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## The Effects of Fiscal Policy in New Zealand: Evidence from a VAR Model with Debt Constraints

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## Abstract

This paper investigates the macroeconomic effects of fiscal policy in New Zealand using a structural Vector Autoregression (SVAR) model. The model is the five-variable structural vector autoregression (SVAR) framework proposed by Blanchard and Perotti (2005), further augmented to allow for the possibility that taxes, spending and interest rates might respond to the level of the debt over time. We examine the dynamic responses of output, inflation and the interest rate to changes in government spending and revenues and analyse the contribution of shocks to New Zealand's business cycle for the period 1983:1-2010:2. We find that the effects of government expenditure shocks in New Zealand appear to be positive but small in the short-run at the cost of higher interest rates and lower output in the medium to long-run. The sign of the effects of tax policy changes are less clear cut, but again the effects on GDP appear similarly modest. Past fiscal policy is analysed through a historical decomposition of the shocks in the model. This suggests that discretionary fiscal policy has had a generally pro-cyclical impact on GDP over the last fifteen years, and a material impact on the real long-term interest rate. A fiscal expansion has a positive but limited impact on inflation.

## Keywords

Fiscal policy, business cycle fluctuations, vector autoregression, debt feedback

## JEL Classification

C32, E32, E62

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# The effects of fiscal policy in New Zealand: Evidence from a VAR model with debt constraints<sup>1</sup>

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This paper investigates the macroeconomic effects of fiscal policy in New Zealand using a structural Vector Autoregression (SVAR) model. The model is the five-variable structural vector autoregression (SVAR) framework proposed by Blanchard and Perotti (2005), further augmented to allow for the possibility that taxes, spending and interest rates might respond to the level of the debt over time. We examine the dynamic responses of output, inflation and the interest rate to changes in government spending and revenues and analyse the contribution of shocks to New Zealand's business cycle for the period 1983:1-2010:2. We find that the effects of government expenditure shocks in New Zealand appear to be positive but small in the short-run at the cost of higher interest rates and lower output in the medium to long-run. The sign of the effects of tax policy changes are less clear cut, but again the effects on GDP appear similarly modest. Past fiscal policy is analysed through a historical decomposition of the shocks in the model. This suggests that discretionary fiscal policy has had a generally procyclical impact on GDP over the last fifteen years, and a material impact on the real long-term interest rate. A fiscal expansion has a positive but limited impact on inflation.

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**JEL CLASSIFICATION** C32 - Time-series models  
E32 - Business fluctuations; cycles  
E62 - Fiscal policy; public expenditures, investment, and  
finance;  
taxation

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## **INTRODUCTION**

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The long-standing debate among economists about the effectiveness of fiscal policy as a counter-cyclical tool has spawned a large literature about the size of fiscal multipliers. Recent interest has been driven by the fiscal stimulus programs put in place in many countries as a response to the global financial crisis, and the fiscal consolidations that have followed. The arguments in favour of activist fiscal policy emphasise the fact that fiscal policy may be particularly effective during recessions when monetary policy can no longer be used effectively to increase aggregate demand (Eggerston and Krugman, 2012; Auerbach and Gorodnichenko, 2012). The opponents of this view, on the other hand, argue that the stabilisation effect is unlikely to materialise as it can be undercut by the expectations of rational agents who observe the government's policy process (e.g., Barro, 2009).

Theoretical considerations aside, the cross-country evidence from previous empirical studies indicate a lack of consensus on the likely effects of fiscal policy shocks on the economy (see Caprioli and Momigliano, 2011 for a review). A major challenge in this regard is to be able to correctly identify the changes in current policy variables that are attributable to actual policies, rather than to endogenous responses to economic conditions. Possible delays in legislation, the lags in actual implementation of the policies and the time to recognise that there is actually a need for stabilisation in the first place are also amongst the problems encountered in empirical analysis of fiscal policy.

The focus of this paper is the estimation of a five-equation structural VAR (SVAR) model for New Zealand to investigate the effects of unexpected discretionary fiscal policies on New Zealand's economic activity. The paper builds on the previous work by Claus et al. (2006) who examine the effects of fiscal policy on New Zealand GDP using the popular 3-equation framework proposed by Blanchard and Perotti (2002).

There has been an increase over the last decade in the number of studies that use the structural VAR approach to investigate the effects of fiscal policy shocks on macroeconomic variables (Blanchard and Perotti, 2002; Perotti, 2005; Giordano et al., 2007; Claus et al., 2006; Caldara and Kamps, 2008; Fatas and Mihov, 2001). Structural interpretations of VAR models require additional identifying assumptions that must be motivated based on institutional knowledge or economic theory. There have been several suggestions to improve the usefulness of these models for fiscal policy analysis.

A notable suggestion in this respect is given by Favero and Giavazzi (2007), hereafter FG, who argue that the majority of fiscal VAR studies rely on potentially misspecified models as they fail to include any feedback from the level of debt, a stock variable, to the variables that enter the government's intertemporal budget constraint (hereafter IGBC). Using US data covering the period 1960:1-2006:2, they show that the misspecification arises since a fiscal shock eventually puts a constraint on the path of taxes and spending in the future that the VAR is unable to respond to. They stress that the bias will be particularly evident in periods when there is a strong relationship between the government's balances and the debt-to-GDP ratio. Similar concerns are also highlighted by Chung and Leeper (2007).

On a more general and technical note, Pagan et al. (2008) emphasise the possible pitfalls of excluding a stock variable in a VAR specification. They show that such an omission introduces non-invertible moving average terms into the model, meaning that the structural VAR (SVAR) representation of the system fails to exist.

Following these considerations, we extend the model used in Claus et al. (2006) along several directions. Using the methodology outlined in FG, we allow for the possibility that taxes, spending and interest rates might respond to the level of debt over time. This is implemented by enriching the model dynamics to include two additional variables: the long-term interest rates and inflation as well as including the government's intertemporal budget constraint as an identity. Additionally, we extend the dataset up to the second quarter of 2010 to allow for a more up-to-date analysis of the effects of fiscal policy on the New Zealand economy.

The results show that the fiscal multipliers from changes in government spending in New Zealand appear to be positive but small in the short-run. The impact multiplier is estimated to be about 0.26 which implies that a 1 percent of GDP change to government expenditure increases GDP by 0.26 percent. The sign of the short-run effects of tax changes is less clear cut, consistent with the puzzle outlined in Fielding et al. (2011), but the magnitude of the effect on GDP is similarly modest. Tax increases are found to drag economic activity in the medium term. The responses of output to both types of fiscal shocks are largely insignificant. The results show that a fiscal expansion leads to a statistically significant increase in the long-term interest rate which results in crowding-out in the medium and long-term. The corresponding effect on inflation is modest which implicitly implies that monetary policy moderates the inflationary effects.

Past fiscal policy is analysed through a historical decomposition of the shocks in the model. This suggests that discretionary fiscal policy has had a generally pro-cyclical impact on GDP over 1998 to 2010, and a material impact on long-term interest rates.

The remainder of the paper is organised as follows. Section 2 discusses the rationale for including the inter-temporal government budget constraint. Section 3 describes the model specification and the data descriptions. Section 4 reports the dynamic effects of shocks to fiscal and other macroeconomic variables in the model. Section 5 analyses the effects of fiscal policy on New Zealand's business cycle. Section 6 reports the results of various sensitivity analyses conducted for checking the robustness of the model and Section 7 concludes.

## THE RATIONALE FOR INCLUDING THE IGBC

This section discusses the pitfalls of excluding the level of the debt variable in a standard VAR framework. Following the exposition in FG, we show why a VAR that excludes the level of the debt is likely to be misspecified and might eventually imply explosive paths for the debt-to-GDP ratio.

Consider that the reduced-form fiscal VAR model with  $k$  lags is described by the system

$$Y_t = \sum_{i=1}^k C_i Y_{t-i} + u_t \quad (1)$$

where  $Y_t = (G_t, T_t, y_t, \Delta p_t, i_t)$  is a five-dimensional vector that includes government spending, taxes, output, inflation and interest rates respectively,  $C_i$  is a coefficient matrix of size  $5 \times 5$  and  $u_t$  is the vector of the reduced form residuals representing unexpected movements in the components of  $Y_t$ .

Excluding the level of the debt-to-GDP ratio,  $d_t$ , in (1) would imply that this variable is instead contained in  $u_t$  along with other exogenous shocks. However, this is problematic since the level of debt and the variables in  $Y_t$  such as government spending, taxes and interest rates are inherently tied via the government's budget constraint. For example, in cases when the rate of growth of the economy is not equal to the average cost of financing the debt, a feedback from the level of debt to fiscal variables is inevitable. Furthermore, interest rates may be affected by changes in the debt dynamics via changes to the risk premium.

The resulting correlation between the error terms and the dependent variables constitutes a violation of a basic assumption of OLS estimation; namely that the regressors and error terms should be uncorrelated. This, in turn, will result in biased estimates of the  $C_i$  coefficients.

Including the level of the debt ratio in (1) alone, on the other hand, is not sufficient and the evolution of the debt dynamics ( $d_t$ ) in relation to the variables in  $Y_t$  should also be included as an identity;

$$d_t = \frac{1+i_t}{(1+\Delta p_t)(1+\Delta y_t)} d_{t-1} + \frac{\exp(G_t) - \exp(T_t)}{\exp(y_t)} \quad (2)$$

where  $i_t$  is the nominal interest rate,  $\Delta p_t$  is inflation,  $\Delta y_t$  is real GDP growth and  $G_t$  and  $T_t$  are the logs of government expenditure (excluding interest payments) and government revenues (net of transfers) respectively. Equation 2 shows that the evolution of debt-to-GDP ratio depends on two sets of factors. The first one represents the previous debt level multiplied by the ratio of the real interest rate  $\left(\frac{1+i_t}{1+\Delta p_t}\right)$  and the inverse of the growth rate  $\left(\frac{1}{1+\Delta y_t}\right)$ . The second part is the primary deficit as a ratio of GDP. The exponentials are used as these variables are expressed in logarithms. The implication of the debt identity is that when real interest rates are higher than the growth rate, a primary surplus is needed to keep the debt to GDP ratio constant (see Blanchard et al., 1990 for details). The structural form of the system to be estimated is therefore:

$$AY_t = c_1 Y_{t-1} + \dots + c_p Y_{t-p} + \gamma_1' d_{t-1} + \dots + \gamma_p' d_{t-p} + B e_t \quad (3)$$

where matrix  $A$  describes the contemporaneous relationships among the variables, the non-zero off-diagonal elements of  $B$  allow some shocks to affect more than one endogenous variable in the system and  $p$  denotes the number of lags used in the SVAR. The reduced form representation can then be obtained by multiplying both sides of (3) by  $A^{-1}$ :

$$A^{-1}AY_t = A^{-1}c_1Y_{t-1} + \dots + A^{-1}c_pY_{t-p} + A^{-1}\gamma_1d_{t-1} + \dots + A^{-1}\gamma_pd_{t-p} + A^{-1}Be_t$$

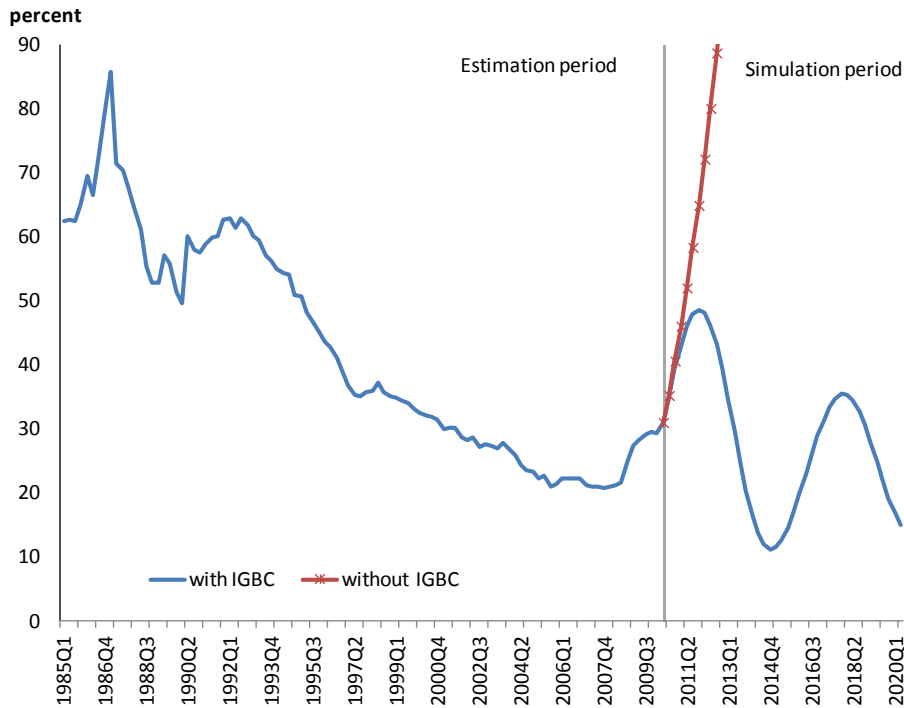
$$Y_t = C_iY_{t-1} + \dots + C_pY_{t-p} + \tilde{\gamma}_1d_{t-1} + \dots + \tilde{\gamma}_pd_{t-p} + u_t$$

(4)

Where  $C_i = A^{-1}c_i$ ,  $C_p = A^{-1}c_p$ ,  $\tilde{\gamma}_1 = A^{-1}\gamma_1$ ,  $\tilde{\gamma}_p = A^{-1}\gamma_p$ ,  $u_t = A^{-1}Be_t$

The presence of  $d_{t-i}$  will amplify the dynamic effect of fiscal shocks and the impulse response calculated from (1) and (2) as the system will diverge from those calculated when such feedback is omitted. The degree of this divergence, on the other hand, will be dependent on the strength of the feedback from debt to macroeconomic variables. FG finds that this feedback plays an important role in the case of US. We find that this feedback is relatively less important for New Zealand given its relatively low debt-to-GDP ratio. Another implication of excluding the debt ratio in (1) is that simulated values for fiscal variables such as government spending and tax revenues from such a system might imply incredible paths for the debt-to-GDP ratio. As an example, we conduct an empirical exercise using New Zealand data, similar to the one reported in FG for the US case. Initially, we estimate the five-variable VAR defined in (1) for the period 1986:1-2010:4. Then, we simulate data for each variable for 80 quarters and calculate the implied debt-to-GDP ratio using (2). The results are presented in Figure 1. It can be seen that the VAR without the debt feedback produces an explosive path for the debt-to-GDP ratio. In such cases, it is likely that the impulse responses calculated from the system will not be reliable (i.e. calculated along implausible paths for the debt ratio). On the other hand, imposing the feedback and linking the variables that constitute the IGBC by the identity (2) creates a relatively more stable debt-to-GDP profile. It is important to note that the explosive behaviour is heavily dependent on the corresponding values of the fiscal variables at the starting point of the simulation.

**Figure 1: Actual and simulated debt-to-GDP ratios (with and without feedbacks)**



Source: Authors' calculations

## MODEL AND DATA

The model is adopted from Perotti (2005) which uses a five-variable VAR comprising government spending, taxes net of transfers, output, interest rates and inflation. The debt equation is added to this system in a deterministic way (i.e. as an identity). The identification of structural shocks in this approach relies on institutional information about tax and transfer systems and on the existence of decision lags in fiscal policy.

