MACROECONOMICS SHOCK ADJUSTMENT TO SMALL OPEN ECONOMIES: A STRUCTURAL VAR MODEL OF THE NEW ZEALAND ECONOMY
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Macroeconomic Shock Adjustment to Small Open Economies: A Structural Var Model of the New Zealand Economy

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ABSTRACT

This research builds a vector Autoregression model of the New Zealand economy and then analyses its dynamic responses to a number of shocks originating from both internal and external sources. In particular, impulse responses from a foreign output shock, terms of trade shock, shocks to domestic interest rates, and the nominal exchange rate are examined, together with the timing of their effects. Although New Zealand has coped well during the recent global financial turmoil, vulnerability to external shocks will remain because of its reliance on commodity exports and high overseas debt.

Keywords: New Zealand, Financial liberalisation, VAR model

JEL: E37, E47, F36

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+ Contribution to this research by Michael Manning was made while he was a postgraduate student at Massey University
1. INTRODUCTION

Small open economies are subjected to various foreign disturbances in addition to the domestic supply and demand shocks also faced by the closed or large open economies. Within New Zealand’s small open economy, the export sector has historically dominated in contributions to New Zealand’s GDP and continues to do so. New Zealand’s dependence on foreign trade—especially its export earnings from primary agricultural products—has created a situation where the economy is particularly vulnerable to changing international economic conditions and external shocks. Open financial markets, a freely floating currency, and capital account convertibility exacerbated such vulnerability.

The aim of this study is to analyse the effects of external and internal economic shocks on the New Zealand economy, including: a foreign output shock, a foreign interest rate shock, export and import price shocks, and domestic interest rate shocks.

A Decade of Reforms

Long regarded as the most extensive welfare state among the world’s industrialized nations, New Zealand embarked on a strategy of radical economic reform/liberalization following a severe foreign exchange crisis in 1984. Private and public sector foreign debt combined rose from 11 percent of GDP to 95 percent between 1974 and 1984, while the current account deficit climbed to 8.7 percent of GDP in 1984 (Evans, et al., 1996). The government of the day was experiencing increasing difficulty with respect to financing ballooning “twin deficits” within international capital markets. New Zealand lost its long-standing triple-A credit rating on sovereign external debt in April 1983; several downgrades followed. Inflation was spiralling out of control, with double digit figures recorded in every year during the entire 1973-1983 decade. Maintaining the status quo in economic affairs became an impossible proposition.

The reform strategy started under the Labour government (1984-1990). The National government (1991-1996) continued the economic reforms. By 1994 New Zealand had completed the most radical economic reform in the industrialized world. As a result of drastic “shock therapy”, within a decade New Zealand’s economy was transformed from one of the most interventionist OECD economies to one of the most open, market-based economies (Bollard et al., 1996).

Liberalisation of Capital Flows

Interest rate controls and foreign exchange controls were among the first to be removed (March 1985). The New Zealand dollar was floated, with no subsequent central bank intervention at all for next twenty years. Continued liberalization of capital flows led to the creation of deep and liquid capital markets and has radically changed the economic environment within which the New Zealand economy operates. While the benefits to this regime when compared to the restraints which were placed on international transactions under the fixed exchange rate regime are substantial, the downside to this has been increased risk from exposure to internationalization and globalization. New Zealand’s openness index (ratio of imports plus exports to GDP) reported by the OECD (1994) increased by 42 percent
between 1983 and 1993, and has been rising steadily since then. One area which has been neglected within the exchange rate literature is the appropriateness of alternative currency regimes for relatively small, open, developed economies that are outside of the European experiment, such as New Zealand, Australia, Iceland and Norway (Bjorksten and Brook, 2002). Although floating rates were believed to equilibrate the balance of payments, the last two decades have shown that large flows of international capital tend to significantly outweigh the flow of goods and services, creating the paradox known as ‘carry trade’ that has added to the variability of the New Zealand dollar.

The organisation of this paper is as follows. The next section outlines the analytical framework and the data. Vector Autoregression (VAR) methodology and related econometric literature and procedures employed in this research are presented in section 3. Section 4 contains the main empirical results from the model and the final section draws conclusions from the research.

2. ANALYTICAL FRAMEWORK AND DATA

This research applies a Vector Autoregression (VAR) model to analyse the dynamic response of the New Zealand economy to a number of impulse responses including a foreign output shock, terms of trade shocks, domestic financial shocks, shocks to domestic interest rates, and the nominal exchange rate. The data and econometric methodology used to estimate the VAR model of the New Zealand economy is presented here. The analysis conducted in this research utilizes time series data from 1985 – 2008.

