



# Reserve Bank of New Zealand Analytical Notes

## *Extending the Reserve Bank's macroeconomic balance model of the exchange rate*

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## NON-TECHNICAL SUMMARY

The exchange rate matters a lot in New Zealand and the Reserve Bank uses several different models, each imprecise, to analyse it. This note focuses on just one of those approaches: the macro-balance model of the exchange rate.

The macro-balance model works backwards, from what we can observe (the actual current account balance and market exchange rate). After adjusting for purely cyclical factors, it allows us to estimate the exchange rate that would, if sustained, be consistent with both internal and external balance. Internal balance occurs when both the New Zealand and world economy are operating at capacity (i.e. the output gaps for both are zero). External balance means that New Zealand's current account deficit, as a share of GDP, is at a level that can be sustainably financed through time.

Estimating the macro-balance model involves making many assumptions. In particular, we need to take a view on how responsive the current account is to changes in the exchange rate. It also requires making a judgment about the size of the current account deficit that can be sustainably financed over a prolonged period. For practical purposes, we focus on the current account that would stabilise the negative net international investment position (as a percentage of GDP) at around current levels. On that measure, the exchange rate appears to have been moderately overvalued for much of the period since 1994 (most notably at the peak of the housing boom, from 2004 to 2006). Different assumptions about the responsiveness of the current account to the exchange rate, or about the sustainable level of New Zealand's net international liabilities, would produce different results. One contribution of this paper is to illustrate the sensitivity of the model estimates to uncertainty about some of the key assumptions.

The macro-balance approach is just one of several possible methods for assessing the level of the exchange rate against medium-term macroeconomic fundamentals. The macro-balance approach is not designed to shed any light on whether the exchange rate has hampered a longer-term acceleration in New Zealand's rate of productivity growth. Other analytical tools are needed for that type of assessment.

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## 1. INTRODUCTION

The exchange rate matters. New Zealand is a small and relatively open economy so changes in the exchange rate, driven by a wide variety of domestic and foreign factors, affect domestic inflation, trade flows, and the value of New Zealand's financial liabilities.

The Reserve Bank uses several different models to analyse the exchange rate. One approach employed by the Reserve Bank for this purpose is the macroeconomic balance (macro-balance) framework. The macro-balance model describes whether the exchange rate is 'misaligned' relative to an estimate of the equilibrium exchange rate.

There is a variety of definitions of the equilibrium exchange rate. These tend to be related to the fundamental drivers of the exchange rate over different horizons (see Driver and Westaway (2005) for a detailed discussion). Hence, the variables used to explain the equilibrium exchange rate depend on the length of the horizon under consideration.

Short-run notions of equilibrium tend to relate the exchange rate to the current values of the factors that influence it over that horizon (see, for example, McDonald (2012)). Over the medium term, equilibrium values tend to be based on the value of the exchange rate that would be consistent with an economy in both internal balance (e.g. the economy operating at full capacity and low and stable inflation) and external balance (e.g. the net international investment position (NIIP) is regarded as being able to be financed indefinitely into the future). Long-run definitions focus on exchange rate developments relative to long-term developments in macroeconomic drivers over this horizon (such as relative productivity and prices).

At any given time the exchange rate may not be consistent with its equilibrium at all horizons. For example, the exchange rate might be consistent with a stable NIIP position over the medium term but maintain an average level that, for some reason, impedes long-term acceleration in economic growth.

When estimating the macro-balance model, we account for temporary and cyclical influences on the economy. This allows us to evaluate whether the level of the exchange rate is in line with economic fundamentals over the medium term, insofar as it is consistent with a stable NIIP to GDP ratio. For the purposes of this paper, the long run is simply a horizon over which monetary policy is considered to have little or no impact on macroeconomic variables.

We present an updated version of the macro-balance model (which was detailed previously in Brook and Hargreaves (2000)) that presents the impact of variations in key assumptions on the model's estimates of the equilibrium exchange rate.

## 2. THE MACRO-BALANCE MODEL

The macro-balance model produces estimates of the medium-term value of the exchange rate that is consistent with internal and external balance. Internal balance occurs when the output gaps for both New Zealand and the global economy are zero. External balance occurs when New Zealand's NIIP is sustainably financed - for simplicity we treat this as equivalent to stabilising at a plausibly sustainable level.

Estimating the model involves the following steps (depicted in Figure 1).<sup>1</sup>

Step 1 involves calculating a measure of the **underlying current account (UCUR)**. The UCUR is the current account that would prevail at the current exchange rate if the domestic and international economies were internally balanced (i.e. when domestic resources are fully employed, taking the Reserve Bank estimates of output gaps and its forecasts as given) and past exchange rate changes have fully passed-through to prices and trade.

The UCUR is itself calculated in three parts. First, the observed current account balance is adjusted for temporary factors such as one-off imports of unusually high-value goods (e.g. frigate purchases in the late 1990s) and then smoothed to remove volatility associated with short-term fluctuations.<sup>2</sup>

Second, we remove from this 'adjusted current account balance' the impact of past exchange rate movements. Past exchange rate changes affect today's current account balance because it takes time for prices and trade flows to adjust. We remove these delayed exchange rate effects so that the underlying current account only reflects the current exchange rate, not the lagged effects of recent exchange rate movements.<sup>3</sup> In order to do this, we make several assumptions about the elasticities of import and export prices and volumes with respect to changes in the exchange rate. These are discussed in the next section.