The reduced form residuals  $u_t$  in (3) are correlated and therefore not purely exogenous. The problem then is to take the observed values of the reduced form residuals,  $u_t$ s, and to restrict the system so as to achieve identification and recover the uncorrelated structural shocks. The identification restrictions of the Blanchard and Perotti SVAR can be expressed as an AB model, see Amisano and Giannini (1997), with:

$$Au_t = Be_t$$

(5)

where  $A$  is a  $n \times n$  matrix of contemporaneous relations among variables,  $B$  is a  $n \times n$  matrix that allow some shocks to affect directly more than one endogenous variable,  $u_t$  is the vector of reduced form residuals with variance-covariance matrix  $\hat{\Sigma} = E(u_t u_t')$  and  $e_t$  is the vector of structural policy ( $e_t^G, e_t^T$ ) and non-policy shocks ( $e_t^y, e_t^{\Delta p}, e_t^i$ ) we want to identify. Using the specification in Perotti (2005) and denoting the five variables as government spending, taxes, output, inflation and interest rates respectively, (4) can be represented as follows:



$$\begin{matrix}
\mathbf{G} & \mathbf{T} & \mathbf{y} & \Delta p & i \\
\begin{bmatrix} 1 & 0 & -a_{gy} & -a_{g\Delta p} & -a_{gi} \\ 0 & 1 & -a_{ty} & -a_{t\Delta p} & -a_{ti} \\ -a_{31} & -a_{32} & 1 & 0 & 0 \\ -a_{41} & -a_{42} & -a_{43} & 1 & 0 \\ -a_{51} & -a_{52} & -a_{53} & -a_{54} & 1 \end{bmatrix} & & & & \\
\begin{bmatrix} u_t^G \\ u_t^T \\ u_t^y \\ u_t^{\Delta p} \\ u_t^i \end{bmatrix} & = & & & \\
\begin{bmatrix} b_{11} & b_{12} & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} & & & & \\
\begin{bmatrix} e_t^G \\ e_t^T \\ e_t^y \\ e_t^{\Delta p} \\ e_t^i \end{bmatrix} & & & & 
\end{matrix}
\tag{6}$$

Each row in (6) is an equation that defines a relationship among the reduced-form residuals and structural shocks that we want to estimate. However, the above system of equations is not identified and needs to be restricted to achieve identification. It is important to note that the debt-to-GDP ratio is an identity and therefore deterministic. This means that equation (2) plays no role in the identification of structural shocks. The identification problem can be described as follows:

By construction, the reduced form disturbances and the underlying structural shocks are related as,

$$u_t = A^{-1} B e_t \tag{7}$$

from which the variance-covariance matrices of  $e_t$ s and  $u_t$ s can be derived as follows:

$$E(u_t u_t') = (A^{-1}) B E(e_t e_t') B' (A^{-1})'$$

where  $E(e_t e_t')$  is an identity matrix (i.e.  $e_t$  is a vector of uncorrelated structural shocks). Substituting the population moments with sample moments, we obtain:

$$\hat{\Sigma} = (\hat{A}^{-1}) \hat{B} I \hat{B}' (\hat{A}^{-1})'. \tag{8}$$

Equation (8) shows that the reduced form and the structural variance-covariance matrix are related to each other and is key to understanding the identification problem. OLS estimation allows us to obtain consistent estimates of the reduced form parameters ( $a_{31}, \dots, a_{54}$ ), the reduced form errors ( $u_t$ s) and the variance-covariance matrix  $\hat{\Sigma}$ . Since  $\hat{\Sigma}$  is symmetric, the left-hand side of (8) contains 15 distinct elements. Therefore, the maximum number of identifiable parameters in matrices A and B is also 15. The number of free parameters to be estimated in the A and B matrices in (6), on the other hand, is 22 (i.e. coefficients excluding zeros and ones). Therefore, the system is under-identified, requiring 7 identifying restrictions.

Using Blanchard's identification strategy, the six parameters in the first two rows of matrix A are identified using external information. The next section discusses the identification of these coefficients for New Zealand in more detail. Since the focus of our analysis is studying the effects of fiscal policy shocks on macroeconomic variables, we are particularly interested in identifying the structural shocks in the first two rows of the matrix A. Therefore, the structural shocks  $e_t^y, e_t^{\Delta p}$  and  $e_t^i$  are identified by using a recursive structure on the last three rows of A and B which is fairly standard in the VAR literature.

The identification of the two off-diagonal elements of the B matrix ( $b_{12}, b_{21}$ ) is not straightforward and depends on our view of the functioning of fiscal policy. We assume

that government expenditure decisions are prior to tax decisions ( $b_{12} = 0$ ) and test the sensitivity of the results to this assumption. In line with other studies, we find that the results are not sensitive to this assumption<sup>3</sup>.

### Elasticities of government revenues and expenditures

The six coefficients that need to be identified using external information are the elasticities of real net taxes and real net spending per capita with respect to each of output, inflation and the interest rate. These correspond to the coefficients  $a_{ty}$ ,  $a_{gy}$ ,  $a_{t\Delta p}$ ,  $a_{g\Delta p}$ ,  $a_{gi}$  and  $a_{ti}$ .

The elasticity of tax revenue with respect to GDP is set to 1 ( $a_{ty} = 1.0$ ). This is consistent with the assumption of Claus et al. (2006), which was based on the estimations in Girouard and Andre (2005).

The elasticity of government spending with respect to output is set to zero ( $a_{gy} = 0$ ). This is based on an assumption that real government spending (which excludes transfer payments, such as the unemployment benefit) would not respond to contemporaneous changes in GDP in a quarter<sup>4</sup>. This is consistent with Claus et al. (2006) and Blanchard and Perotti (2002).

The price elasticity of tax revenue is set at 0.2 ( $a_{t\Delta p} = 0.2$ ). The price elasticity of personal income tax can be estimated by subtracting 1 from the elasticity of tax revenues per person to average earnings (Perotti, 2005). This latter elasticity is estimated to be 1.3 for New Zealand by Girouard and Andre (2005) and a range of methods indicate a range of 1.3 to 1.4 reported in Parkyn (2010). Subtracting 1 from these estimates indicates a price elasticity of around 0.3 to 0.4. Corporate taxes have a very uncertain relationship with price in both directions and so we assume a price elasticity of zero. Indirect taxes are also assumed to have a price elasticity of zero as they have a typically proportional rate. Individual tax has accounted for around half of total tax revenue over 1990 to 2010, and therefore a weighted average of these price elasticities is about 0.2.

The price elasticity of real government spending is set to -0.5 ( $a_{g\Delta p} = -0.5$ ). This is consistent with the assumption used by FG, following Perotti (2005). Perotti reasons that the wage component of government spending is fixed within the quarter. This implies that the elasticity of real government spending on wages with respect to the GDP deflator is 1. The non-wage component of spending is more likely to be effectively indexed to price inflation (although some spending is likely to be fixed in nominal terms in a quarter). This implies that the price elasticity for non-wage spending is likely to be closer to 0. Since direct wage costs account for a significant proportion of real government spending, it seems reasonable to assume that the price elasticity of real government spending must be well below 0 but higher than -1.

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<sup>3</sup> Results are available upon request.

<sup>4</sup> A counterexample that has been cited is disaster relief (Blanchard and Perotti, 2002). The sample used in this study is 1983:1 to 2010:2, which does not include the earthquakes in Canterbury that occurred in September 2010 and February 2011.

The elasticity of government spending with respect to the interest rate is set to zero ( $a_{gi} = 0$ ). This is justified on the grounds that we only consider primary fiscal variables (that is, excludes debt servicing costs and investment income).

The elasticity of tax revenue with respect to the interest rate is set to zero ( $a_{ti} = 0$ ). This follows the assumption of FG and Perotti (2005), noting that this assumption may be slightly uncertain since the tax base does include interest income, although the effects may be quite complex given that dividend streams may also be affected by interest rate movements.

### **Data and estimation**

The data for log real GDP per capita ( $y$ ), log real net taxes per capita ( $T$ ) and log real government spending per capita ( $G$ ) are from an updated dataset of Claus et al. (2006), spanning 1983:1 to 2010:2.

The measure of inflation ( $\Delta p$ ) is the first difference of the log of the expenditure GDP implicit price deflator from Statistics New Zealand, backdated as in Claus et al. (2006) (this deflator is used to deflate the fiscal variables). The data is seasonally adjusted using the X11 method.

The quarterly government gross debt variable ( $d$ ) is the ratio of gross government debt to GDP. A quarterly debt series for New Zealand is available from September 1994. The data for 1983:1-1994:2 on the other hand is only available on an annual basis. The quarterly data for this period is taken from Dungey and Fry (2009) who used the method proposed by Chow and Lin (1971) to splice the annual data on to the quarterly data available from September 1994 onwards.

The interest rate ( $i$ ) is the 10-year government bond yield. The data for 1985:1 to 2010:2 is the average of the daily data available on the RBNZ website ([www.rbnz.govt.nz](http://www.rbnz.govt.nz)). The data from 1983:1 to 1984:4 is the average of the monthly long-term government bond yield series that was compiled by Chay et al. (1993) and reported in Lally and Marsden (2004).

Government spending is the sum of public consumption and public investment. A seasonally adjusted quarterly nominal central government investment series is obtained by multiplying the quarterly general government investment series by the annual ratio of nominal central government investment to nominal general government investment. The net taxes variable is calculated by total tax receipts less transfer payments, according to the Treasury's financial reporting and the estimates made in Claus et al. (2006). Total tax receipts were seasonally adjusted in EViews using Tramo Seats. The sum of net taxes and government spending equals the primary balance, since each variable excludes the government's financing costs or investment income.

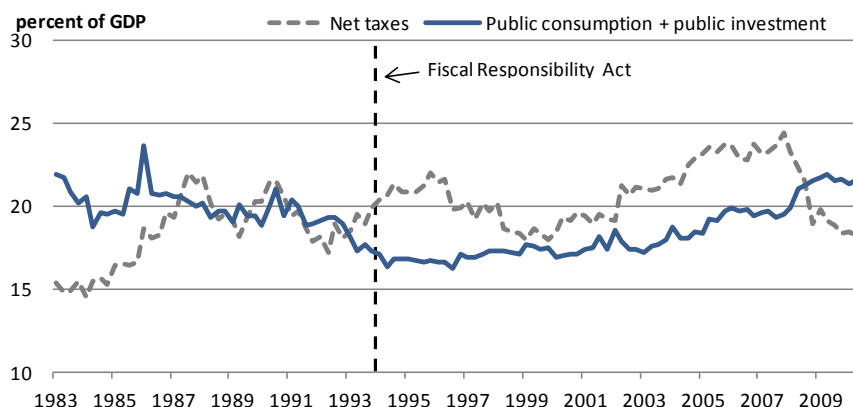
A descriptive overview of the behaviour of the series is given below in Figures 2-5. An examination of the time-series properties of the data then follows.

In the first four years of the sample, 1983:1 to 1987:1, primary government spending is higher than net taxes (Figure 2). This primary deficit is associated with a rise in gross debt over this period from 50 to 80 percent of GDP (Figure 3). Over this period, the primary deficit is reduced with increased net taxes and moderate reductions in spending as a share of GDP. There are some quarters with spikes in government

spending which principally relate to the 'lumpy' path of government investment. Real GDP per capita grows positively at around 2.5 percent and annual inflation (in the implicit GDP deflator) accelerates from 4 percent to 10 percent. The nominal benchmark interest rate, after falling initially, rises to peak at 18 percent in 1986:1 before reducing slightly to about 16 percent by 1987:1.

From 1987:2 to 1993:1, net taxes and government spending is approximately balanced on average. However, there are fluctuations in the level of both variables. Gross debt reduces as a percent of GDP, stabilising at around 60 percent. Inflation was steadily reduced over this period, coinciding with the enactment of an independent monetary policy with the objective of price stability in 1989. Growth in real GDP per capita was low or negative over this period. The nominal benchmark interest rate fell from 16 percent to 8 percent.

**Figure 2: Net taxes and government spending**

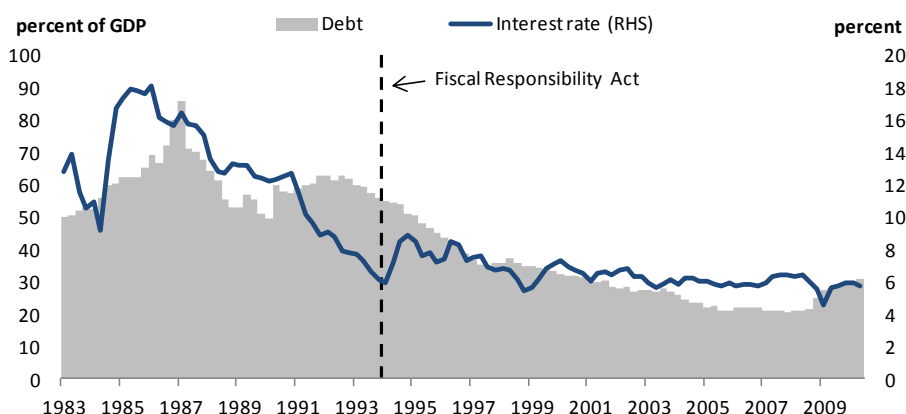


Source: Statistics New Zealand, The Treasury, Claus *et al.* (2006), authors' calculations.

In 1994, the Fiscal Responsibility Act was enacted, which included a requirement that public debt be reduced to prudent levels. From 1993:2 to 2007:4, the primary balance was in surplus, averaging 3.1 percent of GDP and varying between 0.2 and 5.3 percent of GDP. The primary surplus in 2007:4 was 4.9 percent of GDP.

Gross debt decreased steadily from 60 percent of GDP in 1993:2 to 20 percent of GDP by 2007:4 (Figure 3). Net taxes as a percent of GDP fluctuated over this period, generally increasing between 1993:2 at 1996:1, falling between from 1996:2 to 1999:4 and then rising over 2000:1 to 2007:4. Government spending as a share of GDP was broadly stable from 1993:2 to 1999:4 at around 17 percent. Spending lifted to 20 percent of GDP over 2000:1 to 2006:1 and remained at that level until 2007:4.

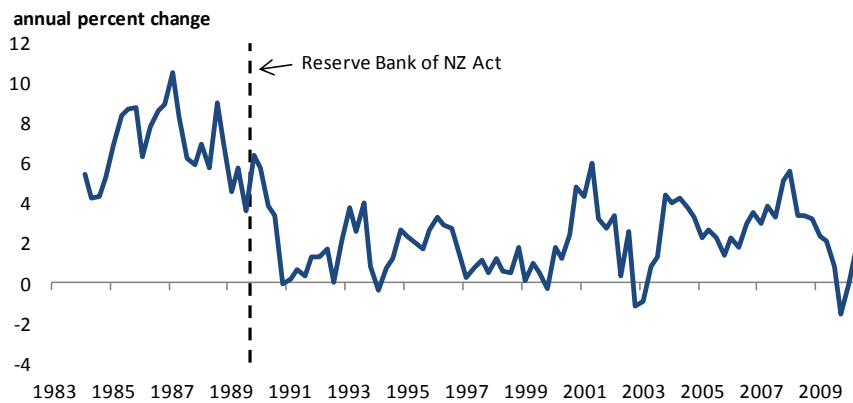
**Figure 3: Government debt and interest rate**



Source: The Treasury

Inflation in the implicit price deflator averaged 2.2 percent over the period 1989-2010, fluctuating within a range of -1.5 and 6.4 percent (Figure 4). Growth in real GDP per capita was strongly positive over 1993 to 1996, before slowing in 1997 (Figure 5). There was a brief recession in 1998 coinciding with the Asian financial crisis and the impact of the severe drought in 1998. Economic growth picked up strongly in 1999 and remained positive until 2007:4. The benchmark interest rate increased sharply from 6.1 percent in 1993:4 to 8.9 percent 1994:4 and then drifted down to around 6 percent.

