5	Rough estimate
Change in bank assets per basis point of minimum capital ratio (if MMI holds perfectly)	4 thousandths of a basis point	Calculated by multiplying the change in the retail interest rate by the sensitivity of bank assets to changes in the retail interest rate, assuming MMI holds (the model produces the change in the retail rate; it is affected by changes in other variables when scenarios are run).
Change in bank assets per basis point of capital ratio (if MMI does not hold at all)	1 tenth of a basis point	Calculated by multiplying the change in the retail interest rate by the sensitivity of bank assets to changes in the retail interest rate, assuming MMI does not hold (the model produces the change in the retail rate; it is affected by changes in other variables when scenarios are run).

Setting	Value	Source
Other variables / settings		
Discount rate (for GDP costs and benefits and bailout costs)	3.00%	Harrison Model
Bank assets	$458 billion	PBB.QLAA11 (March 2016, locally incorporated banks)
Bank equity	$32 billion	PBK.QLAA01 (March 2016, locally incorporated banks). This does not include any components of capital classified as liabilities for accounting purposes.
New Zealand nominal GDP	$249 billion	Expenditure GDP at current prices (March 2016)
Weight given to scenario in which Modigliani-Miller holds perfectly (remaining weight is given to the scenario where it doesn't hold at all).	85%	Harrison model.
Chance that the government will use OBR in the event of a bank failure (versus a pure bailout)	50%	Harrison model.
% change in GDP per percentage point increase in the capital ratio	-0.09%	Basel Committee on Banking Supervision, Long-term Economic Impact Assessment, BCBS173.
Correlation (chart shows correlation by % capital ratio)		Harrison model (with modifications for smaller step size and extended range).
Loss of GDP in the event of a bank collapse (chart shows % of annual GDP lost, by % capital ratio)		Harrison model (with modifications for smaller step size and extended range).
Utility scaling formula to reflect higher value of a dollar in a crisis (chart shows scaling factor by % capital ratio).		Harrison model (with modifications for smaller step size).

Model results

Setting	Values			Corresponding capital ratio (%)		
Basel equation parameters						
Average maturity (years)	1.5	2.5	3.5	15.2	18.4	27.0
Average risk weight	40.0%	50.0%	60.0%	>=30	18.4	14.3
Average loss given default	20.0%	30.0%	40.0%	11.9	18.4	>=30
Average probability of default	1.0%	1.5%	2.0%	13.3	18.4	28.3
Variables affecting the net cost / benefit due to changes in transfers						
Bank borrowing rate (e.g. mortgage)	3.00%	5.67%	7.00%	18.1	18.4	18.6
Average interest rate paid by bank	2.00%	2.63%	4.00%	25.2	18.4	17.2
After-tax required return on unlevered equity	2.00%	2.57%	4.00%	>=30	18.4	14.1
After-tax required return on bank debt	1.00%	1.85%	3.00%	11.6	18.4	>=30
Corporate tax rate (NZ)	20%	28%	36%	17.7	18.4	25.4
Tax rate on debt returns (foreign)	20%	30%	40%	17.1	18.4	26.3
Tax rate on equity returns (foreign)	5%	15%	25%	25.8	18.4	17.2
Sensitivity of bank assets to changes in the retail interest rate*	1	1.5	2	18.1	18.4	18.7

* Note that changes in the sensitivity of bank assets to interest rates are ***not*** passed through to the sensitivity of GDP to the capital ratio (the "% change in GDP per percentage point increase in the capital ratio" variable below) even though this might be a reasonable thing to do.

Setting	Values			Corresponding capital ratio (%)		
Other variables / settings						
Discount rate (for GDP costs and benefits and bailout costs)	2.00%	3.00%	4.00%	25.6	18.4	17.5
New Zealand nominal GDP ($bn)	200	249	300	18.3	18.4	18.5
Weight given to scenario in which Modigliani-Miller holds perfectly (remaining weight is given to the scenario where it doesn't hold at all).	0%	85%	100%	7.1	18.4	>=30
Chance that the government will use OBR in the event of a bank failure (versus a pure bailout)	0%	50%	100%	15.1	18.4	26.3
% change in GDP per percentage point increase in the capital ratio	-0.04%	-0.09%	-0.13%	28.3	18.4	16.6
				(1)	*(2)*	*(3)*
Correlation (chart shows correlation by % capital ratio)				12.6	18.4	20.4
Loss of GDP in the event of a bank collapse (chart shows % of annual GDP lost, by % capital ratio)				29.4	18.4	>=30
Utility scaling formula to reflect higher value of a dollar in a crisis (chart shows scaling factor by % capital ratio).				13.7	18.4	

As an example of how to interpret the table above, consider variations in the average maturity of the bank's portfolio (first row). In the base scenario the average maturity is 2.5 years and there is a capital ratio of 18.4%. If nothing else is changed but the maturity is changed to 1.5 years, the capital ratio becomes 15.2%. Similarly, if nothing else is changed but the maturity is changed to 3.5 years, the capital ratio becomes 27.0%.