Third, we make adjustments for cyclical influences that are assumed to have no impact on the equilibrium value of the currency over the medium term. This accounts for the impacts of the domestic business cycle on imports and the foreign output gap on exports.<sup>4</sup> It is not

<sup>1</sup> We supplement historical macroeconomic data with the Reserve Bank's projections to produce both historical and projected deviations of the exchange rate from its estimated equilibrium. The model uses Reserve Bank forecasts of the real trade-weighted exchange rate, NIIP and its components, export and import prices and volumes, domestic and foreign inflation rates and domestic output and the domestic and world output gap.

<sup>2</sup> The adjusted current account balance (tbcadj) is obtained by smoothing each of the elements of the current account (tbcadj = exports - imports + invincome + transfers) using an HP filter to remove noise and then dividing this by nominal production-based GDP; such that 
$$\text{adjCAB} = 100 \cdot \frac{\text{tbcadj}}{\text{GDP}}$$
. Note that reinsurance inflows following the

Christchurch earthquakes do not affect the current account balance because they are treated as capital transfers and not as current transfers.

<sup>3</sup> The model produces annual equilibrium estimates based on each year's December quarter average of the exchange rate.

<sup>4</sup> UCUR is calculated as 
$$\text{UCUR} = \text{adjCAB} - (\text{FgapX} - \text{DgapM} + \text{Xp} + \text{Xvol} + \text{Mp} + \text{Mvol})$$
, where FgapX is foreign output gap-induced excess exports, DgapM is the domestic output gap-induced excess imports, and Xp, Xvol, Mp and Mvol are the effects of lagged exchange rate changes on export and import prices and volumes (which, in turn,

a matter of ignoring these factors, but of looking through them - working from the current account we observe to an estimate of the persistent component.

Step 2 involves constructing a **desired current account balance (DCA)**. The standard macro-balance approach bases DCA on an estimate of the economy's equilibrium current account balance (described in Isard and Faruqee 1998, Isard *et al* 2001, IMF 2006, or Lee *et al* 2008). Under this approach, the equilibrium current account balance is estimated using the average values of structural variables such as GDP per capita, the fiscal balance, demographic factors and the ratio of Net Foreign Liabilities to GDP. A simpler approach by Cline and Williamson (2012) assumes that the DCA is the current account (surplus or deficit) at 3 percent of GDP.

We depart from the standard macro-balance approach. We use an external sustainability concept to define our notion of external balance. We define DCA as the current account balance that would stabilise the ratio of New Zealand's NIIP to GDP over the long term at its current level (see Edison and Vitek (2009) for an alternative external sustainability approach for New Zealand). The desired current account balance is calculated as a function of the assumed sustainable values of the NIIP to GDP ratio (NIIP), nominal GDP growth (g), and the yield on net foreign liabilities (r).<sup>5</sup> The higher each of these factors is assumed to be in equilibrium, the larger the current account balance consistent with the NIIP stabilising at a given level.

We set the sustainable level of NIIP to GDP equal its current level. When calculating the current level of the NIIP to GDP ratio, we remove the short-term, favourable effect of the offshore reinsurance claims arising from the Christchurch earthquake on the NIIP.<sup>6</sup> These claims are recorded as assets in the other investment category of New Zealand's NIIP statistics, so they reduce the current level of the NIIP. However, as the proceeds of these claims are spent in repairs and reconstruction, all else equal, the NIIP will increase.

The DCA associated with the current period's NIIP ratio may not represent a long-run, sustainable current account balance. But the advantage of using the current period's ratio is that it avoids having to make additional assumptions about what the appropriate equilibrium NIIP ratio is. Over a 20 year horizon, New Zealand's NIIP to GDP ratio has not shown a discernable trend. At 83 percent, our current long-run NIIP assumption is a little higher than the average over this period.

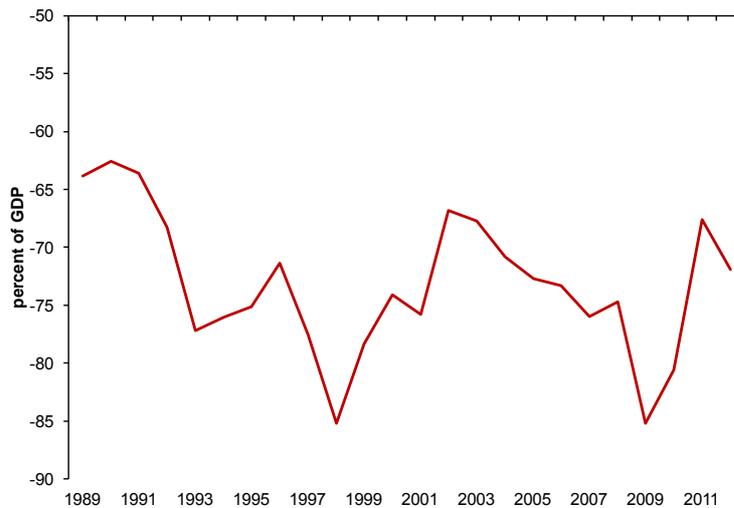
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depend on the exchange rate elasticities of import or export volumes and prices and their assumed adjustment periods).

<sup>5</sup> That is,  $DCA = 100 * NIIP * \frac{g(1+r)}{(1+g)}$ .