Vector Autoregressive Models

Since its introduction by Sims (1980) VAR models have been used extensively for modelling monetary policy mechanisms within closed economies (Sims 1986, Gali (1992), Gordon and Leeper (1994), Christiano, Eichenbaum, and Evans (1996), Sims and Zha (1998), and Brischetto and Voss (1999)), as well as open economies (Sims (1992), Eichenbaum and Evans (1995), Cushman and Zha (1997), and Kim and Roubini (2000)). VAR models were then extended to identify international and domestic shocks and the dynamic responses to these shocks in both small and large economies in subsequent research by Dungey and Pagan (2000), Buckel et al. (2002), and Szeto (2002). Research conducted in this paper draws elements from some of these literatures that are described under “econometric methodology” later in this section.

Data and Proxies

To model New Zealand’s domestic economy, we include measures of aggregate domestic demand, exports, domestic aggregate output, domestic consumer prices, the nominal exchange rate and domestic asset returns. To adequately represent the foreign block within any VAR model of an open economy, we follow Buckel et al. (2002) argument by including a set of foreign variables which measure foreign real output, foreign nominal interest rates, and foreign real asset returns. The basic model in this research includes 10 variables. These variables or their proxies are listed as per below. Each of these variables is explained by a
structural equation which has an associated error term that represents a particular innovation or shock.

The dataset used within this study consist of quarterly observations for domestic aggregate output (LYNZ), domestic aggregate demand (LDNZ), domestic interest rate (DIRATE), domestic inflation (LCPI), a measure of domestic equity returns (LNZX40) and the New Zealand - U.S. bilateral exchange rate (LXRATE). U.S. output was used as a proxy for world output (LFGDP). The foreign price of New Zealand exports was calculated by multiplying Statistics New Zealand’s domestic currency export price index by the trade weighted exchange rate and expressed in logs (LEXP). The foreign currency price of New Zealand’s imports was calculated by multiplying Statistics New Zealand’s domestic currency import price index by the trade weighted exchange rate and expressed in logs (LIP). Foreign interest rates are represented by a weighted average of the US, UK and AUS interest rates, where the weightings used are their respective GDP’s (WIRATES).

Appropriate specification and estimation of the system of 10 equations would capture the systematic effect of export prices and other relevant variables in the model on the behaviour of domestic variables such as real exports, real domestic demand and output in response to ‘export price shocks’.

3. ECONOMETRIC METHODOLOGY

The VAR methodology was originally developed by Sims (1980), and has since been applied extensively to model monetary policy mechanisms within both closed and open economies, and extended to model various economic issues and problems concerning the identification of the dynamic relationships between macroeconomic variables and policy instruments.1 For this research, we follow the methodology and techniques introduced by Cushman and Zha (1997), Dungey and Pagan (2000) and Buckel et al. (2002). The dynamic relationship between macroeconomic variables in our research is represented by the following VAR model:

\[ A_0 Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \]  

Where \( Y_t \) is a (N * 1) vector of endogenous variables at time \( t \), \( A_i \) is a (N * N) matrix of parameters for \( i = 0, 1, 2, \ldots, p \) while \( \varepsilon_t \) is a (N * 1) multivariate white noise error process with the following properties:

\[ E(\varepsilon_t) = 0, \quad (2) \]
\[ E(\varepsilon_t \varepsilon_t') = \Omega t = \tau \quad \text{and} \quad 0 \quad \text{otherwise.} \quad (3) \]

This approach assumes that the structural innovations \( \varepsilon_t \) are orthogonal, the structural disturbances are uncorrelated and the variance-covariance matrix, \( \Omega \) is constant and diagonal. The matrix \( A_0 \) is normalized across the main diagonal so that each equation in the structural autoregressive (SVAR) system has a designated dependent variable.

1 Sims was awarded the 2011 Nobel Prize in Economics for his work in applying VAR models to macroeconomic analysis.
Within the SVAR model, the parameters are estimated in two stages. The first stage is to obtain the following reduced form equations associated with (1):

\[ Y_t = A_0^{-1}A_1Y_{t-1} + A_0^{-1}A_2Y_{t-2} + \ldots + A_0^{-1}A_pY_{t-p} + A_0^{-1}\varepsilon_t \]  
\[ Y_t = B_1Y_{t-1} + B_2Y_{t-2} + \ldots + B_pY_{t-p} + \nu_t \]  

(5) is the reduced form VAR, where \( B_i = A_0^{-1}A_i \), \( i = 1, 2, \ldots, p \) and \( \nu_t = A_0^{-1}\varepsilon_t \). \( \nu_t \) is the innovation associated with the reduced form VAR equation (5), and is assumed to have zero mean and constant variance; \( \nu_t \sim N(0,\Omega) \). Within the VAR model, N equations are then estimated using the reduced form equation by ordinary least squares (OLS) and the residuals \( \nu_t \) are then obtained.

