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Would adopting the Australian dollar provide superior monetary policy in New Zealand?

Aaron Drew, Viv Hall,
John McDermott and Robert St. Clair

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Abstract[1]

Counterfactual experiments with the Reserve Bank of New Zealand's core model provide some insight into the implications for New Zealand's economic performance over the 1990s, had it credibly fixed its currency to the Australian dollar.

If New Zealand had faced the relatively more stimulatory Australian monetary conditions prevailing over the 1990s, then output growth may have been temporarily boosted. However, demand pressures would have probably been greater and inflation higher. In particular, results suggest that over the latter part of the 1990s annual inflation would have been around 1 percentage point higher on average.

Stochastic simulation experiments provide a vehicle to analyse what the implications of currency union might be more generally. Results suggest that if New Zealand were to lose its ability to set monetary policy independently, then the variability of inflation and output would increase over the business cycle.

[1] Aaron Drew: *OECD, Paris, France*. Viv Hall: *School of Economics and Finance, Victoria University of Wellington.* Corresponding author: Viv Hall, E-mail: viv.hall@vuw.ac.nz

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1 Introduction

In a period when countries are becoming increasingly linked to one another through trade and capital flows, the management of the exchange rate regime is a critical factor in economic policy making, and the choice of regime is always controversial. The debate over whether New Zealand should continue to maintain an independent currency, or form a currency union with a larger country, such as Australia, has recently taken on prominence.[2] The initial impetus for this debate came from observing international trends in exchange rate regimes: in particular, the formation of a currency union by the European countries that use the Euro; the contemplation of dollarisation by several Latin American countries; and the adoption of full dollarisation in Ecuador. The key motivating factor behind currency union in Europe was the general move towards tighter political union, while in Latin America it was dissatisfaction with floating exchange rates, and a lack of monetary and inflationary control. However, neither of these reasons applies to the New Zealand situation. The debate in New Zealand is really about the conduct of monetary policy and improved overall performance of the economy in the longer run, rather than the exchange rate regime itself.

Despite the fact that floating exchange rate regimes have not had any detectable ill effects upon economic performance, advocates of currency union for New Zealand have criticised monetary policy for being overly stringent, and not taking sufficient risks to allow growth to occur. For example, it has been suggested that New Zealand's growth performance over the last decade would have been better had it adopted Australian monetary conditions.[3] However, it would be surprising if monetary policy designed for the Australian economy produced superior results for New Zealand.[4]

[2] For example: see Coleman (2001, 1999); Hartley (2001); Bowden (2000); Grimes (2000); Grimes, Holmes, and Bowden (2000); Bowden and Grimes (2000); McCaw and McDermott (2000); and Hargreaves and McDermott (1999).

[3] See HSBC: Economics (1999).

[4] Another argument for joining a currency union often put forward is that it removes significant barriers to trade (see Rose and van Wincoop, (2001)). This

Notwithstanding the similarities of the two economies, the New Zealand economy is subject to different shocks and a floating exchange rate and independent monetary policy can help offset these differential shocks.

The contribution of this paper is the use of a general equilibrium approach to directly assess whether the New Zealand economy could have performed better in the 1990s with Australian interest rates and currency movements. It utilises the core model of the Reserve Bank of New Zealand's Forecasting and Policy System (FPS) to examine the potential effects of adopting Australian monetary conditions on key New Zealand macroeconomic variables such as output and inflation.[5] The empirical results are therefore counterfactual in nature, and should be seen as complementary to other contributions on whether New Zealand should or should not adopt a common currency with Australia.

Our results can be seen as fitting with the traditional analysis of optimal currency areas started by Robert Mundell (1961). That is, when an economy faces mostly real shocks, such as changes in its terms of trade, a floating exchange rate is the most effective regime choice. Indeed, the principal benefit attributed to a floating exchange rate regime is that it facilitates a smooth adjustment to real shocks. In contrast, countries in a currency union have to rely on the adjustment of domestic prices to absorb real shocks that are specific to that country, particularly if other adjustment mechanisms such as labour flows or fiscal transfers are unavailable or limited. Such adjustment can be quite slow and painful, as the current experience in Argentina perhaps most clearly demonstrates.

argument is not emphasised for the case of New Zealand joining a currency union with Australia, probably because Australia already accounts for a significant amount of New Zealand's exports. A notable exception is Grimes (2000), which considers that in a dynamic context the main drawback to retaining the NZD is that it may restrain firms wishing to expand into the Australian market from New Zealand, thereby constituting a form of non-tariff barrier to exports for smaller firms.

[5] The counterfactual results presented here are for Australian monetary conditions, though the work could equally well have been carried out for United States counterfactual interest rate and exchange rate paths.

The remainder of the paper is set out as follows. Section 2 examines the implications of New Zealand having Australian monetary conditions over the 1990s. Using deterministic simulations in FPS, the variability of the counterfactual inflation and output outcomes are measured against the outcomes that actually occurred over the 1990s. Section 3 expands the analysis to include a much wider range of economic shocks than was the experience over the 1990s by using stochastic simulation methods. Section 4 provides a summary of specific results, and some broader conclusions. The appendix of the paper provides a detailed description of FPS and the modelling of the foreign sector within it.

2 Deterministic counterfactual simulations

2.1 Methodology

In this section we analyse the implications of New Zealand having Australian monetary conditions over the 1990s. Using deterministic simulations in FPS, we can trace out how, according to the model, New Zealand inflation and output would have evolved.