<sup>6</sup> We add the most recent estimate of outstanding reinsurance claims by Statistics New Zealand (NZD\$12.8 billion) to the current NIIP. Without the earthquake adjustment, the current NIIP to GDP ratio of about 77 percent of GDP. Note that the model uses the Reserve Bank's projections of production-based GDP data which will differ slightly from the expenditure-based measure. The current period's GDP will be based on Reserve Bank projections, because actual GDP figures have not yet been released.

Figure 1: Net International Investment Position (percent of GDP)



Based on financial year end (quarter 1) data.

**Step 3** involves estimating the **required adjustment in the exchange rate** to eliminate the gap between the UCUR (from step 1) and the DCA (step 2). If the underlying current account differs from the desired current account, we may judge that the current account balance is not externally sustainable given our view of medium-term economic fundamentals. This may imply that the exchange rate is 'misaligned'.

The model assumes that the adjustment in the current account occurs via the goods and services trade balance. The responsiveness of the UCUR to the exchange rate is a function of the elasticities of export and import prices and volumes to changes in the exchange rate.<sup>7</sup> Our elasticity assumptions are detailed in the next section.

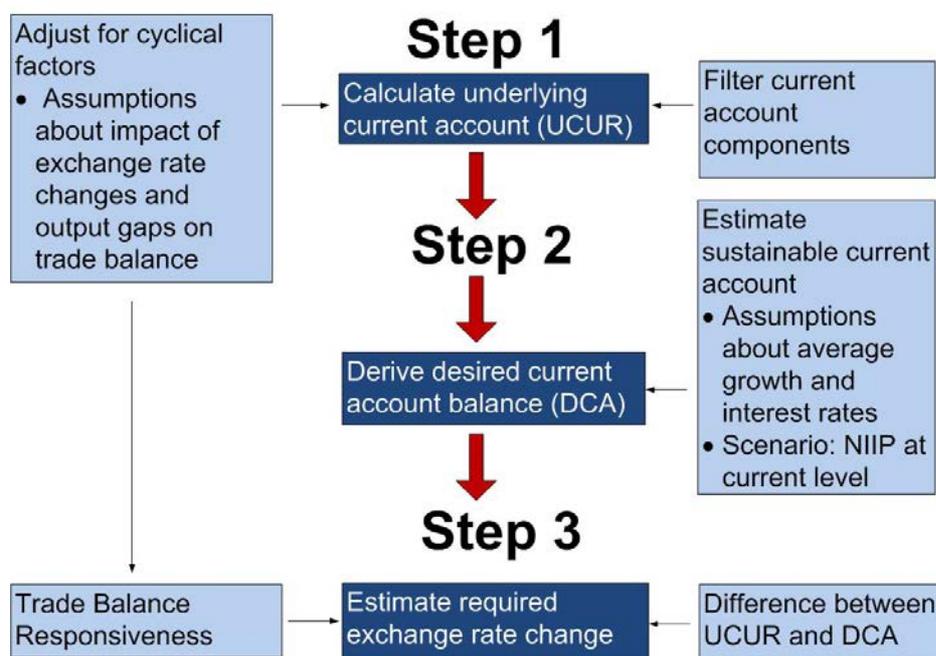
Calculating the required adjustment of the current TWI also allows us to estimate the level of the macro-balance equilibrium exchange rate.<sup>8</sup>

<sup>7</sup> The following equation is used for the calculation of the required exchange rate adjustment (*reqERadj*)  
 $reqERadj = tbresp * (DCA - UCUR)$  where *tbresp* describes the responsiveness of the UCUR to the exchange rate. *Tbresp*, in turn, is calculated as

$tbresp = \frac{-1}{imports(|\epsilon|_{Mvol,ER} - |\epsilon|_{Mp,ER}) + exports(|\epsilon|_{Xvol,ER} + |\epsilon|_{Xp,ER})}$ , with imports and exports as ratios of GDP,  $|\epsilon|_{Mvol,ER}$  is the import volume elasticity of the exchange rate,  $|\epsilon|_{Mp,ER}$  is the import price elasticity of the exchange rate,  $|\epsilon|_{Xvol,ER}$  is the export volume elasticity of the exchange rate, and  $|\epsilon|_{Xp,ER}$  is the export price elasticity of the exchange rate. Note that *tbresp* is the inverse of the trade balance elasticity of the exchange rate.

<sup>8</sup> The calculation is:  $EquilER = RTWI * (1 + \frac{reqERadj}{100})$ , where *RTWI* is the real trade weighted exchange rate and *reqERadj* would be negative if the exchange rate were estimated to be overvalued.

Figure 1: Process for estimating the macro-balance model



### 3. UNCERTAINTY AROUND SOME OF THE MODEL'S ASSUMPTIONS

The equilibrium exchange rate calculation detailed above makes certain assumptions about New Zealand's future nominal GDP growth rate, the yield on net foreign liabilities, and trade elasticities that determine how responsive New Zealand's trade balance is to movements in the real exchange rate. In the earlier version of the model the parameters that described these assumptions were held constant at estimates of their medium term values. However, the model's estimates of the equilibrium exchange rate can be sensitive to these parameter assumptions. For example, the more responsive exports are to changes in the exchange rate, the less exchange rate adjustment is required to deliver any particular sustainable current account balance.

This note updates the model to incorporate some uncertainty about the medium-term values of some of these parameters. This results in ranges within which the overall trade balance elasticity and desired current account balance may fall, and thus allows us to produce 'assumption bands' around the estimate of the deviation of the exchange rate from its estimated equilibrium.