The innovations within structural models which are contained within the white noise process are then linked to the reduced form innovations by the following equations:

\[ E(\nu_t, \nu_t) = A_0^{-1}(\varepsilon_t, \varepsilon_t)A_0^{-1} \]  
\[ \Omega = A_0^{-1}\sum(A_0^{-1}) \]  

The next step is to identify the contemporaneous matrix \( A_0 \) and the associated variance-covariance matrix \( \sum \) which maximises the likelihood function conditional on the parameter estimates of the VAR obtained within the first stage.

**Testing for Unit Roots**

When constructing models with time-series datasets, one must check to make sure the datasets are stationary. A stationary variable has a constant mean and variance, and a covariance that depends only on the time between lagged observations (Wooldridge, 2006). When forecasting is undertaken using time series data, stationary data is also essential in order to obtain non-spurious results.

The method used to test for unit roots in this paper is the Augmented Dickey-Fuller (ADF) test. The general specification for these tests described in Wooldridge (2006) is:

\[ \Delta y_t = \alpha + \delta t + \theta y_{t-1} + \varepsilon_t \]  

Where the null hypothesis is \( H_0: \theta = 0 \) and the alternative is \( H_1: \theta < 0 \), where under the alternative, the series is a trend-stationary process. Hence the purpose of this test is to identify whether the coefficient \( \theta \) is significant. If the test concludes that this variable is not significantly different from zero, then there is evidence of a unit root. The usual t-statistic is used to test the null hypothesis, but the usual critical values are not valid if the data is non-stationary. Econometric packages usually provide the correct critical values to test the null hypothesis. From this test, we conclude that variable is integrated of order zero, I(0) if the null hypothesis can be rejected without differencing the variable. If it becomes necessary to difference the variable once, then the variable is said to be integrated of order one, I(1).
4. **EMPIRICAL RESULTS**

This VAR model of the New Zealand economy containing 10 variables and structural equations as described in the previous sections 2 and 3 was subjected to a number of impulses relating to specific variables.

**Results from Unit Root Tests**

The use of time series data requires that tests are conducted for unit roots. This step is taken in order to determine the order of integration of the variables prior to testing the long-run relationships between them. In this research we employed the augmented Dickey-Fuller (ADF) test to test for the presence of unit roots.

Results from these tests provided in table 1 suggest that DIRATE is stationary in its level form, while LXRATE is stationary at the 10% significance level in its level form. The remainder of the variables, however, had to be first differenced in order to become stationary under the ADF test. These variables which include; WIRATE, LCPI, LDGDP, LXGDP, LNZX40, LFXIMP, LFXEXP, LUSGDP are therefore all I (1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels t-Statistics</th>
<th>P-Values</th>
<th>Differences t-Statistics</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIRATE</td>
<td>-3.579*</td>
<td>0.0081</td>
<td>-11.223*</td>
<td>0.0001</td>
</tr>
<tr>
<td>WIRATE</td>
<td>-2.312</td>
<td>0.1702</td>
<td>-5.360*</td>
<td>1.64E-05</td>
</tr>
<tr>
<td>LCPI</td>
<td>1.455</td>
<td>0.9991</td>
<td>-4.185*</td>
<td>0.0013</td>
</tr>
<tr>
<td>LDGDP</td>
<td>0.0454</td>
<td>0.9594</td>
<td>-2.935*</td>
<td>0.0458</td>
</tr>
<tr>
<td>LXGDP</td>
<td>1.397</td>
<td>0.9989</td>
<td>-3.610*</td>
<td>0.0077</td>
</tr>
<tr>
<td>LNZX40</td>
<td>-2.722</td>
<td>0.075</td>
<td>-9.362*</td>
<td>1.62E-06</td>
</tr>
<tr>
<td>LXRATE</td>
<td>-2.709**</td>
<td>0.0766</td>
<td>-2.353</td>
<td>0.1581</td>
</tr>
<tr>
<td>LFXIMP</td>
<td>-0.549</td>
<td>0.8755</td>
<td>-10.661*</td>
<td>7.77E-06</td>
</tr>
<tr>
<td>LFXEXP</td>
<td>0.2945</td>
<td>0.9769</td>
<td>-7.227*</td>
<td>3.86E-08</td>
</tr>
<tr>
<td>LUSGDP</td>
<td>-0.525</td>
<td>0.8802</td>
<td>-4.651*</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

* Indicates that the Null-Hypothesis of a Unit-Root has been Rejected at the 5% level or better.