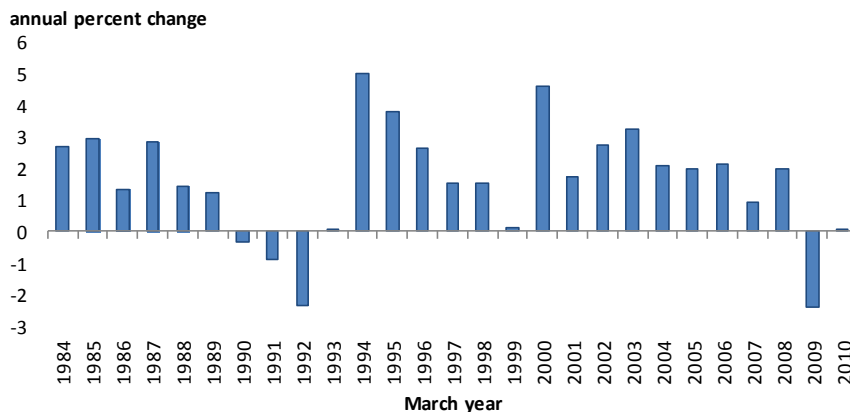
**Figure 4: Inflation (GDP deflator)**



Source: Statistics New Zealand

Over 2007:4 to 2010:2, the primary balance deteriorated by 8.3 percent of GDP, turning from surplus to deficit in 2008:4 (Figure 2). The primary balance ended this sample period in deficit of 3.4 percent of GDP. Over this period, net taxes reduced by 6.2 percent of GDP and government spending increased by 2.1 percent of GDP. Government debt increased by 10 percentage points of GDP to 31 percent GDP. The economy was in recession over 2008:1 to 2009:1. Real GDP per capita contracted by 2.4 percent in the year to March 2009 and grew at 0.1 percent in the year to March 2010. Annual inflation reduced although there was significant volatility. The 10-year yield fell from 6.4 in 2007:4 to 4.6 percent in 2009:1, and then increased to 5.7 percent in 2010:2.

**Figure 5: Real GDP per capita**



Source: Statistics New Zealand

Turning now to the formal time-series properties of the data, the trends in government spending, tax revenues and the real GDP suggest that these variables are non-stationary- i.e. the mean and variance changes over time. The visual interpretation of the remaining series is not straightforward. To formally test the time series properties of the data, we conduct two commonly used unit root tests; the Augmented Dickey Fuller (ADF) and Philips-Perron tests.

The results are reported in Table A1 in Appendix A. ADF test results indicate that all variables have a unit root at 5 percent significance level while the PP test indicate that inflation is stationary.

There are different views on whether the variables in a VAR need to be stationary (Enders, 2004). Sims et al. (1990), for example, recommend against differencing and argue that the goal of a VAR analysis is to determine the interrelationships among the variables rather than determining the parameter estimates. The fiscal VAR model of Mountford and Uhlig (2009) is an example of such an approach. Blanchard and Perotti (2002), on the other hand, adopt two trend specifications for their fiscal VAR: one allowing for deterministic time trends in the data and the other allowing for stochastic trends.

The deterministic specification includes time and time squared as additional regressors on the logarithms of per capita net tax, government spending and GDP while the stochastic specification is estimated using the first differences.

Using first differencing when the variables are cointegrated is problematic as it throws away the information inherent in the cointegrating relationship. This, in turn, leads to a misspecification error making inference invalid (Enders, 2004). The presence of unit roots reported in Appendix Table 1 raises the possibility that variables may be cointegrated. As a likely candidate, we initially test whether there is statistically significant cointegration between government spending and revenues, using Johansen's methodology. Surprisingly, the results reported in the Table A2 in Appendix show that there is no evidence of a statistically significant cointegration between revenues and expenditures. Repeating the test using all of the four trending variables together, on the other hand, shows that there is evidence of a significant cointegrating relationship among the trending variables. Therefore, we prefer to use the variables in levels while allowing for deterministic time trends, rather than first differencing. All data are expressed in natural logarithm, real and per capita terms except the GDP deflator and the long-term interest rate which enter in quarterly percent change and levels respectively. The number of lags for estimating the VAR is set to 3, as suggested by the Likelihood Ratio test.

## **EMPIRICAL RESULTS**

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Table 1 shows the Maximum Likelihood estimates of coefficients of Equation 6 for the benchmark model with the corresponding p-values in parenthesis below each coefficient. The coefficients for the contemporaneous effect of government spending and revenues on income have the expected signs. While higher government spending has a positive contemporaneous effect on income on impact (0.052), the immediate effect of increasing government revenues on income is negative (-0.046). The effect is

slightly higher in the case of government spending but is not statistically significant. The interpretations of these coefficients in terms of dollar multipliers are provided in Section 4.2.3. Government spending has a positive effect on interest rates and the effect is highly significant. A one percent government spending shock increases the interest rates by approximately 7 basis points on impact. The effect of tax increases on interest rates, on the other hand, is negative and insignificant.

**Table 1:** Estimates of A and B in the benchmark model (Equation 6)

$$\begin{matrix}
 \mathbf{G} & \mathbf{T} & \mathbf{y} & \Delta_p & \mathbf{i} \\
 \begin{bmatrix}
 1 & 0 & 0 & -0.5 & 0 \\
 0 & 1 & 1 & 0.2 & 0 \\
 -0.052 & 0.046 & 1 & 0 & 0 \\
 0.009 & 0.031 & -0.242 & 1 & 0 \\
 -0.068 & 0.005 & 0.014 & 0.070 & 1 \\
 (0.00) & (0.75) & (0.81) & (0.30) & 
 \end{bmatrix}
 \begin{bmatrix}
 u_t^G \\
 u_t^T \\
 u_t^y \\
 u_t^{\Delta p} \\
 u_t^i
 \end{bmatrix}
 =
 \begin{bmatrix}
 0.026 & 0 & 0 & 0 & 0 \\
 (0.00) & & & & \\
 0.001 & 0.038 & 0 & 0 & 0 \\
 (0.89) & (0.00) & & & \\
 0 & 0 & 0.011 & 0 & 0 \\
 & & (0.00) & & \\
 0 & 0 & 0 & 0.009 & 0 \\
 & & & (0.00) & \\
 0 & 0 & 0 & 0 & 0.006 \\
 & & & & (0.00)
 \end{bmatrix}
 \begin{bmatrix}
 e_t^G \\
 e_t^T \\
 e_t^y \\
 e_t^{\Delta p} \\
 e_t^i
 \end{bmatrix}
 \end{matrix}$$

Table 2 shows the estimates of the lagged effects of debt in the five equations. The cumulative effect of the lagged levels of debt on government spending is negative which means that higher levels of previous debt results in reduced government expenditures. The corresponding impact on net taxes on the other hand is positive and more pronounced. Furthermore, higher levels of previous debt reduce output and leads to higher inflation and interest rates. The majority of the direct effects of lags, on the other hand, are not statistically significant.

**Table 2:** Estimates of the lagged effects of the level of debt

Variable	Gov. Exp	Net Taxes	Output	Inflation	Interest Rate
$d_{t-1}$	0.069	0.098	-0.084	0.061	0.025
$d_{t-2}$	-0.158	0.213	0.131*	-0.0561	0.001
$d_{t-3}$	-0.012	-0.063	-0.040	0.047	-0.001
<i>Sum</i>	-0.101	0.249	-0.125	0.053	0.025

\*significant at 5 percent level

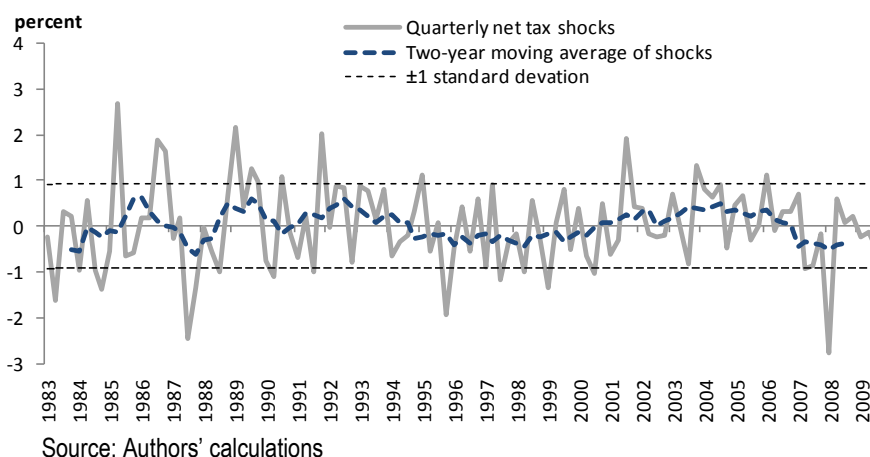
### Interpreting the fiscal shocks

The estimated shocks to net taxes and government spending are shown in Figures 6 and 7 respectively. It would be useful to assess the shocks in relation to other methods of identifying fiscal shocks. One such approach is the narrative approach as employed in Romer and Romer (2010). Estimating shocks using the narrative approach would be a useful area of future work. Nevertheless, from visual inspection we can observe that there is some congruence between the shocks and some well-known policy changes.

For the net taxes shocks, we can observe that there are large negative shocks in 1988:2, 1996:3 and 2008:4 (see Figure 6). This timing is consistent with significant

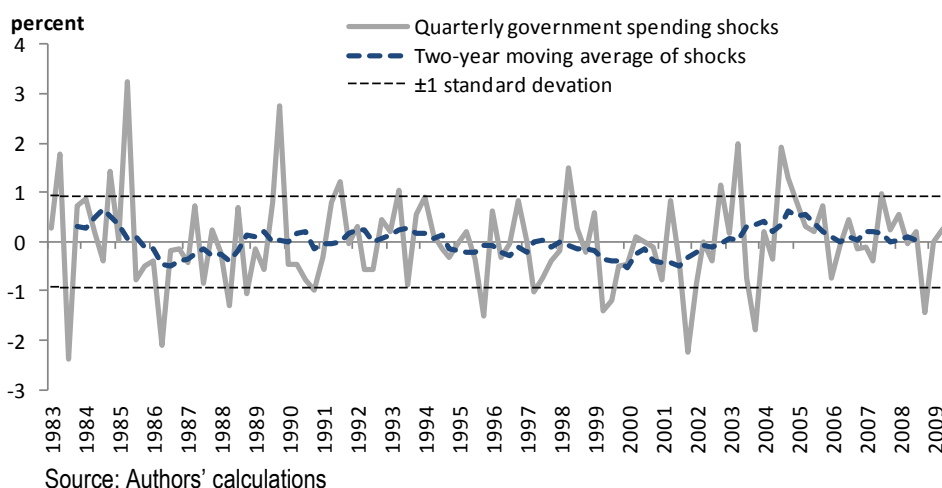
reductions in tax rates that occurred on 1 April 1988, 1 July 1996 and 1 October 2008. Positive tax shocks are harder to relate to policy changes, perhaps as structural revenue increases tend to occur over time through fiscal drag rather than through announced tax rate increases.

**Figure 6: Quarterly net tax shocks**



The two-year moving average of the spending shocks indicates that spending shocks were generally negative in the late 1980s and mid 1990s reflecting fiscal consolidation and expenditure restraint over 1996 to 2003 (see Figure 7). There are positive shocks to government spending occurring in the early-to-mid 1980s (perhaps reflecting 'Think Big' investment projects) and 2004 to 2008 (reflecting structural increases in spending over this period that are discussed in Mears et al. (2010)).

**Figure 7: Quarterly government spending shocks**

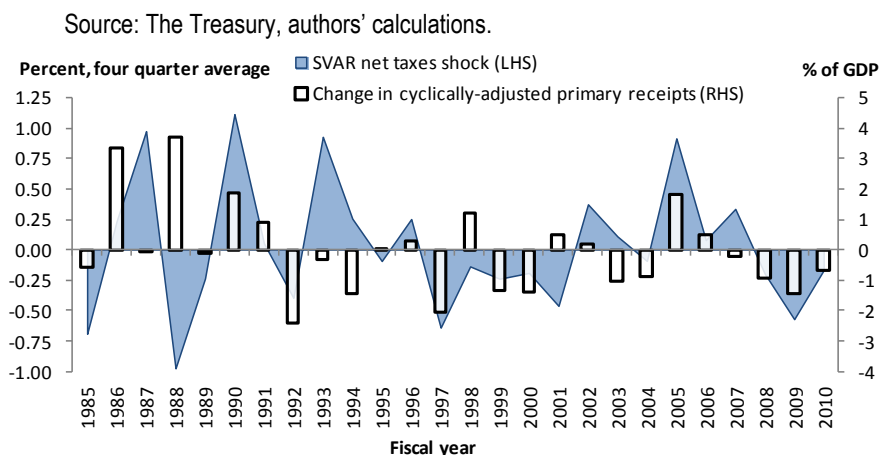


The fiscal shocks can also be compared against the cyclically-adjusted receipts and expenditure measures using the method of Philip and Janssen (2002). We combine the New Zealand Treasury's official estimates that are backdated to 1997 with the unofficial estimates presented in Claus et al. (2006) that are backdated to 1983 (Figure 8 and Figure 9). The measures of government spending shocks are positively correlated over the period from 1997 to 2010 (correlation coef.=0.3) but not over 1983 to 1996 (-0.2).

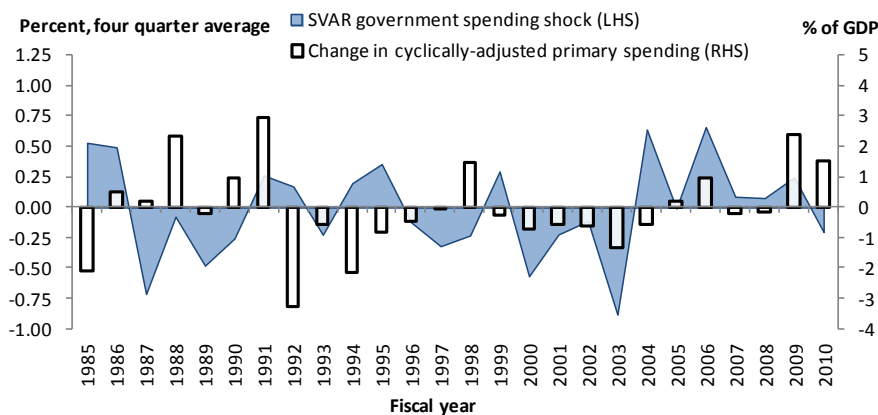


The 1997 to 2010 period is one in which we may have more confidence that the Crown accounting information was prepared on a consistent basis. The correlation between the measures of tax shocks is more pronounced particularly during the period 1997-2010 (correlation coef.=0.7). The SVAR fiscal measures during this period may give a better indication of the stance of tax and spending settings, as they are less contaminated by issues such as changes in the accounting framework and restructuring of government entities.<sup>5</sup>

**Figure 8: Comparing measures of net tax shocks**



**Figure 9: Comparing measures of government spending shocks**



Source: The Treasury, authors' calculations

### Impulse response functions

This section presents empirical results for pure government spending and tax shocks. Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks to the error term. The impulse responses of output and the fiscal variables are normalised to have a contemporaneous impact of one-percent by dividing each shock by the standard deviation of the respective fiscal shock. These impulse

<sup>5</sup> Since the spending data used in the SVAR analysis is from the national accounts not the Crown accounts.

responses are then divided by the ratio of the shocked fiscal variable and the responding variable, where the ratio is evaluated at the sample mean. Therefore, the rescaled impulses for the responses of output to the fiscal shocks can be interpreted as constant dollar multipliers<sup>6</sup> and can be interpreted as giving the reaction of the responding variable, in percent of real GDP, to a fiscal shock of size 1 percent of real GDP. For inflation and interest rates, the responses give the percentage points change in response to a one-percent fiscal shock.

The impulse responses are calculated following the methodology outlined in FG as follows;

1. Set all the shocks to zero and solve (3) dynamically forward to generate a baseline simulation for all variables up to the horizon which impulse responses are needed,
2. repeat step one for all variables by setting the relevant shock under consideration to one,
3. compute the impulse responses to the structural shocks as the difference between step 2 and step 1,
4. compute the one-standard deviation confidence intervals by using a bootstrap methodology (1000 bootstraps).

### ***Government spending shock***

Figure 10 displays the responses of the endogenous variables to a positive spending shock. The government spending shock is highly persistent and turns insignificant after 2.5 years. The persistence of government spending shocks is a typical finding in the majority of the fiscal VAR studies (Blanchard and Perotti, 2002; Perotti, 2005; Fatas and Mihov, 2001).

The government spending shock has a positive impact on output for 7 quarters but the estimated impulse responses are mostly insignificant. The immediate impact of a one percent of GDP increase in spending on output is around 0.26 percent. The peak impact occurs in the third quarter after the shock with a multiplier of 0.33. The cumulative output multiplier is approximately 0.42 in the first year. The GDP response turns slightly negative after 2 years possibly due to the persistently higher level of real interest rates.

