An empirical investigation of fiscal policy in New Zealand

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Abstract

This paper examines the effects of fiscal policy, measured by changes in government spending and net tax (government tax revenue less transfer payments), on New Zealand GDP. The framework of analysis is a structural vector autoregression (VAR) model of the New Zealand economy, employing and extending estimation techniques used by Blanchard and Perotti (2002). This model is then used to examine the dynamic effects of changes in government spending, taxes and transfers on GDP and the contributions of discretionary fiscal policy to New Zealand business cycles.

JEL CLASSIFICATION	C32 - Time-series models
	E32 - Business fluctuations; cycles
	E62 - Fiscal policy; public expenditures, investment, and finance; taxation
KEYWORDS	Fiscal policy, business cycle fluctuations, vector autoregression

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An empirical investigation of fiscal policy in New Zealand

1 Introduction

This paper examines the effects of fiscal policy, as measured by government spending and net tax, on New Zealand GDP. The focus is on the temporary, business cycle effects of fiscal policy on GDP.[1] The work provides a basis for evaluating the impact of fiscal policy on New Zealand GDP, thereby complementing existing fiscal indicators, such as the cyclically adjusted fiscal balance and other measures of fiscal impulse. This paper also furthers previous work examining the sources of fluctuations in New Zealand GDP (Buckle, Kim, Kirkham, McLellan and Sharma, 2002; Buckle, Kim and McLellan, 2003) by analysing the contribution of fiscal policy to New Zealand business cycles.

Different approaches have been used to measure the effects of fiscal policy on key economic aggregates, like GDP, inflation and interest and exchange rates. One approach is to simulate fiscal policy changes using large-scale structural macroeconomic model. An alternative approach is to estimate smaller empirical models, such as vector autoregression (VAR) models to assess the effects of changes in fiscal policy on the economy. A variety of techniques have been used to identify the effects of fiscal policy using these smaller empirical models. For example, Blinder (1981) and Ramey and Shapiro (1998) examine the effects of fiscal policy on the United States economy by identifying particular fiscal episodes or events, such as the temporary income tax reductions in 1968 and 1975 or increases in defence spending associated with the military build-up during the Korean and Vietnam wars. Blanchard and Perotti (2002) and Perotti (2004), who examine fiscal policy in the United States and a selection of OECD economies, use a structural VAR model to measure the dynamic impact of fiscal shocks to output. Their innovation is to use institutional information on the tax and transfer system to identify the effects of fiscal policy shocks on output.

This paper builds on Blanchard and Perotti (2002). It replicates Blanchard and Perotti's three-variable vector autoregression (VAR) model, which was originally estimated using United States data, for New Zealand. The model, which includes gross domestic product (GDP), net tax (i.e. tax revenue less transfer payments) and government spending, is then used to examine the effects of changes in net tax and government spending and their historical contributions of fiscal policy to New Zealand business cycles. Blanchard and Perotti's model is also extended by examining the separate impact of taxes and government transfers.

[1] Fiscal policy also has important long-run economic effects. For a discussion of the long-run economic effects of fiscal policy see Kneller, Bleaney and Gemmell (1999).

The remainder of the paper is organised as follows. Section 2 outlines the model and data. Section 3 discusses the instantaneous (contemporaneous) dynamic effects of shocks in both net tax and government spending. Section 4 reports sensitivity analysis, robustness testing, and compares the New Zealand results to that from other models and economies. The historical contributions of net tax to New Zealand business cycles are examined in section 5. Key conclusions are discussed in section 6.

2 Model and data

This section outlines the modelling framework used to assess the impact of fiscal policy on New Zealand output. The framework of analysis is a structural vector autoregression (VAR) model, employing estimation and identification techniques used by Blanchard and Perotti (2002). This section derives the fiscal VAR model and the restrictions used to identify the effects of net tax and government spending on gross domestic product (GDP). It describes the fiscal and economic data and discusses their time series properties and trend specification.

2.1 Fiscal VAR and identification

The fiscal VAR model is described by a system of reduced-form equations. Ignoring constant terms, it is given by

$$A(L)y_t = \varepsilon_t \tag{1}$$

where $A(L)$ is a p^{th} order matrix polynomial in the lag operator L, such that $A(L)_t = I - A_1L - A_2L^2 - ... - A_pL^p$. Throughout, p is set equal to four as quarterly data are used in the analysis.[2] In this model, $y_t \equiv [T_t, G_t, Z_t]'$ is a three-dimensional vector in the logarithms of quarterly net tax (government tax revenue less transfer payments), government spending and GDP, although our extension of this model also disaggregates net tax into taxes and government transfers. Each variable is expressed in real per capita terms, where all nominal variables are deflated using the GDP deflator. $\varepsilon_t \equiv \left[\varepsilon_t^T, \varepsilon_t^G, \varepsilon_t^Z\right]'$ is the vector of reduced form residuals for net tax, government spending and GDP respectively. The reduced form residuals are unexpected movements in net tax, government spending and GDP and are composite errors of the shocks to the economy. The reduced form VAR model was estimated using quarterly data for the period September 1982 to September 2004.

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2 In the specification of the VAR model used by Blanchard and Perotti to estimate the impact of fiscal policy on United States GDP, seasonal dummy variables are interacted with per capita GDP, net tax and government spending to account for seasonal patterns in net tax. This specification made little difference to New Zealand results, therefore a simpler VAR specification is adopted that excludes interactive seasonal dummy variables.

