

Identifying Fiscal and Monetary Policy in a Small Open Economy VAR*

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Abstract

This paper begins the process of constructing a VAR model for a small open economy, in this case New Zealand, to assess the empirical effects of both fiscal and monetary policy shocks on major macroeconomic indicators. Fiscal policy is represented by government expenditure and government revenue shocks, and monetary policy via the short term interest rate. The innovations in the model are in using the sign restriction methodology for fiscal policy shocks within a more traditionally identified VAR for the remainder of the system, and in accounting for transitory and permanent components in the series as in Pagan and Pesaran (2007). This paper reports on the first stage of this process, the identification of the fiscal policy shocks as a base on which the remainder of the project will be built.

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1. Introduction

After over a decade of preoccupation with both the importance and independence of monetary policy in macroeconomics there is now a resurgence of interest in the potential interactions of monetary policy with fiscal policy shocks. While this has been led by policymakers concerned with co-ordination effects, advances in methodologies in empirical economics have also contributed, particularly in the academic literature. While government policy makers have continued to run structural models incorporating fiscal effects, many researchers shifted to more data determined macroeconomic models encapsulated by the vector autoregression (VAR) approach mooted by Sims (1980). Methods for separately identifying government expenditure and government revenue shocks in VARs have only recently been developed; in particular the work of Blanchard and Perotti (2002) for the US.

The study of fiscal policy shocks and policy interactions in structural vector autoregression (SVAR) models has blossomed since then, many of them building on the Blanchard and Perotti fiscal policy framework: for example Perotti (2002) for a range of OECD countries; Chung and Leeper (2007), and Favero and Giavazzi (2007) who also consider debt variables; and Mountford and Uhlig (2005) who use the Blanchard and Perotti fiscal variables but an alternative sign restriction based identification scheme. The latter papers are all focussed on the US.

The current paper takes the advances in the SVAR methodology in identifying fiscal policy shocks, and applies them to the small open economy of New Zealand. The model is identified using a hybrid of a refinement of the sign restriction methodology developed in Fry and Pagan (2007) and a traditional SVAR. The role of debt is also modelled formally. This preliminary version of the paper presents the results of estimating the SVAR with these features along with an exogenous international sector and a simple detrending process. The results show the rich possibilities uncovered and augur well for the proposed future developments. The major avenue we intend to specifically address in the future is the identification of permanent and transitory shocks using the recent work of Pagan and Pesaran (2007) which takes advantage of the cointegrating vectors in the system.

New Zealand makes an interesting small open case-study for a number of reasons. First, New Zealand has been a policy making leader over the past few decades in both adopting inflation targeting in 1990 and the Fiscal Responsibility Act in 1994. Second, policymakers are actively considering interactions between fiscal and monetary policy, with the Federal Parliament currently conducting an inquiry into the future of the monetary policy framework which includes in its terms of reference the interactions between monetary and other economic policies including fiscal policy (Finance and Expenditure Committee, 2007; Treasury and Reserve Bank of New Zealand (RBNZ), 2006; RBNZ, 2007). An earlier review by Svensson (2001) recommended that monetary and fiscal policy not be coordinated to protect the independence of monetary policy, while the current RBNZ submission points to some of the difficulties for implementing monetary policy in a short-term stimulatory fiscal environment. Third, unlike many small open economies, New Zealand possesses a well-established SVAR modelling framework, which has resolved many of the issues in specification for other aspects of the economy; see particularly Buckle, Kim, Kirkham, McLellan and Sharma (2007) and references therein. Finally, some of these questions have been previously addressed in literature in structural models of the New Zealand economy, particularly Hall and Rae (1998), which provides a useful point of comparison.

The rest of this paper proceeds as follows. Section 2 presents a brief overview of some of relevant literature on identifying fiscal policy in a VAR framework and SVAR modelling in New Zealand. A discussion of identification of the model, both via sign restrictions and more traditional means, is provided in Section 3. The New Zealand data are presented in Section 4. Section 5 presents the empirical results, in terms of impulse response functions and historical decompositions. A brief comment on the implications for the interaction of monetary and fiscal policy is provided in Section 6, while Section 7 concludes with some of our plans for future developments.

2. SVARs and Macroeconomic Policy Modelling

Uncovering dynamic interactions between a small set of macroeconomic variables such as GDP, inflation, exchange rates and interest rates is often undertaken using the SVAR methodology. Traditionally, the effects of monetary policy shocks on the macroeconomy are analysed in such a framework. Examination of fiscal policy in

such a framework is less common, mainly because of the difficulty in identifying fiscal policy shocks, and because the conduct of monetary policy has been the economic innovation of recent focus.

One of the key challenges in modelling fiscal policy is to extract pure fiscal policy shocks from those that are automatic, and to separate dynamics through the economy arising from changes in government revenue from changes in government expenditure (Blanchard and Perotti, 2002). Although the underlying budget balance as well as the overall level of government debt is a function of these two variables, the underlying structure of revenue and expenditure and associated shocks are likely to have different impacts on other aspects of the economy (see Hall and Rae, 1998 for New Zealand evidence). Blanchard and Perotti (2002) and Perotti (2002) overcome these difficulties by using a combination of institutional information and SVAR analysis to separate the two.¹

This paper develops an alternative means of identifying fiscal policy shocks based on a hybrid of the sign restriction technique for identifying VARs and a traditionally identified SVAR model. See Faust (1998), Canova and de Nicolo (2002), Uhlig (2005) and Fry and Pagan, (2007) for further details on the sign restriction methodology, and Mountford and Uhlig (2005) for one way to implement the sign restriction technique in the case of fiscal policy shocks. The approach allows contemporaneous, yet still orthogonal relationships amongst all variables, making this an excellent option for examining fiscal policy. No assumption needs to be made regarding the ordering of events. All variables are thus able to react simultaneously to both fiscal shocks.

The key papers for the current study are listed in Table 1: particularly Blanchard and Perotti (2002), Perotti (2002), Mountford and Uhlig (2005), Claus et al (2006), Favero and Giavazzi (2007) and Chung and Leeper (2007). While there are undoubtedly others (see for example the references in Chung and Leeper, 2007) these are the direct antecedents to the current paper. The Blanchard and Perotti (2002) model contains simply taxation, government expenditure and GDP output in per capita terms (all relevant national accounting data may be presumed to be real in this literature unless

¹ Institutional information on the timing of tax and expenditure decisions and calibrations of a number of elasticity parameters are used to identify their models.

Table 1: Summary of features of the fiscal SVAR literature.

Paper	Variables used	Identification method	Country	Sample period
Blanchard and Perotti (2002)	Taxation per capita, government spending per capita, output per capita	Variable order based on institutional events	US	1974Q1-1997Q4
Perotti (2002)	Taxation per capita, government spending per capita, output per capita, inflation, short term interest rate		US, UK, West Germany, Canada, Australia	vary
Mountford and Uhlig (2005)	Taxation per capita, government spending per capita, output per capita, private consumption per capita, private residential and non-residential investment per capita, short term interest rate, adjusted reserves, PPI, GDP deflator	Sign restrictions	US	1955Q1-2000Q4
Claus et al (2006)	Taxation per capita, government spending per capita, output per capita	As Blanchard and Perotti (2002)	NZ	1982Q3-2004Q3
Favero and Giavazzi (2007)	GDP per capita, GDP deflator, government expenditure per capita, taxation per capita, debt		US	1960Q1-2006Q2
Chung and Leeper (2007)	Output, GDP deflator, short term interest rate, long term interest rate, money base, taxation, government spending, debt		US	1947Q2-2006Q2

otherwise specified). Their application is to the US, and the careful work they undertook in defining the relevant fiscal data sets has led to widespread adoption of their data definitions by almost all other authors working on the US. Perotti (2002) extends their analysis to include inflation and short term interest rates and touches briefly on the interaction between monetary and fiscal policy for the US in his study. In particular, he discusses the common US result of deflationary government expenditure shocks (present in each of the studies of the US listed in Table 1), and associated falls in short term interest rates. Perotti (2002) is one of few papers to consider non-US economies in this framework, additionally considering the UK, West

Germany, Canada and Australia. In these countries he finds that positive government expenditure shocks may well result in higher inflation, and subsequently higher interest rates as monetary policy responds.

Although the Perotti paper considers a number of small open economies in its analysis, there is no attempt to control for other important aspects of macroeconomics of these countries (see for example Dungey and Pagan, 2000; and Cushman and Zha, 1997 for open economy VARs of Australia and Canada). Claus et al (2006) follow the Blanchard and Perotti (2002) framework for New Zealand, but do not extend to include either open economy or other macroeconomic variables. They do however lay the groundwork for the current study in developing the appropriate fiscal data series, and provide a point of comparison.

A greater number of relevant macroeconomic variables are included in the VAR of Mountford and Uhlig (2005), which also specifically examines the interaction of monetary and fiscal policy, for the US in this case. Their identification methodology is developed from the sign restriction literature. In their system of eight variables, four shocks are identified: a government revenue shock, a spending shock, a business cycle shock and a monetary policy shock. They argue that the identification of the business cycle shock in particular, precludes the need to adjust the reduced form residuals to control for automatic adjustments and allows for monetary policy and fiscal shocks to be treated in a similar manner within the model.

Finally, the most recent studies of Chung and Leeper (2007) and Favero and Giavazzi (2007) explicitly recognise the importance of the debt variables in VAR models including fiscal variables. In Chung and Leeper (2007) the analysis is conducted within a framework of fiscal shocks where the path to balanced budget is funded by a specific channel – via taxation, transfers or government consumption as alternatives. Favero and Giavazzi (2007) specifically account for fiscal shocks responses to levels of debt and show that this has important implications for resulting debt to GDP ratios in the model.

The work of Buckle et al (2007), which does not allow a role for fiscal policy, forms the basis of the traditional SVAR part of the hybrid approach to identification proposed here. SVAR models incorporating elements of fiscal policy for New

Zealand includes the work of Claus et al (2006) discussed previously, and Buckle, Kim and Tam (2001). Buckle, Kim and Tam (2001) examine the impact of shocks including fiscal, supply, private demand and nominal shocks on the underlying cash budget balance under alternative (simulated) scenarios. Others not including a role for fiscal policy include Buckle, Kim, McLellan (2003), Claus (2003), Arin and Jolly (2005) and Haug and Smith (2007). See also the earlier work of Wells and Evans (1985) and Conway (1998).

3. The Empirical Methodology

The use of the SVAR methodology to uncover interactions between a small set of macroeconomic variables in a small open economy has a number of attractive features. These include the facility to let the data provide evidence on the dynamic interactions, without the constraint of theoretically imposed structural relationships. The main disadvantage of the VAR approach is the need for identifying assumptions. It is not possible to identify dynamic interactions between all variable simultaneously, some identification strategy needs to be imposed. The simplest is a Wold ordering, where variables are chosen to be prior to other variables in some sense, usually justified with reference to information availability or relative perceived importance in macroeconomic decision making.

Even under such schemes there remain difficulties. The data in such systems may produce strange or unexpected results, such as in the separate identification of taxation and government expenditure shocks on output variables, or in the emergence of the well-known ‘price puzzle’, where a positive shock to the designated monetary policy instrument results in a usually short-lived increase in either inflation or prices, and other noted anomalies such as the ‘exchange-rate puzzle’ (an increase in domestic interest rate results in a depreciation of the domestic currency) and ‘liquidity puzzle’ (an increase in money supply results in an increase in interest rates). Most of these problems seem to be identification problems. For example, see Pagan and Robertson (1999) on the liquidity puzzle, and Blanchard and Perotti (2002) on the identification of fiscal shocks.

Identification problems of this sort have led to the development of the sign restriction identification literature which relaxes strict ordering assumptions, whilst still

obtaining a model in which a set of orthogonal shocks are uncovered (see Faust, 1998; Canova and de Nicolo, 2002; Uhlig, 2005; and Fry and Pagan, 2007). The idea of SVAR models based on sign restrictions is intuitively applied by practitioners in a simple form. VAR models are often identified by assuming a particular ordering of variables, where the results are re-examined under a different ordering of variables. Although impulse responses may differ under the alternative orderings, the underlying set of shocks each represent an orthogonal system, and it is up to the economic intuition of the researcher to unravel the most sensible identification. The examination of alternative model identifications, and the choice of model based on the signs of the impulse response functions is the foundation of the sign restriction technique.

