Monetary policy transmission mechanisms and currency unions: A vector error correction approach to a Trans-Tasman currency union

Alfred A Haug, Özer Karagedikli and Satish Ranchhod*

Abstract

Differences in transmission mechanisms can generate asymmetric behaviour among currency union partners when they experience shocks. This has the potential to widen existing cyclical variation between members of a currency union. Our analysis suggests that the transmission mechanisms of GDP and the CPI of a monetary shock appear to be similar in Australia and New Zealand. However, there are differences in terms of the size of the responses of some variables to identical monetary policy shocks. In a currency union with a different exchange rate pattern and with different monetary policy shocks, New Zealand may experience some new challenges.

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Key words: Impulse responses; vector error correction; monetary transmission mechanism.

Running Title: Monetary policy transmission in the Trans-Tasman.

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1 Introduction

An important concern in the formation of currency unions is the nature of monetary policy transmission mechanisms in the prospective member countries. Monetary policy affects macroeconomic variables, such as GDP and inflation, through monetary transmission channels. An examination of transmission mechanisms allows us to consider the responsiveness of economic variables to policy shocks (the size of the effect) and how the speed of adjustment varies between different countries (the speed of the effect). This issue is receiving attention in Europe, reflecting the concern that differences in transmission mechanisms across Euro countries could widen the existing cyclical variation and potentially impede the inflation-targeting role of the European Central Bank (ECB).[1]

The results of studies on Euro-area transmission mechanisms vary considerably. Gerlach and Smets (1995) concluded that the effects of monetary policy shocks were not very different across EU countries. However, they found the effects to be larger in Germany than in other major EU countries. Dornbusch, Favero and Giavazzi (1998) found the effects of the short term interest rates on output to be about twice as high in Italy and about three times as large in Spain (after controlling for fluctuations in the intra-EU area exchange rate) compared to the other countries. Ramaswamy and Sloek (1998) looked at the speed of adjustment to an unanticipated contraction in monetary policy. They found that the full effect of a policy shock on output took twice as long in Austria, Belgium, Finland, Germany and the Netherlands and was twice as deep in France, Italy, Portugal and Spain, compared to the other countries. There is still much debate on this issue.

In this paper we examine the similarity of transmission mechanisms in New Zealand and Australia and consider the implications this has for a currency union between the two economies. A major concern with the formation of a currency union is how a single monetary policy will affect the member countries and whether it would affect all members equally. The answer to this question cannot be known until monetary union is actually implemented. We can, however, gain some insight into this issue by examining the effect of monetary policy changes in the past. The Lucas (1976) critique suggests that differences in the transmission mechanisms that exist prior to currency union may not continue to exist following unification. However, examining transmission mechanisms in this way may still highlight important concerns with potential currency union partners.

We first estimate empirical models of both the New Zealand and Australian economies. We then compare the transmission mechanisms of the two economies. This is accomplished using Vector Error Correction Models (VECMs). Standard Vector Autoregressions (VARs) that do not impose error-corrections for deviations from the long run equilibrium of the model are a very commonly used methodology in this field. Monetary transmission mechanisms based on VECMs were studied by King, Plosser, Stock and Watson (1991), Ehrmann (1998), Garratt, Lee, Pesaran and Shin (2001), and Camarero et al (2002), among others. In part, our examination aims

[1] See Clements, Kontolemis and Levy 2001.

to explore the suitability of this methodology for modelling economic activity in New Zealand.

Our examination of transmission mechanisms tentatively suggests that they are quite similar for New Zealand and Australia. In particular, when each economy faces an identical exogenous monetary policy shock, similar adjustments seem to occur to GDP and the CPI in the two economies. By contrast, some differences may exist in the adjustment that occurs to the TWI in each country following a monetary policy shock. However the size of the GDP response to a monetary policy shock appears to be larger in New Zealand than in Australia. This suggests that a same size increase in interest rates to reduce union-wide inflation may cause a larger GDP effect in New Zealand.

We note the conditional nature of our findings and that this is a major limitation of the work. In particular, the findings are not robust to changes in the sample period or the variables examined. Note further that important differences exist between the price indices examined from each economy. This complicates a comparison of how monetary policy in each economy is transmitted to the price level.
The remainder of the paper is structured as follows: Section 2 details our methodology and data. Section 3 examines the transmission mechanisms of each economy when they operate independent monetary policies. The transmission mechanisms are estimated by VECMs. Section 4 concludes.

2 Methodology and data

We begin by defining a VECM for each country. Let X_t^i be the vector of endogenous variables for country i in period t

$$X_t^i = (y_t^i, p_t^i, R_t^i, e_t^i, c_t^i).$$

where y_t^i is real GDP, p_t^i is the price level, R_t^i is a short-term nominal interest rate, e_t^i is the Trade Weighted Index (TWI), and c_t^i is a variable that measures the use of private sector credit. The reason for including these variables is to capture the main channels of transmission mechanisms, these being the exchange rate channel, interest rate channel and credit channel. We limit our models to these three channels, and take a parsimonious approach when estimating our models, due to the limited number of observations available. We also consider the inclusion of several exogenous variables, such as commodity price indices, the US GDP growth rate and the US short-term interest rate. The inclusion of such variables aims to control for wider economic conditions in the economies we examine.

We had difficulties with credit variable definitions and with their time series properties. Therefore, we tried instead different monetary aggregates. M1 is highly correlated with private sector credit usage in both economies. We have opted to use it as a proxy for private sector credit usage.

We consider the transmission mechanisms in New Zealand and Australia individually and compare the responses of macroeconomic variables to monetary policy shocks. This aims to highlight similarities and differences in the adjustment mechanisms of the two economies. We then consider some implications of our findings for a hypothetical currency union between New Zealand and Australia.