The trade elasticities in Brook and Hargreaves (2000) were calibrated to reflect New Zealand's status as a commodity exporting, small, open economy. For example, New Zealand's commodity exporters generally do not have much pricing power in global markets and have to accept prevailing foreign currency prices. Hence, in local currency terms, commodity export prices tend to show considerable sensitivity to changes in the exchange rate. Local currency prices of some exports, such as tourism, may also be affected by domestic conditions. In aggregate, export prices tend to react less than one-for-one to exchange rate changes. Importers in a small open economy do not influence

global demand. Import prices at the producer level, on the other hand, are expected to show closer to complete pass-through to domestic prices.

The proportion of adjustment of imports and exports to the exchange rate in each period is unchanged from Brook and Hargreaves (2000). Exchange rate changes are assumed to fully pass-through to export and import prices within 3 years (60 percent of the feed-through is in the first year) and 5 years in the case of export and import volumes (30 percent of final feed-through in year 1).

In order to account for uncertainty about the key assumptions in the model, we introduce probability distributions around the model's parameter values (Table 1). These distributions were selected to encompass parameter estimates from internal Reserve Bank work and other available empirical studies. The chosen means and ranges for growth and interest rates are informed by historical averages.

**Table 1: Distributions around parameter means**

Parameter	Notation	Range (absolute value)	Distribution
Elasticity of Export values to world output gap	$ \varepsilon _{X,Y_{gap}^*}$	1.1-1.5	Uniform
Elasticity of Import values to domestic output gap	$ \varepsilon _{M,Y_{gap}}$	1.3-1.5	Uniform
Elasticity of Export volumes to exchange rate	$ \varepsilon _{X,E}$	0.1-1	Uniform
Elasticity of Import volumes to exchange rate	$ \varepsilon _{M,E}$	0.6-1.1	Uniform
Elasticity of Export prices to exchange rate	$ \varepsilon _{PX,E}$	0.4-0.9	Uniform
Elasticity of Import prices to exchange rate	$ \varepsilon _{PM,E}$	0.1-1.1	Uniform
		<b>Mean (absolute value)</b>	
Average nominal GDP growth	$g$	4.5	Normal*
Trend yield on net foreign liabilities	$r$	7.0	Normal*

\* Standard deviations of 0.5 per cent are used.

The interpretation of the elasticities in Table 1 is straightforward. For example, an export volume elasticity between 0.1 and 1 percent implies that, in the medium term, a 1 percent increase in the exchange rate decreases export volumes by between 0.1 to 1 percent.

In order to incorporate our uncertainty about these parameters into the equilibrium exchange rate estimate, we repeatedly run the model with different parameters drawn from the probability distributions we have imposed. In this way, we run 10 000 versions of the model, each of which calculates the desired current account balance and trade balance elasticity associated with that particular version of the model. This allows us to produce a range of values for the estimation of the desired current account balance and trade balance elasticity, which are used to create a range of estimates of the responsiveness of the trade balance to changes in the exchange rate.

Normal distributions are adopted for our assumptions about nominal GDP growth and the sustainable yield on net foreign liabilities. With normal distributions, over two thirds of the model runs will have values that fall within one standard deviation of the mean. We adopt a uniform distribution for the trade elasticities, because there are very few recently published estimates of these trade elasticities for New Zealand to inform our choice of distribution.<sup>9</sup> Uniform distributions assign equal probability-weights to each of the parameter values drawn from the chosen range. This recognises the uncertainty we face in assigning probabilities to different values within the elasticity ranges. However, adopting normal rather than uniform distributions did not appear to materially change our median equilibrium exchange rate estimates. Nevertheless, parameters informed by normal distributions are occasionally very far from the ranges of parameters that we feel are reasonable.<sup>10</sup>

Together, the elasticities from Table 1 produce an overall trade balance elasticity with a mean slightly below -0.4 (Figure 1 Appendix). This suggests that a 1 percent exchange rate depreciation increases the trade balance by roughly 0.4 percent of GDP. More negative values for this elasticity result in a greater response of the trade balance to the real exchange rate. Consequently, more negative elasticities imply that less exchange rate adjustment is required to move the underlying current account closer to the desired level.

Our chosen probability distributions over the model's parameters imply that stabilising the NIIP to GDP ratio at its current level of 83 percent (Figure 2 Appendix) would require a desired current account balance of around -3.85 percent of GDP, on average.

Because we have drawn distributions around the desired current account balance and trade balance elasticity, we are able to draw assumption bands around the deviation of the exchange rate from the model's estimated equilibrium. But these bands do not capture all sources of uncertainty about the equilibrium estimate. Other possible sources of uncertainty include

- the lag structure of exchange rate effects,<sup>11</sup>
- the Reserve Bank's estimates of output gaps and its projections, which include export and import prices and volumes,
- the feedback to export and import volumes from changes in the prices of exports and imports,
- the level of the steady state NIIP to GDP ratio.

In the next section, we provide the model's equilibrium estimates and discuss the sensitivity of the model to assumptions about the long run level of the NIIP to GDP ratio.

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<sup>9</sup> For estimates of New Zealand's export volume elasticity see, for example, Smith (2004) or for import prices see Campa and Goldberg (2002 and 2005).

<sup>10</sup> Kramer (1996) also draws confidence intervals around the equilibrium estimate using a uniform distribution, as well as distributions informed by an empirically determined distribution of elasticity estimates.