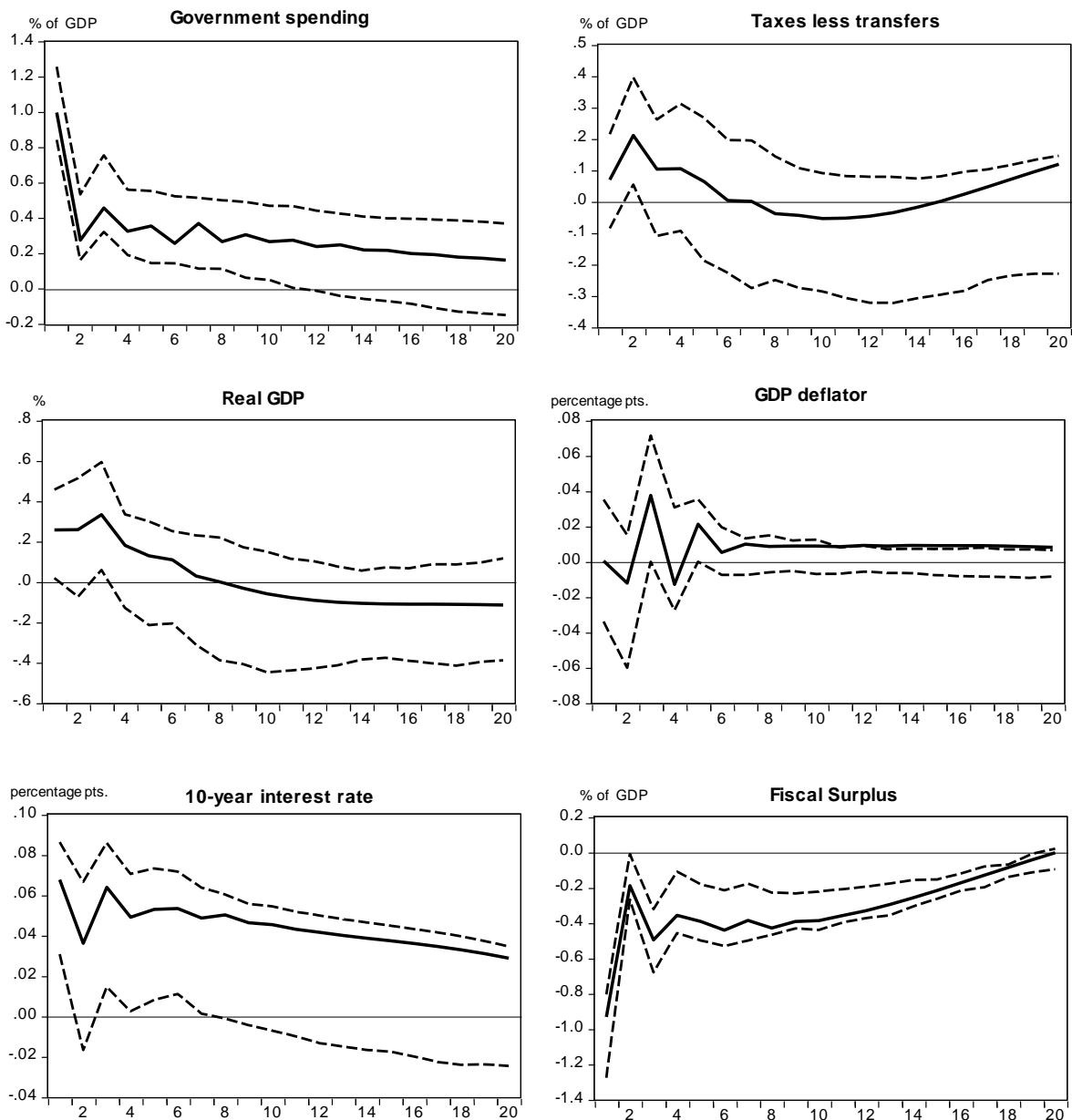
Net taxes respond positively to the spending increase with the response peaking in the second quarter. Inflation picks up slightly as a result of the higher demand pressures but the impulse responses are statistically insignificant. Following a one percent increase in government expenditure, the long-run interest rate (10-year government bond yield) increases initially by approximately 7 basis points. The effect is persistent and mostly significant within the first 7 quarters. The overall impact is a slight increase in real interest rates.

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<sup>6</sup> Suppose we have a shock in spending in the size of 1%. Since a share of spending in GDP is about 30%, this size of the shock corresponds to 0.3 percent of GDP. After this shock assume that output increases by 0.6 percent. The corresponding multiplier (increase in percent of GDP due to a 1 percent of GDP increase in spending would then be  $2 (0.6/0.3=2)$ ).

The initial government spending increase exceeds the increase in taxes and the primary budget balance deteriorates. The deficit is financed by issuing debt which puts upward pressure on the long-term interest rates. Taxes start picking up after 10 quarters which helps to balance the budget in the long-run.

**Figure 10:** Responses to an increase in government spending



Source: Authors' calculations

### **Government revenue shocks**

Figure 11 displays the endogenous responses of each variable following an increase of net taxes. The tax shock is relatively less persistent compared to the expenditure shock and becomes insignificant after 7 quarters. Following a slight initial increase,

government spending starts to decline and the effect is precisely estimated. This result is in line with the results reported by Blanchard and Perotti (2002) and Claus et al. (2006) although the effect here is stronger. As a result, the primary balance improves and starts fading afterwards.

The immediate response of a one percent of GDP increase in net tax is to decrease GDP by 0.23 percent and the effect is statistically significant. This is very close to the estimate of 0.24, reported by Claus et al. (2006). GDP increases in the following two quarters and becomes negative throughout the whole horizon.

As expected, the medium and long-run impact of a positive tax shock on GDP is negative. The positive and significant increases in GDP in the second and third quarters are counter-intuitive but are a common finding in fiscal VAR literature.

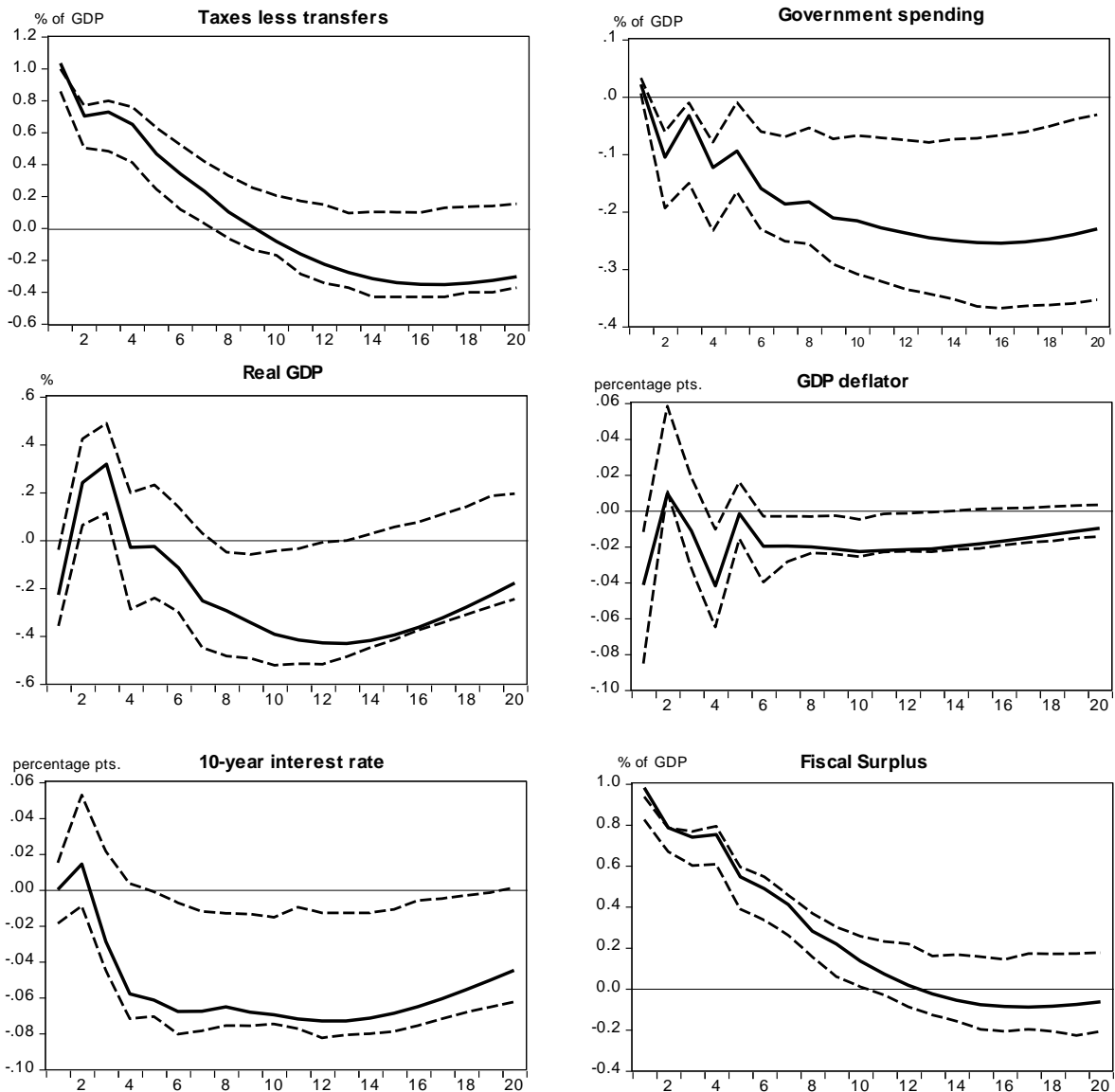
For example, Perotti (2005) finds that tax cuts have a negative and significant impact on the outputs of UK, Germany and Australia. The effect is quite dramatic for the cases of UK and Australia where the negative impacts are sustained throughout a 5-year horizon. Using Spanish data, De Castro and Hernandez de Cos (2008) find that increase in net taxes have a positive and significant impact on output both in the short and medium term. Similarly, Giordano et al. (2007) find that positive tax shocks have positive and statistically significant effect on GDP in Italy. Similar findings are reported for several East Asian countries by Tang et al. (2011). The existence of similar tax puzzles is also highlighted in various studies for New Zealand.

Using the sign-identification methodology, Dungey and Fry (2009) identify fiscal and monetary shocks for New Zealand for the period 1982-2006. They find that tax increases have a small but positive impact on output both in the short and long-term. Using different models and sample periods with New Zealand data, Fielding et al. (2011) conduct an extensive analysis of the effects of fiscal policy in New Zealand. They show that the puzzle of positive effects of tax revenue shocks on GDP is fairly robust across various specifications. They suggest rising productivity in response to the unanticipated rise in tax revenues as a possible explanation.

It is important to note that our results do not show any sustained positive impact of tax increases on output. In this sense, they are similar to the findings of Claus et al. (2006) for New Zealand. In Section 6, we show that the response of output to a revenue shock is highly sensitive to the assumption on the elasticity of tax revenue with respect to GDP. Figure 24 show that the responses of GDP to a positive tax shock in the second and third quarters turn negative as the output elasticity exceeds 2. This is consistent with the findings of Caldara and Kemps (2008) who report similar findings using US data. A more in-depth analysis of the tax puzzle is left as an area for future research.

The inflation response to a net tax increase is small and negative. The effect is barely significant after the initial quarter. The long-term interest rate (10-year government bond yield) falls after two quarters with significant uncertainty around the estimated impact.

**Figure 11: Responses to an increase in taxes net of transfers**



Source: Authors' calculations

***Interpreting the fiscal multipliers***

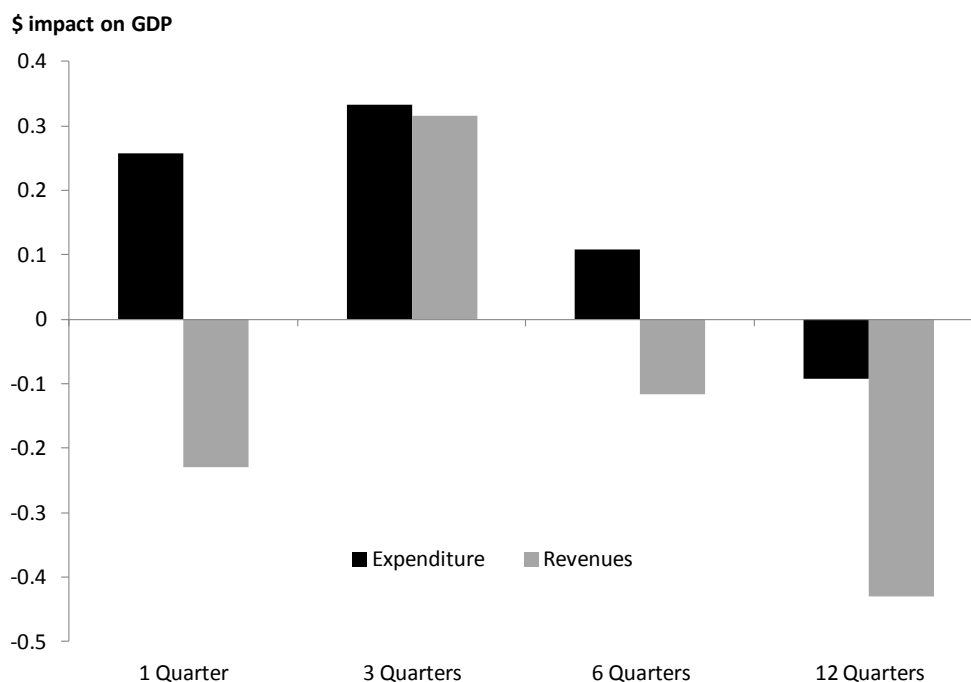
Based on the impulse responses discussed above, Figure 12 displays the fiscal multipliers estimated for New Zealand across various horizons. These multipliers are constant dollar multipliers which correspond to dollar changes in output to the change in government expenditure and revenues.

The government spending multiplier on impact is approximately 0.26 and reaches its peak of 0.33 in the third quarter. The impact multiplier is lower than the value of 0.37 reported in Ilzetzi et al. (2010) for high-income countries. As this study points out, focusing on the impact multiplier alone may be misleading because fiscal stimulus packages can only be implemented over time. Therefore, the impulse response functions provide a better measure of the overall impact of the fiscal stimulus on

macroeconomic variables. The impact starts to fade away in 8 quarters and turns slightly negative within 12 quarters.

The revenue multiplier is negative on impact with a magnitude of approximately 0.23. The multiplier is positive in the third quarter and then turns negative in the medium to long term.

**Figure 12:** Fiscal impact-multipliers (GDP response to \$1 increase in fiscal variables)



Source: Authors' calculations

To put these estimates into perspective, Table 3 displays the summary statistics for 34 studies summarised by the IMF in their April 2012 Fiscal Monitor. The first-year spending and revenue multipliers are shown for studies using both VAR and DSGE methodology for the US and Europe. The multipliers that are estimated for New Zealand in our study are within the range of the estimates found in this literature. Both the expenditure and revenue multipliers are smaller in magnitude (closer to zero) than found in the mean, median and mode of these other studies.

**Table 3:** First-year accumulated fiscal multipliers: comparing estimates with summary findings from international literature

Size of First-Year Government Spending Fiscal Multipliers (positive spending shock)							New Zealand: Parkyn and Vehbi (2012) VAR*
	All Samples		United States		Europe		
	VAR	DSGE	VAR	DSGE	VAR	DSGE	
Mean	0.9	0.7	1.0	0.7	0.8	0.6	
Median	0.8	0.6	0.9	0.7	0.6	0.5	
Mode	0.6	0.5	0.6	0.0	0.5	0.5	0.42
Maximum	2.1	1.9	2.0	1.6	1.5	1.5	
Minimum	0.4	0.0	0.4	0.0	0.5	0.1	

Size of First-Year Government Revenue Fiscal Multipliers (negative revenue shock)							New Zealand: Parkyn and Vehbi (2012) VAR
	All Samples		United States		Europe		
	VAR	DSGE	VAR	DSGE	VAR	DSGE	
Mean	0.2	0.3	0.7	0.3	-0.3	0.1	
Median	0.3	0.2	0.7	0.2	-0.3	0.1	
Mode	0.7	0.2	0.7	0.2	..	0.1	-0.10
Maximum	1.4	1.0	1.4	1.0	0.4	0.3	
Minimum	-1.5	0.0	-0.7	0.0	-1.5	0.0	

Sources: IMF (2012), authors' calculations. Note: VAR denotes summary statistics from linear vector autoregressive models, and DSGE denotes results from dynamic stochastic general equilibrium models. The summary statistics reflect results from 34 studies between 2002 and 2012 with large outliers excluded.