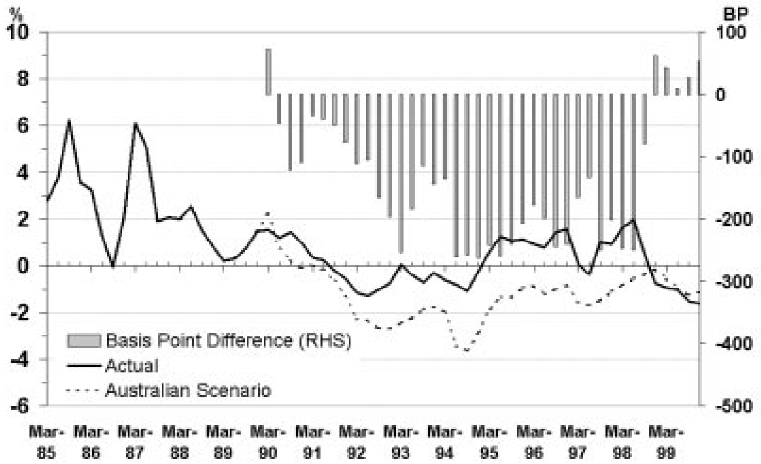
There are two factors that need to be kept in mind when considering this research. First, as in standard economic theory, an essential component of FPS is that in the long run monetary policy affects only nominal variables, and has no marked impact on real economic activity (ie the long-run Phillips curve is vertical). Nonetheless, monetary policy can have a significant impact on economic output in the short-run. Since Australian monetary conditions were, on average, looser over the 1990s than New Zealand monetary conditions, under those conditions FPS will generate higher inflation and a temporary boost to output. The real issue is then how much additional inflation will be generated and how transitory the output boost will be. Using FPS allows us to gauge the quantitative aspects of this.

Second, we assume that FPS is an equally good approximation to reality whether New Zealand is in a currency union or not. That is, the model does not vary across regimes, whereas the economy would probably undergo some structural changes if we entered a currency union. In particular, it is assumed that New Zealand's potential output and other underlying 'equilibrium' trends (such as that for the real exchange rate) do not change from their estimated historical values.

To carry out the deterministic counterfactual experiments FPS was simulated over history from September 1983 to December 1999, with Australian monetary conditions imposed from March 1990 to December 1999. Specifically, we used the Australian nominal yield curve, and a nominal exchange rate growing at the same rate as the Australian TWI over the 1990s. These nominal Australian monetary conditions are taken as exogenous to the model (figure 1).[6]

Figure 1
New Zealand's yield slope curve and Australian counterfactual scenario

(percentage/basis points)

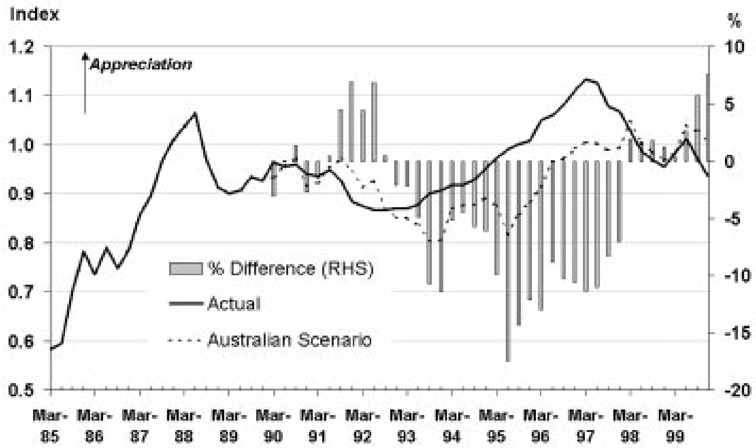


[6] We also explored the impact of keeping New Zealand long-term interest rates in the yield curve. However, the results from this alternative specification for monetary conditions are broadly in line with the results we present which utilise the entire Australian yield curve.

Under the counterfactual experiment, using Australian monetary conditions, the yield curve is significantly lower. On average for the decade, it is 140 basis points more stimulatory than New Zealand conditions were, and the real exchange rate is, on average, 4 percent lower. In fact, on average over 1995-97 the real exchange rate is 12 percent lower.

Although the Australian nominal exchange rate and interest rate are imposed exogenously in this simulation the real exchange rate is endogenous. Looser Australian nominal monetary conditions result in a more depreciated real exchange rate than was New Zealand's actual historical experience (figure 2). However, the significantly lower 'Australian TWI' exchange rate used in the simulations is not allowed to directly increase import prices. To the extent that this assumption is unrealistic, the results will under-predict the full impact on CPI inflation. The new CPI outcomes presented represent the impact of changes in medium-term (demand side) inflation pressure only.