2.1 Econometric methodology

In this section we will explain why we chose a VECM as our methodology and how we proceed in applying it. Impulse response functions can be derived from two types of VARs. One is a standard VAR with all variables specified in levels. The other is a VECM that explicitly models variables integrated of order one [I(1)] and cointegrating relationships that are present in the data. A VECM can be derived from a levels VAR by imposing cointegrating restrictions. If a VAR is estimated in levels, without imposing cointegrating restrictions present in the data, VAR parameters are estimated consistently by least squares (Sims, Stock, and Watson 1990). However, this method of estimating parameters is not efficient because information about cointegration (ie about the long run) is ignored in an unrestricted levels VAR.[2] VECM estimation instead will produce more precise and efficient parameter estimates.

Deriving impulse response functions from either a levels VAR or a VECM specification requires a representation of the model in terms of shocks, which is a vector moving-average representation. Impulse responses for the monetary transmissions mechanisms based on a levels VAR were studied by Sims (1992), Christiano, Eichenbaum, and Evans (1998), Ramaswamy and Sloek (1998), and Clements et al (2001), among others. Impulse responses for monetary policy transmission mechanisms based on VECMs were explored by King et al (1991), Ehrmann (1998), Lütkepohl and Wolters (1998), Cecchetti (1999), and Garratt et al (2001), among others.[3]

In order to derive impulse responses, a set of identifying restrictions has to be imposed. There are two approaches used to achieve identification of the shocks. One is based on imposing restrictions on the contemporaneous effects of shocks, the other is based on imposing long run restrictions on the effects of shocks. To impose contemporaneous restrictions, the standard approach is a Choleski decomposition of the residual covariance matrix from the VAR or VECM model, ie from the so-called reduced form model. It imposes a contemporaneous recursive structure on the shocks that depends in a crucial way on the ordering of the variables in the system. The ordering reflects the speed with which variables respond to shocks. The triangular form used for the Choleski decomposition only imposes contemporaneous restrictions without any restrictions on the lagged structural parameters.[4] The literature on monetary transmissions has suggested several different orderings. There is no agreement on the ordering because different economic theories imply different

[2] Peersman and Smets (2001) and some others follow this approach.

[3] Gerlach and Smets (1995) specified a model in first differences but did not account for cointegration.
[4] See also Pesaran and Shin (1998) for an alternative to Choleski decomposition.

orderings.[5] Several potential variable orderings are considered in this paper. The orderings examined reflect our priors regarding the operation of monetary policy transmission mechanisms based on economic theory.

The second approach imposes long run restrictions in order to achieve identification of the shock structure.[6] An example of a long run identifying assumption could be that nominal shocks have no effects on real output. Let a_{ijk} measure the effect on real output of the i-th variable in a VAR at lag t-k for the j-th shock, which is a nominal shock. If there are no long run effects of the j-th shock on real output, then the sum over all k from zero to infinity is zero. King et al (1991) use the VECM model to impose long run restrictions implied by cointegrating vectors in order to achieve identification for the impulse response analysis.[7] The arguments for imposing certain restrictions are usually based on economic theory, and depending on the theory, different long run restrictions have been proposed.

Faust and Leeper (1997) pointed out situations for which long run restrictions that are imposed to identify impulse responses can give unreliable results. In particular, they question the reliability of the estimates of the a_{ijk} parameters. However, they suggested several possible solutions to assure more reliability, including the imposition of zero effects of shock after a specified time period.

In this paper, we will not follow the approach of imposing binding long run restrictions in order to achieve identification of the shocks. We will use instead restrictions on the contemporaneous effects of shocks, within a VECM model. The cointegrating relationships in our model impose certain behaviour on the short run dynamics within the VECM framework and our interest lies with the effects of shocks in the short run. In other words, we do not use infinite horizon restrictions on a_{ijk} to identify shocks.

In VARs or VECMs, the impulse response coefficients are non-linear functions of the underlying parameters of the models. In addition the asymptotic theory for impulse response functions is different from that for VARs or VECMs. Analytic results for confidence intervals are available for stationary VARs (percentile-t intervals). However, size distortions can be large in finite samples. Kilian (1999) analysed the issue for stationary models. For cointegrated systems, Lütkepohl and Reimers (1992) derived asymptotic distributions for impulse responses in the case of only contemporaneous restrictions. Vlaar (1998) extended these results to long run restrictions. The performance of asymptotic confidence intervals of VECMs has not yet been studied for finite samples.

Phillips (1998) criticised using levels VARs in the presence of some unit roots or some near unit roots in order to derive impulse responses. Many macroeconomic variables are well described by unit root processes so this criticism should be taken

[5] See for example Cushman and Zha (1997).

[6] An often-cited example here is the paper by Blanchard and Quah (1989).

[7] See for example Garratt et al (2001) who discuss details of the requirements to achieve identification of shocks by means of long run cointegrating restrictions.

seriously. Phillips showed that long run impulse response estimates are inconsistent in unrestricted (nonstationary) levels VARs. On the other hand, reduced rank regressions in VECMs produce consistent impulse responses.[8] Phillips demonstrated for finite samples with the Monte Carlo method that the error-correction-based impulse responses are highly accurate, whereas levels VARs can produce very poorly estimated paths.

In this paper, we first analyse the time series properties of each variable involved in order to determine the order of integration. Next, we set up a VECM to account for unit roots and cointegration. We use Johansen's (1995) maximum likelihood-based method as a first step in estimating the number of cointegrating vectors, which is asymptotically equivalent to reduced rank regression. Then, we compute impulse response functions from the VECM residuals, applying a standard Choleski decomposition.

2.2 Data

We use quarterly data from March 1987 to December 2001. Both the availability of data and occurrence of economic reforms in Australia and New Zealand during the 1980s have influenced our choice of sample period. Details on data construction are provided in Appendix A.