** Indicates rejection at the 10% level.

**Legend:** DIRATE is the New Zealand 90-day interest rate, WIRATE is the proxy for world interest rates, LCPI is the log of New Zealand’s CPI, LDGDP is the log of domestic GDP, LXGDP is the log of expenditure on GDP, LNZX40 is the log of the quarterly NZX40, LXRATE is the log of the NZ-US bilateral exchange rate, LFXIMP is the log of the trade-weighted foreign exchange price of New Zealand’s imports, LFXEXP is the log of the trade-weighted price of New Zealand’s exports, and LUSGDP is the log of US GDP as a proxy for world output.
Determining the Lag Length of the VAR model using the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC)

The lag length of the VAR model must be set long enough so that serial correlation in the error terms is eliminated, but not too long as to reduce the power of the test. The following equations are estimated using EViews 6. A range of lag lengths ranging between 0 and 3 were selected and the Schwarz Bayesian Criterion (SBC) and Akaike Information Criterion (AIC) used to test the preferred lag length. The model was estimated using an unrestricted VAR model with the maximum value of the respective information criterion indicating the preferred lag length for the model. The results of this estimation are presented below.

Table 2: Testing for the Order of the VAR

<table>
<thead>
<tr>
<th>Order of VAR</th>
<th>Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIC</td>
</tr>
<tr>
<td>1</td>
<td>-16.68*</td>
</tr>
<tr>
<td>2</td>
<td>-18.21</td>
</tr>
<tr>
<td>3</td>
<td>-21.43</td>
</tr>
</tbody>
</table>

Within this model, the selection of lag length is not clear. In this model, the AIC suggests order one is appropriated while the SBC suggests order three is more suitable. Wooldridge (2006) reasons the AIC to be a more robust measure than the SBC and we selected a VAR model of order one.

Macroeconomic responses to trade and financial shocks

Previous research conducted using structural VAR models have typically aimed to identify the dynamic responses of an economy to particular shocks. This procedure then provides a means of analysing an estimated structural VAR and it reveals information about the dynamic properties of the economy investigated (Buckel et al., 2002). The results can then be used to inform policymakers how economic variables such as real output and prices respond overtime to changes in policy or other events.

The information value of dynamic simulations depends on the validity of the structure of the simulated empirical model. Accordingly, here we only analyse dynamic properties in response to shocks that appear to have been identified. These include shocks to international variables, domestic financial variables and domestic economic variables that were discussed earlier.

Impulse Response Functions

Traditionally, analysing estimated structural VAR models has been conducted through the impulse response functions (Hamilton, 1994). These impulse response functions represent
the dynamic response of a variable in the model to an error term, (which is referred to as a shock or innovation) in the structural equations. The transmission of the shocks will depend on the form of the structural equations. These dynamic responses together with two standard error (SE) bars are reported below.

**Foreign Output Shock**

**Figure 1: Responses to foreign output shock**

The first shock examined is the impact of a positive innovation to US GDP. Figure 1 illustrates the immediate response of a foreign output shock, with the peak response of both import and export prices occurring four periods after the positive innovation. The exchange rate depreciates in direct response to the foreign output shock, with the peak response being recorded in the fourth quarter; however, it eventually appreciates back to the original level. The impact on domestic GDP is that there is an increase in domestic output, which also reaches a high in the fourth quarter, then slowly dissipates away.
The domestic responses to a rise in the world interest rates are illustrated in Figure 2. This shock is transmitted in the first period into lower domestic interest rates; however the shock does induce the domestic interest rate to increase in the following six quarters. These higher domestic interest rates would imply higher demand for domestic bonds, and therefore lower demand for domestic equities, reducing the return on domestic equities. Domestic demand falls shortly after the shock, and then increases after about five periods.
Terms of Trade Shocks

Export Price Shock

Figure 3: Response to export price shock

The responses of an export price shock are shown in Figure 3. The immediate impact of this shock causes the exchange rate (NZ dollar) to appreciate. GDP increases in the following the shock, although it decreases in the second quarter. The domestic interest rate increases sharply following this shock.
The response to an increase in import prices is shown in Figure 4. Although domestic output falls one quarter after the shock, the maximum response doesn’t occur until the third quarter. This decline in output may reflect the higher cost of importing immediate inputs into production. The exchange rate depreciates sharply following this innovation, which is to be expected. Domestic prices increase following the innovation, however declines over the long run.
Domestic interest rate shock

**Figure 5: Response to domestic interest rate shock**

The responses to an increase in the domestic interest rate are shown in Figure 5. As one would expect, there is a decline in the return on domestic equity in the second period following the shock, as equities are substituted for bonds. The exchange rate appreciates, although the strongest reaction is after two quarters. This response may reflect the impact of an increase in the interest rate differential between domestic and foreign interest rates.