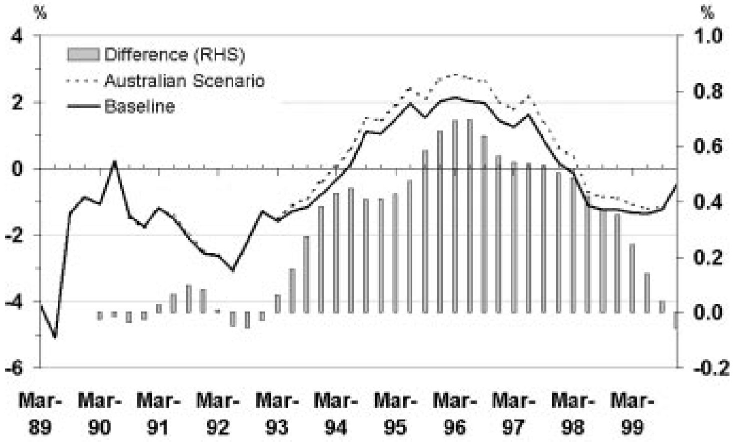
Figure 2
New Zealand's real exchange rate and Australian counterfactual scenario



2.2 Results

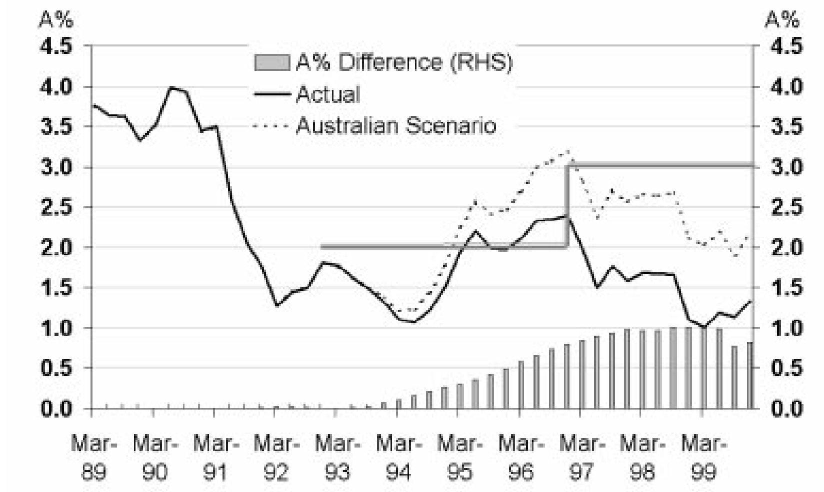
The yield curve and the real exchange rate are significantly lower than New Zealand's actual experience over the 1990s. If New Zealand had faced these more stimulatory monetary conditions, by credibly adopting Australian monetary conditions over the 1990s, then excess demand pressures would have been greater and inflation would have been higher (figures 3 and 4).

Figure 3
Baseline output gap and Australian counterfactual scenario
(percentage points)



Under Australian monetary conditions the level of output and the estimated output gap is on average around 0.3 percentage points higher over the 1990s than New Zealand's historical experience. Excess demand pressures peak over 1996, where the output gap is around 0.7 percentage points higher. However, at the end of the decade the level of output returns to baseline.

Figure 4
The Reserve Bank's target measure of annual inflation and Australian scenario
(percentage points)



Note: The horizontal lines denote the Reserve Bank's target band.

Results suggest annual inflation outcomes may have been around 1 percentage point higher from 1997 onwards. Under Australian monetary conditions the Reserve Bank's target measure of annual inflation would have peaked at 3.2 percent for the year ended December 1996, and fallen to about 2 percent by 1999. However, as outlined in the previous section, this is likely to be a 'lower bound' on what might have occurred to inflation given the lower exchange rate is not allowed to be passed onto import prices.

3 Stochastic Simulations

3.1 Modelling interactions

The results of the deterministic simulations only provide information about how the economy may have responded given the particular historical experience of the 1990s. To provide a more robust basis for evaluating the common currency issue, results from a wider range of economic shocks are required. The historical experience of the 1990s is unlikely to represent the full gamut of shocks that the economy may experience. In the economy multiple shocks occur simultaneously, and often interact with each other in a way that deterministic simulations could never capture. Within the economy we observe outcomes that are a combination of exogenous shocks and policy actions. Stochastic simulations match this reality more closely than do deterministic simulations, providing a vehicle to analyse what the implications of currency union might be more generally. The stochastic simulation analysis enables us to explore 'all likely' counterfactual outcomes for the New Zealand economy operating without an independent monetary policy. Each alternative path is a function of randomly generated 'typical' macroeconomic shocks that New Zealand is likely to experience, and a policy reaction.[7]

Before outlining the stochastic experiments conducted in this paper, it is useful to outline 'an ideal' modelling framework which would capture key elements relevant for analysing the impact of currency union. If the New Zealand economy lost monetary policy independence, with a foreign economy taking control of interest rate setting under a common currency, then the principal transmission mechanisms that would be desirable to capture would include:

- real flows – such as trade patterns, migration, and investment flows – with the rest of the world and between New Zealand and the foreign economy;
- both temporary and permanent shocks from the rest of the world which impact on both the New Zealand economy and the foreign economy;
- temporary and permanent shocks idiosyncratic to both the New Zealand and the foreign economy.

Modelling this ideal system would require developing comprehensive models of a foreign economy, the rest of the world,

7 The methodology for generating shock terms and carrying out stochastic simulations of the FPS model is presented in Drew and Hunt (2000 and references therein).

and New Zealand – where the interaction of real flows and macroeconomic shocks is explicitly captured.

Rather than tackle all of this relatively large and complex problem we have focused our attention on the monetary policy channel, given that seems to be the area that has generated most of the debate. This allows us to simplify the problem considerably. The standard FPS model is used to represent the New Zealand economy, augmented by a stylised representation of a foreign economy, as outlined in the following section. The foreign economy, which may be thought of as Australia or the United States, has its own objective for monetary policy and meets that objective by controlling its own interest rates. Finally, the rest of the world is simply a source of shocks that impact on both New Zealand and the foreign economy.