We examine a number of macroeconomic variables for each economy. We endeavoured to select comparable time series from each country. This was assessed with regard to what the series measured and with regard to their time series properties. The aim is to ensure the comparability of the models for Australia and New Zealand.

There is serious reason to question the findings of time series studies that do not properly account for unit roots in the data. Failing to account for the presence of unit roots can lead to inconsistent coefficient estimates and result in wrong inferences being drawn. We begin our analysis by examining the order of integration.

We examine our data using the Augmented Dickey-Fuller test and the Phillips-Perron test. The findings of our tests are presented in Appendix A. We cannot reject the null hypothesis of one unit root for each of our series that we use in the VECMs, whereas the null hypothesis of two unit roots is rejected. All of the series included in our VECMs are therefore assumed to be I(1).

3 Examination of the New Zealand and Australian economies when independent monetary policies operate

[8] See also Mills (1998) for a survey on modelling non-stationary VARs.

3.1 Model specification

We estimate separate VECM models for each economy and examine their properties. In determining the specifications of each model, a trade-off is necessary. We must balance the inclusion of all theoretically relevant variables with the development of a parsimonious model given our limited sample size.

All of the models we estimate include real GDP, the Consumer Price Index (CPI), the 90-day interest rate and the Trade Weighted Index (TWI) as endogenous variables. We note a conceptual difficulty with our measure of consumer prices in New Zealand (NZ). From March 1999 onwards, the CPI, as measured by Statistics New Zealand, excludes interest costs and is denoted CPII. Hence, the CPI series may contain a discontinuity. In New Zealand, the CPI is I(1) for the period from March 1987 to December 2001, while the CPI excluding interest rates (CPII) is I(0). In most of the New Zealand models estimated, we have made use of the CPI. We note that the residuals from these models are normally distributed and stationary. While we will focus on the findings for these models, we will briefly discuss our findings using the CPII. For the Australian economy we consider the use of both the CPI and the CPI excluding interest rates, CPII.

We also examine whether holdings of liquid assets are an important channel for the transmission of monetary policy. We accomplish this by examining models that include the M1 money aggregate against ones that do not.

We explicitly account for unit roots and cointegration in our data by setting up a VECM. The cointegration rank is determined from the data. Cointegration imposes a long run "equilibrium" relation on the variables. A VECM imposes on the short run dynamics the long run relations that stem from cointegration. The literature on forecasting has documented that accounting for unit roots and cointegration provides important information that can dramatically improve forecasting performance over specifications that ignore unit roots and cointegration.[9] We would expect the same improvements for impulse response analyses. Furthermore, the Monte Carlo results of Phillips (1998) have shown that levels VAR specifications instead of VECMs can produce poorly estimated impulse response paths in finite samples.

In order to identify the short run effects of monetary policy shocks on the levels of the endogenous variables in the VECM, we use a standard Choleski decomposition. The Choleski decomposition we use to generate impulse responses depends crucially on the ordering of the variables in the system. We adopt the following ordering of endogenous variables in each of our models, which is fairly standard in the recent empirical literature on the Euro-area: Real GDP, the CPI,[10] the 90-day interest rates, the TWI, and the M1 money supply.[11] This ordering reflects our priors regarding the operation of monetary policy transmission mechanisms. It assumes that interest rates are responsive to contemporaneous changes in real GDP or the CPI, but not vice versa.

[9] See Christoffersen and Diebold (1998) on theoretical issues, and Anderson, Hoffman and Rasche (1998) for an example of the performance of VECMs for forecasting the US economy.

[10] The CPI excluding interest rates replaces the CPI in certain models.

[11] The M1 money supply variable is only included in certain models.

It also allows contemporaneous changes in the interest rate to influence the TWI and holdings of liquid assets.[12] Clements at al (2001) suggest that such an ordering allows for the interest rate equation in a VAR to be interpreted as a monetary policy reaction function. The interest rate does not react contemporaneously to TWI changes. This assumes that the central bank does not adjust interest rates in response to short run fluctuations in exchange rates but rather in response to long run "trends" as captured by the effect of lags of the TWI that do enter our policy reaction function.

Several potential combinations of lag lengths and exogenous variables were considered for each country. We utilised the Schwarz Bayesian information criterion (SBIC) when specifying our models and in addition checked that the residuals from our VECMs were white noise applying a Lagrange multiplier test for serial correlation. We also consider whether each specification generates sensible impulse responses.

The potential exogenous variables we examined are the US 90-day interest rate, real US GDP and two commodity price indices.[13] The commodity price indices that we considered were the CRB commodity price index and the Economist Price index. The inclusion of such indices aims to avoid the occurrence of "price puzzles" following monetary policy shocks. However, the price puzzle still exist in some of the models. Again all variables, except for interest rates, are measured in log-levels. All of the exogenous variables are transformed using first differences so that they enter the VECM in stationary form.

Holdings of liquid assets may play a much larger role in the transmission of monetary policy in New Zealand than in Australia. When liquid assets are excluded from the model of the New Zealand economy or included as an exogenous variable, the resulting impulse responses are not sensible.[14] In the Australian model, the inclusion of liquid assets as an endogenous variable generates impulse responses that are not sensible. Including liquid assets as an exogenous variable has little effect on this model. Given these findings, we include the M1 money aggregate only in the model of the New Zealand economy. It is included as an endogenous variable. We note that this introduces differences between the models for New Zealand and Australia that we estimate. This complicates any comparison of the two countries.

Models of the Australian economy estimated using either the CPI or the CPI excluding interest rates have similar SBIC criteria. However, those models that include the CPI generate problematic impulse responses, which is another expression of the fragility of applying this type of analysis to Australian and New Zealand data. We opt to use the CPI excluding interest rates in our models of the Australian economy. This creates same difficulties when comparing the models of the two

[12] We note that in New Zealand the implementation of monetary policy has changed from a previous approach where the Reserve Bank of NZ controlled the money supply to the current approach where the RBNZ influences the economy by setting the interest rate on its liabilities and relying on arbitrage to transmit this to the economy. The former approach would suggest an ordering of endogenous variables where the money supply proceeds the interest rate. We examined this ordering and found that our results were robust to such a change.