It is worth considering the implications of the nature of the data in the VAR. One stream of research has argued for the dominance of the data dynamics, that is, letting the data reveal relationships empirically and thus allowing all data to enter in levels. However, more recently arguments for specific account of the (near) non-stationarity of components of the data sets have prevailed, leading to the development of VECM technology and VARs in first differences. When all data are non-stationary it is relatively straightforward to consider these aspects. However, these approaches all lose some information. A more desirable path is to include components of both the stationary and non-stationary data, and specifically incorporate their properties into a model. Recently, Pagan and Pesaran (2007) have shown a methodology to separately identify permanent and transitory shocks in a system of $I(1)$ variables and produce a coherent SVAR system, effectively extending and generalising the Blanchard and Quah (1989) methodology. This development has the added benefit that the specification of the cointegrating vector makes available extra instruments for identifying the system. Hence the two problems of identification and data properties are intrinsically related.

Ultimately we aim to use a combination of the sign restriction methodology to identify the fiscal shocks following the methods proposed in Fry and Pagan (2007), and the distinction between temporary and permanent shocks in cointegrating data proposed in Pagan and Pesaran (2007) to incorporate the properties of the data in the system as in contemporaneous work in Dungey and Pagan (2007). This will allow us to both account for the difficulties in identifying fiscal shocks and account for the

mixed I(1) and I(0) variables in the same system. However, as a starting point, the earlier tradition of levels based estimation of the VAR prevails (using detrended data), and there is no explicit accounting for non-stationarity in variables or cointegrating relationship. The following outlines first the sign restriction methodology and the restrictions imposed to identify the model for New Zealand.

3.1. Sign Restrictions

Define a SVAR(1) with an initial arbitrary identification choice as

$$B_0 y_t = B_1 y_{t-1} + \varepsilon_t, \quad (1)$$

with corresponding VAR

$$y_t = A_1 y_{t-1} + v_t, \quad (2)$$

and

$$\hat{v}_t = \hat{B}_0^{-1} \hat{\varepsilon}_t \quad (3)$$

being the relationship between the estimated VAR and SVAR residuals. The vector moving average form of the SVAR is

$$y_t = C(L) \varepsilon_t, \quad (4)$$

with $C(L) = C_0 + C_1 L + \dots$, and $C_j = D_j B_0^{-1}$ being the impulse responses to the structural shocks ε_t , and D_j being the corresponding VAR impulse responses to a unit shock in v_t .

Defining \hat{S} as containing the estimated standard deviations of the structural residuals along the diagonal and with zeros elsewhere,

$$\begin{aligned} \hat{v}_t &= \hat{B}_0^{-1} \hat{S} \hat{S}^{-1} \hat{\varepsilon}_t \\ &= T \eta_t. \end{aligned} \quad (5)$$

T is an impact matrix, and η_t are the estimated shocks, where η_t has unit variances. The sign restriction method produces an alternative set of shocks and an alternative impact matrix by choosing some orthonormal matrix Q which by definition has the

properties $Q'Q = QQ' = I$. The original shocks can be redefined as a function of this orthonormal matrix

$$\begin{aligned} v_t &= TQ'Q\eta_t \\ &= T^*\eta_t^*, \end{aligned} \tag{6}$$

whereby the new set of estimated shocks η_t^* also has the property that their covariance matrix is I since $E(\eta_t^*\eta_t^{*\prime}) = QE(\eta_t\eta_t')Q' = I$. Thus there is a combination of shocks η_t^* that has the same covariance matrix as η_t but which will have a different impact upon y_t through their impulse responses C_j^* . Intuitively, the initial arbitrary shocks are rotated to produce an alternative set of shocks while maintaining the desirable property that the shocks remain orthogonal.

There are an infinite number of candidates for Q which produce an orthogonal set of shocks, but which all have the same VAR representation. The impact matrix of the shocks is not required to follow a recursive pattern, although a recursive structure is an admissible decomposition. The orthonormal matrices Q , may be generated by either a Given's rotation matrix or a householder (QR) decomposition; see Canova and de Nicolo (2002), and Peersman (2005) for applications using the Given's matrix, and Rubio-Ramirez, Waggoner and Zha (2005) for the householder decomposition. There are, however, many such rotations to consider, so economic concepts are used to narrow down the range of options of orthonormal matrices Q considered. This is the key to the implementation of the sign restriction method. As the naming convention implies, the sign restriction methodology restricts attention to rotations which produce shocks which satisfy an anticipated sign in responses of key variables. That is, information on the expected signs of responses to key economic variables is used to select the combinations of TQ' which make sense economically.

As the dimension of the SVAR increases, the number of sign restrictions necessary to identify the system of equations increases dramatically. The SVAR models in the Buckle et al (2007) pedigree for New Zealand contain seven endogenous domestic variables, a trade block and an international economy block, and adding further fiscal variables makes it difficult to identify the system of shocks using sign restrictions alone. As the underlying structure of SVAR models for New Zealand are relatively

stable and encompass key theoretically derived restrictions, identification of the underlying contemporaneous and lagged structure of most variables follows Buckle et al (2007). It is only the fiscal policy shocks to which the sign restriction methodology is applied.

Define the vector of data as

$$y_t = \{lg_t, ltax_t, lgne_t, ldebt_t, lgdp_t, inf_t, short_t, ltwi_t\}, \quad (7)$$

where lg_t is real government expenditure, $ltax_t$ is real taxation revenue, $lgne_t$ is real GNE, $ldebt_t$ is the ratio of sovereign issued debt to GDP, $lgdp_t$ is real GDP, inf_t is inflation, $short_t$ is the short term interest rate, and $ltwi_t$ is the trade weighted exchange rate for the New Zealand dollar. Further definitions of the variables are given in the Data Appendix. The matrix Q chosen is based on the Given's rotation and is

$$Q = \begin{bmatrix} \cos \theta & -\sin \theta & 0 & \dots & 0 \\ \sin \theta & \cos \theta & & & \vdots \\ 0 & & 1 & & \vdots \\ \vdots & & & \ddots & 0 \\ 0 & \dots & \dots & 0 & 1 \end{bmatrix}, \quad (8)$$

where θ is chosen randomly and adopts a value between 0 and π . This choice of rotation matrix means that only the shocks corresponding to the first two variables of government expenditure and taxation are rotated. It is clear that the shocks corresponding to the remaining variables are those of a traditional SVAR system. By applying the sign restriction method to only two shocks and identifying the rest of the shocks conventionally means that a system is estimated which is large enough to properly control for other shocks in the system, such as business cycle shocks.

Even with these restrictions in place, it is likely that there are many combinations of TQ' and D_j that produce impulse responses satisfying the required sign restrictions. Standard practice is for researchers to draw Q matrices until there are d number of impulses satisfying the set of economic restrictions stated. The median of the impulse response functions C_j^d are then chosen as the reported impulse, usually in association with impulses corresponding to chosen percentile bands. However, recent work in Fry and Pagan (2007) highlights some of the econometric problems of the use of that

means of implementing sign restriction methodology. A key issue is that taking the median response across the set of impulses no longer guarantees that the shocks of the system are orthogonal and hence the impulses presented represent results from a mixture of models. To circumvent this problem and following Fry and Pagan (2007), a Q matrix is chosen so that the impulses selected are as close as possible to the median with the property of orthogonal shocks retained. To implement this, the impulses are standardized and grouped into a vector ϕ^d for each of the d draws of Q . The expression ϕ^d is then minimised, and the corresponding Q^d matrix is then used to calculate the impulse response functions. In this application $d=10,000$.

3.2. SVAR restrictions

The model in this paper contains both an endogenous domestic economy sector and an exogenous international and climate sector, based largely on the work of Buckle et al (2007). The exogenous variables are

$$x_t = \{y_t^*, r_t^*, clim_t\}, \quad (9)$$

where y_t^* is real international activity, r_t^* is an international interest rate, and climate conditions for New Zealand are $clim_t$. The endogenous variables are summarised in (7). A summary of the restrictions of the model are contained in Table 2. Section 3.2.1 specifies the restrictions imposed on the fiscal shocks, and section 3.2.2 specifies the restrictions on all other variables.

3.2.1 Sign restrictions

The shocks identified through the sign restriction technique pertain to the two fiscal policy shocks which correspond to the first two sets of impulse responses in the system denoted $\tau = 1, 2$, for each draw.² To disentangle the impulses and to assign them to particular shocks, three levels of criteria are examined.

² In their system for the US, Mountford and Uhlig (2005) identify a government revenue shock, spending shock, a business cycle shock and a monetary policy shock whereby: i) a positive shock to government revenue leads to positive government revenue for four quarters; ii) a positive government spending shock leads to positive government spending shock for four quarters; iii) a business cycle shock increases government revenue, GDP, consumption and non residential investment for four quarters; and a monetary policy shocks where interest rates rise for four quarters, and adjusted reserves

Table 2: Structure of the SVAR.

◆,•,◦ denote sign, contemporaneous and lag relationships respectively.

Depend. variables	Explanatory variables								Exogenous variables		
	<i>lg</i>	<i>ltax</i>	<i>lgne</i>	<i>ldebt</i>	<i>lgdp</i>	<i>inf</i>	<i>short</i>	<i>ltwi</i>	<i>y*</i>	<i>i*</i>	<i>clim</i>
Contemporaneous structure											
<i>lg</i>	◆	◆	◆	◆	◆	◆	◆	◆			
<i>ltax</i>	◆	◆	◆	◆	◆	◆	◆	◆			
<i>lgne</i>	•	•									
<i>ldebt</i>	•	•	•								
<i>lgdp</i>	•	•	•	•							•
<i>inf</i>			•								
<i>short</i>			•			•				•	
<i>ltwi</i>	•	•	•	•	•	•	•		•	•	
Lag structure											
<i>lg</i>	◦	◦	◦	◦	◦	◦	◦	◦			
<i>ltax</i>	◦	◦	◦	◦	◦	◦	◦	◦			
<i>lgne</i>	◦	◦	◦			◦	◦	◦			
<i>ldebt</i>	◦	◦	◦	◦							
<i>lgdp</i>	◦	◦	◦	◦	◦			◦	◦		◦
<i>inf</i>			◦			◦		◦			◦
<i>short</i>			◦			◦	◦			◦	
<i>ltwi</i>	◦	◦	◦	◦	◦	◦	◦	◦	◦	◦	

Criteria 1

The first criterion is purely sign based. For a positive Government expenditure shock (G), both government expenditure and GNE respond positively for j periods such that

$$\begin{aligned}
 C_{lg,j}^{G,\tau} &\geq 0, \forall j \\
 C_{lgne,j}^{G,\tau} &\geq 0, \forall j,
 \end{aligned}
 \tag{10}$$

for either of $\tau=1$ or $\tau=2$. The signs of the remaining impulses in τ are free to take on any sign. In the empirical example, $j=1$.

and prices fall for four quarters. They use a criterion based on a penalty function to choose their final set of impulses.

For a positive taxation shock (T), taxation rises and GNE falls for j periods following the shock whereby

$$\begin{aligned} C_{tax,j}^{T,\tau} &\geq 0, \forall j \\ C_{lgne,j}^{T,\tau} &\leq 0, \forall j, \end{aligned} \tag{11}$$

for either of $\tau=1$ or $\tau=2$. Again, the signs of the remaining impulses in τ remain unconstrained.

Criteria 2

In certain draws, it is not possible to disentangle the two shocks using these sign restrictions alone, and further disentanglement is needed. This occurs: (i) in the case of a government expenditure shocks occurring in impulses τ when the response of taxation in the same set of impulses is negative ($C_{tax,j}^{G,\tau} \leq 0, \forall j$); (ii) in the case of a taxation shock in impulses τ where the response of government expenditure in the same set of impulses is positive ($C_{lg,j}^{T,\tau} \geq 0, \forall j$). In these cases, the G shock could be labelled a T shock and vice versa. It is not possible to uniquely label the impulses as government expenditure or a taxation shock, as the signs of the responses of the two shocks correspond with both combinations of signs previously postulated in (10) and (11).

Rather than also restricting the sign on taxation in response to a government expenditure shock, and the sign on government expenditure in response to a taxation shock quantitative information is used. If in a set of impulses, τ , the magnitude of the response of government expenditure is greater than the magnitude of the response of taxation,

$$C_{lg,j}^{\tau} > C_{tax,j}^{\tau}, \forall j, \tag{12}$$

the shock is a government expenditure shock. If it is the reverse case, then the set of impulses is considered a taxation shock. This magnitude restriction is similar to that of Peersman (2005) when disentangling supply and oil price shocks.