\* The sum of the GDP response over the first four quarters divided by the sum of the corresponding spending or revenue response.

Iizetzki et al. (2010) use a structural VAR model to model a panel of 44 countries (excluding New Zealand) to show that the impact of government expenditure shocks depends on several country-specific factors. The results show that fiscal multipliers are larger in industrial rather than developing countries. They also find that the multiplier is relatively large in economies operating under fixed exchange rate but zero in economies operating under flexible exchange rates. Fiscal multipliers in open economies are found to be lower than in closed economies and fiscal multipliers in high-debt countries are also small. Since New Zealand is a small, open economy with a floating exchange rate, our findings fit with the stylised result that the output multipliers from fiscal policy are likely to be small.

Table 4 shows that the inclusion of the debt constraint also plays a role on the magnitudes of the impact multipliers reported in Figure 12. These results show that both the spending and revenue multipliers are generally higher when the debt feedback is excluded.

**Table 4:** Fiscal impact-multipliers with and without a debt constraint

Spending Multipliers				
	Q1	Q3	Q6	Q12
With debt feedback	0.26	0.33	0.11	-0.09
Without debt feedback	0.29	0.65	0.39	0.15
Revenue Multipliers				
	Q1	Q3	Q6	Q12
With debt feedback	-0.23	0.32	-0.12	-0.43
Without debt feedback	0.09	0.32	-0.08	-0.55

## FISCAL POLICY AND THE BUSINESS CYCLE

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In the previous section, the dynamic responses to government spending and net tax shocks were analysed using impulse response functions. In this section, we calculate the forecast error variance decompositions (FEVD) as another way to assess how shocks to economic variables transmit through a system. We only report the decomposition of output but full results are also available on request. Next, we use historical decompositions of the fiscal VAR to assess the contribution of fiscal policy shocks to the New Zealand business cycle over 1985:1 to 2010:2. We use this to draw some conclusions about the cyclical stance of fiscal policy over time.

### Forecast error variance decompositions

FEVDs for each variable measure the contribution of each type of shock to the forecast error variance of that variable. Thus, they provide information about the relative importance of each shock in affecting the endogenous variables in the VAR.

Table 5 shows the results of the variance decompositions of output. In line with the majority of fiscal VAR studies, the shocks to output itself (i.e. residual) explain almost all of its forecast error variance at short horizons. This is in line with the findings of Dungey and Fry (2009). Fiscal shocks in total explain approximately 6 and 13 percent of the forecast error variation in output within 12 and 20 quarters respectively. Net tax shocks are found to have relatively more impact on the variations in output than spending shocks.

Thus, consistent with Claus et al. (2006), we find that the impact of fiscal policy on the GDP cycle has been relatively small.

**Table 5:** Forecast error variance decomposition

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Horizon, quarters	Spending shock	Revenue shock	Output shock
1	1.50	2.58	95.83
4	2.49	3.68	89.61
12	1.32	5.25	84.03
20	1.62	11.58	74.95

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Source: Authors' calculations

### Historical decomposition of the business cycle

Using historical decompositions, we also estimate the individual contributions of each structural shock to the movements in GDP, inflation and the long-term interest rate over the sample period. The historical decompositions of each variable into the estimated structural shocks are calculated as follows:

1. The VAR(3) model is written in companion form<sup>7</sup> (i.e. as a VAR(1) model) as,

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<sup>7</sup> Any stationary VAR(P), where  $P > 1$ , can be rewritten as a VAR(1) by constructing the companion form. This allows the statistical properties of any VAR(P) to be directly computed using only the results of a VAR(1).



$$Y_t = c + AY_{t-1} + e_t$$

2. Using backward substitution and the Wald decomposition (see Enders (2004) for details), the model variables at each point in time ( $Y_t$ ) can be represented as a function of initial values ( $Y_0$ ) plus all the structural shocks of the model

$$Y_t = A^t Y_0 + \sum_{k=1}^t A^{t-k} e_k.$$

The historical decomposition of the shocks to GDP is shown in Figure 13, which is discussed below.

In the late-1980s, government spending subtracts from output while net taxes contribute positively. Interest rate shocks play a modestly dampening role on GDP. GDP's own shocks on itself and inflation shocks contribute positively to GDP.

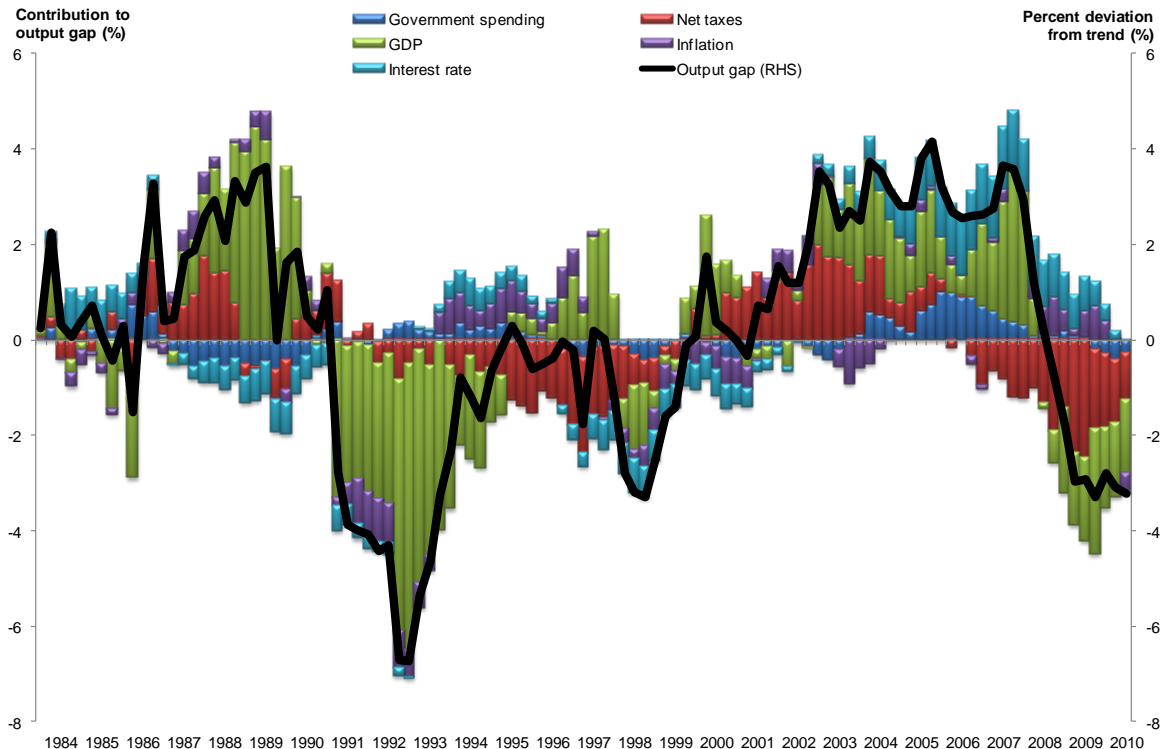
In the recession of the early 1990s, neither government spending nor net taxes shocks make any material contribution to output. Interest rate shocks and inflation shocks dampen output, but GDP's own shocks are by far the most significant component of the negative shocks to output.

During the recovery period of the mid-1990s, government spending makes a very small positive contribution to output, whereas net taxes play a dampening role. During the 1998 growth slowdown, which coincided with the Asian economic crisis, both government spending and net taxes make a negative contribution to output.

Over 2000 to 2007, GDP rises to levels well above trend. Net taxes make a strongly positive contribution to the output gap over 2000 to 2005, before becoming negative in their contribution. Government spending makes a minimal contribution over 2000 to 2003, but then makes a positive contribution over 2004 to 2007. Shocks from the long-term interest rate dampen GDP over 2000 and 2001, and thereafter make a positive contribution. Inflation shocks appear to make a minimal contribution to the output cycle over this period. GDP's own shocks on itself explain a significant portion of the positive output gap over 2003 to 2007.

In 2008, the economy entered recession and the output gap turned negative in 2009. Government spending makes virtually no contribution to the downturn over this period, whereas net taxes make a negative contribution. Interest rate and inflation shocks make a positive contribution, partially offsetting the large negative contribution from GDP's own shocks. The negative contribution from net taxes is counter-intuitive since there were substantial permanent tax cuts delivered in late 2008. This may be partly due to the counter-intuitive result in section 4 that net tax shocks have a negative output multiplier at certain horizons or the lagged effects of previous positive shocks to net taxes.

**Figure 13: Historical decomposition of GDP**



Source: Authors' calculations

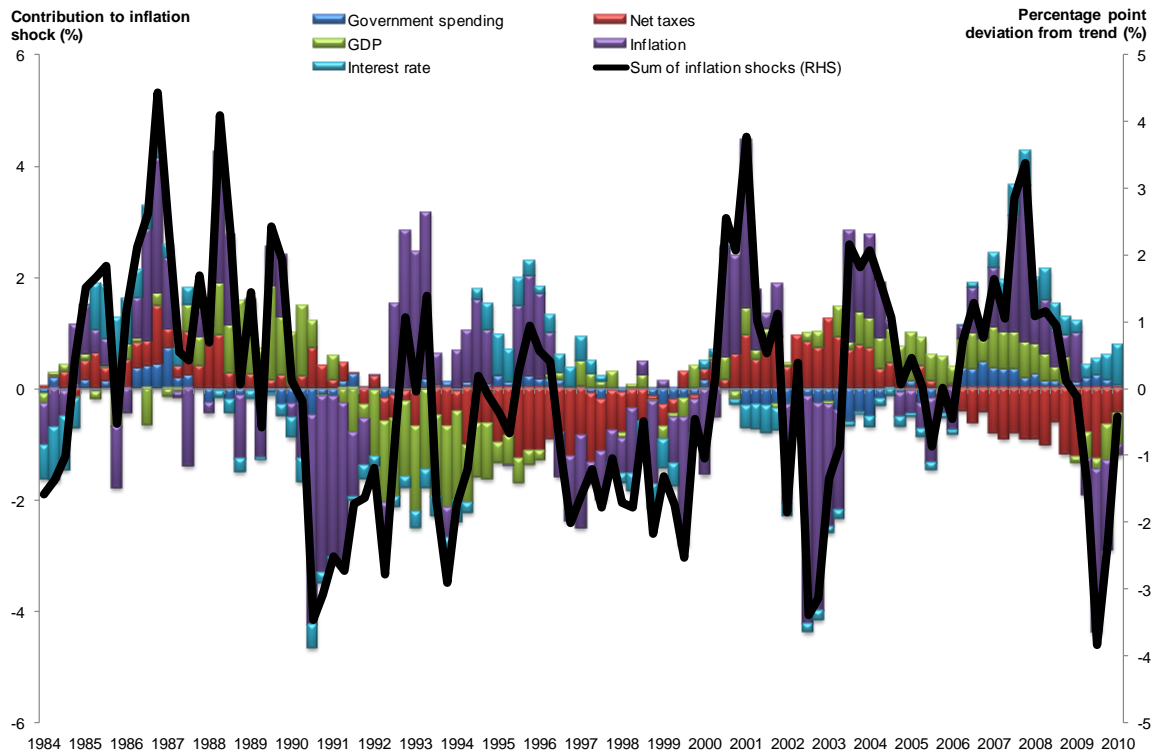
The historical decomposition of the shocks to inflation in the GDP deflator rate is shown in Figure 14.

In the 1980s, a period in which inflation is mostly above trend, net taxes and government spending contribute somewhat positively to inflation shocks. GDP shocks also add to inflation during the late 1980s. Interest rates and inflation shocks on itself (i.e., residual) have contributions which change sign throughout the decade.

In the 1990s, net taxes generally dampen inflation while government spending plays a very minor role in adding to inflation. In the first half of the decade, GDP and interest rate shocks also subtract from inflation. Later in the 1990s, net taxes dampen inflation along with interest rates and inflation shocks on itself.

In the 2000s, net taxes add to inflation in the first half of the decade and then make a negative contribution in the latter half. Government spending shocks partially offset this by making a negative contribution in the first half of the decade and a positive contribution in the latter half. GDP shocks make a positive contribution throughout the decade. Interest rate shocks play a dampening role in the first half of the decade, and add modestly to inflation in the latter half.

**Figure 14: Historical decomposition of inflation (GDP deflator)**



Source: Authors' calculations

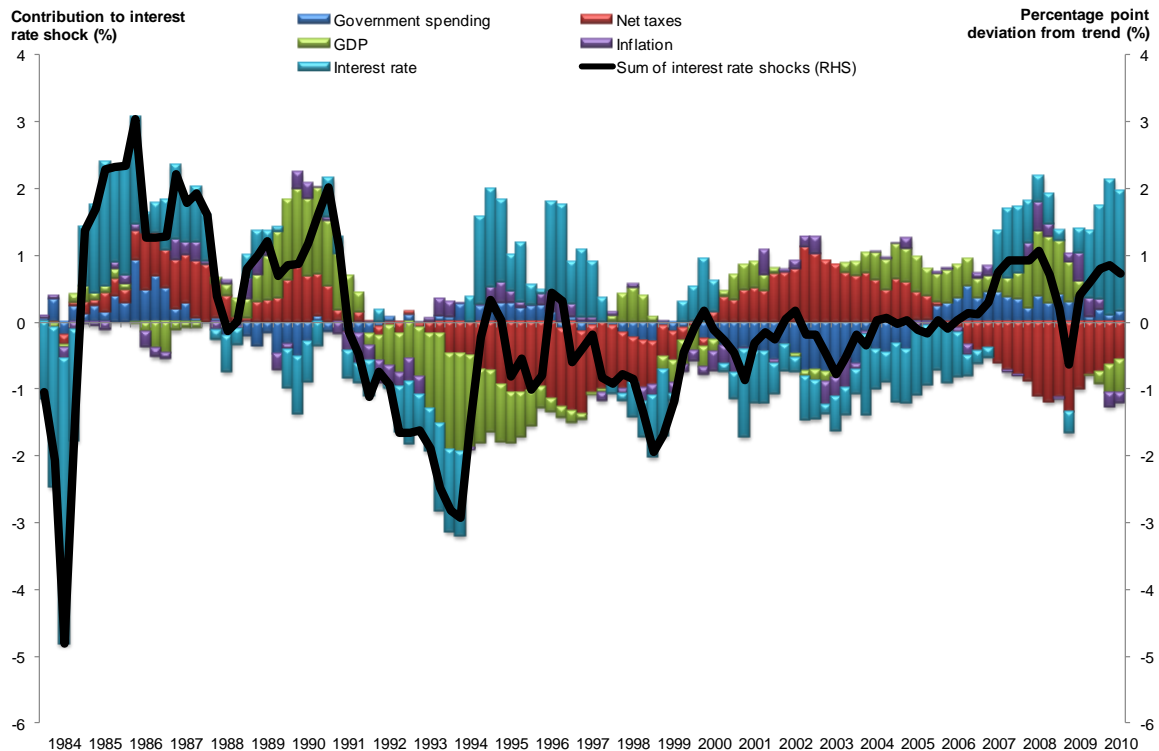
The historical decomposition of the shocks to the long-term interest rate (10-year government bond yield) is shown in Figure 15.

Over the mid to late 1980s, net taxes make a positive contribution to interest rate shocks. Government spending shocks are positive in the mid-1980s but become a modest dampening factor in the late 1980s. GDP's own shocks and own interest rate shocks also make a significant positive contribution to interest rate dynamics.