We further simplify the ideal system by placing two restrictions on the shock processes. First, it is assumed that all shocks are temporary in the sense that they don't have any long-run affects on the model economy. Second, there are no idiosyncratic shocks to the foreign economy. The transmission mechanisms are also simplified by assuming that the foreign sector model is not affected by developments in the domestic economy – an assumption that is realistic when considering New Zealand's economic importance to the United States, but less realistic when considering the relationship to Australia.

As a whole, the analysis that follows sheds some light on how important country-specific shocks are, and whether that would change in a currency union. It does not, however, consider how alternative adjustment mechanisms can alleviate the costs of shocks, nor how effective they may be.[8] This implies that the results that follow may over-state the importance of maintaining an independent monetary policy. On the other hand, given that there are no foreign economy specific shocks, to the extent these matter the analysis may actually understate the cost of losing monetary policy independence.

8 Alternative means of adjustment through prices and wages, capital and labour mobility, and fiscal policy are discussed in McCaw and McDermott (2000).

3.2 Modelling the foreign economy

A key element of the analysis is to understand how shocks from the rest of the world are transmitted to New Zealand, and how the exchange rate can buffer these shocks. To do this we utilise the foreign sector model within FPS, which consists of the following relationships:

- an 'IS curve' written in output gap-interest rate space;
- a Phillips curve relating inflation to both inflation expectations and the output gap;
- inflation expectations that are a mixture of forward- and backward-looking inflation rates;
- the behaviour of world commodity prices and imported consumption goods have been specified to correspond to observed relationships;
- a forward-looking monetary authority, very similar to that in the domestic sector, where policymakers increase short-term nominal interest rates in response to deviations of expected inflation from a target rate; and
- real interest rates that are determined by a Fisher equation, while the long-term nominal interest rate is derived from the expectations theorem.

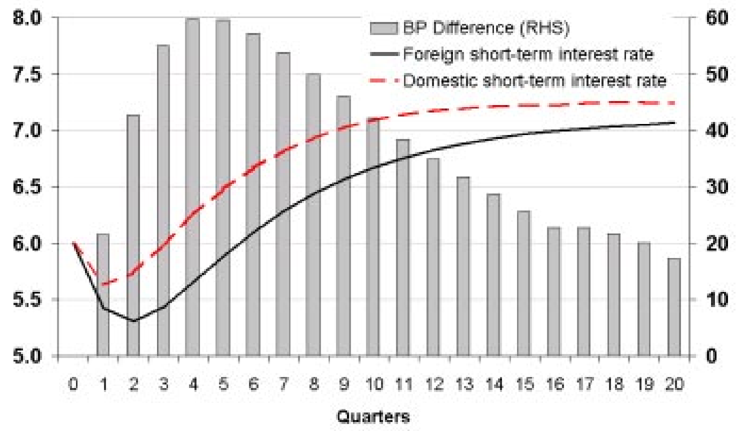
As table 1 shows, in the long run the equilibrium yield gap – which directly affects economic activity in FPS – is identical under both the foreign and domestic sectors. Thus, there is no long-run bias between the foreign sector and the domestic sector in terms of the tightness of policy. Furthermore, the central bank reaction function within the foreign sector model was adjusted, to ensure that any differences in the simulation results purely reflect differences in the model structure of the economies and the shocks faced, not differences in preferences of the central banks.

Table 1
Long-run properties of the foreign sector and the domestic NZ sector in FPS

	Long-run value (percentage points)
Real short-term foreign interest rate	**3.5**
Real short-term domestic interest rate	4.5
Short-term foreign interest rate	**6.0**
Short-term domestic interest rate	6.0
Long-term foreign interest rate	**6.5**
Long-term domestic interest rate	6.5
Foreign yield gap	**-0.5**
Domestic yield gap	-0.5
Foreign inflation target	**2.5**
Domestic inflation target	1.5

The economic structure and macroeconomic adjustment to shocks is different under the foreign sector compared to the domestic sector. Adjustment costs in the foreign sector are not as complex as in the domestic sector. For example, stock-flow adjustment is not built into the foreign sector model. The resulting dynamic adjustment paths to a common shock are therefore different. This is illustrated in figure 5 which shows the resulting path for nominal short-term interest rates in the sectors after a one-percentage point permanent increase in the inflation target.

Figure 5
Interest rate response within the domestic and foreign sectors after a 1 percent rise in their respective inflation targets
(percentage points)



3.3 Experiments undertaken

Four stochastic simulation experiments are conducted to explore the impact on the New Zealand economy should it lose monetary policy independence. Under each experiment two simulations are run. First, New Zealand operates under ‘status quo’ independent (fully endogenous) monetary policy. Second, monetary policy is exogenous to New Zealand being controlled by a foreign monetary authority. That is, the foreign sector yield curve (solved for in the endogenous foreign sector of FPS) is imported into the New Zealand model economy.