[13] The exogenous variables enter our VECMs with loading factors restricted to zero, as in Wickens and Motto (2001).

[14] When the M1 money aggregate is included as an exogenous variable, it is differenced to ensure that it is stationary.

economies, as the CPI measures used in each model are conceptually different. This complicates the examination of how each economy responds to monetary policy shocks and how such shocks are transmitted to the price level.

The inclusion of exogenous variables in our model aims to account for wider trends in the world economy that may influence the observed movement in our endogenous variables. Our examination indicates that both economies respond to the contemporaneous US 90-day interest rate. Trends in US GDP also affect both economies, however they tend to be more persistent in Australia.[15] Hence in addition to the US 90-day rate, the model of the Australian economy includes the lag of US real GDP.[16] The New Zealand model includes the US 90-day interest rate and the contemporaneous value of US real GDP.

Our findings do not support the inclusion of commodity price indices as exogenous variables in the model of either economy. When commodity price indices are included in our models, the price puzzle is still persistent. Each of our VECMs contains 4 lags of each endogenous variable. This is a specification based on SBIC. The variables included in each of our VECMs are listed in table 3.1.

Table 3.1
VECM descriptions

[15] When only the contemporaneous values of US real GDP are included, the residuals from the model of the Australian economy are serially correlated. No significant autocorrelation is present when either the lag of US real GDP or both the contemporaneous and first lag of US real GDP are included in the Australian model.

[16] In specifying the model of the Australian economy, we compared a model that included both the contemporaneous and the first lag of US real GDP as exogenous variables to one that only included lagged US real GDP. (The models were the same in terms of the other variables they included.) The impulse responses generated by the two models are almost identical. However, when both contemporaneous and lagged US real GDP are included, the results of our cointegration tests were borderline cases at the 5% level. In order to ensure that we develop a parsimonious model that is also comparable to the model of the New Zealand economy, we opt to include only the lagged value of US GDP in our model of the Australian economy.

	New Zealand Variable	New Zealand Abbreviation	Australia Variable	Australia Abbreviation
Endogenous variables (Four lags of each endogenous variable are included in each model)	Real GDP	NZ_LGDP	Real GDP	AU_LGDP
	CPI	NZ_LCPI	CPII	AU_LCPII
	90-day interest rates	NZ_INT	90-day interest rates	AU_INT
	TWI	NZ_LTWI	TWI	AU_LTWI
	M1 Money Aggregate	NZ_LM1SA		
Exogenous variables (All in first difference form)	US real GDP	D(US_LGDP)	US real GDP (First lag)	D(US_LGDP(-1))
	US 90-day interest rate	D(US_INT)	US 90-day interest rate	D(US_INT)

We proceed to test for no co-integration among our series. This is accomplished using Johansen's maximum likelihood-based method. We examine both trace and maximum eigenvalue statistics. As we include exogenous variables in our specifications, we use the modified critical values calculated according to a programme described in MacKinnon, Haug and Michelis (1999). We allow for the presence of an intercept but not for deterministic trends in the co-integrating equations. We reject the presence of no cointegrating (CE) vectors among our variables.[17, 18] We fail to reject the hypothesis of at most one cointegrating vector in each model for New Zealand and Australia. The results of our cointegration tests are presented in tables 3.2 and 3.3.

Table 3.2
Co-integration tests for the Australian economy model

Trace statistic findings

Hypothesized No. of CE(s)	Trace Statistic	5 Percent Critical Value	Accept/ Reject H0
None	67.2518	68.97	Accept
At most 1	30.5768	46.99	Accept
At most 2	12.7538	28.88	Accept
At most 3	1.2074	14.39	Accept

Maximum eigenvalue statistic findings

Hypothesized No. of CE(s)	Max-Eigen Statistic	5 Percent Critical Value	Accept/ Reject H0
None	36.6750	34.49	Reject
At most 1	17.8230	28.11	Accept

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c … er, at this significance level the result is a
b … rejected at the 10 per cent level.

Table 3.3
Co-integration tests for the New Zealand economy model

Trace statistic findings

Hypothesised No. of CE(s)	Trace Statistic	5 Percent Critical Value	Accept/ Reject H0
None	104.8216	94.89	Reject
At most 1	65.1224	68.97	Accept
At most 2	34.4770	46.99	Accept
At most 3	13.3721	28.88	Accept
At most 4	0.8795	14.39	Accept

Maximum eigenvalue statistic findings

Hypothesized No. of CE(s)	Max-Eigen Statistic	5 Percent Critical Value	Accept/ Reject H0
None	39.6993	40.75	Accept*
At most 1	30.6454	34.49	Accept
At most 2	21.1049	28.11	Accept
At most 3	12.4925	21.52	Accept
At most 4	0.8795	14.39	Accept

Notes: The Maximum eigenvalue statistic rejects the presence of no co-integrating vectors at the 10% significance level.