Criteria 3

Occasionally it is the case that after criteria 2 is imposed, there are cases where both sets of impulses appear to be the same shock (either both G or both T shocks). Rather than discarding these draws, the impulses are disentangled by examining the ratio of the absolute value of the contemporaneous response of government expenditure to the contemporaneous response of taxation in impulses τ . The value for each set of impulses

$$abs\left(\frac{C_{lg,1}^\tau}{C_{tax,1}^\tau}\right), \tau = 1,2; j = 1, \quad (13)$$

is calculated. If

$$abs\left(\frac{C_{lg,1}^1}{C_{tax,1}^1}\right) \geq abs\left(\frac{C_{lg,1}^2}{C_{tax,1}^2}\right), \quad (14)$$

then the first set of impulses is a government expenditure shock and the second is a taxation shock and vice versa. If the two are equal, then it is assumed that the shock is a government expenditure shock. Table 5 presents statistics relating to the number of times each criterion is satisfied for the empirical example.

3.2.2 Traditional SVAR restrictions

The specification of the equations for the remaining domestic variables in the system generally follows those of Buckle et al (2007), although they identify 4 different blocks in their specification: a totally exogenous climate block; an international economy block; a trade block containing export and imports; and a domestic block which imposes the small open economy assumption with regards to the other blocks. Here we deviate and adopt a SVARX formation whereby the climate and international economy blocks in x_t are simply incorporated as exogenous variables. Recent work on the similarly structured Dungey and Pagan (2000) model for Australia has shown little difference in the domestic economy's responses in the move from an SVAR including international economic variables and the small open economy assumption, to an SVARX where all international variables are exogenous to the domestic economy. At this point we have not added the international trade sector, although that could be included in future extensions.

Domestic demand (GNE) represented by *lgne* is assumed to be a function of both of the contemporaneous and lagged fiscal policy variables, and all lags of all of the variables in the system. Dummy variables corresponding to quarters 1986:4 and 1989:3 are included to capture two spikes in domestic demand coinciding with the quarters prior to announced increases to the GST rate (see Buckle et al, 2007).

In line with the recent work on the importance of debt in similar systems, the log of the debt to GDP ratio is added to the system. This adds to the stability of the system, see Fry and Pagan (2005) on the role of stock variables in VAR models. The debt variable is dependent on each of the fiscal variables and GNE as an indicator of cyclical pressure. What is not currently imposed is a restriction on the relationship between the fiscal variables and the debt variable in order to avoid the ‘incredible’ debt to GDP ratios noted in Favero and Giavazzi in an unconstrained system. Note that at this point, no such incredible ratios were found in the estimated system, and it may be that as with Chung and Leeper (2007) it is sufficient for debt to be present. This is a testable hypothesis for exploration. Also as noted in Favero and Giavazzi (2007) it is important to include feedback from debt to other variables, and for this reason the debt variable is then included in the other aspects of the model, particularly the fiscal policy variables.

GDP is a function of both of the contemporaneous and lagged fiscal policy variables, debt and domestic demand, as well as all lags of the short interest rate and the exchange rate. Exogenous variables include lags of foreign real output, and the contemporaneous and lagged climate variable.

The inflation equation encompasses a Phillips curve type specification, where contemporaneous and lagged domestic demand is key. Pass through effects from imported inflation are possible through the inclusion of the lagged exchange rate in the specification. This pass through possibility is slightly different to that of Buckle et al (2007), as they have an additional restriction with the exchange rate appearing in the inflation equation contemporaneously. The exogenous variables include the two dummy variables discussed in relation to the GNE equation above, as well as lags of the climate variable.

The equation for the short interest rate contains only three variables both contemporaneous and lagged. These are domestic demand, inflation and the lagged interest rate. The foreign short interest rate is included in the lag and contemporaneous relationship as well.

The exchange rate is assumed to respond to everything in the system, and is thus a function of all variables both contemporaneous and lagged, and also includes the exogenous variables of foreign output and the foreign interest rate.

4. The Data

The dataset consists of the eight endogenous variables, y_t , and three exogenous variables x_t outlined in (7) and (9). All variables are in natural logarithms except for the interest rates and inflation rates which are in percent, and the climate variable which is discussed below. Complete data descriptions are provided in Appendix I; Figure 1 presents a present a plot of the data for all variables, and Table 3 gives descriptive statistics for the endogenous variables.

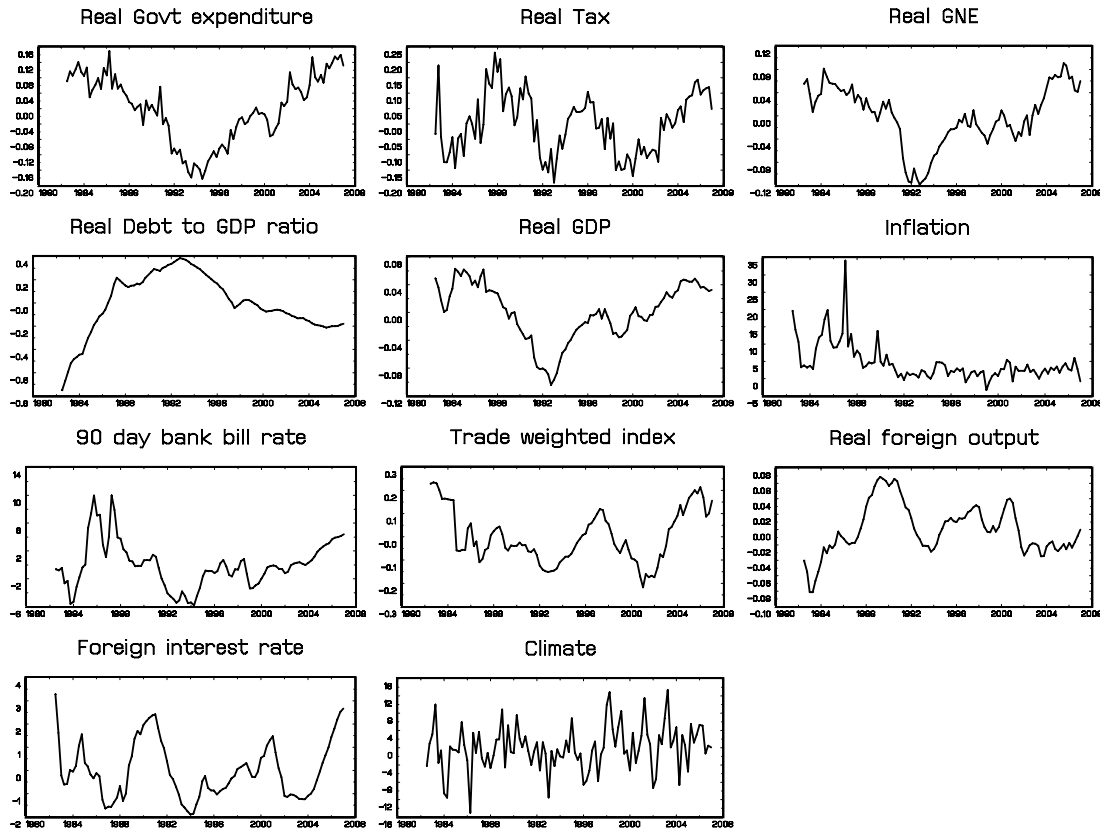
Unlike a number of existing models, shown in Table 1, the data are not expressed in per capita terms. This aids in embedding the model in an existing SVAR tradition for New Zealand and in interpretation for policy purposes.

The government expenditure variable is defined as real total government consumption plus real total government investment consistent with Blanchard and Perotti (2002) and Claus et al (2006) for New Zealand, although unlike in Claus et al, the government investment series has been purged of investment by state owned enterprises, and is the result of recent work at the New Zealand Treasury. Real taxation revenue is total government revenue less transfer payments as in Claus et al (2006) and Mountford and Uhlig (2005).

Buckle, Kim, Kirkham, McLellan and Sharma (2007) specify their price variable as being the difference between the log of the domestic consumer price index and its trend value. Here inflation is treated as the annualised quarterly inflation rate in the CPI, which is a more standard approach to inflation.

Figure 1: Plot of the data 1982Q2 to 2006Q4.

All variables are expressed in natural logarithms except for the interest rates and the inflation rate which are in percent, and the climate variable which is demeaned on a quarterly basis.



The main policy instrument for New Zealand since March 1999 has been the Official Cash Rate (OCR). There are two disadvantages with using this directly in the model. The first is simply lack of length in the time series data on that indicator. Secondly, like many short term target rates, it has become essentially a step-function in the inflation targeting period. However, the short-term rate, in this case the 90 day bill yield is very highly correlated with the OCR over the available sub-sample. For the period March 1999 to December 2006 the correlation between the two series is 0.989. Hence we use the 90 day short rate as the indicative policy indicator. Buckle et al (2007) also use this series.

The exogenous variables in the system directly correspond with a selection of the external sector used in Buckle et al (2007). In particular, foreign output is an export weighted average of industrial production indices; the foreign interest rate is a weighted average of a selection of foreign interest rates; and the climate variable is

Table 3: Descriptive statistics of the endogenous variables 1982Q2 to 2006Q4.

Statistic	<i>lg</i>	<i>ltax</i>	<i>lgne</i>	<i>ldebt</i>	<i>lgdp</i>	<i>inf</i>	<i>short</i>	<i>ltwi</i>
Mean	8.431	8.418	10.036	0.454	10.043	4.519	10.477	4.734
Median	8.339	8.434	9.991	0.429	10.012	2.891	8.063	4.727
Max	8.828	9.002	10.449	0.865	10.376	34.147	25.783	5.036
Min	8.225	7.848	9.712	-0.145	9.761	-3.265	4.452	4.481
Std. Dev.	0.177	0.295	0.213	0.266	0.181	5.315	5.390	0.120
Skewness	0.841	0.116	0.460	-0.057	0.388	2.566	1.037	0.450
Kurtosis	2.372	2.453	1.977	1.764	1.844	12.333	3.146	3.144
Jarque-Bera Probability	13.301 0.001	1.459 0.482	7.808 0.020	6.359 0.042	7.995 0.018	467.936 0.000	17.841 0.000	3.432 0.180
Obs	99	99	99	99	99	99	99	99

the number of days of soil moisture deficit in each quarter demeaned by the corresponding quarterly long run average. For a through discussion of climate, see Buckle et al (2007).

The data are quarterly and spans 1982Q2 to 2006Q4 for a total of 99 observations. The starting point is determined purely by the availability of data, and has been shown to work well in existing New Zealand studies. New Zealand implemented a number of important changes in macroeconomic policy during this period, including the adoption of formal inflation targeting in 1989, and the use of the Monetary Conditions Index (MCI) based on inflation and exchange rate movements as a reference for monetary policy decisions between 1994 and 1997. Buckle et al (2007) find that accounting for the MCI period makes little difference to their results so we do not include that specifically here. On the fiscal policy side New Zealand experienced a period of rapidly rising debt over the 1980s, which led to a focus on debt reduction and the adoption of the Fiscal Responsibility Act in 1994 and the Public Finance Act in 1989 (amended in 2004), where the Government was charged with following principles of responsible fiscal management, including ensuring that Government debt be maintained at prudent debt levels.³

³ Prudent is not defined, as the meaning of prudent is likely to change over time given economic structures and other factors.

Unit root tests of the variables in levels and also in changes are given in Table 4.⁴ Both the augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests are presented. Both tests indicate that the variables are non-stationary at the 5 percent level of significance with the exception of the inflation rate and the climate variable for the ADF and PP tests, while the PP test also indicates that the tax variable and the debt to GDP ratio is stationary.

There are clearly many issues raised by the empirical properties of the data in terms of how to proceed with the practical modelling. In particular, the non-stationarity suggests the potential presence of cointegration between these variables, and using Johansen-Julieus procedures we have thus far established two cointegrating vectors between $\{g_t, itax_t, lg ne_t, ldebt_t\}$ and a further relationship between $\{y_t^*, lg ne_t, ldebt_t, lg dp_t\}$. Note, that the relationship between the first set of variables is consistent with sustainable fiscal policy, see for example footnote 6 of Favero and Giavazzi (2007) and Blanchard and Perotti (2007). Blanchard and Perotti (2007) find limited evidence for cointegration between their taxation and government expenditure variables; however, it appears likely this is due to the omission of debt. Our intention is to use the proposed methodology in Pagan and Pesaran (2007) to take advantage of these long run relationships in the model, allowing for a mixture of I(1) and I(0) variables in the modelling framework.

Before proceeding to implement the Pagan and Pesaran approach we first look to a simple model in levels in an older VAR tradition allowing the data to speak to the order of integration, to establish our framework for identification of the fiscal shocks via sign restrictions. An important issue in New Zealand macroeconomic modelling is that of detrending. The behaviour of New Zealand data has led researchers based at the New Zealand Treasury and Reserve Bank to veer away from simple linear detrending as producing unrealistic output gaps in particular. They instead favour gaps produced using the multivariate Hodrick Prescott filter developed by Laxton and Tetlow (1992); see Claus (2003) for an overview of the debate in New Zealand. Sensitivity to other trend assumptions will be considered in future developments.