In the 1990s, total shocks to the interest rate are generally negative. Government spending shocks have a small positive effect on the interest rate in the middle of the decade. Net tax shocks initially make minimal contribution, but make a material negative contribution in the latter half of the decade. GDP and inflation dampen interest rates in the early half of the decade. Interest rate shocks on itself contribute negatively in the early 1990s, add positively to the middle of the decade, and then dampen again in the late 1990s.

In the first half of the 2000s, net tax shocks and GDP shocks contribute positively to the interest rate shocks. This is offset by negative contributions from government spending and interest rate shocks on itself. In the second half of the 2000s, government spending shocks contribute positively to the interest rate while net taxes dampen the interest rate. GDP shocks and interest rate shocks also contribute negatively over this period.

**Figure 15: Historical decomposition of interest rate (10-year bond yield)**



Source: Authors' calculations

### Has fiscal policy been pro-cyclical?

A key policy question is whether fiscal policy has been counter or pro-cyclical over time. The stylised fact from cross-country studies is that fiscal policy has tended to be a-cyclical or counter-cyclical in industrial countries, but has tended to be pro-cyclical in developing countries (Ilzetzki and Vegh, 2008).

We quantify the impact of fiscal stance on the level of both GDP and long-term interest rates by conducting the following counterfactual exercise. Using the moving average representation of the SVAR model, we simulate an alternative path for each variable by comparing the actual path with a simulated path in which fiscal shocks (both net taxes and government spending) are suppressed. In this way, the model is used to simulate the outcome of alternatives to the observed policy shocks to create a counterfactual with which to compare the observed history and is essentially a different way of presenting the results shown in Figures 13-15.

Figure 16 shows actual GDP detrended and the counterfactual output gap that excludes the contribution of the fiscal shocks. The difference comprises the fiscal impulse, defined as the net contribution to GDP from net taxes and governments spending. Discretionary fiscal policy is defined as pro-cyclical (counter-cyclical) if detrended actual GDP is further away from (closer to) the horizontal axis than the counterfactual simulation of GDP without fiscal shocks. Equivalently, fiscal policy would be pro-cyclical if the fiscal impulse is the same sign as the output gap and the fiscal impulse is not larger in magnitude than the output gap.

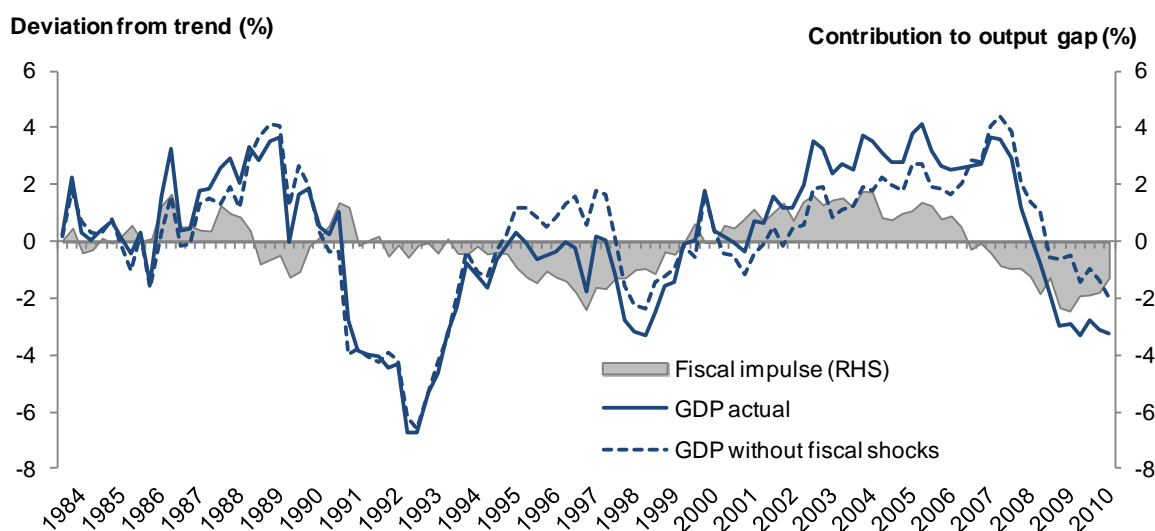
Discretionary fiscal policy appears to have avoided pro-cyclical contributions to output over 1984 to 1997, but has acted in a pro-cyclical manner for much of the subsequent period. In other words, this model suggests that over 1998 to 2010, New Zealand has experienced a more pronounced cycle in GDP than would have been the case without unexpected changes in discretionary fiscal policy.

Fiscal shocks are broadly a-cyclical over the late 1980s and early 1990s. From 1994 to 1997, fiscal policy appears to have played a counter-cyclical role by dampening an upturn in GDP. Over 1998 and 1999, fiscal policy dampens GDP which exacerbates the negative output gap. Over 2000 to 2006, fiscal policy is pro-cyclical by exacerbating the upturn in GDP.

Over 2007 to 2010, fiscal policy dampens GDP which is initially counter-cyclical but then pro-cyclical as the output gap turned negative. This outcome is mainly driven by the dampening effects of net taxes as the effect of government spending during this period is slightly positive (see Figure 13).

This rather counter-intuitive result could again be partly explained by the tax puzzle mentioned in previous sections. The comprehensive study by Kearney et al. (2000) also shows that the SVAR measure of fiscal impulse may be biased during periods of major shifts in the economy. By comparing across five alternative measures, they find that the SVAR measure of fiscal impulse can diverge substantially from the others particularly during episodes of major structural changes in the economy. They argue that in such cases, the model cannot capture the major shift that took place in that period and so is applying a common estimate of the whole period.

**Figure 16: GDP cycle and fiscal policy**

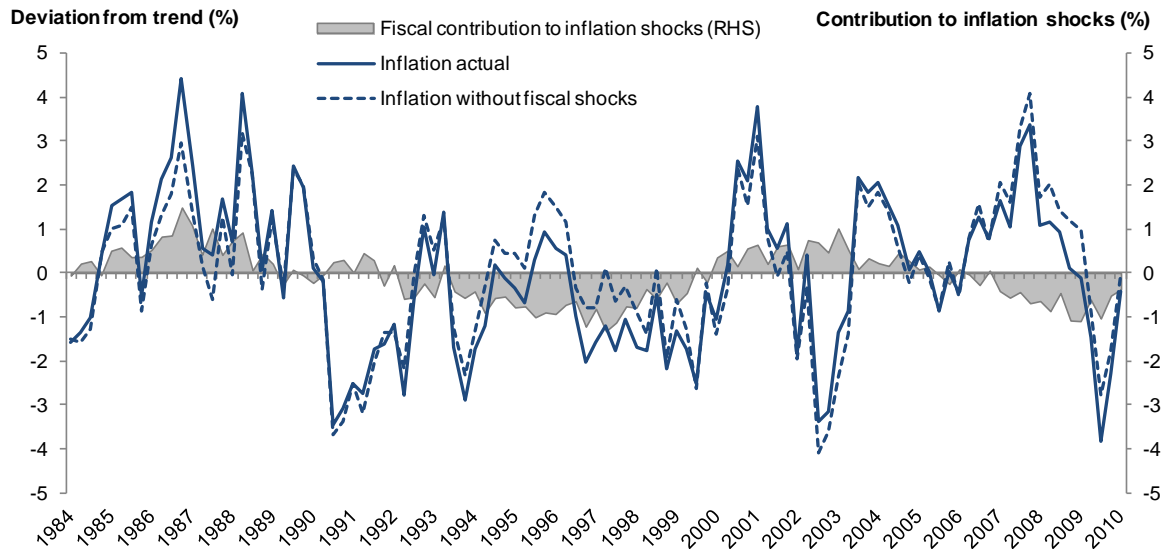


Source: Statistics New Zealand, authors' calculations.

Figure 17 shows the de-trended actual inflation and a counter-factual simulation without contributions from fiscal policy. The pro-cyclical nature of fiscal policy with respect to inflation can be assessed in a similar manner to the GDP cycle. Overall, fiscal policy appears to make only a minor contribution to inflation deviations from trend. In the mid 1980s, fiscal policy makes a small pro-cyclical contribution by exacerbating above-

trend inflation. Over the early and mid 1990s, fiscal policy appears broadly a-cyclical with respect to inflation. During the late 1990s, fiscal policy dampens inflation in a pro-cyclical manner. Fiscal policy is a-cyclical or modestly counter-cyclical over the 2000s.

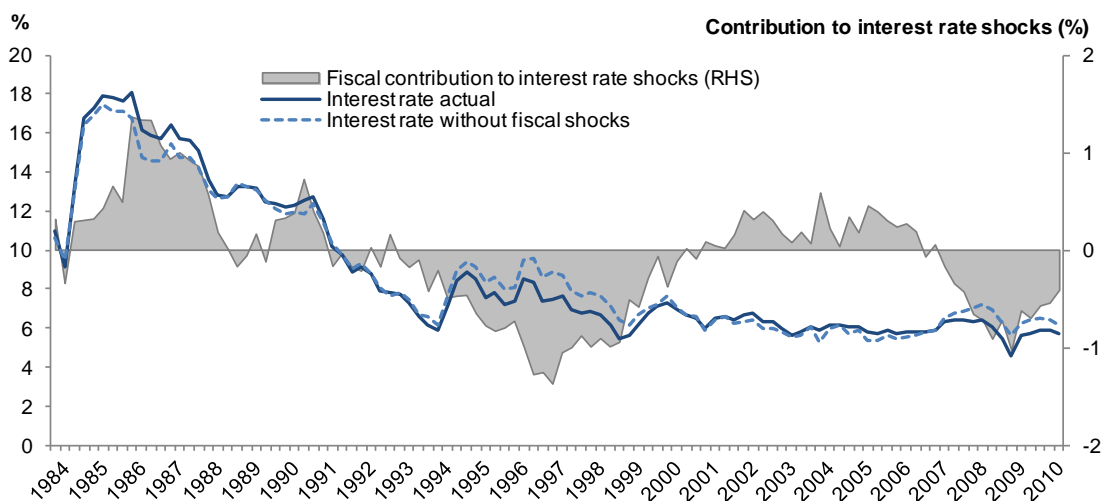
**Figure 17: Inflation cycle and fiscal policy**



Source: Statistics New Zealand, authors' calculations.

Figure 18 shows the actual long-term interest rate and a counter-factual interest rate without fiscal policy shocks. This indicates that fiscal policy induced a higher long-term interest rate over 1984 to 1990 (averaging around 50 basis points) and 2000 to 2007 (averaging around 25 basis points) and dampened the interest rate over 1991 to 1999 (averaging around 60 basis points) and 2007 to 2010 (averaging around 60 basis points).

**Figure 18: Interest rate and fiscal policy**



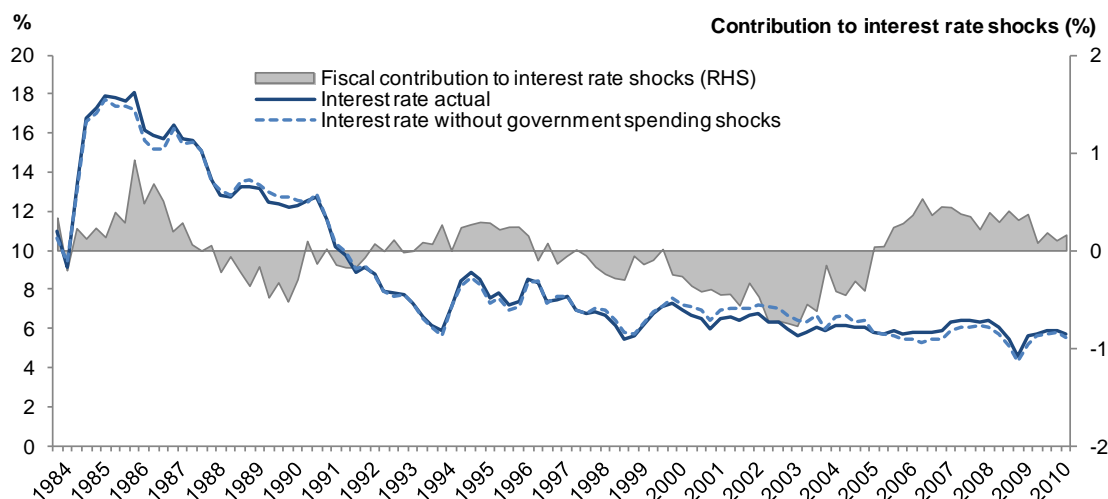
Source: Statistics New Zealand, authors' calculations.

Figure 19 shows the counterfactual interest rate which isolates the effect of only government spending shocks, since we may be more confident about the identification

of government spending shocks compared with net tax shocks. This shows that government spending dampened the interest rate over 2000 to 2004 by 45 basis points on average and then exerted an upward contribution by an average 30 basis points over 2005 to 2010.

The results suggest that fiscal policy can exert quite a significant impact on the long-term interest rate. As context, the standard deviation of the absolute quarterly change in the 10-year bond yield over 1990:1 to 2010:2 is 35 basis points.

**Figure 19: Interest rate and government spending**



Source: Statistics New Zealand, authors' calculations.

Brook (2012) argues that pro-cyclical discretionary fiscal policy over the 2000s likely exacerbated the interest rate and exchange rate cycles in New Zealand thereby worsening the current account balance. Our analysis is broadly congruent with Brook (2012) in finding evidence of pro-cyclical fiscal policy and upward pressure on the interest rate during parts of the 2000s.

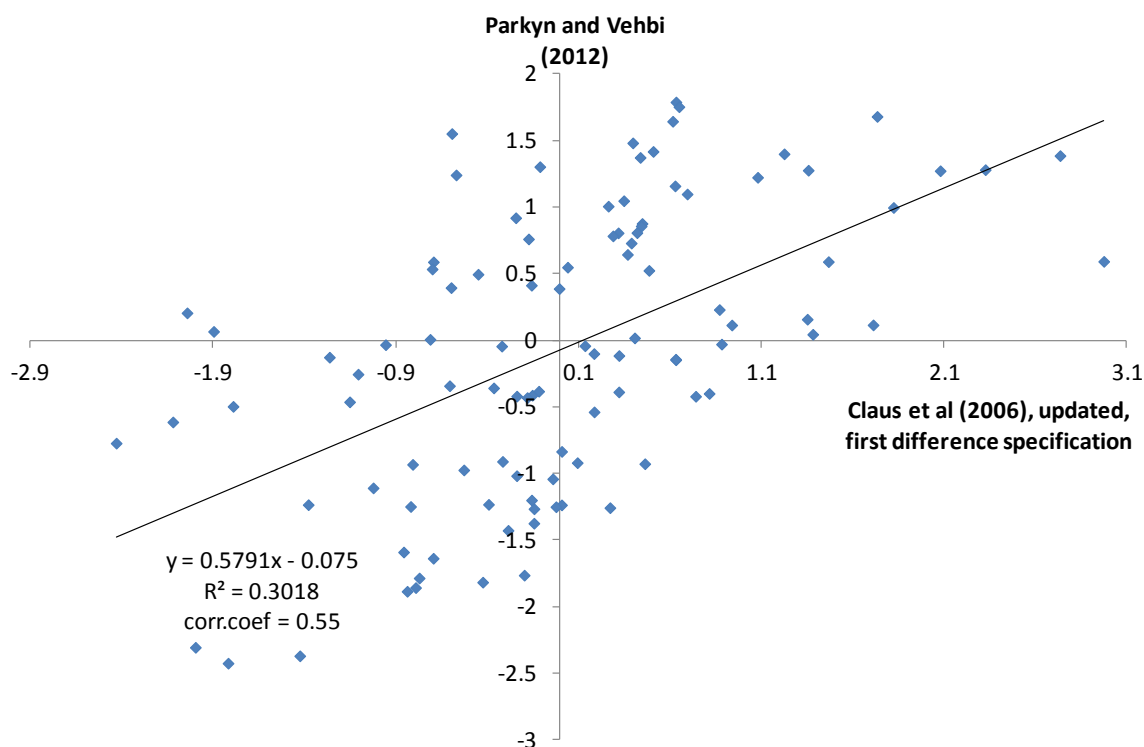
### Comparison with previous work

The fiscal impulse measure that we show in Figure 16 can be compared with that using the three-variable SVAR of Claus *et al* (2006) using updated data. The Claus *et al* (2006) SVAR has three variables (net tax, government spending and GDP), estimated in first differences and the fiscal impulse is interpreted as the contribution of fiscal policy to GDP growth. The SVAR in our paper has five variables (net taxes, government spending, GDP, inflation and the interest rate) and feedbacks from the level of public debt. It is also estimated in levels and the fiscal impulse should therefore be interpreted as the contribution of fiscal policy to deviations in the level of GDP from trend (i.e., the output gap).