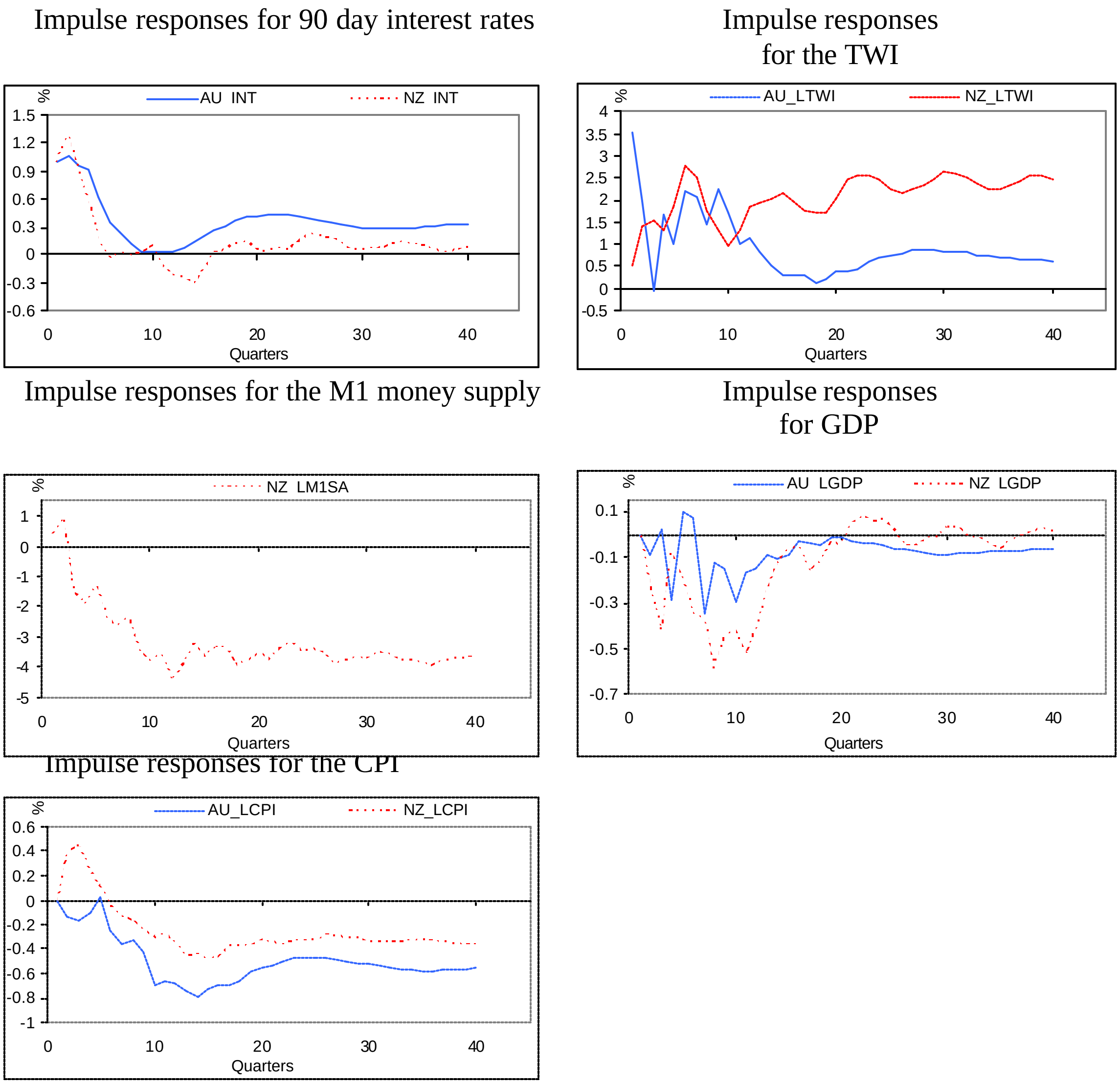
Given these findings, we estimate VECMs with one co-integrating vector for each economy. This forces the long run relationship between variables onto the short run dynamics of the VECM. This also permits for effects of past disequilibria in the dynamic behaviour of our variables.

We estimate our models of each economy without imposing any restrictions on the cointegrating vector. Cointegration ties the variables together in the long run and they cannot move apart too far over time. The findings from our regressions are presented in Appendix B, tables B1 for Australia and in table B2 for New Zealand. Lagrange multiplier tests indicate that both our models are free from significant autocorrelation.

3.2 Impulse responses for monetary policy shocks

We examine the similarity of monetary policy transmission mechanisms in each economy when they operate independent monetary policies and face flexible exchange rates. We examine the effect of an exogenously imposed monetary policy shock reflecting a 100 basis point shock to the 90-day interest rate in each economy. This is accomplished using impulse response functions with a standard Choleski decomposition and the variable ordering discussed in section 3.1. A 40-quarter horizon is considered. Figure 3.1 presents the impulse responses for both economies. The impulse responses for New Zealand are slightly more volatile than those for Australia, though it should be remembered that there are slight differences to the model specifications and thus comparisons should not necessarily be accepted at face value.

Figure 3.1
Impulse responses for the Australian and New Zealand economies



With the caveats mentioned above, we observe some similarities in the response of each country to a monetary policy shock. The effect of the monetary policy shock to interest rates persists in both economies for approximately 10 quarters. Interest rates follow a similar path in both countries.

Consistent with our priors, the TWI in both countries responds immediately to the monetary policy shock. In Australia, the TWI increases sharply. It then briefly (and somewhat unexpectedly) declines before increasing again and eventually settling after approximately 30 quarters. In New Zealand, the TWI increases following the monetary policy shock, however, in contrast to the Australian model, the effect seems to be persistent. This is unexpected as we would not expect a temporary increase in the interest rate to have a persistent effect on the TWI. The Australian TWI settles slightly more quickly than its New Zealand counterpart. This unexpected finding in the New Zealand model may reflect the differing nature of the variables included in this model relative to those included in the Australian model.

M1 holdings in New Zealand decline sharply after 3 quarters and settle at a new level after approximately 20 quarters. The new level of M1 holdings is approximately 3.5 per cent lower.

GDP growth in both nations responds quite rapidly, only one quarter after the monetary policy shock occurs. The speed of this response is faster than we would have expected. In both economies the negative effect of the shock peaks after approximately 8 quarters. GDP growth slows by slightly more in New Zealand than in Australia. In Australia, GDP growth slows by approximately 0.3 per cent while in New Zealand real GDP growth slows by approximately 0.6 per cent. The effect of the shock dissipates in both economies within approximately 20 quarters. However, the size of the GDP response to the same size monetary policy shock appears to be larger in New Zealand.