⁴Calculations in Tables 3 and 4 are performed in EViews, Version 5.

Table 4: Augmented Dickey-Fuller and Phillips-Perron unit root tests on all data 1982Q2 to 2006Q4.*

	ADF tests				PP tests			
	levels		changes		levels		changes	
	t-stats.	p-values	t-stats.	p-values	t-stats	p-values	t-stats	p-values
<i>lg</i>	-1.133	0.917	-4.818	0.000	-1.286	0.886	-14.838	0.000
<i>ltax</i>	-2.224	0.471	-5.241	0.000	-3.710	0.026	-15.605	0.000
<i>lgne</i>	-1.775	0.709	-4.951	0.000	-1.599	0.787	-9.976	0.000
<i>ldebt</i>	-3.014	0.134	-3.344	0.016	-4.333	0.004	-3.886	0.003
<i>lgdp</i>	-1.361	0.866	-4.916	0.000	-1.580	0.794	-8.076	0.000
<i>inf</i>	-3.468	0.049	-6.725	0.000	-5.896	0.000	-15.369	0.000
<i>short</i>	-2.025	0.580	-4.992	0.000	-2.298	0.431	-7.466	0.000
<i>ltwi</i>	-2.594	0.284	-5.185	0.000	-2.213	0.477	-8.474	0.000
y_t^*	-3.277	0.076	-4.813	0.000	-2.122	0.527	-5.655	0.000
i_t^*	-2.573	0.293	-4.458	0.001	-2.957	0.150	-6.227	0.000
$clim_t$	-6.222	0.000	-17.241	0.000	-8.097	0.000	-17.241	0.000

*Unit root tests on the levels of the data contain a constant and trend. The tests on the changes of the variables contain a constant. The lag length is set at 3 for all specifications. McKinnon one sided p-values are used.

5. Empirical Results

The SVAR presented in the previous sections is estimated in Gauss 6.0 with 3 lags of each of the endogenous variables consistent with the majority of the existing New Zealand literature. Analysis of the results is here given with respect to the impulse response functions from shocks to the system and historical decompositions. At this stage error bands are not presented for the full system as the simulations required to calculate them have not yet been undertaken. However, the extent of variation in the impulses for the sign restricted shocks (that is shocks to government expenditure and taxation) are presented and discussed below.

5.1. Dynamic Interrelationships

This section details the impulse response functions for the system as described thus far. This forms the building block for future developments in the model.

5.1.1. Shock to government expenditure

Figure 2: Impulse responses to a shock to government expenditure

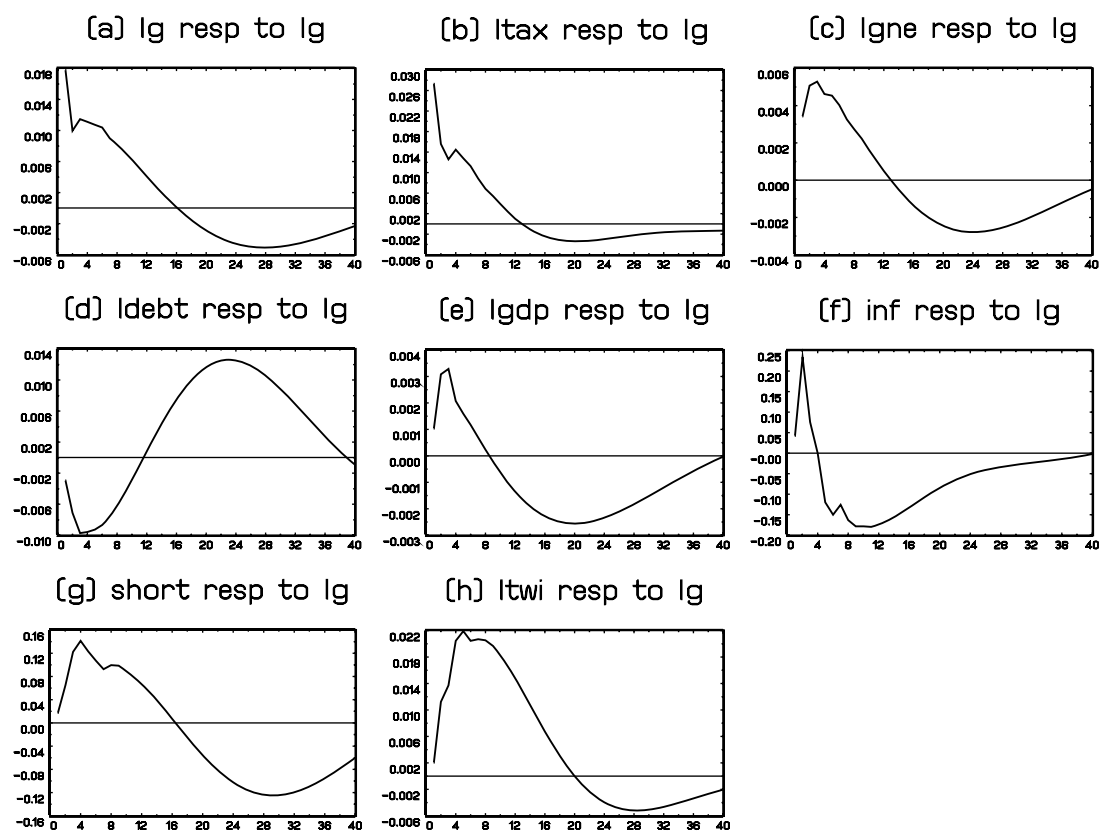


Figure 2 gives the impulse responses for each of the eight endogenous variables to a shock to government expenditure, with the behaviour of the shock itself shown in panel (a) of Figure 2. It is readily seen that the impact of the increased government expenditure is reflected in higher domestic demand (panel (c)) and higher output (panel (e)) which results in higher taxation revenue (panel (b)). The impact is initially inflationary, (panel (f)), but the monetary policy response in terms of higher short term interest rates (panel (g)) quickly dampens the inflationary pressures after the first year, and slows the economy (something also seen in the structural model in Hall and Rae, 1998). The association of higher government expenditure with higher output and higher taxation revenue are consistent with the results in Blanchard and Perotti (2002), Perotti (2002) for a range of countries and the preferred specification in Claus et al (2006), and some of the earlier period specifications explored in Favero and Giavazzi (2007).⁵ However, the existing literature is more mixed in its results for

⁵ In Favero and Giavazzi's model for the period corresponding most closely to the current sample, taxation falls in response to the government expenditure shock.

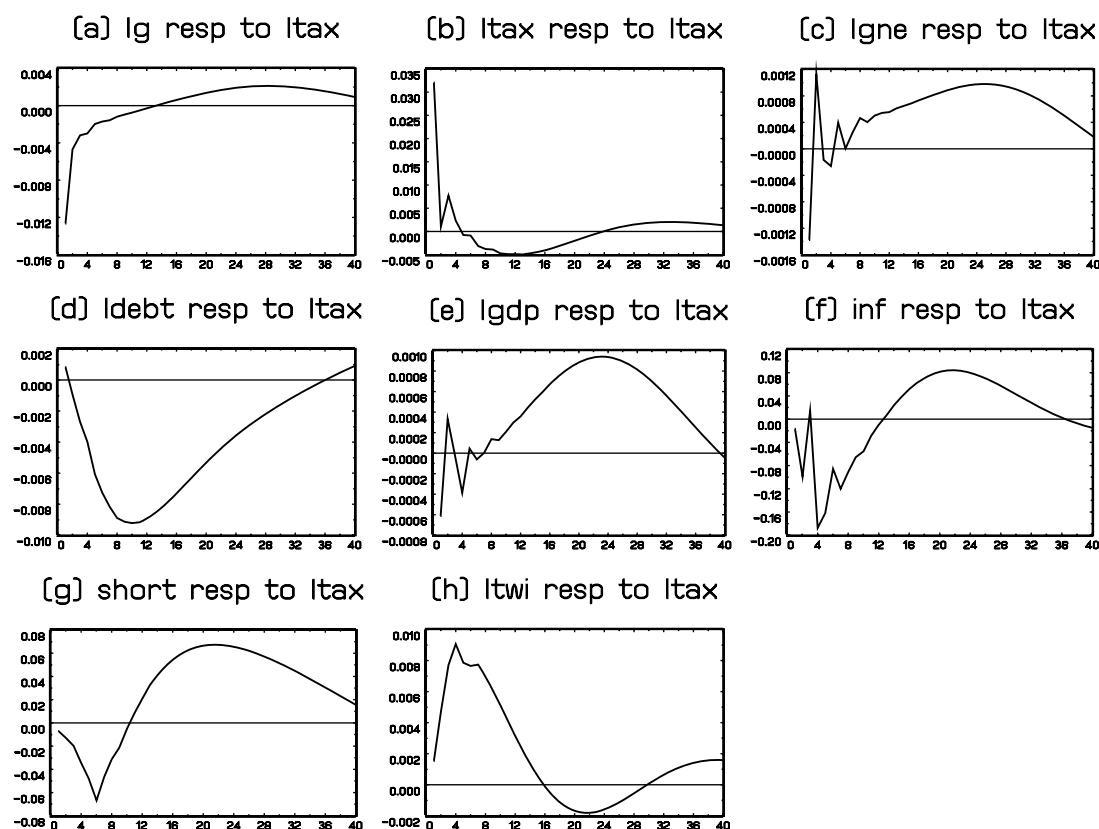
inflation and the short term interest rate (clearly linked through monetary policy). In the current model government expenditure shocks are initially inflationary, but in the US based studies of Chung and Leeper (2007), Mountford and Uhlig (2005) and most of the Favero and Giavazzi (2007) explorations they are deflationary. In these papers the interest rate declines in response to the government expenditure shock, although Mountford and Uhlig (2005) find an initial rise when the expenditure is delayed for a year (which becomes insignificant after the first quarter). In contrast, the results in Perotti (2002) across five different OECD countries confirm the US results, but find additionally that there are a number of instances of higher inflation and higher interest rates as a response to a government expenditure shock. There are clearly some issues remaining in terms of model performance in the interaction of the government expenditure shock and the price process in the economy, which have important policy implications.

The response in the debt to GDP ratio (panel (d)) to the government expenditure shock is for a decline in the first two years, which results from higher taxation collections – the increase in taxation revenue is greater than the initial government expenditure shock. This does suggest something of a Keynesian solution to growth through increased government expenditure which in light of post-war experience seems somewhat naïve and suggests scope for further refinements of our fiscal policy variables. In particular it seems important to restrict the taxation response to isolate the pure government expenditure effects.

The movement in the exchange rate in this, as in most of the scenarios explored here reflect the changes in the real interest rate relative to unchanging international real interest rates. Although not shown, here the path for the real interest rate has a similar profile to the exchange rate, with higher real rates associated with an appreciation of the New Zealand dollar (shown by a positive impulse response in panel (h)).

5.1.2. Shock to taxation

Figure 3: Impulse responses to a shock to taxation



The impulse responses for the taxation shock are shown in Figure 3. The taxation shock (panel (b)) is matched by a fall in government expenditure (panel (a)) consistent with the existing literature. Both GNE and GDP register an initial fall (panels (c) and (e)) representing the impact of the higher taxation collections, with inflation also falling (panel (f)). The lower output and inflation prompts a fall in the short term interest rate which prompts the economy back towards positive growth. The inflation response is again one where mixed results occur in the literature. Favero and Giavazzi (2007) similarly find that inflation falls in response to a taxation shock and interest rates respond with a fall, while Mountford and Uhlig (2005) find a rise in prices. In their alternative experiments, interest rates rise in the case where there is no delay in the implementation of the taxation shock, but fall when there is a 12 month delay. In both cases there is no recovery in the output variable to the taxation shock in their model. Perotti (2002) again finds that while his US results are consistent with these models, the outcomes for other countries differ, as they do here. The model presented here seems to suggest that the interaction of the fiscal and monetary policy shocks can facilitate a better growth outcome. However, this does not necessarily imply that

purposely coordinating monetary policy and fiscal policy in anticipation of these results would result in the same outcome, as looser monetary policy in the face of a taxation rise may simply be inflationary.