To gauge the impact of fiscal policy on GDP, restrictions need to be imposed on the reduced form errors. To derive the identification scheme adopted in this paper, write:

$$\varepsilon_t^T = a_1\varepsilon_t^Z + a_2u_t^G + u_t^T \quad (2)$$

$$\varepsilon_t^G = b_1\varepsilon_t^Z + b_2u_t^T + u_t^G \quad (3)$$

$$\varepsilon_t^Z = c_1\varepsilon_t^T + c_2\varepsilon_t^G + u_t^Z \quad (4)$$

where u_t^T, u_t^G, and u_t^Z are the mutually uncorrelated structural residuals for net tax, government spending and GDP. These structural shocks need to be recovered to identify the impact of net tax and government spending on GDP.

Equation (2) shows that unexpected movements in net tax are a function of unexpected movements in GDP and structural shocks to government spending and net tax. Equation (3) states that unexpected movements in government spending are also owing to unexpected movements in GDP and structural shocks in net tax and government spending. Finally, equation (4) states that unexpected movements in GDP are related to unexpected movements in net tax and government spending and structural shocks to GDP.

The key challenge is to estimate the parameters of equations (2) to (4). This is done using the identification procedures developed by Blanchard and Perotti (2002) and Perotti (2004) for the purpose of evaluating the effects of fiscal policy on GDP for the United States and a group of OECD economies.

Contemporaneous changes in net tax and government spending in response to GDP movements could potentially occur for two reasons. First, net tax and government spending may automatically change in response to GDP movements under existing fiscal policy settings. Second, the government may discretionarily vary net tax and spending in response to movements in GDP by changing fiscal policy settings. However, as noted by Blanchard and Perotti (2002), the use of quarterly data virtually eliminates the operation of the second channel owing to recognition and implementation lags with regards to discretionary fiscal policy. Therefore, a_1 and b_1 can be obtained from independent estimates of elasticities of net tax and government spending to output.

Girouard and André (2005) provide estimates of output elasticities for direct taxes on individuals, corporate income taxes, and indirect taxes for a number of OECD countries. They estimated New Zealand tax to output elasticities using annual data for the period 1989 to 2003. Based on these estimates a_1 is set equal to one. This means that a one percentage point increase in GDP leads to a one percentage point increase in taxes. Following Blanchard and Perotti (2002) and Perotti (2004) it is assumed that government spending does not automatically respond to unexpected movements in GDP, therefore b_1 is set equal to zero.

Estimates for a_1 and b_1 provide the basis for estimating the parameters c_1 and c_2 of equation (4). Following Blanchard and Perotti (2002), cyclically adjusted reduced form net tax and government spending residuals are used as instrumental variables to estimate c_1 and c_2. The cyclically adjusted net tax (ε_t^{T*}) and government spending (ε_t^{G*}) reduced form residuals are calculated as $\varepsilon_t^{T*} = \varepsilon_t^T - a_1\varepsilon_t^Z = \varepsilon_t^T - \varepsilon_t^Z$ and $\varepsilon_t^{G*} = \varepsilon_t^G - b_1\varepsilon_t^Z = \varepsilon_t^G$. The cyclically adjusted reduced form residuals ε_t^{T*} and ε_t^{G*} can be used as instruments as they are not correlated with the structural GDP shock u_t^Z.

Finally, estimates are required for a_2 and b_2. As noted by Blanchard and Perotti (2002), it is difficult to determine the ordering of government net tax and spending decisions. Do governments make a decision to tax first and then spend, or do they spend and then tax? In the baseline model net tax is ordered before government spending. But because there is no clear answer to the question, the reverse ordering is considered in the sensitivity analysis in section 4. When net tax is ordered before government spending $a_2 = 0$ and b_2 is estimated. When government spending is ordered before net tax $b_2 = 0$ and a_2 is estimated. As is discussed in Section 4, in practice this issue is of little consequence because the dynamic response of GDP to both net tax and government spending shocks is basically invariant to the ordering of net tax and government spending.

2.2 Data

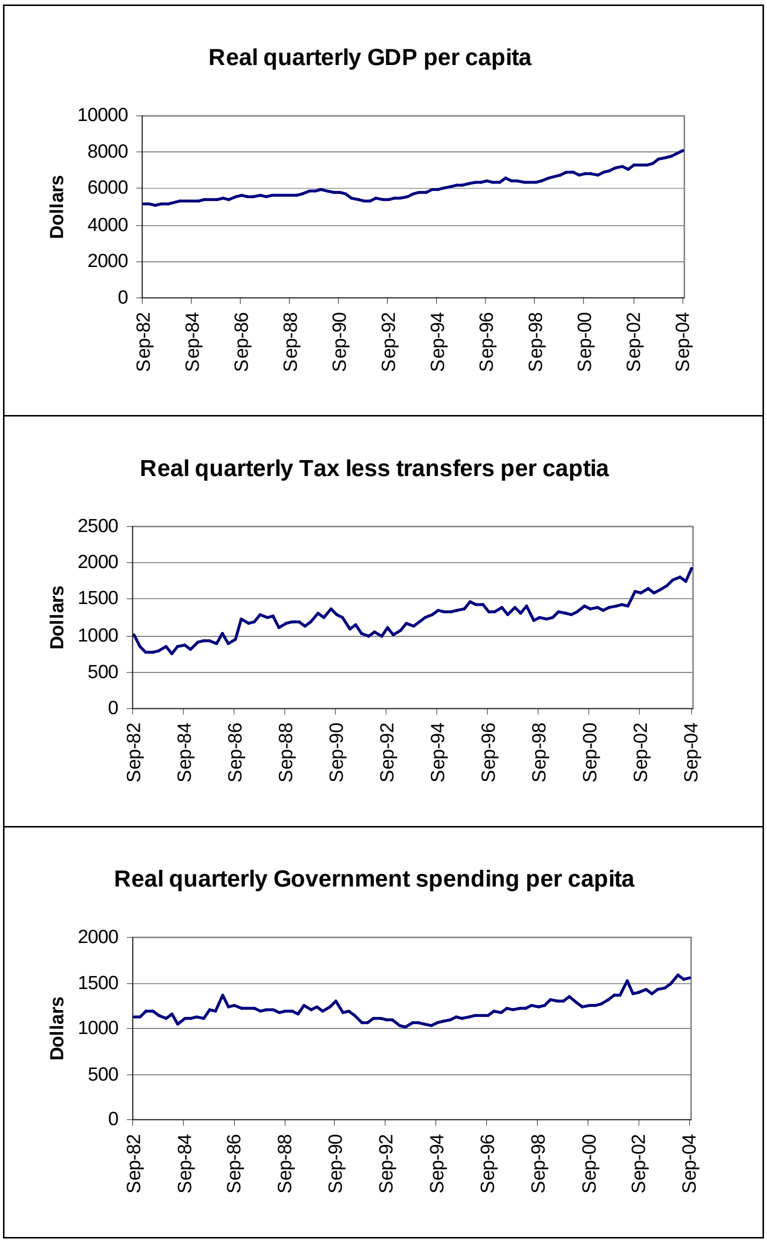
To estimate the fiscal VAR for New Zealand at least three variables are required: net tax (i.e. government tax revenue less transfer payments), government spending (purchases of goods and services), and GDP. GDP is measured by Statistics New Zealand's real production GDP series. The net tax variable is the sum of direct and indirect taxes less total transfer payments. Government spending includes both current (consumption) and capital (investment) spending. All data enter the model in real per capita, seasonally adjusted terms. Fiscal data are deflated using the implicit GDP deflator. The real per capita data are plotted in Figure 1.