When we examine the effects of a monetary policy shock on the CPI in New Zealand we encounter a price puzzle, which is a common finding in the literature and is thought to reflect endogenous nature of monetary policy.[19] Monetary policy in New Zealand responds to expected inflation. The observed price puzzle may reflect that monetary policy settings are tightened in response observed increases in inflationary pressures, which eventuate in higher inflation some quarters later. It should also be noted that the price index used in our New Zealand model includes the effects of interest rates for most of our sample period. Our price puzzle findings may therefore partly reflect the influence of interest rates on the price index when monetary policy is tightened. The CPI in New Zealand nevertheless begins to decline after 5 quarters, which is a plausible policy lag. The Australian CPI excluding interest declines immediately following the monetary policy shock. Australia's CPII settles at a level that is 0.6 per cent lower. The New Zealand CPI settles at a level that is 0.4 per cent lower.

We note that the speed of the adjustment of the variables in both economies is similar except for the TWI. Some differences are observed in the sizes of adjustments. In New Zealand, the observed persistent increase in TWI is unexpected. Potentially this apparent difference between the two economies may stem from the measurement change that occurred in the New Zealand CPI. We explore the nature of the relationship between our variables using an alternative measure of consumer prices that is adjusted for interest rates (CPII). This measure of consumer prices is comparable to that used in the Australian models. We note that the New Zealand measure of the CPII is I(0), hence its inclusion in our VECM is conceptually problematic. Despite this complication we proceed to explore the possible use of this variable.

[19] Christiano et al (1998) note that focusing on the actions of policy makers may not be a suitable method to identify the effects of monetary policy changes, because monetary policy is endogenously determined. An examination of policy changes is likely to reflect not only the effects of the changes, but also of the conditions to which policymakers respond.

When the CPII variable is used in the New Zealand model[20] the resulting impulse responses are highly problematic, frequently moving in unexpected directions and displaying a high level of volatility. The use of the CPII variable therefore does not appear to be appropriate in our analysis. In the remainder of this paper we shall proceed with the CPI variable in the New Zealand models. However, we are aware of the less than ideal nature of this variable.

3.3 Models incorporating long run restrictions

We note the presence of anomalies in our models. Besides the persistent TWI effect that is observed in the New Zealand model following a monetary policy shock, several of the coefficients in both models have unexpected signs, particularly the coefficients on interest rates and GDP. Further, in some cases we observe economic variables responding to monetary policy shocks much faster than might be expected. The models presented above assumed that the variables were tied together in the long run, but did not use a priori information from economic theory when defining the nature of this relationship.

For New Zealand, we explore the results when restrictions are imposed on the cointegrating vectors so that they can be given the interpretation of a standard money demand function. Imposing such restrictions requires removal of the TWI from the cointegrating vector but still leaving it in the VECM otherwise. We also consider the possibility of imposing further restrictions on the cointegrating vector as implied by a standard money demand model that relates real money balances to real GDP and nominal interest rates. These restrictions lead to very similar impulse responses as the model without such restrictions. We observe that the persistent increase in the TWI is still present when a monetary policy shock occurs. Also, the signs on the coefficients are similar to those from the unrestricted model. Further, the coefficient estimates for money demand that we obtained for the restricted cointegrating vectors did not all have the correct sign. We therefore do not report results for these cases. The unrestricted coefficient estimates for the cointegrating vector above can still be given an interpretation within a money demand framework that considers currency substitution. However, our primary aim is to develop a model for impulse responses and not for money demand.

For Australia, the determination of appropriate restrictions is more problematic. As noted above, the Australian model does not include money as an endogenous variable. The models with money included tended not to perform well, even when long run restrictions were imposed. Consequently we do not develop a restricted Australian model.

3.4 Implications for currency union

Differences in transmission mechanisms may be costly to smaller economies within a currency union whose macroeconomic conditions are likely to have less influence on

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[20] We note that the inclusion of an I(0) in our model is conceptually inappropriate. However, some uncertainty exists regarding the order of integration of CPII in New Zealand. Our use of this variable is done as robustness check on our findings.

the setting of common monetary policy.[21] Our examination of transmission mechanisms suggests that New Zealand and Australia display both differences and similarities in their respective transmission mechanisms. Importantly, GDP and the CPI in the two economies respond to identical monetary policy shocks with a similar speed and movement, albeit with different size of the effects.

One notable difference is the TWI adjustment, which shows larger swings in New Zealand than in Australia, indicating that this channel plays a larger role in the transmission of monetary policy in New Zealand. This finding is consistent with the suggestions of McCaw and McDermott (2000). However, entry into a currency union involves the loss of an independent exchange rate for both economies. This is likely to be more costly for New Zealand. By virtue of its larger size, economic conditions in the Australian economy are likely to have more bearing on the exchange rate under a common currency. This would reduce the responsiveness of what is an important adjustment mechanism for New Zealand, placing greater strain on other channels when monetary policy changes occur.

4 Conclusion

Monetary policy transmission mechanisms play a significant role in the operation of economies. Differences in transmission mechanisms can generate asymmetric behaviour between currency union partners, even when they experience the same monetary policy shock. This has the potential to widen existing cyclical variation between currency union partners. Small economies, such as New Zealand, are likely to have limited influence on monetary policy under any joint currency arrangement. Hence, they may face a monetary policy that is determined by union wide economic conditions, but which is not suited to their own conditions. For such economies, the similarity of transmission mechanisms in the economies of prospective currency union partners is an important concern.