In the analysis, when interest rates are foreign controlled there is no UIP effect to cause the nominal exchange rate to move between the domestic and foreign economies. However, the real exchange rate will still adjust given shocks applied to it in the stochastic simulation experiments. In general, the shocks applied result in the real

exchange rate moving in a counter-cyclical fashion, or in other terms, the real exchange rate acts as a macroeconomic ‘stabiliser’.[9]

Each experiment consists of a 25 year simulation period with 100 draws of ‘typical’ macroeconomic shocks that New Zealand has experienced recently. This provides 10,000 observations for calculating measures of the average deviation from trend.

We explain the four shock experiments in turn. In the first experiment the New Zealand economy is hit with domestic specific shocks to consumption, the real exchange rate, inflation, and investment. The shocks from ‘the rest of the world’ which impact on both the New Zealand economy and the foreign sector are shocks to world export prices and world demand. We have labelled this experiment as **‘all shocks’**.

The second experiment subjects the New Zealand economy to shocks solely of domestic origin ie terms of trade and world demand shocks are excluded. This gives a better indication of what the costs of a fixed currency arrangement might be when the foreign monetary authority ‘looks through’ New Zealand specific macroeconomic disturbances. We have labelled this experiment as **‘domestic shocks’**.

The third experiment subjects the New Zealand economy and the foreign sector to shocks emanating solely from ‘the rest of the world’. That is, these shocks do not originate in the potential currency union. The types of shocks we are considering in this experiment are terms of trade and world demand shocks. The

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[9] The shocks applied in the analysis include disturbances to domestic demand (consumption and investment), world demand, the terms of trade, domestic price inflation, and the real exchange rate. The auto and cross-correlation structure of the shocks are determined by a VAR system estimated over the 1990s. In the VAR system the real exchange rate acts in a stabilising fashion. For example, as is seen in Drew and Hunt (1998), it appreciates following a positive impulse to domestic demand, world demand, and the terms of trade. This is in contrast to econometric evidence of ‘orbitals’ presented in Bowden and Grimes (2000), who conclude that the real exchange rate does not buffer movements in the terms of trade. The VAR evidence also runs against Coleman’s (1999) evaluation of the modern literature on currency union, which suggests that in a low inflation environment exchange rate volatility may be a cause rather than a means of adjusting to economic shocks.

experiment with '**rest of the world shocks**' is the opposite of the second experiment above.

The fourth experiment assumes that the New Zealand economy and the foreign sector experience world shocks all of the time, but three out of ten years the New Zealand business cycle goes out of phase as it is hit with domestic specific shocks. This experiment attempts to incorporate empirical evidence surrounding the degree of synchronisation of New Zealand's business cycle with the rest of the world. For example, Hall, Kim and Buckle (1998) find that New Zealand's business cycle is around 70 percent correlated with that of the USA over the late 1970s to the mid 1990s. Furthermore, concordance analysis by McCaw and McDermott (2000) over the period 1960-99 revealed that the proportion of time that New Zealand's business cycle was in the same phase with those of Australia and the United States was about 70 percent. We have called this scenario **'mixed shocks'**.

3.4 Results

Table 2 provides the absolute and relative deterioration in the central bank's 'societal loss' under the four shock scenarios, while table 3 (and figure 6) presents the average volatility outcomes. In table 2 the losses are calculated using a standard quadratic loss function of the form:

$$L = \sum_{t=1}^{\infty} (1-\lambda)(y_t - y^*_t)^2 + \lambda(\pi_t - \pi^T)^2$$

where $(y - y^*)$ is the output gap, π is annual CPI inflation, π^T is the Reserve Bank target rate of inflation (1.5 percent), and λ is the relative weight on inflation versus output variability. This is set at 1/2, which presumes the central bank cares as much about inflation being away from the target as output being away from the economy's supply potential.[10] Placing a higher weight on inflation deviating from the target would represent a 'hawkish' central bank's

[10] Econometric evidence presented in Drew and Plantier (2000) is not inconsistent with the Reserve Bank of New Zealand placing an equal weight on output and inflation deviations when setting monetary policy.

preferences; in contrast, a 'dovish' central bank would place a higher weight on output deviating from potential.

The volatility in both output and inflation is the lowest, and therefore the loss is also the lowest, under the scenario where the New Zealand economy experiences only domestic shocks and operates an independent monetary policy. At the opposite end of the spectrum, the loss is the highest when all shocks occur and monetary policy is foreign controlled.

Table 2
Collation of stochastic simulation volatility properties into a standard loss function

(output and inflation variability are weighted equally)

Simulation	Loss under Domestic Policy	Loss under Foreign Policy	Percentage change in Loss
Domestic Shocks	1.0	3.8	273
World Shocks	1.3	2.9	120
Mixed Shocks	1.6	3.3	105
All Shocks	2.3	3.9	71

Intuitively, the loss under the domestic shocks and independent monetary policy scenario should be the lowest as there are the least amount of shocks to contend with, and policy is geared towards responding to them. In stark contrast, in the case where only domestically generated shocks occur, and the foreign central bank sets policy, the variability in inflation is the highest seen (table 3). In losing monetary policy independence, inflation variability increases four-fold, from 0.5 to 2 percent, while output variability increases from 1.3 to around 2 percent. The overall deterioration in performance is such that the loss arising from inflation and output variability increases around 300 percent (table 2). The reason why inflation is notably more volatile under this scenario is because it is the only one where monetary policy is playing no buffering role. Under all other simulations, whether it is the foreign or domestic central bank setting interest rates, there is some leaning against inflation pressures.