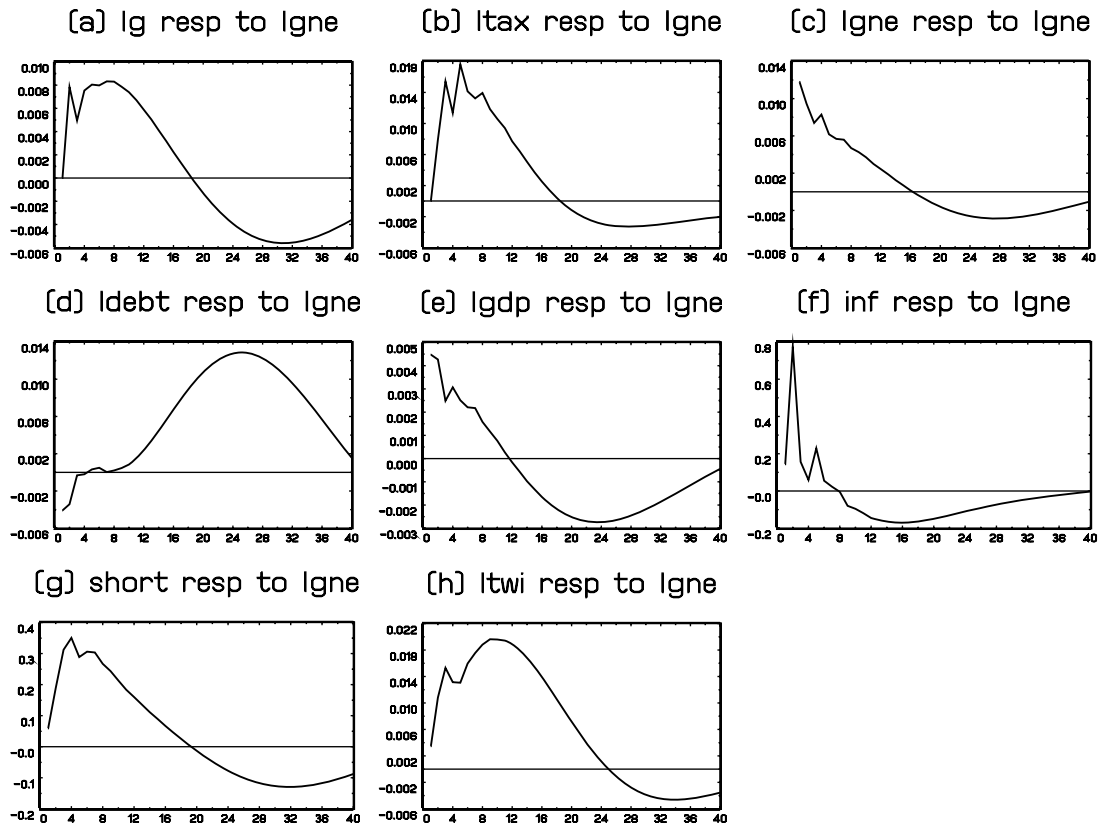
The debt outcome for this shock (panel (d)) represents an initial rise in the debt to GDP ratio, as the fall in output outstrips the difference between the growth in taxation and fall in government expenditure. By the third quarter, however, the reduced government expenditure and increased government revenue begins to result in a lower debt to GDP ratio, despite the recovery in GDP.

The exchange rate response (panel (h)) again represents the profile of the implied real interest rate in the system.

5.1.3. Shock to GNE

An increase in real domestic expenditure in the model leads to higher output (panel (e) of Figure 4), higher government expenditure (panel(a)), but still higher taxation revenue (panel (b)). Initially the growth of taxation revenue over government expenditure growth is sufficiently greater than the growth in GDP to reduce the debt to GDP ratio, however, after 2 years this ratio begins to grow again. This effect reflects the fact that higher inflation (panel (f)) has prompted a rise in interest rates (panel (g)), slowing the economy, with GDP growth slowing faster than any of domestic expenditure, taxation revenue or government expenditure. Government expenditure in this case has reacted in a non-discretionary manner to a domestic demand shock which has been calmed by monetary policy, and inadvertently led to an increase in the debt to GDP ratio. Such a scenario is not explored in other papers, but it would certainly be of use to consider in future work the more restricted case of disallowing government expenditure rises in association with this shock and explore the possibilities for the debt ratio and the impact on inflation.

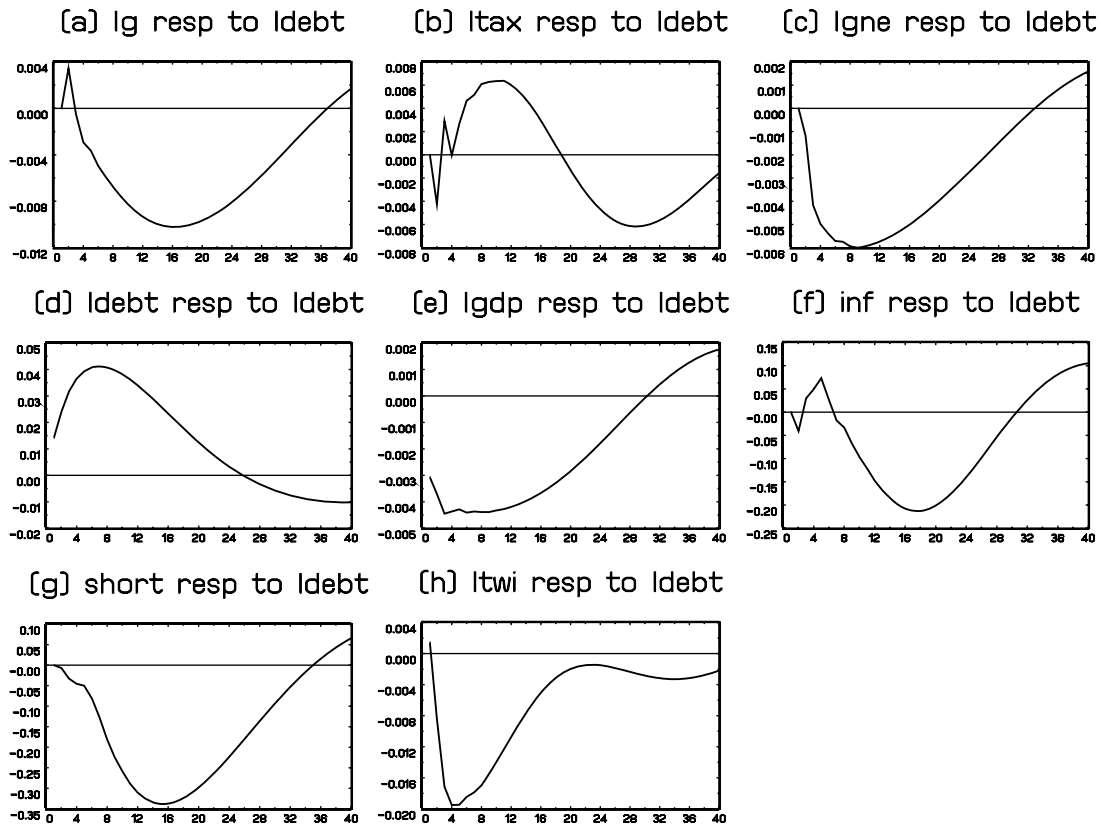
Figure 4: Impulse responses to a shock in GNE



5.1.4. Shock to the debt to GDP ratio

A shock to debt in this model is essentially a decision to allow the debt to GDP ratio to rise by some exogenous means. The immediate effect is an increase in taxation and decrease in government expenditure to bring the ratio back towards its initial value (see Figure 5). The initial fall in taxation is associated with the fall in GDP. By both increasing taxation and decreasing expenditure, domestic demand and output decrease (panels (c) and (e)). The fall in output of course exacerbates the debt to GDP ratio and leads to further increases in taxation and falls in government expenditure. Meanwhile, however, monetary policy has reacted to the poor economic outcome with lower interest rates (panel (g)) despite a small rise in inflation (panel (e)) which are most likely to be associated with higher import prices via the fall in the exchange rate (panel (h)). Eventually the debt to GDP ratio returns to its initial values.

Figure 5: Impulse responses to a shock in the debt to GDP ratio



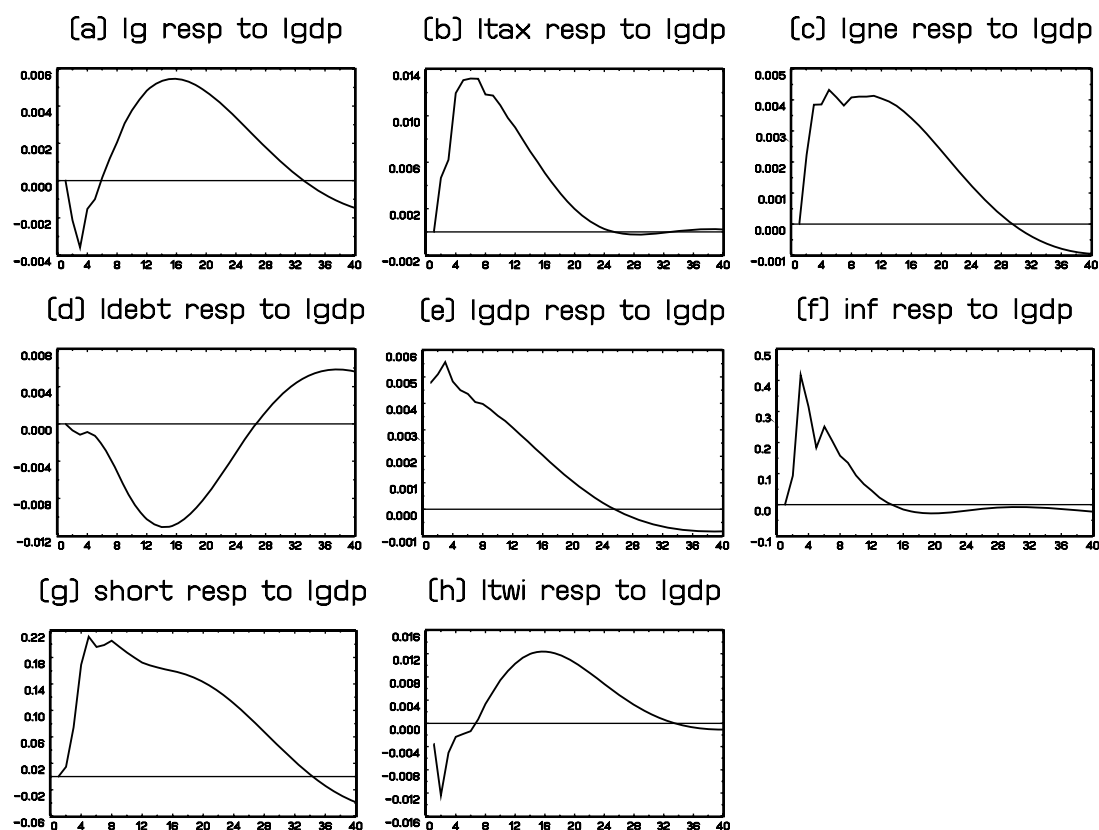
This particular analysis highlights the potential for monetary and fiscal policy to be acting in contrary directions. Forcing the economy to return to the initial debt to GDP ratio highlights that a primary focus on paying down the debt via fiscal policy may slow the economy sufficiently to worsen the problem. Here monetary policy is acting to improve output and eventually counters the fiscal problem.

The shock analysed here is not directly comparable to that in Hall and Rae (1998), who consider specifically a policy decision to permanently raise the debt to GDP ratio, and different means by which this could be achieved. Analysis of this scenario in the current model is one which will particularly benefit from the introduction of the permanent and temporary shock approach of Pagan and Pesaran (2007) as it will allow adjustment to a new permanently higher (or lower) debt to GDP ratio. Distinguishing between a temporary and permanent shock to the debt to GDP ratio is likely to be equivalently important to distinguishing between temporary and permanent shocks to imported inflation for monetary policy. Although Blanchard and

Perotti (2007) report little difference by allowing for cointegration between taxation and government expenditure they do not conduct analysis of debt in their system.