Our analysis from individual country models provides qualified evidence that the monetary policy transmission mechanisms of New Zealand and Australia are similar in many respects, especially in terms of the speed and the nature of the adjustment that occurs to the CPI and GDP in response to monetary policy shocks. However, the sizes of GDP and exchange rate responses seem different between the two countries. Whether these results would persist under a currency union is an open question. Therefore, further research, particularly into the nature of business cycle harmonisation under a union, is still necessary as was argued by Frankel and Rose (1998).

The results we obtained in this paper are only tentative, and sensitive to the definition of the variables and the sample period examined. Further, while our results seem fairly intuitive, some anomalies are evident. In particular, when we examined the operation of monetary policy in NZ we encountered difficulties modelling the speed with which economic variables respond to monetary policy and more general

[21] See Clements et al 2001.

difficulties modelling movements in exchange rates. We suspect that these weaknesses reflect data limitations. New Zealand data is especially problematic due to the numerous structural changes that have occurred since the early 1980s and changes in the measurement of CPI. As a result, we had to use a shorter sample period than we would have preferred. This reduces the robustness of our conclusions. Nevertheless, the results may provide insights into transmission mechanisms at work by applying new techniques to what data is available.

Examining the transmission mechanisms under a hypothetical currency-union model can be one of the directions for future research.

Appendix A

Description and properties of Australian and New Zealand data

The variables we examined are:

au_int, nz_int:	Our chosen measure of interest rates in both Australia (au) and New Zealand (nz) is the 90-day interest rate on bank accepted bills.
au_lgdp, nz_ldgp:	The natural log of real GDP in Australia and New Zealand.
au_lcpi, nz_lcpi:	The natural log of the Consumer Price Index.
au_lcpii, nz_lcpii:	The natural log of the Consumer Price Index excluding interest rate effects.
au_ltwi, nz_ltwi:	The natural log of the Trade Weighted Index.
au_lcre, nz_lcre:	For Australia this series reflects loans and advances by financial intermediaries plus total bank bills outstanding.[22] In New Zealand private sector credit is the sum of the Reserve Bank and M3 institutions' New Zealand dollar claims on the private sector, excluding inter-institutional claims.
au_lm1sa, nz_ lm1sa:	The natural log of the M1 money aggregate, using seasonally adjusted data. M1 includes notes and coins held by the public plus chequeable deposits, minus inter-institutional chequeable deposits, and minus central government deposits.

The real GDP and the CPI series are available quarterly. However the other series we use are in monthly form. We transform these series using three month averages to obtain quarterly series.

The results of our unit root tests are given in tables A.1 and A.2 below. We used the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. To determine the number of lagged differences to include in the ADF test regression, we use Akaike's information criterion (AIC). The PP test for unit roots corrects for possible autocorrelation by means of a Bartlett kernel instead of lag augmentations. The bandwidth is selected automatically as proposed by Newey and West (1994). The ADF test has relatively better size properties than other unit root tests, whereas the PP test dominates in terms of test power. Our results indicate that all our series, except for the credit variable in Australia, are well described by an integrated process of order one over our sample period. This holds across both tests.

[22] Reserve Bank of Australia Bulletin (March 2001) p S89.

Our findings for the credit series for Australia are not conclusive. We initially examined this series using a three-month average of seasonally adjusted data. The ADF test indicates that this series is stationary however the PP test indicates that it is integrated of an order greater than one. The alternative definitions of the credit series that we considered were non-seasonally adjusted three-month averages and monthly estimates of credit using both seasonally adjusted and non-seasonally adjusted data.[23] The use of these alternative definitions does not affect the findings regarding the order of integration of this series.

Holdings of liquid assets are highly correlated with the use of private sector credit. We explore the use of a proxy for private sector credit holdings. We measure holdings of liquid assets with the M1 money aggregate. This aggregate includes holdings of notes and coins by the public and funds held in transaction accounts. These series are I(1) in both New Zealand and Australia. Given these findings, we use holdings of liquid assets as a proxy for private sector credit.

Table A.1
Unit root tests for Australia for the period 1987Q1 to 2001Q3

		Null of one unit root		Null of two unit roots		
Variable	Case	AIC	PP	AIC	PP	Order of integration
Interest	2	Accept	Accept	Reject	Reject	I(1)
GDP	3	Accept	Accept	Reject	Reject	I(1)
CPI	3	Accept	Accept	Reject	Reject	I(1)
CPI (excluding interest rates)	3	Accept	Accept	Reject	Reject	I(1)
Exchange rate	2	Accept	Accept	Reject	Reject	I(1)
Credit	3	Reject	Accept	-	Accept	Indeterminate
M1 (SA)	3	Accept	Accept	Reject	Reject	I(1)

Note: A 5% rejection level is used. Case 2 includes a constant only in the test regression and case 3 includes a constant and a deterministic time trend in the test regression.

Table A.2

[23] For January, April, July and October.

Unit root tests for New Zealand for the period 1987Q1 to 2001Q3

		Null of one unit root		Null of two unit roots		
Variable	Case	AIC	PP	AIC	PP	Order of integration
Interest	2	Accept	Accept	Reject	Reject	I(1)
GDP	3	Accept	Accept	Reject	Reject	I(1)
CPI	3	Accept	Accept	Reject	Reject	I(1)
CPI (excluding interest rates)	3	Reject	Reject	-	-	I(0)
Exchange rate	2	Accept	Accept	Reject	Reject	I(1)
Credit	3	Accept	Accept	Reject	Reject	I(1)
M1 (SA)	3	Accept	Accept	Accept *	Reject	I(1)

Note: A 5% rejection level is used. For the definitions of case 2 and 3 see the above notes.
* The AIC statistic for M1 rejects the null at the 10% level