Out of all the cases where monetary policy is set in the foreign sector, the volatility in output and inflation is the lowest when the model is hit with solely world shocks. Not surprisingly, this implies that under common shocks from the rest of the world, foreign monetary policy is more appropriate. However, the deterioration in loss associated with losing policy independence in this case is still significant at over 100 percent.

A final inference that can be drawn from the stochastic analysis is that, given the shocks applied and the model, the cost of losing monetary policy independence is felt more in terms of a deterioration in inflation performance than output performance. The increase in output variability lies in a band of around 0.4 to 0.6 percent, whereas the increase in inflation variability lies between 0.8 to 1.5 percent. These results suggest that, overall, the more a central bank and society care about inflation control, the less advisable it would be to enter into a common currency arrangement. Conversely, if the costs of inflation variability are low, and there are large efficiency gains to be had from entering into a common currency arrangement, then that could well outweigh any increase in the variability of output associated with a loss of monetary policy independence.

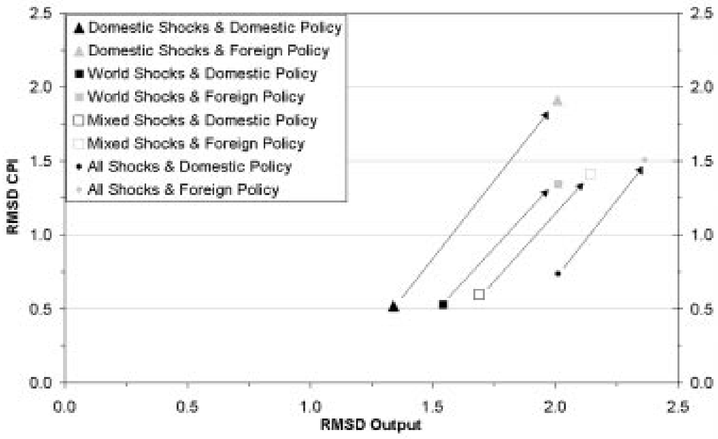
Table 3
Average volatility properties for output gap and inflation
(25 year simulation period – 100 shock draws – 10,000 observations)
(percentage point units)

Simulation:	80% Confidence Interval for Output Gap	80% Confidence Interval for CPI Inflation	RMSD Output*	RMSD CPI Inflation
Domestic shocks & domestic policy	-1.7 to 1.7	0.8 to 2.2	1.340	0.517
World shocks & domestic policy	-2.0 to 2.0	0.8 to 2.2	1.543	0.527
Mixed shocks & domestic policy**	-2.2 to 2.2	0.7 to 2.3	1.689	0.595
All shocks & domestic policy	-2.6 to 2.6	0.6 to 2.4	2.013	0.734
Domestic shocks & foreign policy	-2.6 to 2.6	-0.9 to 3.9	2.010	1.909
World shocks & foreign policy	-2.6 to 2.6	-0.2 to 3.2	2.011	1.346
Mixed shocks & foreign policy	-2.7 to 2.7	-0.3 to 3.3	2.143	1.409
All shocks & foreign policy	-3.0 to 3.0	-0.4 to 3.4	2.366	1.505

* Root Mean Square Deviation. This is the average squared deviation in the observed series from its control long-run equilibrium. The RMSD for output is the averaged squared deviation in output from potential, and the long-run equilibrium is zero ie the output gap is closed. The RMSD for inflation is the average squared deviation in the Bank's target measure of inflation from the mid-point of the target range ie 1.5 percent.

** Under the 'mixed shocks' simulations the average correlation (across the draws) between the domestic and the foreign sector output gap is 0.72. This suggests that our specification of mixed shocks captures the spirit of Hall *et al* (1998), and McCaw and McDermott (2000) ie the finding that the New Zealand business cycle is synchronised with that of the USA and Australia around 70 percent of the time.

Figure 6
Long-run average inflation and output volatility
(percentage point units)



4 Summary and conclusions

Deterministic simulations show that New Zealand's output gap measure would have been on average 0.3 percentage points higher than New Zealand's actual historical experience, if the more stimulatory Australian monetary conditions had been applied to New Zealand during the 1990s. By 2000, though, output would have been approximately back to baseline. This greater excess demand pressure would have led to, on average, 1 percent higher CPI inflation. This implies that the Reserve Bank's previous 0 to 2 percent inflation target band would have been exceeded by a greater amount, and for a greater number of periods than was actually the case. Moreover, the current 0 to 3 percent band would have been exceeded over the last two quarters of 1996. These outcomes eventuate despite the advantage of a conservative exchange rate pass-through assumption.

Stochastic simulation results show that the volatility in output and inflation are the lowest under the case where the New Zealand

economy experiences domestic shocks and operates an independent monetary policy. In contrast, volatility is the highest when domestic and world shocks occur, and New Zealand's monetary policy is controlled offshore. Moreover, irrespective of the shock scenario considered, model results show the volatility in output and inflation to be greater under a common currency policy environment than with New Zealand operating with an independent monetary policy.

In utilising these counterfactual model-based outcomes to assist judgement on whether New Zealand should consider adopting some form of common currency, and therefore, whether New Zealand should retain or consider giving up the independent setting of monetary policy, our research suggests it is necessary to consider:

- outcomes from a representatively wide range of possible stochastic shocks, as well as from the shocks which have occurred during one specified historical period, and
- results not just for output and inflation, but also for their relative variability.