Quarterly aggregate data are collated for all variables from June 1982. All fiscal series cover central government with the exception of government investment, which also includes local government, because a central government investment series is unavailable. The purchase of frigates in 1997 and 1999 are removed from both the purchases of government goods and services and the goods and services tax (GST) series.

Quarterly fiscal data were constructed using two data sources: Statistics New Zealand National Accounts Data and the New Zealand Crown Accounts (and their supporting financial data). Data on government purchases of goods and services (both current and capital) were drawn from the National Account (1993) expenditure GDP series for the period June 1987 to date, and were backdated to June 1982 using the National Accounts (1968) expenditure GDP series.

For direct taxes (source deductions and gross companies tax payments), data are available on a quarterly basis from June 1982. These series account for in excess of 73 percent of annual total tax receipts prior to the introduction of GST in December 1986, and in excess of 86 percent thereafter. Where quarterly data at a disaggregate level are unavailable (between June 1982 and June 1987), quarterly data are estimated by allocating the annual figures in the crown financial statements over the quarters based on the distribution of receipts in the later period (post June 1987). Total tax receipts and the sum of direct and indirect tax have been reconciled back to the crown financial statements from 1983/84 to 1990/91. In 1991/92 the crown accounts moved from a cash basis to accruals basis. Due to GST and source deductions being on a cash basis, our cash receipts figures no longer reconcile back to the Crown Financial Statements. However, the variance between the calculated total tax receipts and the crown financial statements is small, with the average error being around 1.4 percent. Prior to 1994 transfer payments data are available on a less frequent basis. Based on the known relative quarterly allocations, the quarterly transfer payments data can be constructed.[3]

Figure 1 – Variables used in the estimation of the fiscal VAR



[3] The variance in the quarterly government transfer series is small (observed from the later period), with the total average quarterly transfer ranging from 24.5 percent to 25.5 percent of the total annual transfers.

2.3 Time series properties of the data and trend specification

Figure 1 shows that per capita real GDP, net tax and government spending have grown over time. To account for the upward trend in the data structural VAR models are often specified to identify shocks that move variables temporarily away from their long-run paths. Structural VARs in this tradition include Sims (1980), Bernanke and Blinder (1992) and Dungey and Pagan (2000). This modelling approach is also adopted by Buckle, Kim, Kirkham, McLellan and Sharma (2002) for their structural VAR model of the New Zealand economy. It is also the modelling approach followed by Blanchard and Perotti (2002) and in this paper.

Blanchard and Perotti (2002) adopt two trend specifications for their United States 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. The assumption here is that variables grow along long-run equilibrium paths that are a function of time. The stochastic specification is estimated using the first differences of the logarithms of net tax, government spending, and GDP less a changing mean that is calculated as the geometric average of past first differences with a decay parameter set equal to 0.025 per quarter.[4] The stochastic specification allows for persistent shocks to variables' long-run equilibrium paths. Variables that exhibit persistent shocks (upward or downward movements) are said to be non-stationary.

One way to assess the appropriateness of the deterministic versus stochastic trend specification is to test whether time series are stationary. A test of stationarity is the unit root test. Appendix A reports the results for the augmented Dickey and Fuller (Said and Dickey, 1984) unit root test. The results provide evidence that the level of per capita net tax, government spending, and GDP are non-stationary, suggesting the stochastic specification may be more appropriate. Therefore, in the sensitivity analysis in section 4 two alternative stochastic trend specifications are considered. First, net tax, government spending and GDP are first differenced. Second, the data are detrended by removing time varying stochastic trends using the Hodrick and Prescott (1997) filter. The second alternative specification is consistent with previous work that examines the impact of international and domestic shocks on the New Zealand economy using structural VAR methodology (Buckle et al, 2002 and Buckle, Kim and McLellan, 2003).