5.1.5. Shock to GDP

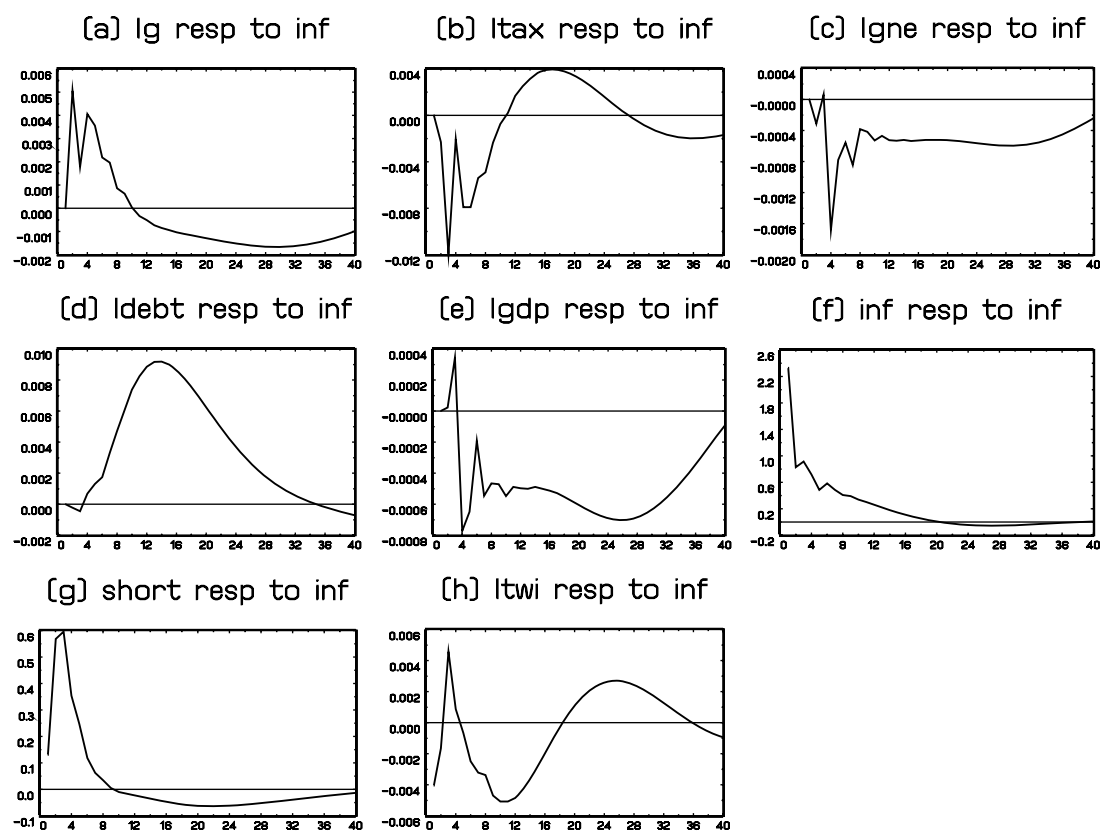
Figure 6: Impulse responses to a shock in GDP



A shock to domestic output has different implications to a shock to the domestic demand shock. It first results in a major increase in taxation revenue (panel (b) of Figure 6), with an initial decline in government expenditure (panel (c)), although government expenditure begins to rise again two years after the initial shock. The rise in government revenue over expenditure is sufficient to decrease the debt to GDP ratio (panel (d)). Domestic inflation rises in response to the improved activity (panel (f)) and monetary policy responds by tightening short term interest rates (panel (g)), although the real interest rate still falls, resulting in an initial decline in the exchange rate (panel (h)). The analysis here is entirely consistent with the business cycle shock analysed in Mountford and Uhlig (2005), unfortunately most other authors do not provide the impulses for an output shock for our comparison.

5.1.6. Shock to inflation

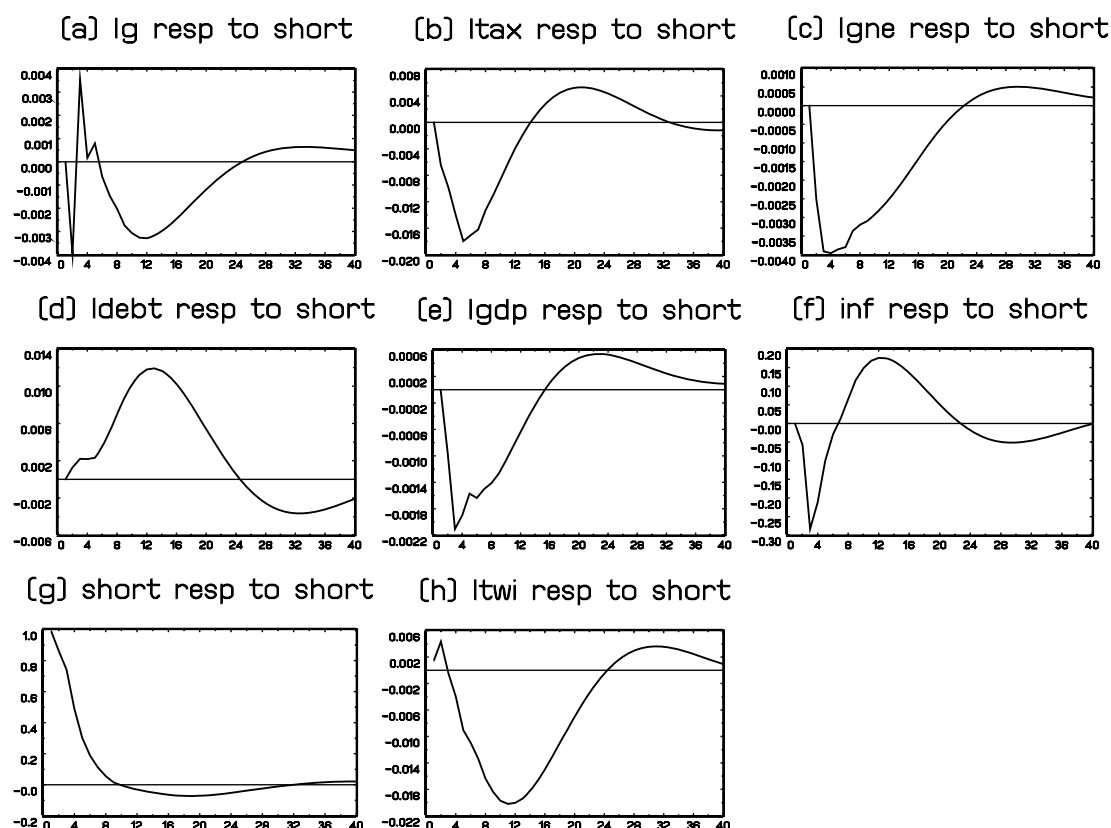
Figure 7: Impulse responses to a shock in inflation



Inflation shocks are notoriously difficult to characterise in small open economy SVAR models. Here higher inflation in Figure 7 results in the desired monetary policy response of higher interest rates (panel (g)) and after some delay falls in output and domestic demand, although there is some initial rise in GDP which is difficult to understand. Taxation revenue falls (panel (b)), in part due to higher inflation eroding the value of nominal receipts, and then as a result of falling output, real government expenditure rises (panel (a)). Clearly under these circumstances the debt to GDP ratio rises (panel (d)).

5.1.7. Shock to short term interest rates

Figure 8: Impulse responses to a shock in short term interest rates



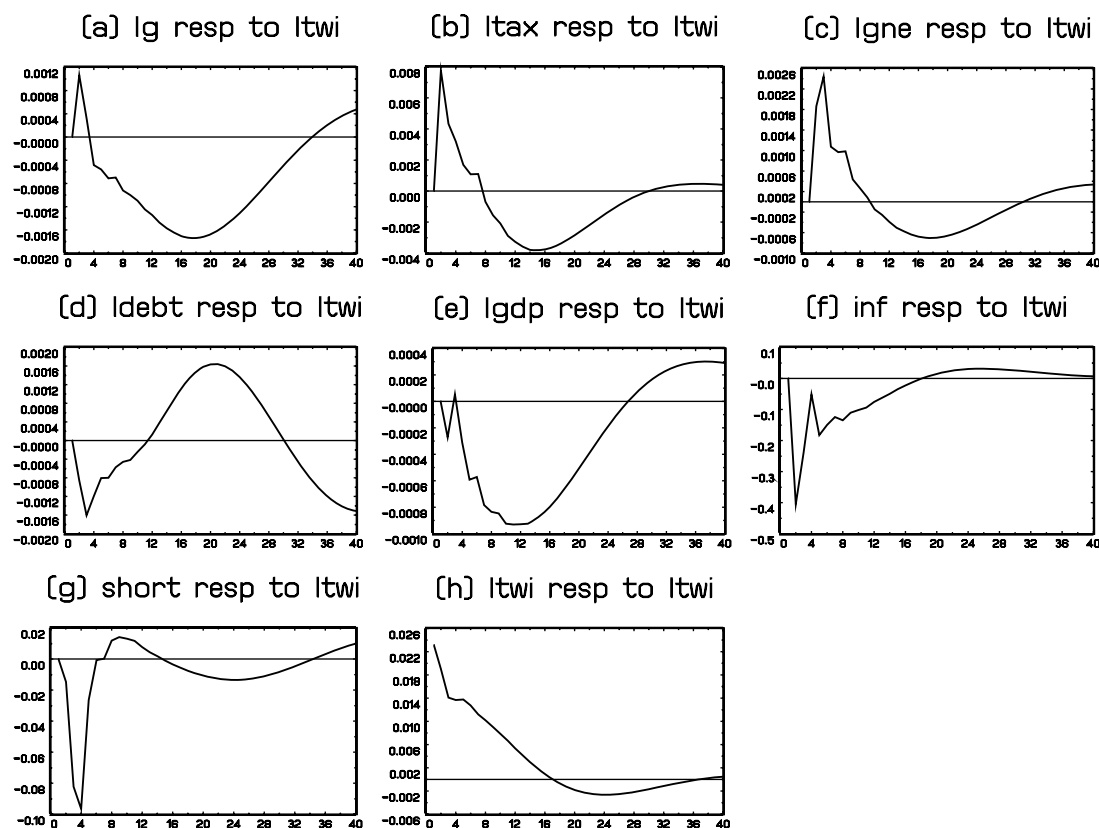
Shocks to short term interest rates in this model represent changes in monetary policy (although we are aware of the Rudebusch (1998) discussion on whether this is appropriate representation it remains the norm in the literature). The basic elements of this model behave as would be expected to a rise in the short term interest rate, with output and domestic demand and inflation falling (panels (c,e,f) of Figure 8), as in the Buckle et al (2007) SVAR for New Zealand. The relatively short horizon for which higher interest rates can effect a fall in inflation in New Zealand is common to the studies of that economy. The effects of the lower output are shown by the fall in taxation revenue. Government expenditure is a little difficult to interpret for the first year, first falling and then rising before settling to a negative impulse. The rise in the debt to GDP ratio (panel (d)), however, is expected with a fall in activity in the economy. Here the actions of monetary policy in slowing the economy result in higher debt to GDP due both to a drop in taxation revenue and a fall in output.

In this case, despite a rise in the domestic real interest rate for the first 2 years, the New Zealand dollar appreciates for only part of the first year and then depreciates,

presumably in line with the relatively lower activity in the economy and the higher debt.

5.1.8. Shock to the exchange rate

Figure 9: Impulse responses to a shock in the exchange rate



Orthogonal exchange rate shocks are notoriously difficult to interpret. A higher exchange rate does result in lower inflation, presumably associated with lower import prices, and is thus associated with a rise in GNE (panel (c) in Figure 9). The rise in domestic demand and simultaneous drop in domestic output (panel (e)) is consistent with a shift in domestic preferences to imported goods as a result of the rise in the exchange rate, as well as decreased demand for New Zealand exports. Interpreting monetary policy responses are difficult in this case, as the shock to the exchange rate here is known to be temporary, the monetary authorities should not respond to the import price component, but only the induced behaviour in the output, which accounts for the relatively small response to inflation and the relatively prolonged decline in output. However, the New Zealand experience also includes the MCI period in the 1990s when exchange rate changes were specifically taken into account in directing the stance of monetary policy. The debt to GDP ratio (panel (d)) falls in response to

the fall in GDP and rise in taxation revenue and then builds again as output falls. Although this is a difficult shock to conceptualize it does usefully illustrate the differences from a domestically and externally sourced inflation shock.

5.2. Fiscal Variable Shocks

This section presents the range of impulse responses drawn which satisfied the sign restriction identification criteria⁶ presented in Section 3.2, along with a corresponding histogram of thetas used to generate the impulse responses. It was from these that the impulse responses presented in the preceding section were drawn, based on the methodology of Fry and Pagan (2007). Some additional statistics on the success in selecting those draws from all the draws considered are also provided in Table 5.