Appendix B

Estimation results

Table B.1
VECM for Australia

Sample(adjusted): 1988:2 2001:3

Included observations: 54 after adjusting endpoints

Cointegrating Eq:	Coefficients
AU_LGDP(-1)	1.000000
AU_LCPII(-1)	-1.862198
AU_INT(-1)	-0.024555
AU_LTWI(-1)	-0.207917
C	-1.885612

Error Correction	Coefficients			
	D(AU_LGDP)	D(AU_LCPI)	D(AU_INT)	D(AU_LTWI)
CointEq1	0.042751 ***	0.059345 *	8.235224 *	0.026851
D(AU_LGDP(-1))	-0.086400	-0.240921	9.667965	2.236722 *
D(AU_LGDP(-2))	-0.125971	-0.197738	7.910499	-1.087416
D(AU_LGDP(-3))	-0.160708	0.168053	0.957419	0.892649
D(AU_LGDP(-4))	-0.121394	-0.128078	4.515757	0.452772
D(AU_LCPII(-1))	-0.148640	-0.145081	6.390525	0.470025
D(AU_LCPII(-2))	-0.123771	0.087514	6.675449	0.537584
D(AU_LCPII(-3))	-0.341338 ***	0.014698	10.428160	0.874872
D(AU_LCPII(-4))	0.336298 ***	0.392935 ***	-10.494150	1.340763
D(AU_INT(-1))	0.002954	-0.000277	0.277680 ***	-0.018191 ***
D(AU_INT(-2))	-0.001229	0.002208	0.001870	-0.010588
D(AU_INT(-3))	-0.001511	0.000893	0.108587	0.018370 ***
D(AU_INT(-4))	0.004719 *	0.002555	-0.008435	-0.008621
D(AU_LTWI(-1))	-0.071084 **	0.023948	1.579720	0.104856
D(AU_LTWI(-2))	0.056065 **	-0.023218	4.076765 ***	-0.099816
D(AU_LTWI(-3))	-0.030636	0.028428	4.328503 ***	-0.111252
D(AU_LTWI(-4))	0.044216 ***	-0.004600	2.809653	0.106123
C	0.012396 *	0.013383 *	-0.373073	-0.053648 *
D(US_LGDP(-1))	0.436345 *	-0.461598 *	1.854403	0.234148
D(US_INT)	0.002565	-0.002097	-0.232023	0.032634 *

Notes: Asterisks indicate the significant with which the null hypothesis: $\beta = 0$ can be rejected

* = Significant at the 1% level

** = Significant at the 5% level

*** = Significant at the 10% level

Table 3.2
VECM for New Zealand

Sample(adjusted): 1989:3 2001:3
Included observations: 49 after adjusting endpoints

Cointegrating Eq:	CointEq1
NZ_LGDP(-1)	1.000000
NZ_LCPI(-1)	-2.758174
NZ_INT(-1)	-0.042170
NZ_LTWI(-1)	0.175028
NZ_LM1SA(-1)	0.259281
C	6.124068

Error Correction:	**Coefficients**				
	D(NZ_LGDP)	D(NZ_LCPI)	D(NZ_INT)	D(NZ_LTWI)	D(NZ_LM1SA)
CointEq1	0.130799 ***	0.010682	7.032436 ***	-0.081421	0.135427
D(NZ_LGDP(-1))	-0.496811 ***	-0.015535	-16.145470	0.752701	0.714945
D(NZ_LGDP(-2))	-0.293871 *	0.011447	-35.908750 ***	1.372401 **	0.471191
D(NZ_LGDP(-3))	-0.515906 ***	0.113696	15.138280	0.457971	-0.829618
D(NZ_LGDP(-4))	-0.575501 ***	-0.074878	-10.045340	0.090545	-0.173939
D(NZ_LCPI(-1))	-0.321318	0.049803	45.547550 *	0.594185	-1.041717
D(NZ_LCPI(-2))	0.407790	-0.020618	-1.242486	0.803699	1.606125 *
D(NZ_LCPI(-3))	-0.309486	0.337397 ***	2.654500	0.597473	1.574420
D(NZ_LCPI(-4))	-0.144064	0.288135 **	18.153200	0.408844	0.772086
D(NZ_INT(-1))	0.002708	0.004308 ***	0.551795 ***	0.004115	0.010446
D(NZ_INT(-2))	0.004507 **	-0.000026	-0.334530 *	-0.005667	-0.012066
D(NZ_INT(-3))	0.003543 *	0.000319	0.267394	0.004642	0.004784
D(NZ_INT(-4))	0.002972	-0.001451 *	-0.146510	-0.001351	-0.004673
D(NZ_LTWI(-1))	0.114212 **	0.006074	1.498525	0.194855	-0.105770
D(NZ_LTWI(-2))	0.160706 ***	-0.027285	2.994259	-0.236830	0.187777
D(NZ_LTWI(-3))	0.108221 *	0.014286	1.333940	-0.055324	-0.060616
D(NZ_LTWI(-4))	0.004749	-0.025263	10.920140 *	-0.198387	-0.285575
D(NZ_LM1SA(-1))	-0.105493 *	-0.007376	4.134050	0.095420	-0.045694
D(NZ_LM1SA(-2))	-0.055194	-0.051054 *	-2.658225	-0.242416	-0.078413
D(NZ_LM1SA(-3))	-0.109389 *	0.025896	-3.884690	-0.291816	0.283734
D(NZ_LM1SA(-4))	-0.034495	0.000756	-1.334937	-0.091376	-0.142403
C	0.034475 ***	0.002368	0.026057	-0.028501	-0.021965
D(US_LGDP)	-0.660210 *	-0.051499	-6.747519	0.354854	2.529867 **
D(US_INT)	0.009782 ***	0.001515	0.308320	0.005509	0.004003

Notes: Asterisks indicate the significant with which the null hypothesis: $\beta = 0$ can be rejected

* = Significant at the 5% level
** = Significant at the 1% level
*** = Significant at the 10% level

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