3 Effects of fiscal policy

This section replicates Blanchard and Perotti's (2002) deterministic and stochastic trend models using New Zealand data. It first examines the instantaneous (contemporaneous) effects of government spending and net tax shocks and then assesses the dynamic effects using impulse response analysis.

[4] Blanchard and Perotti (2002) note that varying the decay parameter used to calculate the geometric average does not change their results for the United States.

3.1 Contemporaneous effects

Table 1 reports the estimated coefficients of the relationships between shocks shown in equations (2) to (4) for both the deterministic and stochastic specifications. Although the parameters a_2, b_2, c_1 and c_2 are elasticities, to aid interpretation, the point estimates in Table 1 have been transformed to derivatives evaluated at their means and, therefore, can be interpreted as the constant dollar change in one variable per constant dollar in another.

Table 1 – Estimated contemporaneous coefficients

	a_2	b_2	c_1	c_2
		Deterministic specification		
Coefficient	-0.16	-0.06	-0.25	0.14
t-statistic	-0.88	-0.87	-2.23	0.76
		Stochastic specification		
Coefficient	-0.12	-0.05	-0.25	0.13
t-statistic	-0.68	-0.68	-2.27	0.70

The direction of the contemporaneous impact of GDP from both the net tax and government spending shocks are consistent with the predictions of a simple neo-Keynesian model, with limited price flexibility in the short-run. Both the deterministic and stochastic specifications show that the contemporaneous effect of a net tax shock on GDP (c_1) is negative, while the contemporaneous effect of a government spending shock on GDP (c_2) is positive. These estimates also suggest the initial absolute impact of an increase in net tax on GDP is larger than an equivalent increase in government spending.

For the deterministic specification, a one dollar increase in net tax immediately reduces GDP by 0.25 dollars. For the stochastic specification, the immediate impact is equal -- with a one dollar increase in net tax also reducing GDP by 0.25 dollars in the first quarter.

For a government spending shock, the contemporaneous impact on GDP is also almost the same for the deterministic specification and the stochastic specification. The estimate for c_2 under the deterministic specification shows an increase in government spending by one dollar results in an immediate increase in GDP of 0.14 dollars. For the stochastic specification, the increase in GDP is 0.13 dollars. Note that point estimates for c_1 are statistically significant from zero at the 5 percent significance level. This is not the case for c_2.

Table 1 also suggests the issue of whether net tax or government spending are ordered first is inconsequential. Because the correlation between cyclically adjusted net tax and government spending shocks is low, the point estimates for a_2 (i.e. when net tax are ordered first) and b_2 (i.e. when government spending is ordered first) are close to zero. This result is confirmed in the sensitivity analysis in section 4.

3.2 Dynamic effects

Next, the dynamic effects of fiscal shocks are assessed using impulse response functions, which trace out the response over time of variables to an exogenous shock. Here, the responses of net tax, government spending and GDP to both a discretionary net tax shock and a discretionary government spending shock are considered.

In the deterministic model, variables grow along a long-run equilibrium path and only temporarily deviate from this set path. Impulse responses, which capture these transitory deviations from steady state, therefore eventually converge back to zero. For example, a government spending shock may cause GDP to temporarily move away from its long-run growth path, but eventually GDP returns to the level implied by its long-run growth path. Therefore, if the model is stationary, while shocks may have long-lasting effects they are not permanent.

In the case of the stochastic specification, the interpretation of the impulse responses is somewhat different. Because the endogenous variables are believed to be non-stationary, and are therefore transformed and modelled as first differences less a moving average of past first differences, in contrast to the deterministic specification, fiscal shocks have a permanent impact on the *level* of these variables. This means that the impulse responses do not converge back to zero following a fiscal shock. For example, a government spending shock causes GDP to converge to a new, higher or lower, level.[5]

Figures 2 and 3 show the responses of net tax, government spending and GDP to two fiscal shocks. The first shock is to net tax (Figure 2) and the second shock is to government spending (Figure 3). Both shocks are temporary; that is, net tax and government spending unexpectedly increase by one dollar for one quarter. All impulses are normalised to show the constant dollar shock of the response variables to the respective fiscal shock. Sixty-eight percent symmetric confidence bands, which were computed using 1000 bootstrap simulations, are shown by dotted lines in Figures 2 and 3.[6]

For the deterministic specification, Figure 2 shows the immediate response of a one dollar increase in net tax is to decrease GDP by 0.24 dollars. This negative impact on GDP persists for a couple of quarters, after which it is partly reversed with GDP increasing above trend, before the impact of the net tax shock dissipates. One possible explanation for the increase in GDP, after the decrease in GDP, is that other macroeconomic variables (such as interest and exchange rates) adjust in response to the initial fall in GDP, eventually stimulating the increase in GDP after the first year. To confirm this explanation it would be necessary to include these additional variables within the fiscal VAR model.[7] The response of government spending to the net tax shock is minimal.