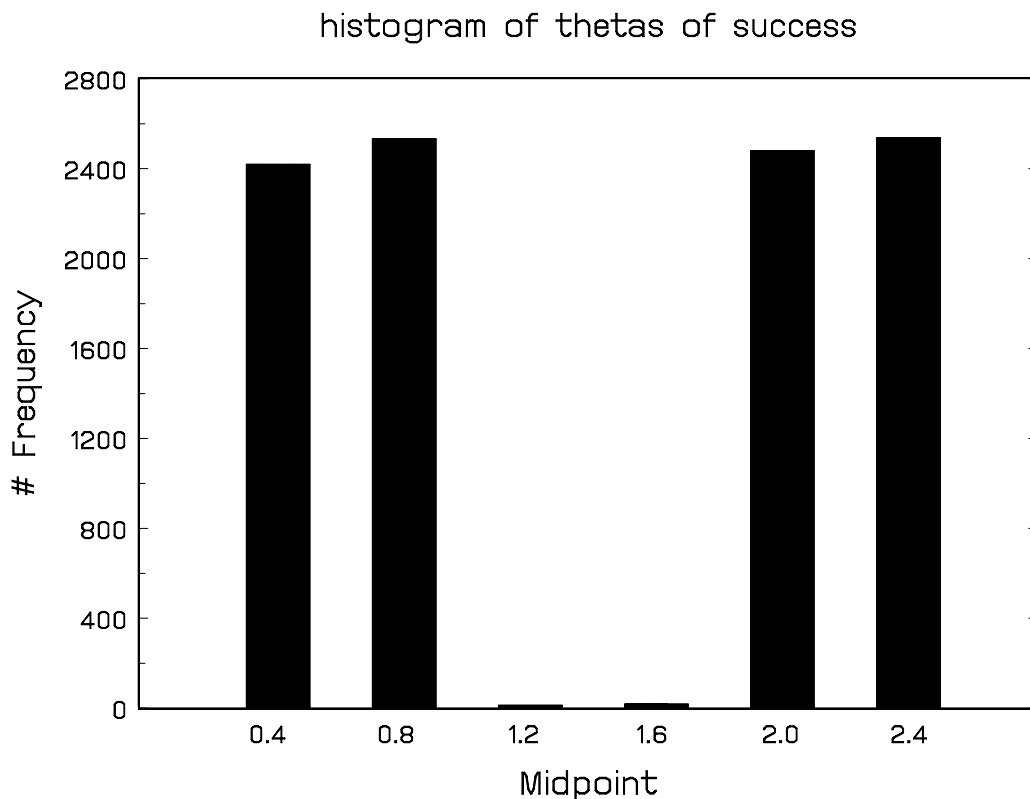
Figures 10 and 11 show that for the government expenditure shock, the range of the impulses considered is quite narrow, particularly in the early part of the impulse response functions. The impulse responses to the taxation shocks are more widely dispersed, although are still quite contained. This result provides a reasonable level of confidence that choosing the median impulse response function from this selection of impulses is reasonably likely to be a good approximation of the effects of the fiscal policy shocks. Figure 12 presents the histogram of the thetas generating the impulse responses whereby the sign restrictions are satisfied. In general, they are relatively clustered. The bimodality evident represents the symmetry that is generated by the possibility of both positive and negative shocks (which are then normalised to be positive for the purposes of the impulse response analysis).

⁶ A representative 1,000 draws are presented due to the size of the Figures generated and the capacity of the software program to accommodate them.

INS Fig 10

INS Fig 11

Figure 12: Distribution of the thetas used in generating the impulse responses.



The statistics in Table 5 also shed some light on the nature of the fiscal policy shocks. On average, the set of fiscal policy shocks are identified in less than every second draw. A total of 19,899 draws of theta for the Q matrix were made to generate the $d=10,000$ successful draws required. It appears that government expenditure shocks are more likely to be uncovered using the first criterion. 18,438 government expenditure shocks were uncovered in the first set of impulses ($\tau = 1$) and 18,374 were found in the second set of impulses ($\tau = 2$). In contrast, a taxation shock was found in just over 7,000 cases in the either set of impulses. The second level of criteria applied to non-unique cases (where both a government expenditure and a taxation shock are found in both a set of impulses τ) whereby the relative magnitudes of the response of the impulse response function for government expenditure and taxation are compared results in more taxation shocks being identified than government expenditure shocks.

The final criterion (applied in cases where there is non-uniqueness across the sets of impulses), results in 6,913 possible cases of duplicate government expenditure shocks,

Table 5: Statistics on the sign restriction draws

Statistics and Criteria	Value
Total number of successful draws	10,000
Total number of draws	19,899
First set of impulses ($\tau = 1$)	
Criteria 1	
Number of occurrences of a G shock	18,438
Number of occurrences of a T shock	7,946
Criteria 2 (implemented on non-unique results after criteria 1)	
Number of occurrences of a G and T shock in ($\tau = 1$) after criterion 1	7,946
Number of occurrences of a G shock $C_{lg,j}^1 > C_{lax,j}^1, \forall j$ after criterion 2	2,910
Number of occurrences of a T shock $C_{lax,j}^1 > C_{lg,j}^1, \forall j$ after criterion 2	5,036
Second set of impulses ($\tau = 2$)	
Criterion 1	
Number of occurrences of a G shock	18,374
Number of occurrences of a T shock	7,890
Criterion 2 (implemented on non-unique results after criterion 1)	
Number of occurrences of a G and T shock in ($\tau = 2$) after criterion 1	7,890
Number of occurrences of a G shock $C_{lg,j}^2 > C_{lax,j}^2, \forall j$ after criterion 2	2,926
Number of occurrences of a T shock $C_{lax,j}^2 > C_{lg,j}^2, \forall j$ after criterion 2	4,964
Both sets of impulses	
Criterion 3 (implemented on non-unique results after criteria 1 and 2)	
Number of occurrences of a G shock in both impulses $\tau = 1$, and $\tau = 2$	6,913
Number of occurrences of a T shock in both impulses $\tau = 1$, and $\tau = 2$	0
Final results	
G shock in impulse 1 ($\tau = 1$)	4,964
G shock in impulse 2 ($\tau = 2$)	5,036
T shock in impulse 1 ($\tau = 1$)	5,036
T shock in impulse 2 ($\tau = 2$)	4,964

and no case of duplicate taxation shocks. The application of the three criteria results in roughly a 50-50 split between the first set of impulse generated being a government expenditure shock and a taxation shock (leaving the same split for the second set of impulses).

5.3. Historical decompositions

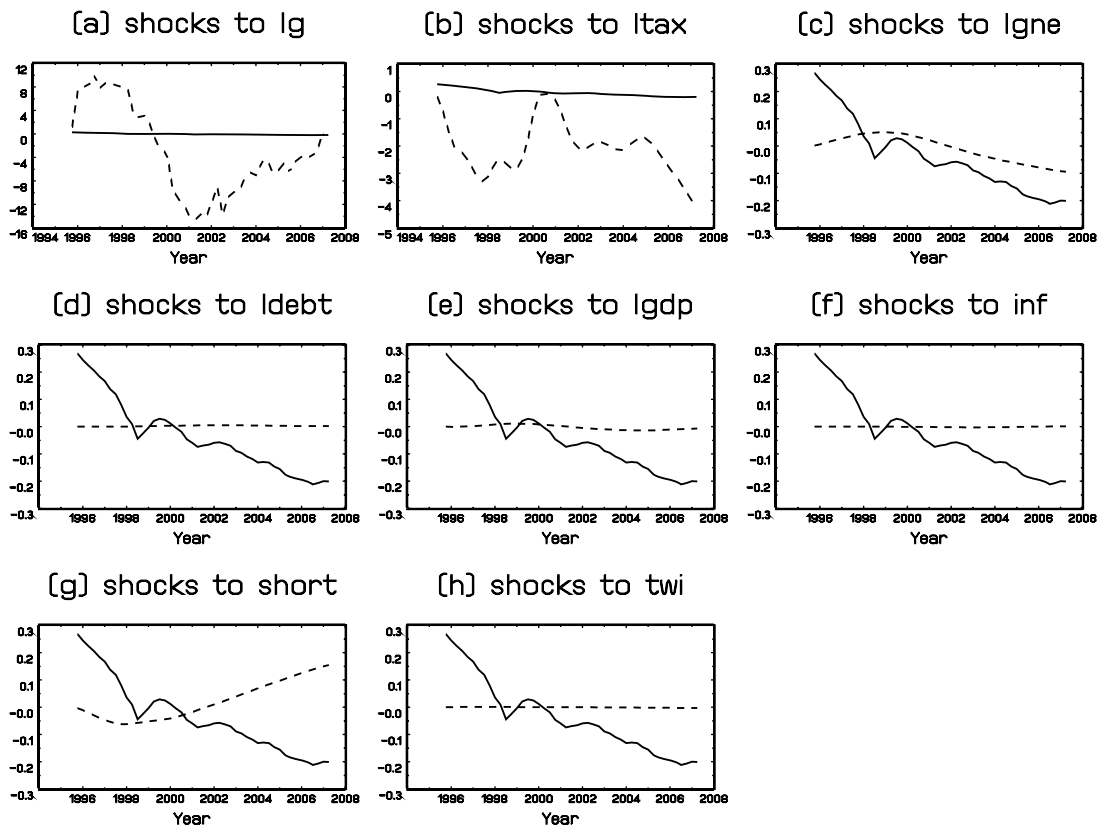
A further tool of analysis in this style of modelling is historical decompositions. These have taken a number of forms over the recent periods. Fundamentally they recognise that the vector moving average representation of the system means that at any point in the sample time each variable in the system can be written as a weighted sum of the structural errors in the system ('the shocks'). Thus it is possible to consider the contribution of each 'shock' to the composition of the variable of interest. In Sims (1992), Dungey and Pagan (2000) and Buckle et al (2007) for example analysis of this kind is presented. Another form of this decomposition is to isolate the shocks which deviate from the projection of the system based on the overall estimation of the system. In this case it is simply the 'excess' shocks, relative to the behaviour of the system over the sample period, which are analysed. Analysis of this type occurs in Rapach (2001), Dungey, Fry and Martin (2004) and Peersman (2005). Here we present this latter form of decomposition. For quite a number of the variables analysed the shock components are not substantially different from the projection of the system, the analysis highlights the case where the shocks are more substantially distant from the system. The following focuses on a number of the more interesting of these decompositions, considering the period from September 1995 onwards, when the debt to GDP ratio is declining in line with the requirements of the Fiscal Responsibility Act of 1994. The full debt series was shown in Figure 1. It is of some interest to understand the means by which the change in debt profile evolved.

5.3.1. Decomposition of the Debt to GDP ratio

Figure 13 gives the historical decomposition of the debt to GDP variable. The debt to GDP variable itself is given by the solid line in each panel of the Figure. This is more evident in some panels than others – for example panel (c) clearly gives the path of the variable. In panels such as (a) it is barely evident as it is dwarfed by the shocks.

The results show that the profile of the debt to GDP ratio which is generally declining over the period, owes most to taxation and government expenditure (panels (a) and (b)), as would be hoped. In the initial period of the decline in the debt to GDP ratio, government expenditure is still acting to increase the ratio, while taxation is not. The adjustment in taxation draws some parallels with Chung and Leeper's finding that

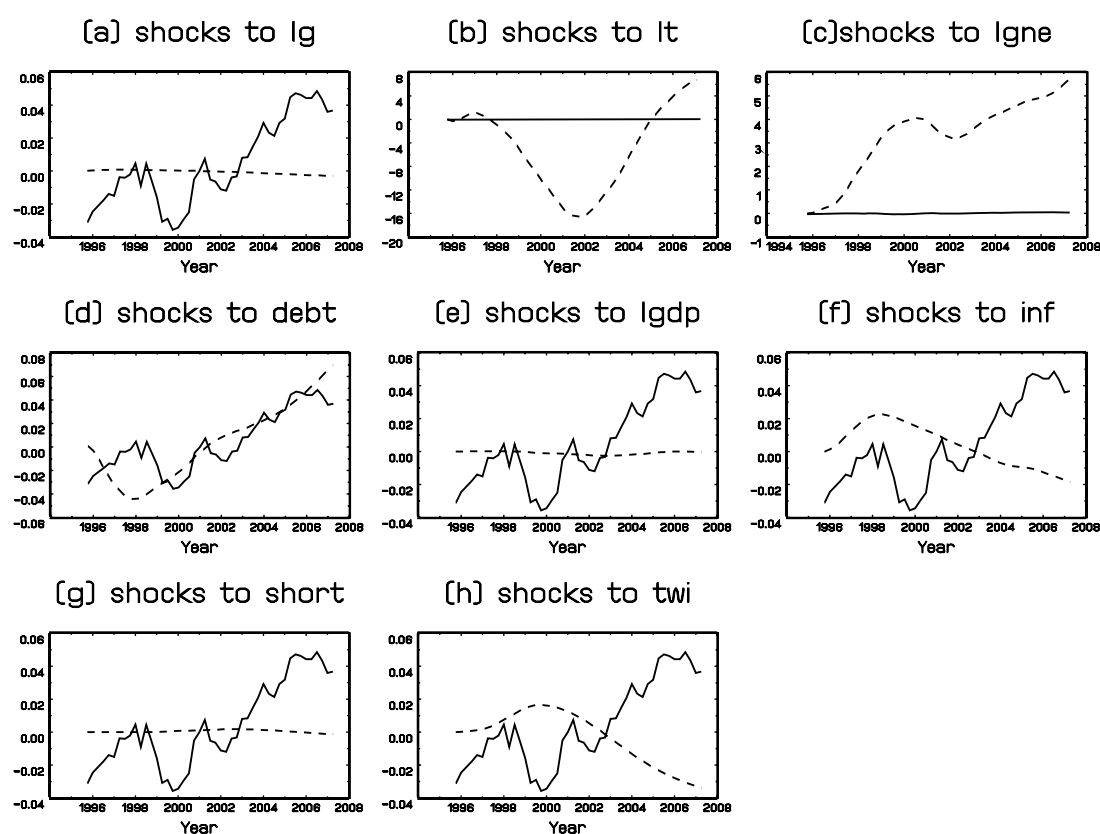
Figure 13: Historical Decomposition of the debt to GDP ratio.



debt can adjust relatively quickly to tax shocks compared with expenditure shocks. However, from 1999 onwards, the reductions in government expenditure are substantial contributors to the reduction in the ratio. Domestic expenditure shocks through GNE also have a role to play (panel (c)), while short term interest rates initially aided in the reduction of the debt to GDP ratio, since 2002 they have provided a countervailing force by acting to increase the debt to GDP ratio (as shown in panel (g)).