Figure 20 shows that the two series are generally congruent which suggests that the interpretation of fiscal policy on the business cycle in this paper is somewhat robust to model specification. It also suggests that inclusion of debt feedbacks have not been so large in New Zealand as to provide significantly different results as the model without

debt feedbacks. The modest importance of debt likely reflects that public debt was relatively low in New Zealand from after the mid-1990s.

**Figure 20: Fiscal impulse**



Source: Authors' calculations.

## ROBUSTNESS CHECKS AND DIAGNOSTICS

In this section, we report the results from various robustness checks conducted to test the sensitivity of the results presented above to various model assumptions. In line with the main focus of the paper, we only report the sensitivities of the corresponding shocks and the fiscal multipliers. The full sets of impulse responses are also available on request.

Furthermore, we report the results from a selection of diagnostic tests performed to test the statistical validity of the model results. These include the tests for autocorrelation, heteroskedasticity, normality and model stability.

### Sensitivity analysis

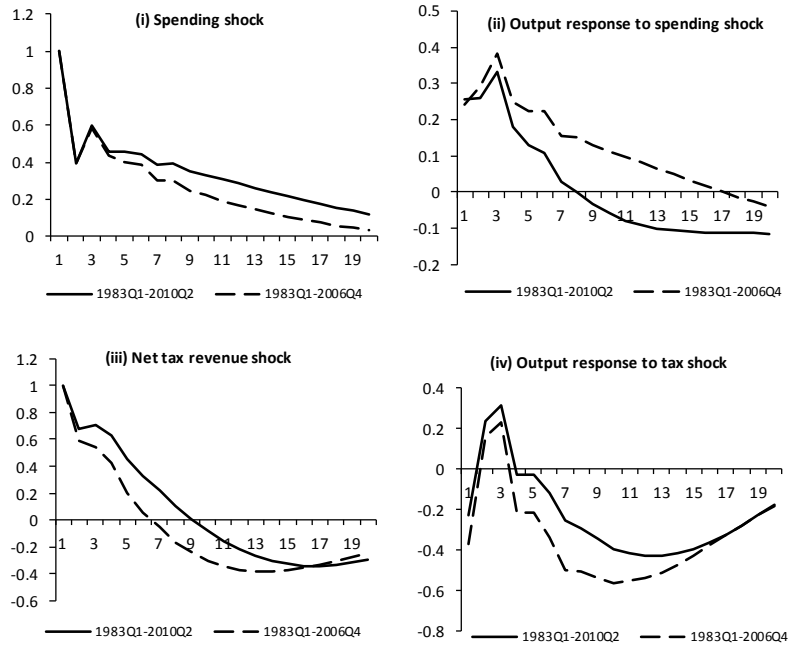
The purpose of the first robustness check is to check whether the results are sensitive to the sample size chosen for model estimation. We consider two episodes that could potentially lead to parameter instability. The first is the period following the global financial crisis (GFC).

To test whether the model results are robust to the inclusion of the crisis period in estimation, we re-estimate the model for the period 1983:1-2006:4 and calculate the



impulse response functions. The results are shown in Figure 21. While the output response to the spending shock is more persistent in the shorter sample, the results are fairly robust particularly in the short-run.

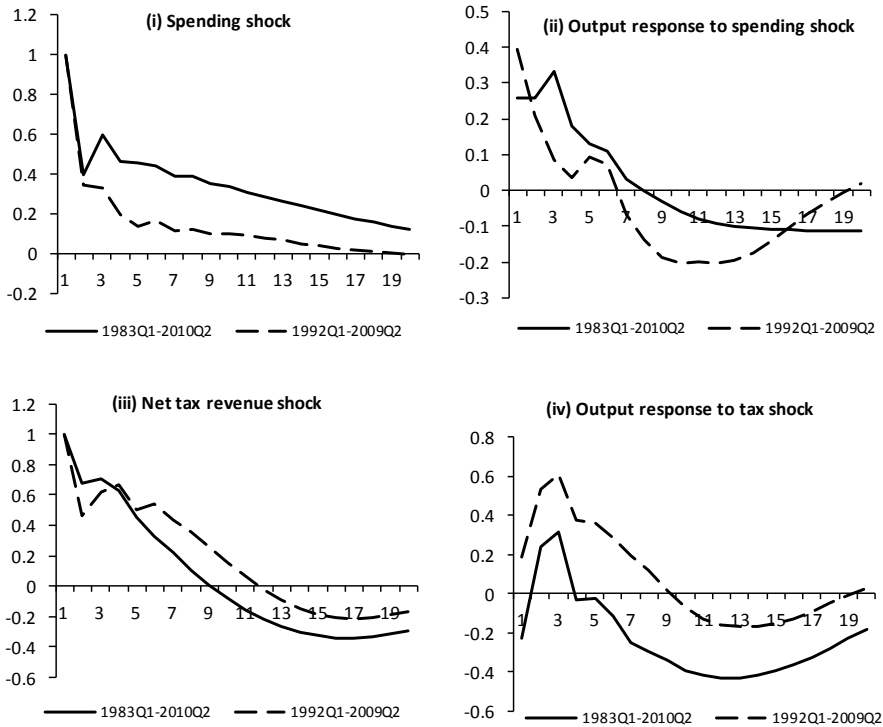
**Figure 21: Sample size sensitivity (1983:1-2006:4)**



Source: Authors' calculations.

The second sub-sample period we consider runs from 1992:1-2009:2. The period prior to 1992 is characterised by major policy changes in the economy such as the adaptation of inflation targeting regime and the amendment of the Fiscal Responsibility Act. We re-estimate the model for the later sub-sample and calculate the corresponding impulse responses. The results are displayed in Figure 22.

**Figure 22: Sample size sensitivity (1992:1-2009:2)**



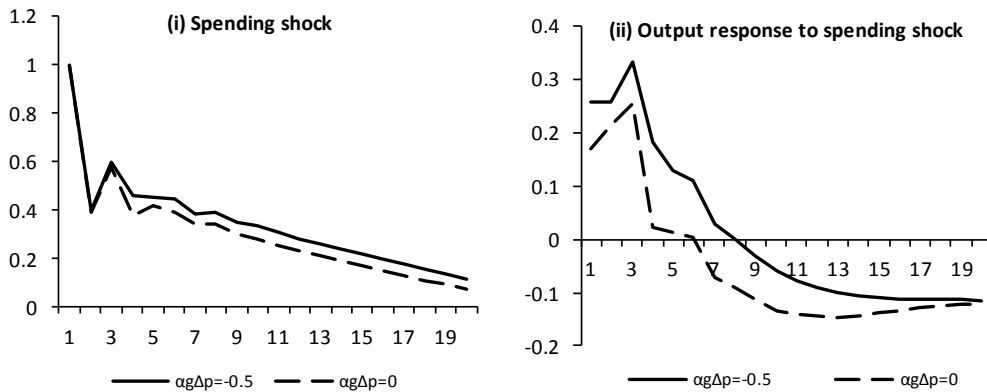
Source: Authors' calculations.

It can be seen that the government spending shocks have a smaller impact on output during this period. The effect of revenue shocks, on the other hand, is higher.

In another sensitivity analysis, we experiment with different values for the elasticities of government revenues and expenditures described in Section 3.1.

Firstly, we run the model by setting the price elasticity of real government spending,  $a_{g\Delta p}$ , to zero. The impact of this change on the government spending shock and the corresponding output multiplier is shown in Figure 23. The impulse responses are qualitatively similar.

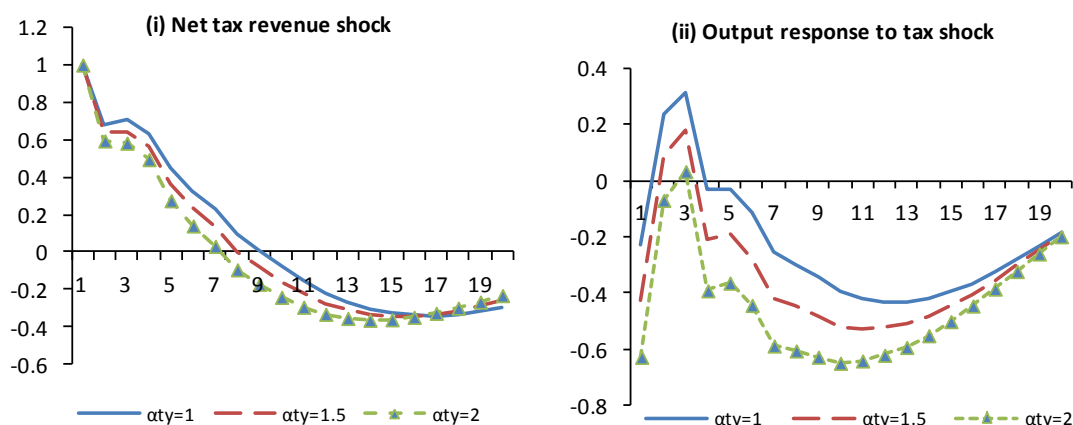
**Figure 23: Sensitivity to the price elasticity of government spending**



Source: Authors' calculations.

Secondly, we experiment with the elasticity of tax revenue with respect to GDP,  $a_{ty}$  by setting set its values to 1.5 and 2 respectively. The corresponding effects are displayed in Figure 24. The results appear broadly similar, although it is notable that the sign of the response of output to a net tax shock is almost entirely negative if the elasticity is set at 2. This is a more intuitive result, suggesting that it would be useful to investigate whether net taxes are more sensitive to GDP than is assumed in the base case.

**Figure 24:** Sensitivity to the output elasticity of tax revenue



Source: Authors' calculations.

### Diagnostic tests

Tables A3-A4 and Figures A1-A3 in the Appendix show the results of various diagnostic tests. These tests are carried out to detect potential violations of the Gauss-Markov assumptions. Model stability tests show the model is stable-all the roots of the characteristic polynomial are less than one (Appendix Figure A1). The Portmanteau and the White tests do not indicate any significant autocorrelation and heteroskedasticity in the residuals of the model (Appendix Tables A3 and A4). The quantile plots for the residuals displayed in Appendix Figure A2 show that the residuals are normally distributed with only slight divergences. Finally, the cumulative sum of squares (CUSUM) test results displayed in Appendix Figure A3 is not suggestive of any parameter or variance instability in the model.

### CONCLUSION

This paper has estimated a fiscal SVAR model for New Zealand to investigate the effects of discretionary fiscal policies on New Zealand's economic activity (building on the contribution of Claus et al., 2006). Its contribution over recent New Zealand literature is to explicitly include a feedback from the level of government debt in a manner that incorporates the government's inter-temporal budget constraint, using the technique in Favero and Giavazzi (2007).

The fiscal multipliers from changes in government spending in New Zealand appear to be positive but small, estimated to be about 0.26 on impact. An unexpected one dollar increase in government spending would typically raise GDP temporarily by around 42

cents in the first year, at the cost of higher interest rates and lower output in the medium to long-run. The effect on GDP is less clear cut from a discretionary increase in taxes less transfer payments, but the results suggest that an unexpected one dollar increase in taxes would lower GDP on impact by 23 cents and have a similarly negative medium-term impact on GDP.

The model included the government's long-term interest rate, which is also likely to be an important variable in the wider economy linked to the cost of capital of firms and the borrowing rate for households. The results show a statistically significant and persistent increase in the nominal interest rates of approximately 7 basis points in response to a one percent increase in government spending. The corresponding impact on inflation is rather modest.

Past fiscal policy was analysed through a historical decomposition of the shocks in the model. This suggests that discretionary fiscal policy has had a generally pro-cyclical impact on GDP over 1998 to 2010, and a material impact on long-term interest rates. For example, the model suggests that discretionary changes in government spending dampened the long-term interest rate over 2000 to 2004 by 45 basis points on average and then exerted an upward contribution by an average 30 basis points over 2005 to 2010.

### **Future work**

There are a number of possible extensions to the analysis conducted in this paper:

First, the approach adopted here only portrays average estimates of fiscal multipliers across the sample time period. Inferences for policy or forecasting will be appropriate so long as the main structural characteristics of the New Zealand economy remain unchanged. For example, the fiscal multipliers are likely to be different depending on the monetary regime, the capacity for monetary policy accommodation, the amount of fiscal space, and whether there is a financial crisis. The multipliers may also differ over the cycle depending on the underlying state of the economy (IMF, 2012). The model is linear so does not account for this possibility. It may be reasonable to assume that the linear estimates will be broadly reasonable so long as unemployment is within the range of historical experience. For the G7 economies, Baum et al. (2012) find that, on average, government spending and revenue multipliers tend to be larger in downturns than in expansions. Therefore, a useful extension would be to extend this framework to a time-varying VAR setting in order to investigate possible changes to the effectiveness of fiscal policy over time.

Second, a further extension of this work would be to add an external sector and exchange rate. The model did include an interest rate, and detected a positive response in the interest rate in response to fiscal expansion. To the extent that uncovered interest parity holds, changes in interest rates induced by fiscal policy shocks should also affect the exchange rate.

Net tax shocks have a counterintuitive output multiplier at certain horizons (i.e., GDP increases in response to a positive net tax shock), consistent with the puzzle discussed in Fielding et al. (2011). Although we show that this result is highly sensitive to the choice of the elasticity of tax to GDP, it also raises the possibility that the model is misspecified and we should be conscious of this when interpreting these responses. It

would be useful for further work to investigate alternative means of identifying tax shocks to check the robustness of this result.

## REFERENCES

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- Amisano, G. and C. Giannini (1997). Topics in SVAR econometrics, 1997.
- Auerbach, A. and Y. Gorodnichenko (2012). Fiscal multipliers in recession and expansion. In: Fiscal Policy after the Financial Crisis. National Bureau of Economic Research, Inc.
- Barro, R.J (2009). Government spending is no free lunch. Wall Street Journal, 22.
- Baum, A., M. Poplawski-Ribeiro and A. Weber (2012). Fiscal multipliers and the state of the economy. IMF Working Paper (forthcoming).
- Blanchard O. and R. Perotti (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. The Quarterly Journal of Economics, 117(4): 1329-1368.
- Brook, A.M (2012). Making fiscal policy more stabilising in the next upturn: Challenges and policy options, New Zealand Economic Papers, DOI:10.1080/00779954.2012.721691.
- Caldara, D. and C. Kamps (2008). What are the effects of fiscal shocks? a VAR-based comparative analysis. Working Paper Series 877, European Central Bank.
- Caprioli, F. and S. Momigliano (2011). The effects of fiscal shocks with debt-stabilizing budgetary policies in Italy. Bank of Italy Working Paper No, 839.
- Chay, J, A. Marsden and R. Stubbs (1993). Historical rates of return to equities, bonds, and the equity risk premium: New Zealand evidence. Pacific Accounting Review, 5(1):27-46.
- Chow G.C. and A. Lin (1971). Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. The Review of Economics and Statistics, pages 372-375.
- Chung, H. and E. M. Leeper (2007). What has financed government debt? NBER Working Papers 13425, National Bureau of Economic Research, Inc.
- Claus, I., A. Gill, B. Lee and N. McLellan (2006). An empirical investigation of fiscal policy in New Zealand. Treasury Working Paper.
- De Castro, F. and P. Hernandez de Cos (2008). The economic effects of fiscal policy: the case of Spain. Journal of Macroeconomics, 30(3):1005-1028.
- Dungey, M. and R. Fry (2009). The identification of fiscal and monetary policy in a structural var. Economic Modelling, 26(6):1147-1160.
- Eggertsson, G.B. and P. Krugman (2012). Debt, deleveraging, and the liquidity trap: A Fisher-Minsky-Koo approach. The Quarterly Journal of Economics, 127(3):1469-1513.
- Enders, W. (2004). Applied econometric time series. Wiley (New York).