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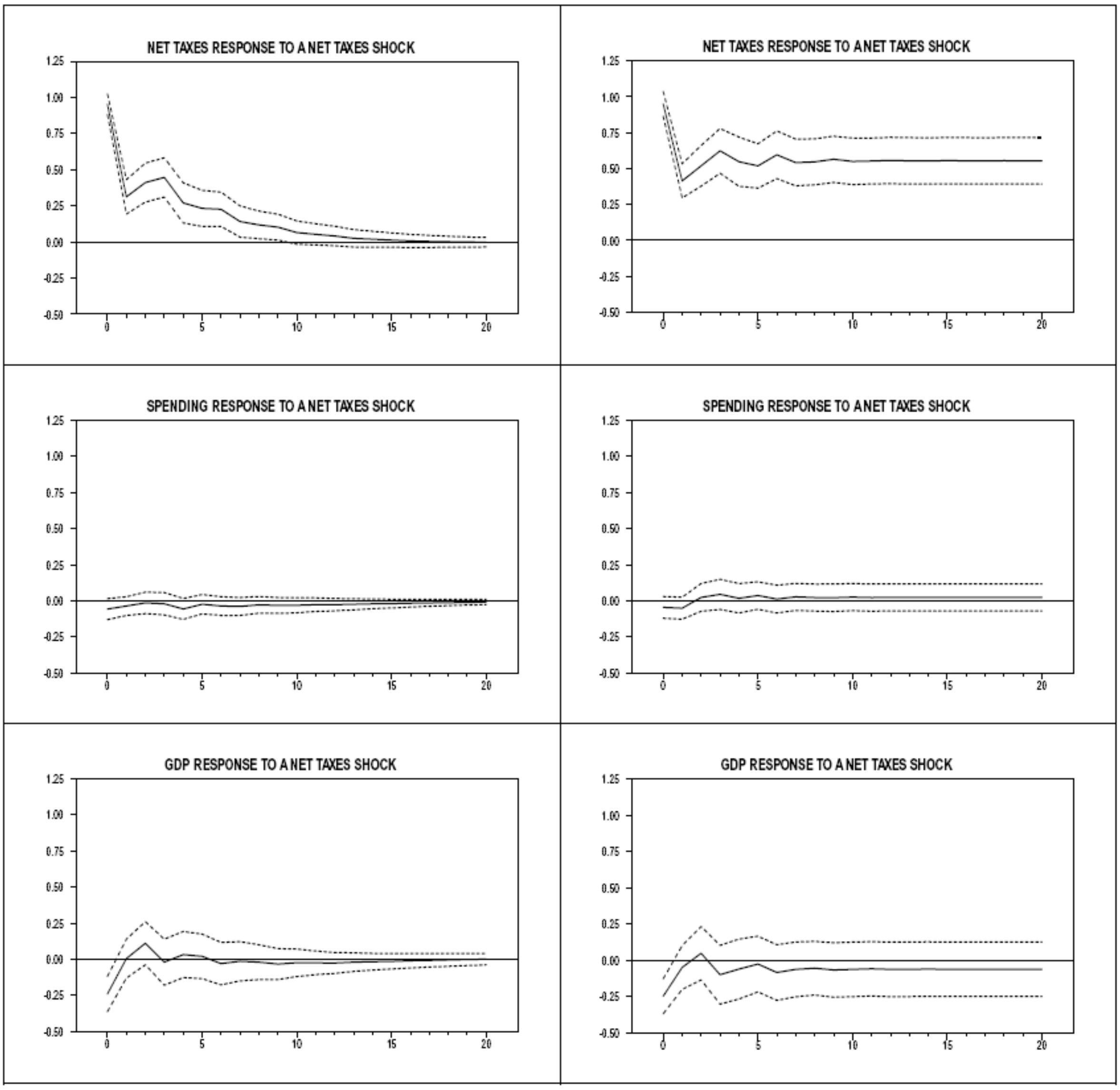
5 To aid comparison of the deterministic and stochastic specifications of the fiscal VAR, the impulse response show the constant dollar responses for a fiscal policy shock. For the stochastic specification, where the endogenous variables are modelled as first differences less a moving average of first differences, this requires the impulses to be accumulated to make them comparable with the deterministic specification.

6 For each simulation, random draws (with replacement) are taken from the series of estimated residuals and used to form synthetic data for each endogenous variable. The VAR model is then re-estimated and impulse response functions are computed. When the 1000 simulations are completed, the standard deviation of the impulse response is calculated at each time horizon.