It follows, therefore, that any summary conclusion from the above system-wide macroeconomic evidence will depend on the relative weighting placed on the degree of variability of inflation and output. If a high weight is placed on avoiding such variability, then our results imply a common currency should not be adopted, and an independent monetary policy should be retained.

Appendix: Modelling framework

The potential effects of New Zealand adopting a foreign currency are analysed using the core model of the Reserve Bank of New Zealand's Forecast and Policy System (FPS).[11] This appendix provides an overview of the model used to generate counterfactual paths for output and inflation, under the assumption that New Zealand had Australian monetary conditions through the 1990s. The implications of whether New Zealand had joined a currency union with Australia, or simply adopted the Australian dollar (ie dollarised) can be analysed the same way. Because Australia has six times the population of New Zealand the New Zealand business cycle conditions would be of secondary importance in setting monetary conditions. Australian monetary conditions would therefore have dominated in either case.

FPS describes the interaction of five economic agents: households, firms, government, a foreign sector, and the monetary authority. The model has a two-tiered structure. The first tier is an underlying steady-state structure that determines the long-run equilibrium to which the model will converge. The second tier is the dynamic adjustment structure that traces out how the economy converges towards that long-run equilibrium.

The long-run equilibrium is characterised by a neo-classical balanced growth path. Along that growth path, consumers maximise utility, firms maximise profits and government achieves exogenously-specified targets for debt and expenditures. The foreign sector trades in goods and assets with the domestic economy. Taken together, the actions of these agents determine expenditure flows that support a set of stock equilibrium conditions that underlie the balanced growth path.

The dynamic adjustment process overlaid on the equilibrium structure embodies both 'expectational' and 'intrinsic' dynamics. Expectational dynamics arise through the interaction of exogenous disturbances, policy actions and private agents' expectations. Policy actions are introduced to re-anchor expectations when exogenous disturbances move the economy away from equilibrium. Because policy actions do not immediately re-anchor private expectations, real variables in the economy must follow dis-equilibrium paths until expectations return to equilibrium. To capture this notion, expectations are modelled as a linear combination of a backward-looking autoregressive process and a forward-looking model-consistent process. Intrinsic dynamics arise because adjustment is costly, and these costs are modelled using a polynomial adjustment framework. In addition to expectational and intrinsic dynamics, the behaviour of both the monetary and fiscal authorities also contributes to the overall dynamic adjustment process.

[11] See Black *et al* (1997), and Hunt *et al* (2000), for a more complete description of the FPS model.

In FPS, goods are differentiated by a system of relative prices. Overlaid on this system of relative prices is an inflation process. While inflation can potentially arise from many sources in the model, it is fundamentally the difference between the economy's supply capacity and the demand for goods and services that determines inflation in domestic prices. Further, the relationship between goods market dis-equilibrium and inflation is specified to be asymmetric. Excess demand generates more inflation than the deflation caused by an identical amount of excess supply.

A.1 Households

There are two types of households in the model: 'rule-of-thumb' and 'forward-looking'. Forward-looking households hold all of the economy's financial assets and, on average, save. Rule-of-thumb households spend all their disposable income each period and hold no assets. The theoretical core of the household sector is the specification of the optimisation problem for forward-looking households. The specification is based on the overlapping generations framework of Yaari (1965), Blanchard (1985), Weil (1989) and Buiter (1988), but in a discrete time form as in Frenkel and Razin (1992) and Black *et al* (1994). In this framework, the forward-looking household chooses a path for consumption – and a path for savings – that maximises the expected present value of lifetime utility subject to a budget constraint and a fixed birth-rate. This basic equilibrium structure is overlaid with polynomial adjustment costs, the influence of monetary policy, an asset dis-equilibrium term, and an income-cycle effect.

The population size and age structure is determined by the simplest possible demographic assumptions. We assume that new consumers enter according to a fixed birth rate and that existing consumers exit the economy according to the fixed probability of death. For the supply of labour, we assume that each consumer offers a unit of labour services each period. That is, labour is supplied inelastically with respect to the real wage.

A.2 The representative firm

The formal introduction of a supply side requires us to go beyond the simple endowment economy of the Blanchard *et al* framework. The firm is modelled very simply in FPS, but as with the characterisation of the consumer, some extensions are made to capture essential features of the economy. Investment and capital formation are modelled from the perspective of a representative firm. This firm acts to maximise profits subject to the usual accumulation constraints. Firms are assumed to be perfectly competitive, with free entry and exit to markets. Firms produce output, pay wages for labour input, and make rental payments for capital input.[12] The production technology is Cobb-Douglas, with constant returns to scale. Profit maximisation is sufficient to determine the level of output, the level of employment, and the real wage. FPS extends this framework in a number of directions as firms face adjustment costs for capital and a time-to-build constraint.

A.3 The Government

Government has the power to collect taxes, raise debt, make transfer payments, and purchase output. As with households and firms, the structure of the model requires clear objectives for government in the long run. However, whereas households' and firms' objectives arise through explicit maximisation, we directly impose fiscal policy choices for debt and expenditure. The government's binding

[12] We also assume that households own the capital stock.

intertemporal budget constraint is used to solve for the labour income tax rate that supports the fiscal choices. The interactions of debt, spending and taxes create powerful effects throughout the rest of the model; government is non-neutral.