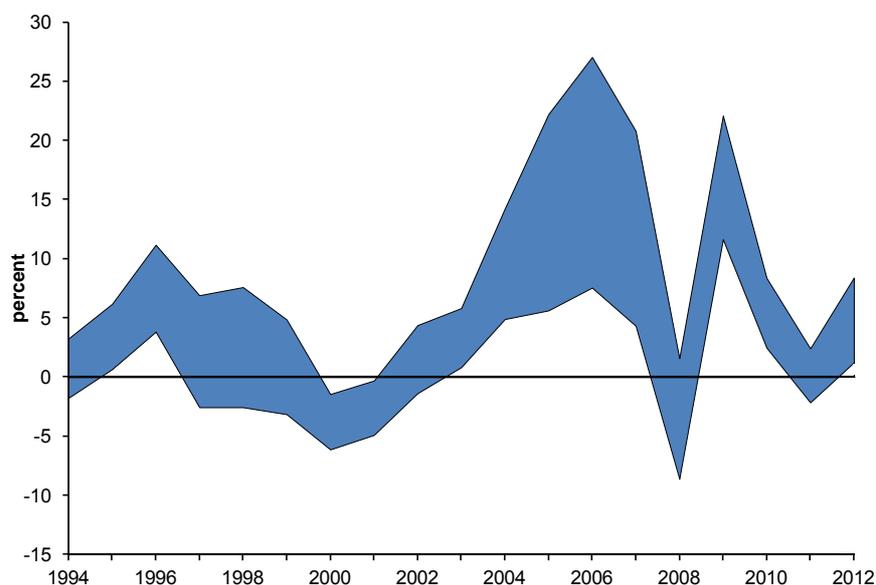
<sup>11</sup> Brook and Hargreaves (2000) discuss the implications of assuming shorter or longer lags for the pass-through of exchange rate changes to imports and exports than are currently used in the model. They show that shorter lags, for example, speed up the feed-through of exchange rate changes to the trade balance.

#### 4. ESTIMATION OF THE MACROBALANCE MODEL

The model provides estimates of the deviation of the actual exchange rate from its macro-balance equilibrium (consistent with the NIIP stabilising at its current level). The actual exchange rate may diverge from the estimated equilibrium for long periods of time. For example, during periods when domestic cyclical factors (e.g. the domestic housing market) put upward pressure on New Zealand's relative interest rates, the actual exchange rate may rise while the equilibrium estimate is unchanged because the model removes the impact of cyclical factors (including the influence of monetary policy, since the model assumes internal balance).

Figure 3 suggests that the exchange rate has been at levels modestly above those consistent with stabilisation of the NIIP to GDP ratio at its current level (around -83 percent) for much of the last decade (the largest deviation occurring at a period when domestic demand factors, rather than commodity prices, appeared to be boosting the exchange rate, over 2004 to 2006). The blue band shows the range of possible estimates of the equilibrium exchange rate, which depend on different combinations of parameters in the model. The top edge of the band reflects estimates of misalignment that assume the current account balance is not particularly responsive to changes in the exchange rate. In contrast, the bottom edge of the band reflects misalignment estimates under the assumption that the current account balance is more responsive to the exchange rate. The desired current account balance is held constant throughout the sample.

**Figure 3: Deviation of real TWI from macro-balance equilibrium estimate (current level of NIIP)**



Estimated on 1 October 2012 using up-to-date data and Reserve Bank forecasts. The 2012 estimate is illustrative only and is based on the average exchange rate for the September 2012 quarter, as well as the assumptions and forecasts from the September 2012 Monetary Policy Statement.

To explain changes in the deviation of the exchange rate from equilibrium over time, figure 4 shows a decomposition of the UCUR into its components. The smoothed current account balance (*adjusted current account*) is corrected for cyclical factors (*cyclical adjustment*) and the lagged effects of exchange rate changes (*export volumes, import*

volumes, export prices, and import prices). These adjustments depend partly on the impact of changes in the exchange rate on output, prices and trade. The depreciation of the exchange rate in 2008, for example, saw a substantial improvement in the model's estimate of the underlying current account balance. This is because the model supposes that a weaker exchange rate will support export prices and volumes, while import prices will rise and import volumes will fall.

**Figure 4: Contributions to Underlying Current Account Balance**

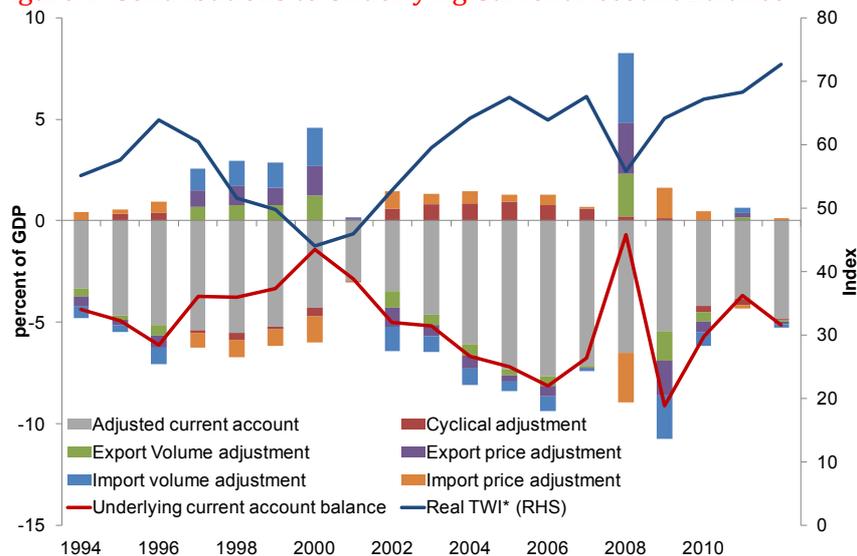


Chart based on median values from the model as estimated on 1 October 2012 using up-to-date data and forecasts. The 2012 figure is illustrative only and is based on the average exchange rate for the September 2012 quarter, as well as the assumptions and forecasts from the September 2012 *Monetary Policy Statement*. \* The Real TWI has been scaled to the level of the nominal TWI for the September 2012 quarter.