7 The inclusion of additional variables is left for future work.

Figure 2 – Responses to a net tax shock

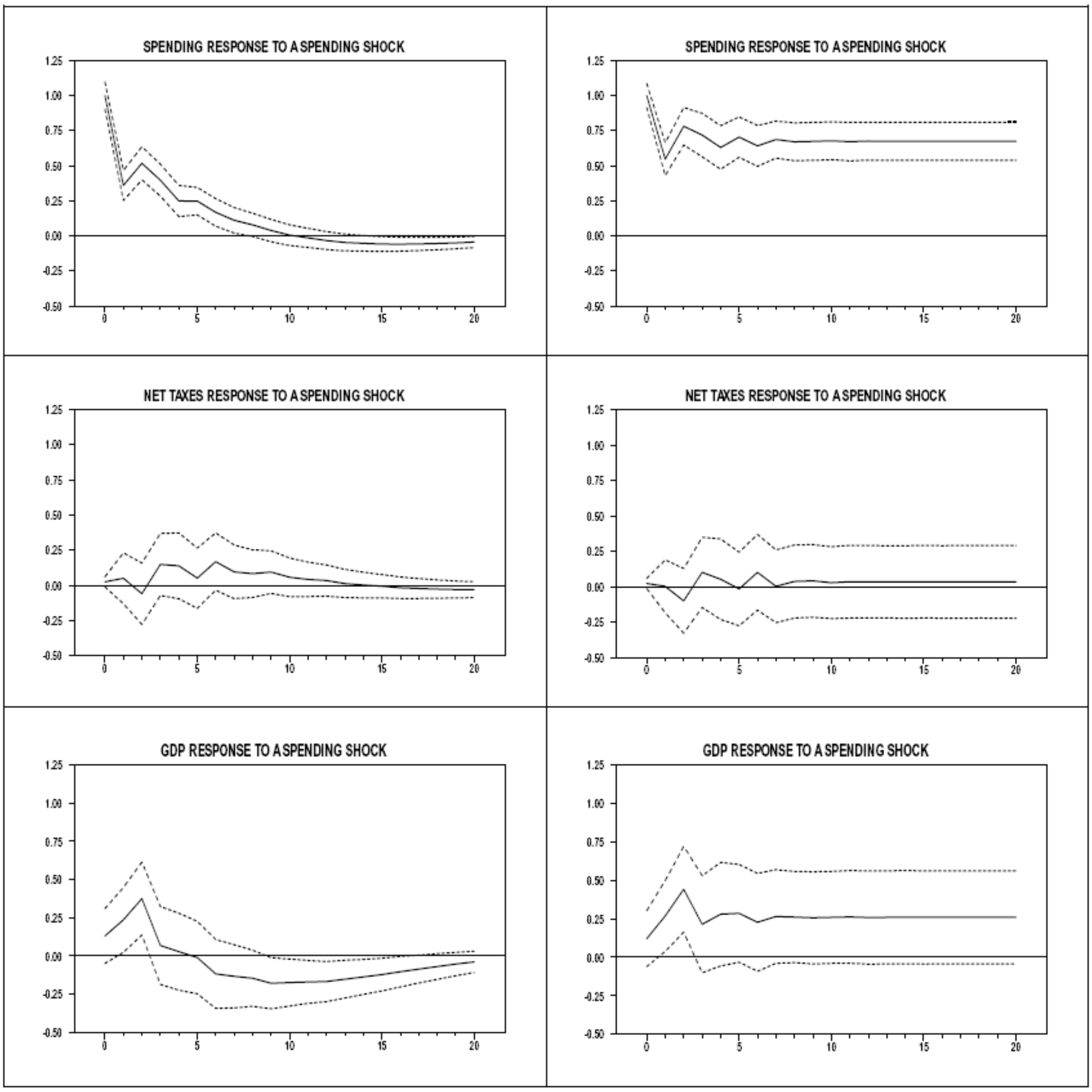
Deterministic specification ***Stochastic specification***



For the stochastic specification, Figure 2 shows that in response to a one dollar increase in net tax, GDP falls by almost the same magnitude as in the deterministic specification. This negative impact on GDP persists for a couple of quarters, after which it is temporarily reversed with GDP increasing above trend, before converging to a lower long-run level. Like the corresponding deterministic specification, the response in government spending from the net tax shock is small. The permanent impact on net tax of the initial shock is to increase net tax by around 0.55 dollars per quarter.

Figure 3 – Responses to a government spending shock

Deterministic specification ***Stochastic specification***



For the deterministic specification, a one dollar increase in government spending leads to an immediate 0.14 dollar increase in GDP (see Figure 3). This positive effect persists for around one year, before the impact of the government spending shock on GDP becomes negative. Net tax also increases in response to the government spending shock. Note, however, that while net tax immediately increases by around 0.03 dollars, the peak response occurs after about a year and a half. This most likely reflects lags in the collection of tax revenue and the lagged impact of changes in GDP on the labour market (and hence transfer payments like unemployment benefits). The initial increase in government spending persists for over two years, although the stimulus reduces from the initial one dollar increase in the first quarter to around 0.36 dollars by the second quarter.

For the stochastic specification, the initial one dollar shock to government spending has a permanent positive impact on itself, net tax and GDP. The immediate one dollar increase in government spending diminishes over the first year, eventually resulting in a permanent 0.67 dollar increase in government spending per quarter. The peak response in output occurs during the first year, eventually leading to a permanent increase in GDP of around 0.26 dollars. Net tax permanently increases by around 0.04 dollars.

Results reported in this section show that for both the deterministic and stochastic specifications an increase in government spending leads to an increase in GDP. In the case of the deterministic specification, the positive stimulus to GDP lasts just over one year. For the stochastic specification, the government shock results in a permanent increase in the level of GDP.

To assess the individual effects of tax revenue and transfer payments we re-estimate the stochastic model by splitting net tax into tax revenue and transfer payments. The fiscal VAR now includes four variables; GDP, government spending, tax revenue and transfer payments. Government spending shocks were identified as outlined in Section 2.1. Transfer payments were cyclically adjusted using an elasticity of -0.3. Total tax revenue were cyclically adjusted using an elasticity of 1. The fiscal variables were ordered as follows: total tax revenue, transfer payments, and finally government spending. Sensitivity analyses suggested impulse responses were fairly insensitive to the ordering of government spending, transfer payments and total tax revenue.

Figure 4 shows the impulse responses of GDP, government spending, tax revenue and transfer payments to a government spending, tax revenue and transfer payments shock, respectively. The results show that following a tax revenue shock, GDP declines and remains at a lower level. But the decline is small. In contrast, following a rise in transfer payments GDP initially rises and then falls. Moreover, GDP falls by more following the rise in transfer payments than it falls following the increase in tax revenue.

The finding of a negative effect of tax revenue on output is in line with recent international literature that finds distortionary taxes have a negative long-run impact on economic growth (e.g. Widmalm, 2001, Padovano and Galli, 2002, and Li and Sarte, 2004). The result of a negative effect on output of an increase in transfer payments, on the other hand, is supportive of the empirical finding that transfer payments are unproductive government spending (e.g. Kneller, Bleaney and Gemmell, 1999, and Bleaney, Gemmell and Kneller, 2001). Increased transfer payments may reduce economic growth because of adverse labour supply incentives, for example.