- Fatas, A. and I. Mihov (2001). The effects of fiscal policy on consumption and employment: theory and evidence. CEPR discussion paper.
- Favero, C. and F. Giavazzi (2007). Debt and the effects of fiscal policy. NBER Working Papers 12822, National Bureau of Economic Research, Inc.
- Fielding, D., O. Parkyn and P. Gardiner (2011). Explaining some puzzles in the estimated response of New Zealand GDP to fiscal shocks. New Zealand Association of Economists Annual Conference.
- Giordano, R., S. Momigliano, S. Neri and R. Perotti (2007). The effects of fiscal policy in Italy: Evidence from a VAR model. *European Journal of Political Economy*, 23(3):707-733.
- Girouard, N. and C. André (2005). Measuring cyclically-adjusted budget balances for OECD countries. OECD Economics Department Working Paper, No.434.
- Ilizetki, E. and C.A. Vegh (2008). Procyclical fiscal policy in developing countries: Truth or fiction? Technical report, National Bureau of Economic Research.
- Ilizetki, E., E.G. Mendoza and C.A. Vegh (2010). How big (small?) are fiscal multipliers? NBER Working Papers 16479, National Bureau of Economic Research.
- Kearney, I., D. McCoy, D. Dufy, M. McMahon and D. Smyth (2000). Assessing the stance of Irish fiscal policy. *Budget Perspectives*, Dublin: The Economic and Social Research Institute.
- Lally, M. and A. Marsden (2004). Tax-adjusted market risk premiums in New Zealand: 1931-2002. *Pacific-Basin Finance Journal*, 12(3):291-310 .
- Mears, T., G. Blick, T. Hampton and J. Janssen (2010). Fiscal institutions in New Zealand and the question of a spending cap. New Zealand Treasury Working Paper 10/07.
- Mountford, A. and H. Uhlig (2009). What are the effects of fiscal policy shocks? *Journal of Applied Econometrics*, 24(6): 960-992.
- Pagan, A.R., L. Catao and D. Laxton (2008). Monetary transmission in an emerging targeter: The case of Brazil. *IMF Working Papers*, pages 1-42.
- Parkyn, O. (2010). Estimating New Zealand's structural budget balance. Technical report, New Zealand Treasury.
- Perotti, R. (2005). Estimating the effects of fiscal policy in OECD countries. CEPR discussion paper.
- Philip, R. and J. Janssen (2002). Indicators of fiscal impulse for New Zealand. New Zealand Treasury Working Paper, 2/30.
- Romer, C.D. and D.H. Romer (2010). The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks. *The American Economic Review*, 100(3):763-801.

Sims, C.A., J.H. Stock and M.W. Watson (1990). Inference in linear time series models with some unit roots. *Econometrica: Journal of the Econometric Society*, pages 113-144.

Tang H.C., P. Liu and E.C. Cheung (2010). Changing impact of fiscal policy on selected Asean countries. *Journal of Asian Economics*.

## APPENDIX A

Table A1: Unit root test results

	<i>ADF</i>	<i>Philips-Perron</i>
Government Spending	-2.05*	-1.64*
Net Tax	-2.80*	-1.74*
GDP	-1.67*	-1.67*
Inflation	-2.54*	-9.68
Interest Rate	-2.58*	-2.25*
Debt	-2.36*	-2.80*

Note: \* indicates statistically significant unit root at 5 percent significance level. The lag lengths are selected based on Akaike Information Criteria (AIC). The ADF statistics for all variables are based on regressions including constant and linear trend with the exception of inflation which include constant only.

Table A2: Johansen cointegration test results

Selected (0.05 level\*) Number of Cointegrating Relationships by Model

Data Trend:	None	None	Linear	Linear	Quadratic
	No				
Test Type	Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0

\*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
	No				
Rank or No. of Coint.Eqns.	Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Log Likelihood by Rank (rows) and Model (columns)					
0	421.2739	421.2739	423.0708	423.0708	425.0898
1	425.0364	425.5393	427.2717	428.6582	430.0346
2	425.8361	427.2742	427.2742	430.4015	430.4015
Akaike Information Criteria by Rank (rows) and Model (columns)					
0	-7.722149	-7.722149	-7.718317	-7.718317	-7.718675
1	-7.717667	-7.708288	-7.722108	-7.729400	-7.736502*
2	-7.657284	-7.646684	-7.646684	-7.667954	-7.667954
Schwarz Criteria by Rank (rows) and Model (columns)					
0	-7.420628*	-7.420628*	-7.366542	-7.366542	-7.316646
1	-7.315638	-7.281133	-7.269826	-7.251991	-7.233967
2	-7.154749	-7.093894	-7.093894	-7.064911	-7.064911

Note: The sample period is 1983:1-2010:2. The variables are logarithms of real per capita government spending and real per capita tax revenues net of transfers. The lag length for VAR is chosen as 3 based on AIC.



Selected (0.05 level\*) Number of Cointegrating Relationships by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	2	1	1	1
Max-Eig	1	0	0	1	1

\*Critical values based on MacKinnon-Haug-Michelis (1999)

#### Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of Coint Eqns.	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend

#### Log Likelihood by Rank (rows) and Model (columns)

0	1185.134	1185.134	1193.423	1193.423	1196.948
1	1198.959	1199.270	1206.883	1213.599	1216.820
2	1206.521	1211.581	1214.253	1222.422	1225.250
3	1208.871	1216.196	1217.842	1226.387	1228.979
4	1208.871	1218.492	1218.492	1229.728	1229.728

#### Akaike Information Criteria by Rank (rows) and Model (columns)

0	-20.96607	-20.96607	-21.04406	-21.04406	-21.03541
1	-21.07199	-21.05945	-21.14333	-21.24725	-21.25127
2	-21.06402	-21.11966	-21.13188	-21.24403	-21.25909*
3	-20.96128	-21.03992	-21.05168	-21.15249	-21.18145
4	-20.81585	-20.91804	-20.91804	-21.04960	-21.04960

#### Schwarz Criteria by Rank (rows) and Model (columns)

0	-20.18048*	-20.18048*	-20.16027	-20.16027	-20.05342
1	-20.08999	-20.05291	-20.06314	-20.14251	-20.07288
2	-19.88563	-19.89216	-19.85529	-19.91834	-19.88430
3	-19.58649	-19.59148	-19.57869	-19.60585	-19.61026
4	-19.24466	-19.24866	-19.24866	-19.28201	-19.28201

Note: The sample period is 1983:1-2010:2. The variables are logarithms of real per capita government spending, real per capita tax revenues net of transfers, real GDP per capita and 10 year interest rates. The lag length for VAR is chosen as 2 based on AIC.

Table A3: VAR residual Portmanteau tests for autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	3.767290	NA*	3.802831	NA*	NA*
2	9.796390	NA*	9.946771	NA*	NA*
3	29.70909	NA*	30.43387	NA*	NA*
4	56.27069	0.1427	58.02700	0.1099	46
5	79.75032	0.2232	82.65758	0.1624	71
6	95.63549	0.4913	99.48643	0.3834	96
7	110.7778	0.7368	115.6887	0.6193	121
8	147.0489	0.4601	154.8908	0.2915	146
9	175.1920	0.3971	185.6184	0.2105	171
10	203.8717	0.3351	217.2548	0.1422	196
11	221.8366	0.4715	237.2782	0.2155	221
12	250.2876	0.4121	269.3231	0.1469	246

Note: Null hypothesis: no residual autocorrelations up to lag h. df is degrees of freedom for (approximate) chi-square distribution.

\*The test is valid only for lags larger than the VAR lag order.

Table A4: White test for heteroskedasticity

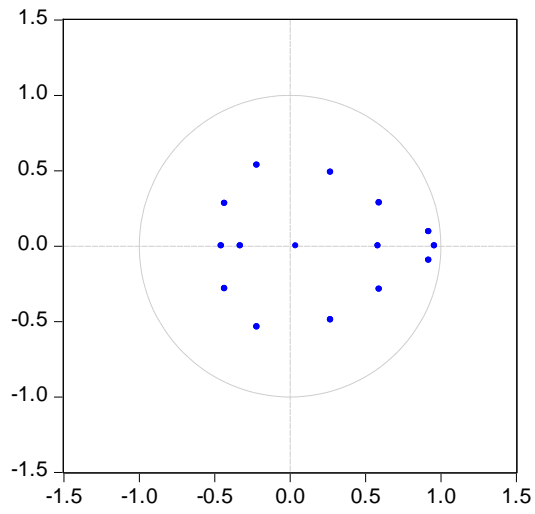
VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares), Sample: 1983:1 2010:2.

Joint test:

Chi-sq	df	Prob.
517.9624	480	0.1120

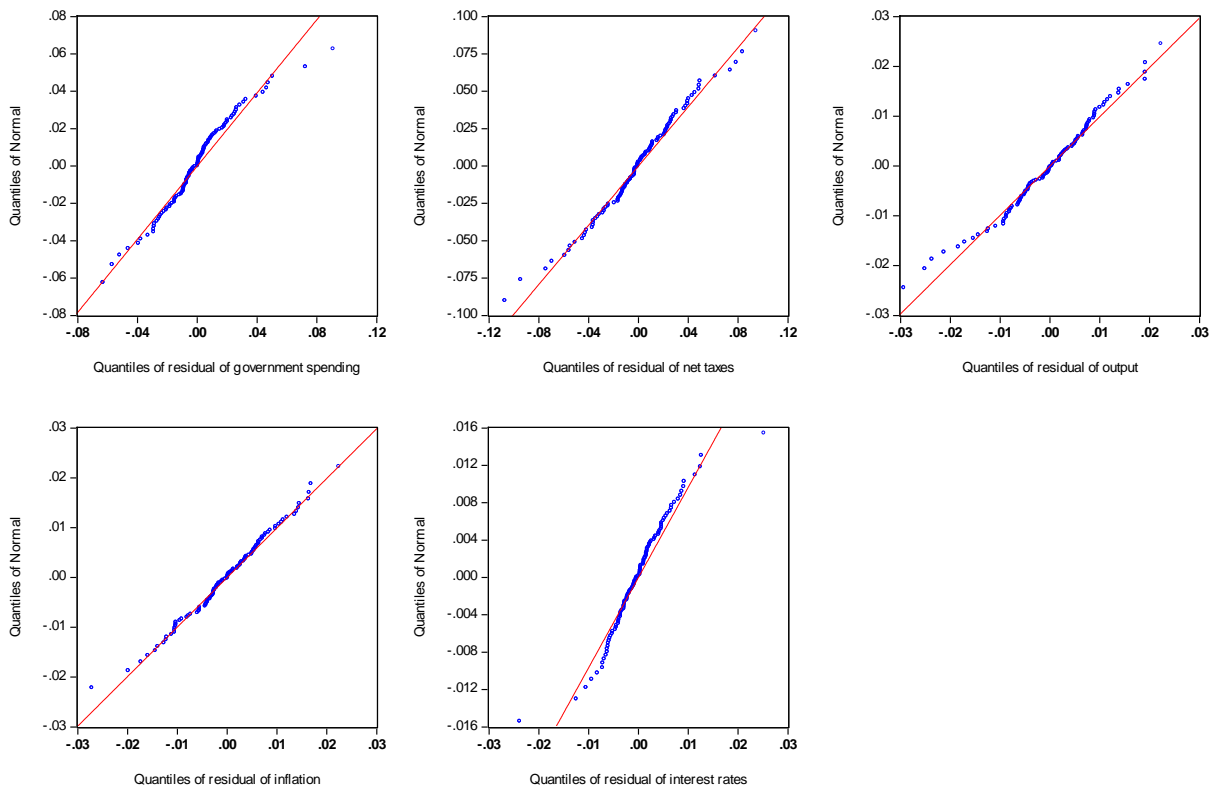
Note: Null hypothesis: no residual heteroskedasticity

Figure A1: Inverse roots of AR characteristic polynomial



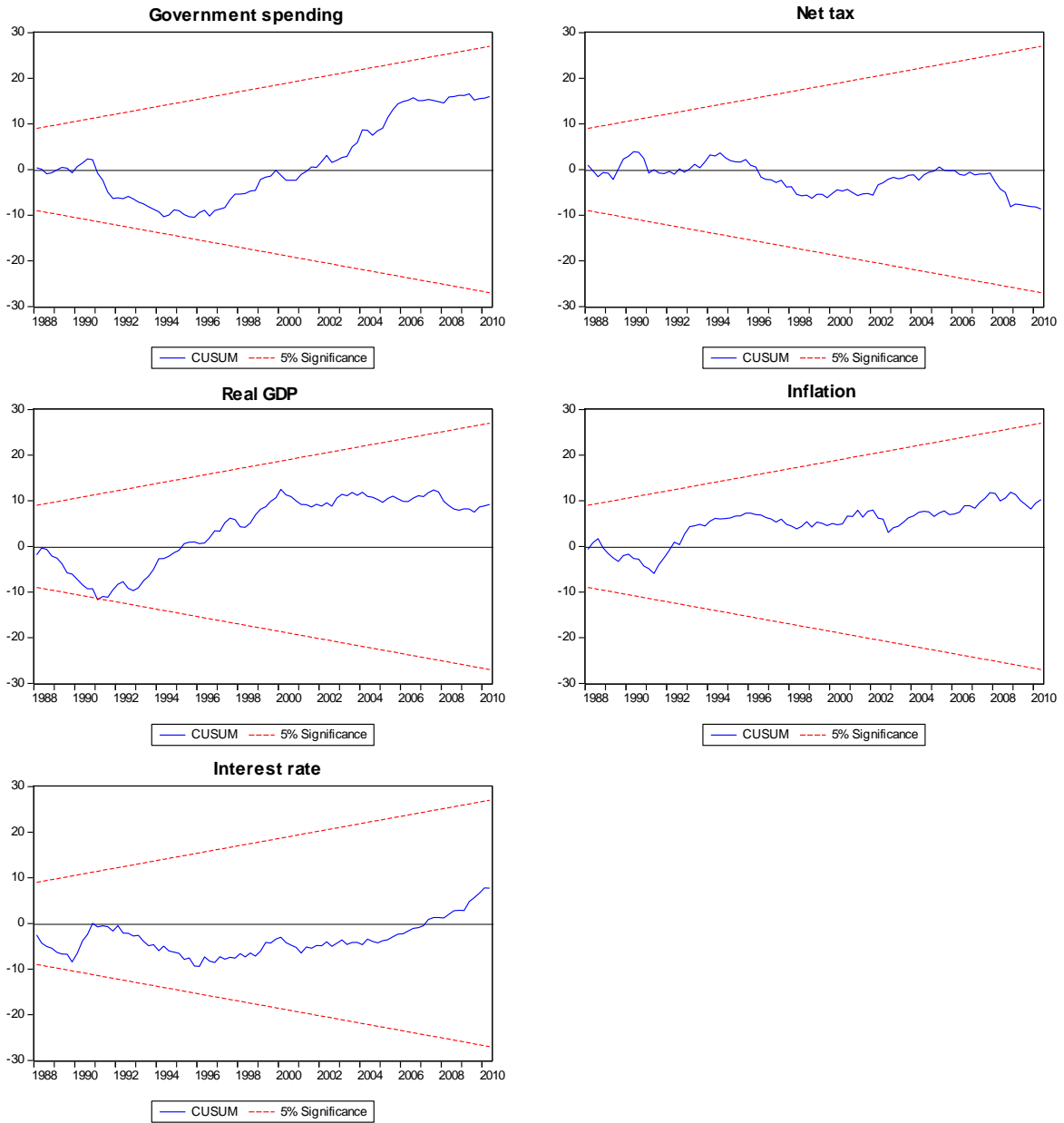
Source: Authors' calculations.

Figure A2: Residual quantile plots



Source: Authors' calculations.

Figure A3: CUSUM plots



Source: Authors' calculations.