A.4 The foreign sector

The foreign sector is a stylised representation of a foreign economy, not necessarily the United States or Australia. The foreign sector is treated as completely exogenous to the domestic economy. It supplies the domestic economy with imported goods and purchases the domestic economy's exports, and thus completes the demand side of the model. Further, the foreign sector stands ready to purchase assets from, or sell assets to, domestic households – depending on whether households choose to be net debtors or net creditors relative to the rest of the world.

A simplified summary of the key foreign sector model equations is presented below. The equations denoted with an arrow illustrate a subtle re-calibration of the foreign sector to match the properties of the domestic central bank reaction function.

IS curve:

$$(y-y^*)_t = \delta(y-y^*)_{t-1} - \sum_{i=1}^{2}\gamma_i(r-r^*)_{t-i}$$

$$\Rightarrow (y-y^*)_t = \delta(y-y^*)_{t-1} - \sum_{i=1}^{2}\gamma_i(rsl-rsl^*)_{t-i}$$

Phillips curve:

$$\pi_t = \pi_t^e + \sum_{i=0}^{2}\alpha_i(y-y^*)_{t-i}$$

Inflation expectations:

$$\pi_t^e = \varpi_1\sum_{i=1}^{4}\eta_i\pi_{t-i} + (1-\varpi_1)\sum_{i=1}^{4}\eta_i\pi_{t+i}$$

Long-term inflation expectations:

$$\pi_t^{le} = 0.20(\pi_{t+4}^e + \pi_{t+8}^e + \pi_{t+12}^e + \pi_{t+16}^e + \pi_{t+20}^e)$$

Reaction function:

$$rn_t = \left[\left(1+r_t^*\right)\left(1+\pi^T\right)-1\right]+\sum_{i=6}^{8}2.5\left(\pi_{t+i}^e-\pi^T\right)$$

$$\Rightarrow rn_t - rnl_t = rn_t^* - rnl_t^* + \sum_{i=6}^{8}1.4\left(\pi_{t+i}^e-\pi^T\right)$$

$$\Rightarrow rsl_t = rsl_t^* + \sum_{i=6}^{8}1.4\left(\pi_{t+i}^e-\pi^T\right)$$

Fisher equation:

$$r_t = \left(\frac{1+rn_t}{1+\pi_t^e}-1\right)$$

Long nominal interest rate:

$$rnl_t = \varepsilon\left[\left(1+rnl_{t+1}\right)\left(\frac{1+tp_t^*}{1+tp_{t+1}^*}\right)\left(\frac{1+rn_t}{1+rn_{t+20}}\right)^{0.05}-1\right]+\left(1-\varepsilon\right)\left[\left(1+rl_t^*\right)\left(1+\pi^T\right)-1\right]$$

Fisher equation:

$$rl_t = \left(\frac{1+rnl_t}{1+\pi_t^{le}}-1\right)$$

where:

$\left(y-y^*\right)_t$ is the output gap at time *t*;
π_t is annual inflation at time *t*;
π_t^e is expected inflation at time *t*;
π_t^{le} is long-term expected inflation at time *t*;
π^T is the policy target;
rn_t is the nominal interest rate at time *t*;
r_t is the interest rate at time *t*;
rnl_t is the nominal long-term interest rate at time *t*;
rl_t is the long-term interest rate at time *t*;
r_t^* is the equilibrium interest rate at time *t*;
rl_t^* is the equilibrium long-term interest rate at time *t*;
rn_t^* is the equilibrium nominal interest rate at time *t*;
rnl_t^* is the equilibrium nominal long-term interest rate at time *t*;
rsl_t^* is the equilibrium yield gap at time *t*;
rsl_t is the yield gap at time *t*;

$\left(r-r^*\right)_t$ is the interest rate gap i.e actual less equilibrium at time *t*;
$\left(rsl-rsl^*\right)_t$ is the yield curve gap i.e actual less equilibrium at time *t*;
tp_t^* is the equilibrium term premium at time *t*.

A.5 The Monetary Authority

The monetary authority effectively closes the model by enforcing a nominal anchor. Its behaviour is modelled by a forward-looking reaction function that moves the short-term nominal interest rate in response to projected deviations of inflation from an exogenously specified target rate. The reaction function can be expressed as:

$$rn_t - rnl_t = rn_t^* - rnl_t^* + \sum_{i=6}^{8}1.4\left(\pi_{t+i}^e-\pi^T\right)$$

where rn and rnl are short and long nominal interest rates, respectively; rn^* and rnl^* are their equilibrium equivalents; π_{t+i}^e is the model consistent projection of inflation *i* quarters ahead, and π^T is the policy target.[13] Although the reaction function is *ad hoc* in the sense that it is not the solution to a well-defined optimal control problem as in Svensson (1997), its design is not totally arbitrary. The forward-looking nature (ie 6-8 quarters ahead) of the reaction function respects the lags in the economy between policy actions and their subsequent implications for inflation outcomes. Further, the strength of the policy response to projected deviations in inflation (1.4) implicitly embodies the notion that the monetary authority is not single minded in its pursuit of the inflation target. Other factors such as the variability of its instrument and the variability of the real economy are also of concern.

[13] The terms of the current Policy Targets Agreement, signed between the Governor of the Reserve Bank of New Zealand and the Treasurer, dictates that the Reserve Bank target an inflation *band* of 0 to 3 percent. In FPS the policy target is the mid-point of this band, ie 1.5 percent.

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