Figure 4 – Four variable VAR for the stochastic specification

Total Taxes Shock | ***Transfer Payment Shock*** | ***Government Spending Shock***

4 Sensitivity analysis

This section reports some sensitivity analysis of the baseline three variable fiscal VAR. To test the robustness of the results, we estimate two alternative fiscal VAR models. We then provide diagnostic tests and consider alternative ordering of variables and elasticities for the baseline model. We also compare the New Zealand results to that from other models and economies.

4.1 Alternative specifications

Unit root tests discussed in section 2 suggest that net tax, government spending, and GDP are non-stationary and that the stochastic specification may be more appropriate than the deterministic model. This section considers two alternative stochastic trend specifications. First, net tax, government spending and GDP are included in first differences. Second, the data are detrended by removing time varying stochastic trends using the Hodrik-Prescott filter.

The parameter estimates of the contemporaneous relationships shown in equations (2) to (4) for the first difference and Hodrick-Prescott trend specification of the fiscal VAR are reported in Table 2. As with the baseline deterministic and stochastic specifications, the tax to output elasticity (a_1) is set equal to one and the government spending to output elasticity (b_1) is set equal to zero.

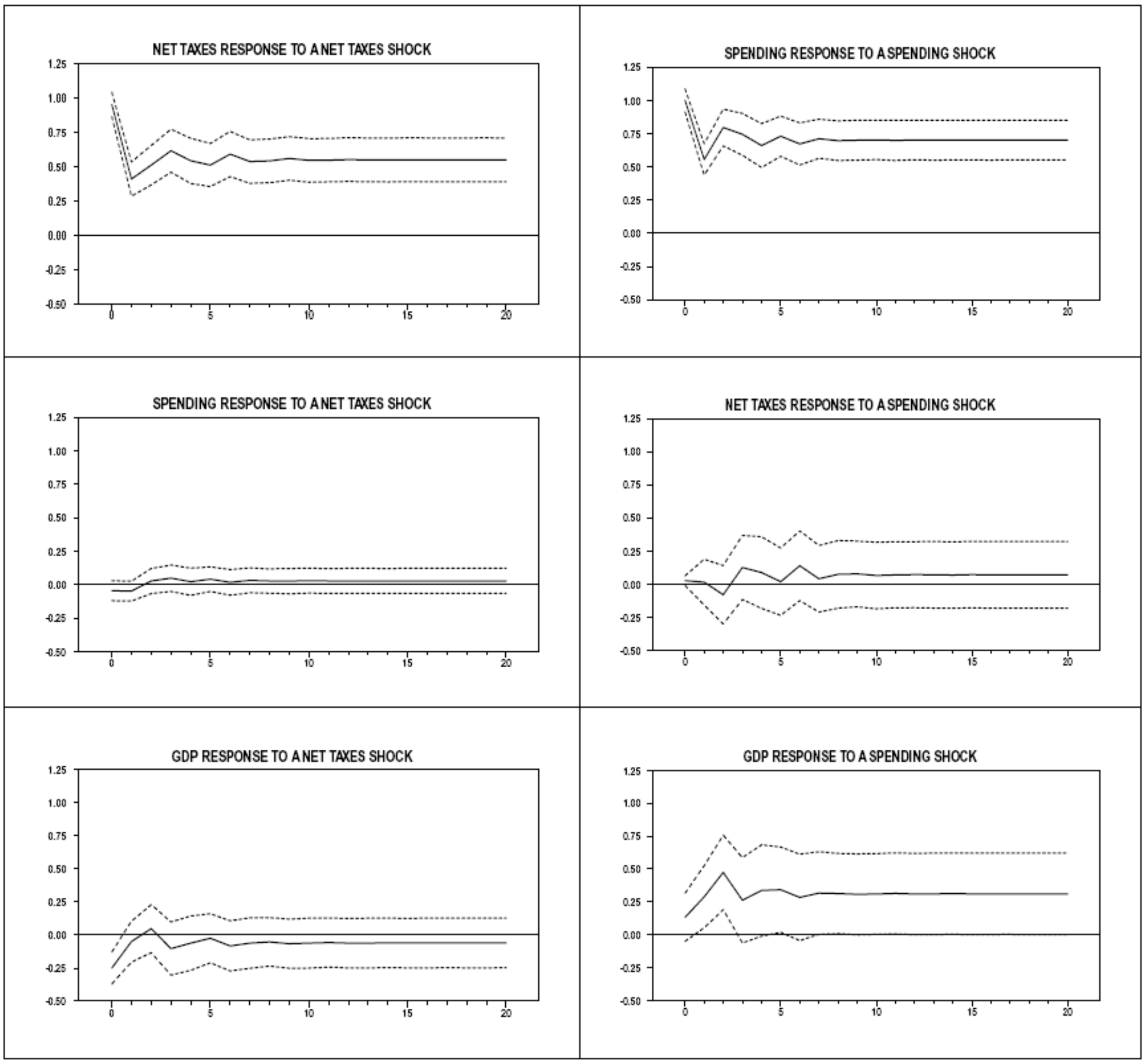
Table 2 – Estimated contemporaneous coefficients: alternative model specifications

	a_2	b_2	c_1	c_2
		First Difference specification		
Coefficient	-0.12	-0.04	-0.26	0.14
t-statistic	-0.64	-0.64	-2.27	0.78
		Hodrick-Prescott specification		
Coefficient	-0.06	-0.02	-0.21	0.03
t-statistic	-0.32	-0.32	-1.89	0.16

A comparison of the estimated contemporaneous coefficients from the baseline deterministic and stochastic models (Table 1) with the estimates from the two alternative specifications (Table 2) shows broadly similar results. The contemporaneous effect of a net tax shock on GDP (c_1) is negative, while the contemporaneous effect of a government spending shock on GDP (c_2) is positive. The coefficient estimates for the first difference model are almost identical to the estimates from the baseline stochastic model. For the Hodrick-Prescott specification, the estimate for c_1 is slightly smaller than for the first difference, deterministic and stochastic specifications and the estimate for c_2 is smaller than for the other models.