Over the same period as the decomposition for the debt variable discussed above, the profile of GDP was one of decline in the late 1990s and growth post the new millennium, this is evident in the solid line in each panel of Figure 14, see particularly panels (f-h). In some of the panels in Figure 14 the size of the shocks obscures the shape of the GDP variable. This is particularly the case for GNE (panel (c)) and shocks to taxation (panel (b)). Domestic expenditure shocks clearly contributed to increasing output over the period under examination from 1995, relating also to the increased immigration effects noted by RBNZ (2007). Taxation, however, tended to act to decrease output, consistent with the analysis in Figure 13, where taxation acted

Figure 14: Historical Decomposition of GDP.



to reduce the debt to GDP ratio. It is also possible to see that the results of the reduction in the debt to GDP ratio had a positive (although small) impact on output itself (panel (d)). There were positive feedback effects for the economy. Monetary policy effects via the short term interest rate in Figure (g) were relatively small, consistent with much of the literature on their contribution; recalling of course that this is policy effects which are not accounted for by the projection of the model in the period.

6. The interaction of monetary and fiscal policy in the model

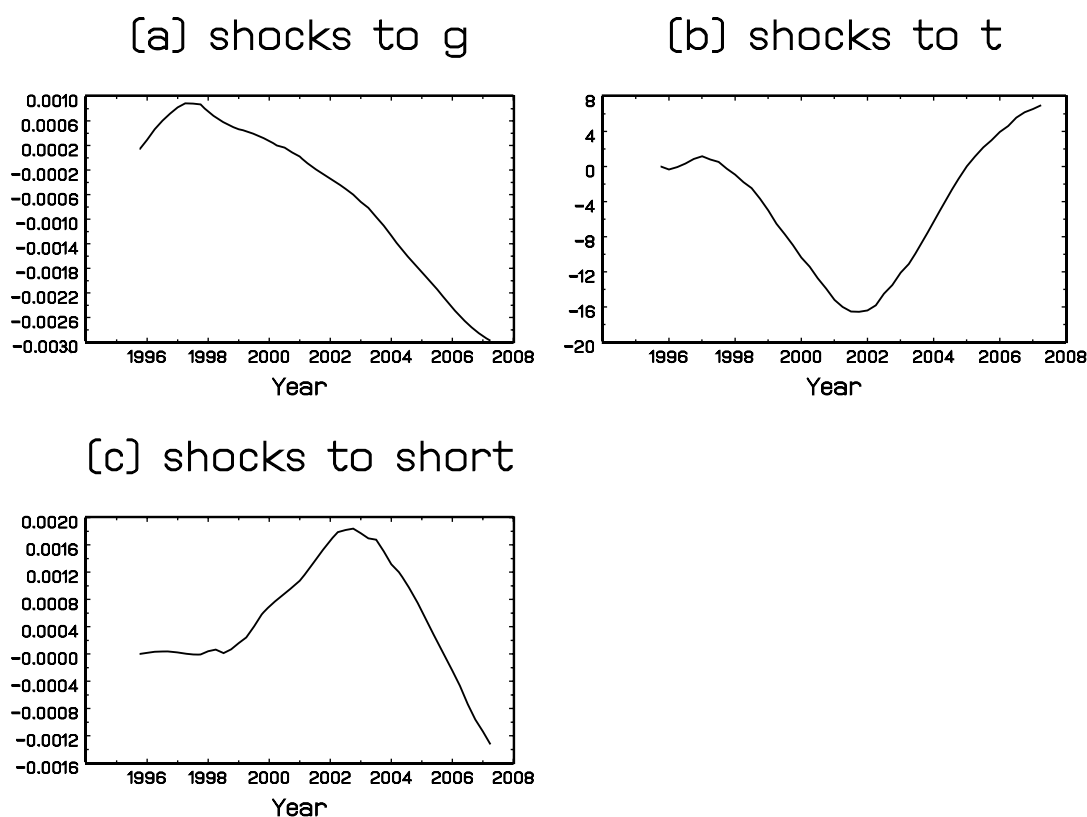
In the impulse responses and historical decompositions reported above there are a number of interactions between fiscal and monetary policy shocks. In light of the ongoing Federal Parliament review of the future of monetary policy, which includes in its terms of reference interactions between monetary policy and fiscal policy it seems timely to draw out the models implications for the New Zealand.

As already noted in Section 5 there is disagreement in the empirical literature about the effects of expansionary fiscal policy on inflation and hence monetary policy. In

many US studies government expenditure shocks are associated with lower inflation. Here, as in some of the cases studied in Perotti (2002), expansionary government expenditure is inflationary. As shown in Figure 2 (panel (g)) this prompts an increase in short term interest rates which acts to dampen inflation and output in the domestic economy. Likewise with a contractionary increase in taxation revenue, shown in Figure 3, the fall in inflation is countered by a fall in short term interest rates and subsequent economic recovery. There is a definite interplay of policy effects drawn out in the model. There are some interesting asymmetries, however, due to the source of the shock. The government expenditure shock is much smaller than the taxation revenue shock shown in the two Figures, around half the size. However, the increase in inflation from the government expenditure shock is somewhat greater than the deflation caused by the taxation shock. Further, the rise in the cash rate to reduce inflation in the case of the government expenditure shock is almost twice the fall in the cash rate used to counter the deflationary effects of the taxation shock. Consistent with existing literature fiscal policy through government expenditure shocks produces effects which are more difficult to counter, see for example Chung and Leeper (2007).

Consider now the case of cash rate shocks as an indicator of monetary policy. Here a rise in the cash rate reduces inflation and slows the economy, reducing taxation revenue and resulting in an increase in the debt to GDP ratio. Government expenditure reduces as part of the mechanism to return the debt ratio to prudent levels. The interactions here suggest also that there are feedback effects from monetary policy via fiscal policy due especially to consequences for the debt to GDP ratio and desires to keep that indicator stable in the current model. In the next stage of the model it will be possible to analyse the potential for allowing a permanent effect on the debt to GDP ratio as a result of these types of shock, which should clarify the options available in understanding the interaction between monetary and fiscal policy.

Figure 15: Historical decomposition of GDP, contributions of fiscal and monetary policy variables



In the RBNZ (2007) submission to the review of the future of monetary policy implementation the RBNZ suggest that in the last few years of the sample period shown here fiscal expenditure has been stimulatory (p.14 of their submission) and fiscal policy has contributed to cyclical fluctuations. This statement is now examined in light of the model results reported above. Figure 15 is a subset of Figure 14 and shows simply the contributions in the historical decomposition of GDP of the shocks to government expenditure, taxation and the short term interest rate, that is the two fiscal policy variables and the short term interest rate representing monetary policy. The Figures suggest that for the period from 2000 to 2005 both types of fiscal shock were contractionary, but that since then while government expenditure has not contributed to output pressures, taxation shocks have. Note importantly the difference in scales of the effects, with the government expenditure effects being very small. Interestingly, panel (c) of Figure 15 shows that monetary policy shocks have been stimulatory from September 1997 to June 2005. Note that the scale of the effects of the interest rate shocks is such that the contribution is smaller than that of government

expenditure shocks. There are two caveats to this analysis. The first is that the analysis may change with a different detrending process by which the output is measured. The second, is that these are shocks away from projections of the model, so that the absolute statement of the RBNZ may be consistent with the behaviour of the model projection.

7. Conclusions and plans for future work

The paper has presented progress so far on our aim of incorporating fiscal and monetary policy shocks into a VAR model with fiscal policy identified using sign restrictions. The next major step is the incorporation of the Pagan and Pesaran (2007) techniques to take advantage of the cointegrating relationships which exist in the system and allow distinction of transitory and permanent shocks. In addition, we intend to explore extending the scope of the variables in the model; particularly to include asset prices in the form of long bond rates, housing prices and equity markets. The inclusion of such variables would allow us to consider the effects of fiscal policy on private investment, as in Mountford and Uhlig (2005). Long bond rates are clearly important in their relationship to debt markets, efforts are constrained somewhat in that New Zealand data exists only from 1985, further shortening our sample period. Housing price inflation has been a major issue for New Zealand, as with many other countries in the last decade, and raises a number of troublesome issues for monetary policy – other than the standard asset price inflation issues commonly discussed Bowden (2006) raises the possibility that the preponderance of fixed rate mortgages in New Zealand effectively drives monetary policy effects to the longer end of the yield curve. Additionally, Buckle et al (2007) have demonstrated the importance of import and export prices in their model, see also Wells and Evans (1985). It will be of particular interest to explore the enrichment of the current results with these extensions.

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Appendix 1: Data Definitions

The sample period begins in 1982Q2 and extends to 2006Q4; all data were provided by the NZ Treasury.

ENDOGENOUS VARIABLES:

Exchange rate: Logged nominal trade weighted index for New Zealand, average of 11 am observations from RBNZ (RTWI11am).

Government debt: Log of gross sovereign-issued debt issued including stock, consistent with the New Zealand's Government's measure of its debt objective. Quarterly data is interpolated from the annual Figures. Until 1989 the fiscal year ended with March quarter each year, thereafter in June quarter, this change has been accounted for in interpolations. – More frequent data is available from 1994 and we are looking into other measures of debt.

Gross domestic product: Logged New Zealand Real GDP(P) s.a. \$NZ m., chain-volume expressed in 1995/96 prices. The production based measure of GDP (GDP(P)) is preferred for quarter-on-quarter and annual changes by The New Zealand Treasury as the expenditure based series displays more volatility.⁷ The official Statistics New Zealand data for GDP(P) is used from 1983Q1. Prior to 1983Q1 the series is backdated as was used in Buckle et al (2007).

Government expenditure: The logged sum of real government consumption and real government investment.

Government consumption is central government consumption s.a. \$NZm, chain volume series expressed in 1995/1996 prices.

Government investment is s.a. \$NZ m., chain volume series expressed in 1995/1996 prices. The purchase of frigates in 1997 and 1998 are excluded from both the expenditure and taxation (GST) variables; see also Claus et al (2006). The series is also purged of investment by state owned enterprises.

⁷As discussed in correspondence between the authors and The Treasury.

Gross national expenditure: Logged real GNE s.a. \$NZ m., chain-volume expressed in 1995/96 prices. Data prior to 1983Q1 is backdated as was used in Buckle et al (2007).

Inflation: Annualised quarterly rate calculated from the log difference of the New Zealand CPI - All groups, multiplied by 400.

Short term interest rate: New Zealand nominal 90 day bank bill yield, average 11 am rates.

Taxation: The log of real taxation minus real transfers. The series is deflated by the GDP(E) implicit price deflator s.a. based at 1995/1996=100.

Nominal taxation is total direct plus indirect taxation with intra-government GST removed, s.a. \$NZ m.

Transfers are s.a. \$NZ m.

EXOGENOUS VARIABLES:

Foreign output: logged real foreign output index from New Zealand Treasury, 2000Q1=100 made up of industrial output indices weighted by export value share. Until 1983Q1, the weights are a 4 quarter moving average of nominal exports. From 1983:2 onwards the weights are a 2 year moving average. Component countries are: Australia, Hong Kong, Japan, Germany, US, UK, Taiwan and South Korea.

Foreign interest rate: Nominal 90 day interest rate as used in Buckle et al (2007), nominal GDP weighted sum of US, Japanese, German and Australian interest rates, weights change with GDP each quarter.

Climate: Number of days of soil moisture deficit recorded in each quarter, as measured by National Institute of Water and Atmospheric Research. The variable has been adjusted by removing from each quarterly value the long-run average for that quarter, and is the same as that used in Buckle et al (2007):