As a consequence of the higher domestic interest rate, the domestic consumer price inflation increases sharply following the innovation; however, it soon falls with the trough occurring 15 months after the initial shock. This conclusion is consistent with the underlying assumption of price rigidities and slow exchange rate pass through (IMF, 2001).

In general, the impulse response functions generated from the VAR model have produced expected reactions by variables contained within the domestic economy block. These impulse response functions can be useful in analysing how the domestic economy responses if particular shocks occur.
5. CONCLUSION AND POLICY IMPLICATIONS

The objective of this research was to analyse the effects of external and internal economic shocks to New Zealand’s economy, including: a foreign output shock, a foreign interest rate shock, export and import price shocks and domestic interest rate shocks. To this objective this research first built a vector Autoregression model of the domestic economy and then went on to analyse its dynamic responses to a number of shocks which originated from both New Zealand’s internal and external factors. Finally, the different impacts of these shocks on a variety of domestic variables were then analysed to model the impact and timing of their effects.

New Zealand’s radical macroeconomic shock therapy has been labelled "one of the most notable episodes of liberalization that history has to offer" (Henderson, 1995). Transforming a protected economy to an unregulated open economy has its perils. Currently, nearly one-third of New Zealand’s GDP is made up of revenue from exports (one of the stated goals of the New Zealand Government is to increase exports to 40 percent of GDP by 2025). In 2010, net foreign debt stood at 132 percent of GDP. High external reliance makes New Zealand’s small island economy particularly susceptible to shocks which emanate from outside of its domestic jurisdiction. Fallouts to New Zealand economy from the Asian economic crisis of 1997-98 and the global recession of 2008-09 are prime examples of New Zealand’s susceptibility to global events. Results obtained from this research show that external economic developments can and will have a significant impact on New Zealand’s domestic economy, with positive innovations stemming from foreign output shocks having a direct impact on New Zealand’s domestic output, exchange rate, imports and exports. For example, the impact of a foreign output shock, reached a maximum after between three and four periods, and then continuously dissipated thereafter. As the New Zealand economy is fundamentally primary production driven, the model has shown that export and import price shocks can have significant effects on domestic demand and supply, which can take long periods to revert to the original level.
## APPENDIX: VARIABLES AND DATA SOURCES

The variables and sources for the data sets used in the estimation of the model are presented in the following appendix.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Currency Price of New Zealand Exports</td>
<td>Statistics New Zealand <a href="http://www.stats.govt.nz/NR/rdonlyres/33729C5B-32F0-4BBB-95CF-F0AFB8A02488/38852/OTIPricesJun08alltables.xls">http://www.stats.govt.nz/NR/rdonlyres/33729C5B-32F0-4BBB-95CF-F0AFB8A02488/38852/OTIPricesJun08alltables.xls</a></td>
</tr>
<tr>
<td>New Zealand’s Expenditure on GDP</td>
<td>Statistics New Zealand</td>
</tr>
<tr>
<td>Foreign Currency Price of New Zealand Imports</td>
<td>Reserve Bank of New Zealand</td>
</tr>
<tr>
<td>US GDP Data</td>
<td><a href="http://www.bea.gov/">http://www.bea.gov/</a></td>
</tr>
<tr>
<td>NZX40</td>
<td><a href="https://www.nzx.com/">https://www.nzx.com/</a></td>
</tr>
<tr>
<td>New Zealand 90-day Interest Rate</td>
<td>Statistics New Zealand:</td>
</tr>
<tr>
<td>World Interest Rates</td>
<td>Calculated based on a weighted average of the Australian, United States, United Kingdom, and German interest rates, with weights based on the respective levels of GDP. <a href="http://stats.oecd.org/wbos/Index.aspx?querytype=viewanfqueryname=86">http://stats.oecd.org/wbos/Index.aspx?querytype=viewanfqueryname=86</a></td>
</tr>
</tbody>
</table>
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