The decline in exchange rate over-valuation over the last two years reflects the fall in the UCUR-DCA gap. All else equal, a smaller gap between the desired and underlying current account balances meant that less exchange rate depreciation was needed to boost the trade balance enough to equate the desired and underlying balances. A major reason for the observed improvement in underlying current account is New Zealand's improved terms of trade over recent years.

Changes in the width of the assumptions band reflect changes in the gap between UCUR and DCA. The larger the gap between UCUR and DCA, the larger the required change in the current account balance to meet the model's sustainability criterion. This is because assumptions about the responsiveness of the current account to the exchange rate tend to matter more when there is a large gap between UCUR and DCA (Figure 5).<sup>12</sup> In 2006, for example, the underlying current account deficit was larger than the model judged to be sustainable, so the exchange rate was estimated to be overvalued.

<sup>12</sup> The calculation of the required change in the exchange rate is multiplicative in the model, see footnote 7.

**Figure 5: The gap between the underlying and desired current account balances**

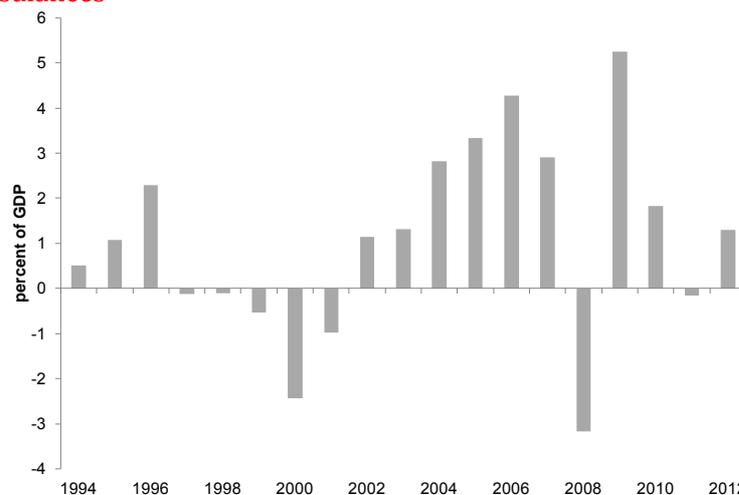


Chart based on median values from the model. Estimated on 1 October 2012 using up-to-date data and Reserve Bank forecasts. The 2012 estimate is illustrative only and is based on the average exchange rate for the September 2012 quarter, as well as the assumptions and forecasts from the September 2012 *Monetary Policy Statement*.

The model's projections of exchange rate deviations from equilibrium assume that the terms of trade evolve as projected by the Reserve Bank. If New Zealand's medium-term terms of trade were assumed to be weaker than those projected, then all else equal, this will tend to drag down the exchange rate equilibrium. This is because more resources need to be employed in the export sector to keep the current account in line with what is judged to be a sustainable level. But, in such a scenario, all else is unlikely to be equal. The exchange rate tends to act as a buffer to external shocks, so we might expect the observed exchange rate to depreciate. This would offset some of the impact of weaker terms of trade on the trade balance.

It is difficult to compare the results from our macro-balance model with those from international studies that estimate exchange rate disequilibrium for New Zealand. Based on data as at May 2012, the IMF, for example, suggested that the required adjustment in the real effective exchange rate to keep the external balance sustainable was depreciation of 10 to 20 percent, depending on the estimation approach used (IMF 2012). Likewise, Cline and Williamson (2012) estimated that New Zealand's real effective exchange rate would need to weaken by around 15 percent to achieve a target current account deficit of 3 percent of GDP (which is lower than the desired current account assumption used in our estimates).

Differences in estimates of the misalignment of the New Zealand dollar will reflect the use of different methodologies, different exchange rate measures, different vintages of data (and forecasts), and different assumptions about the desired level of the current account balance and long-run NIIP to GDP ratio. Equilibrium estimates are also subject to large amount of estimation and model uncertainty. An IMF paper by Edison and Vitek (2009), for example, shows that the 90 percent confidence intervals around their macro-balance point estimate for New Zealand's exchange rate at the time was between -22 percent undervalued and 20 percent overvalued.

Figure 6 summarises the impact of different assumptions about the long-term NIIP to GDP ratio on the estimated misalignment of the exchange rate. A less negative desired NIIP to GDP ratio requires a smaller current account deficit over the long term, since the NIIP represents the cumulative sum of historical current account balances. Using the model's estimate for 2012Q4 to illustrate this point, a less negative desired NIIP ratio implies a larger estimated misalignment in the exchange rate. This is because a larger exchange rate adjustment is required to boost the trade balance sufficiently to meet the sustainability criterion.

**Figure 6: Change in the estimated deviations from exchange rate equilibrium**

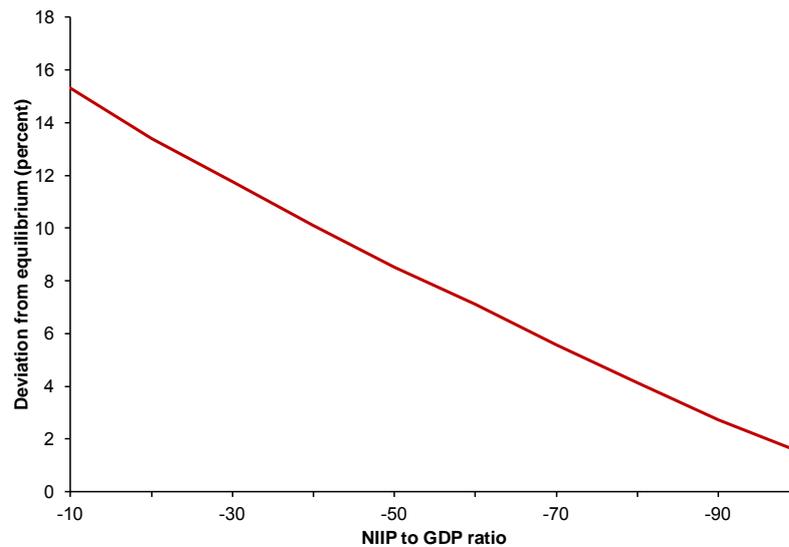


Chart based on the median estimate of the assumption band for 2012Q4. The 2012 estimate is illustrative only and is based on the average exchange rate for the September 2012 quarter, as well as the assumptions and forecasts from the September 2012 *Monetary Policy Statement*.

Figure 6 illustrates that, as currently specified, the model is not very sensitive to the NIIP to GDP ratio: a 10 percent change in the NIIP to GDP ratio results in an approximately 2 percent change in the deviation from equilibrium. Having added distributions around the underlying trade elasticities, the addition of a distribution around the long-run level of the NIIP to GDP ratio does not have a large impact on the distribution around the DCA (compare figures 2a and 3b in the Appendix).

## 5. CONCLUSION

The macro-balance model is one of several models used by the Reserve Bank to evaluate whether the current level of the exchange rate is line with medium-term economic fundamentals. In particular, the macro-balance model sheds light on how far the exchange rate might be, all else equal, from the level consistent with eventual stabilisation in the NIIP to GDP ratio. This note describes the inclusion of uncertainty around some key parameters in the model and the impact of this change on the model's estimate of the deviations of the actual exchange rate from the model's medium-term equilibrium. The addition of assumption bands helps to describe the impact of changes to the key assumptions in the model.

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Future extensions to the macro-balance model could aim to improve the completeness with which the uncertainty around the average values of the model's parameters is characterised. For example, it could be useful to estimate the moments of the model's parameters directly from New Zealand data.<sup>13</sup> Uncertainty around additional parameters, such as the adjustment periods to changes in the exchange rate and output gaps, could also be introduced. Prices, volumes, output and the NIIP could also be explicitly modelled within the model. Future work could also try to account for the adjustment path of the exchange rate to the estimated equilibrium rate or between different steady state levels of the NIIP to GDP ratio.

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<sup>13</sup> It is, for instance, possible that the distributions of some parameters may be skewed if there are upside/downside risks over the average values of the parameters, while the shape of their distributions may even be time-varying.

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APPENDIX

Figure 1a: Trade Balance Elasticity

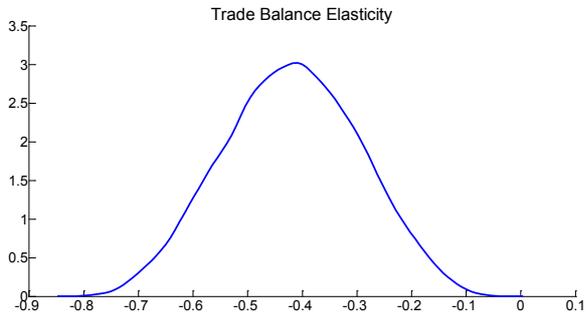


Figure 1b: Distribution for UCUR parameters

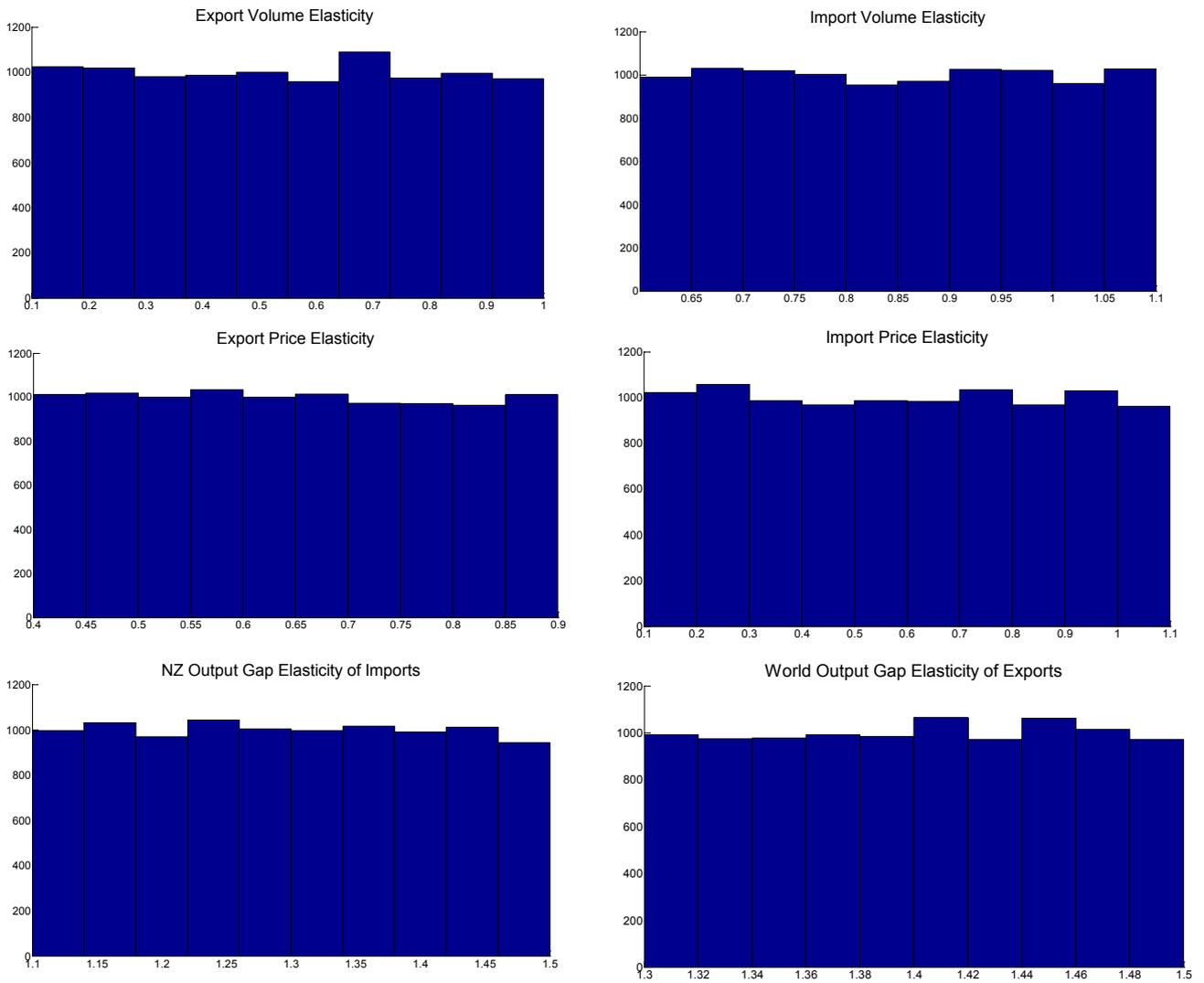


Figure 2a: Distribution for the desired current account balance

NIIP/GDP = current = -83 percent

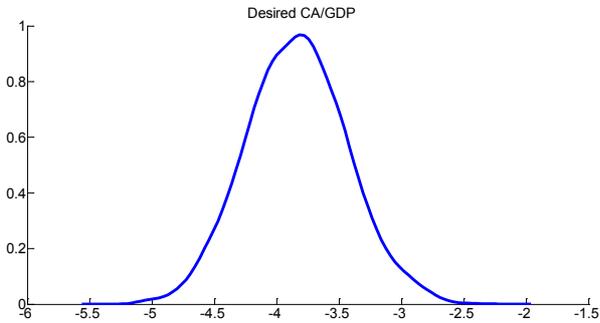


Figure 2b: Distribution for average yield on NFL (%) Figure 2c: Distribution for average GDP growth (%)

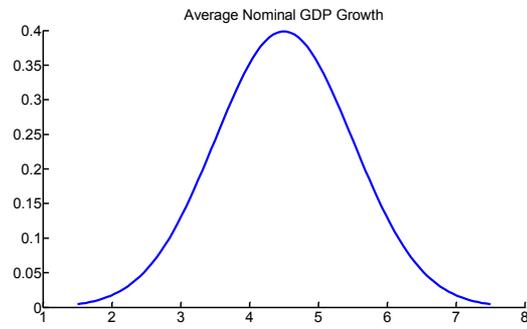
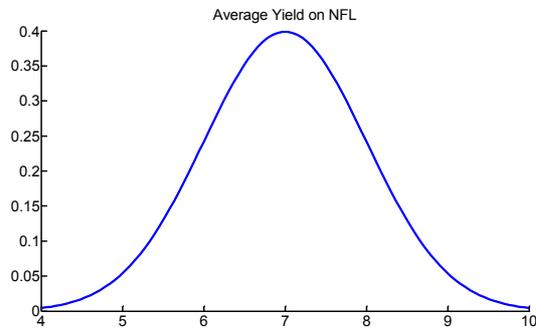


Figure 3a: Distribution for the long run NIIP ratio

NIIP/GDP with Normal Distribution (mean=-83 percent, std dev=10 percent)

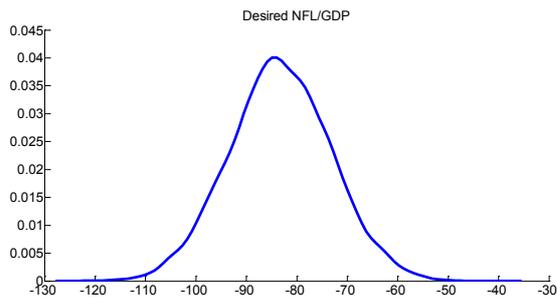


Figure 3b: Distribution for the desired current account balance

NIIP/GDP with Normal Distribution (mean=-83 percent, std dev=10 percent)