Figure 5 – Responses to a net tax and government spending shock: first difference model

Net tax shock	***Government spending shock***

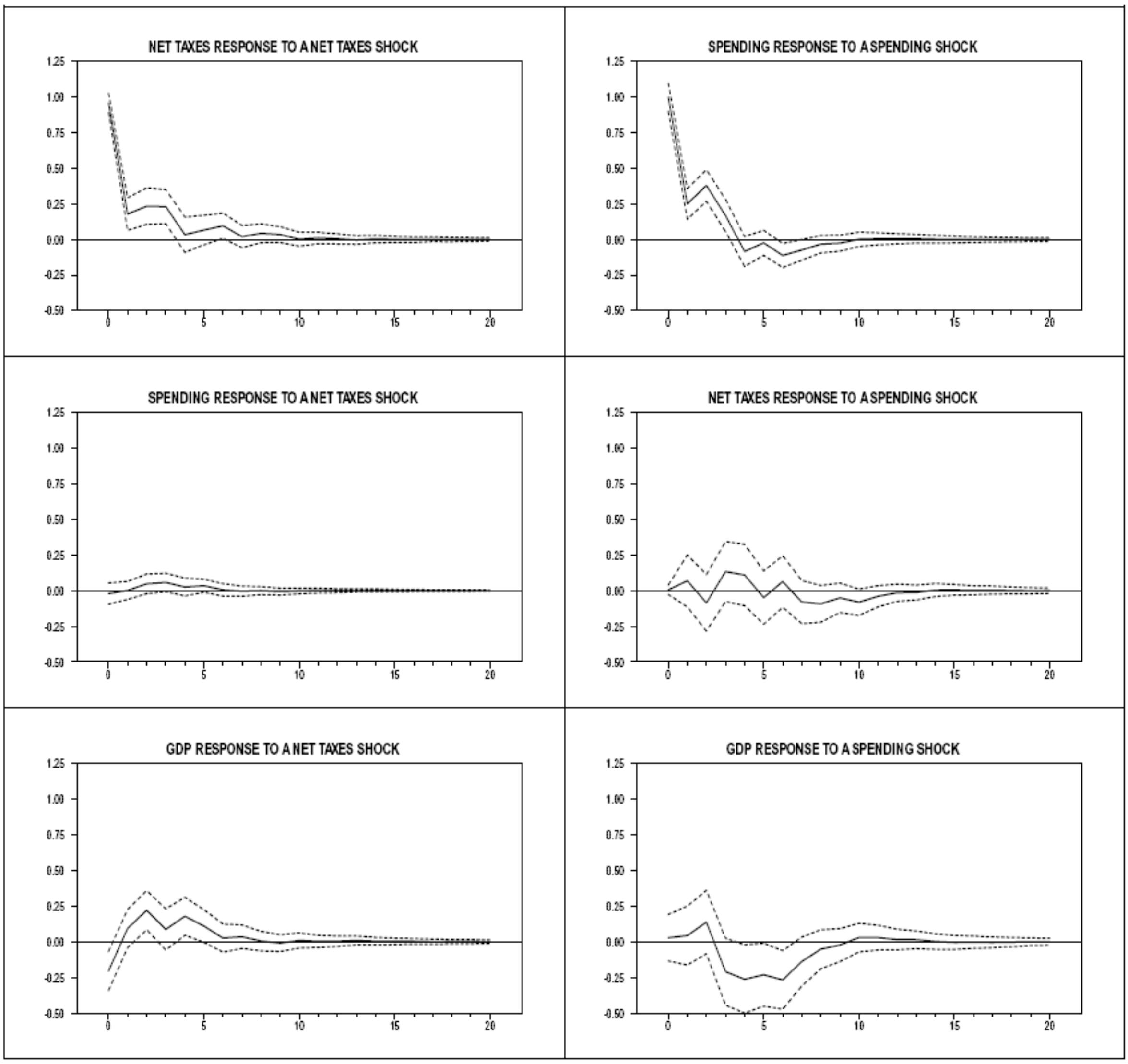


The impulse responses of net tax, government spending and GDP to a one dollar net tax and government spending shock are plotted in Figure 5 for the first difference model and in Figure 6 for the Hodrick-Prescott specification. Figure 5 shows that the impulse responses of the first difference and baseline stochastic trend model are virtually identical.

For the Hodrick-Prescott specification, Figure 6 shows that the fiscal shocks lead to temporary deviations of variables from their long-run time varying trend (as measured by the Hodrick-Prescott filter) but eventually the impulse responses converge back to zero, as is the case for the deterministic model. For the Hodrick-Prescott specification, the reduction in GDP caused by the net tax shock persists for around two quarters, before the economy experiences a period where GDP is above trend. As suggested earlier, this period where GDP increases above its long-run path could be owing to the influence of other macroeconomic variables (such as interest and exchange rates) that change in response to the initial net tax shock. The decline in GDP may also cause the small decrease in government spending. Following the net tax shock, government spending initially declines (as in the case of the deterministic, stochastic and first difference specifications). This result is further discussed in section 4.3.

Figure 6 – Responses to a net tax and government spending shock: Hodrick-Prescott specification

Net tax shock ***Government spending shock***



One noticeable difference is that the government spending shock is less persistent for the Hodrick-Prescott specification than the deterministic model. The one dollar government spending shock dissipates over the first year. The positive effect on GDP from the government spending shock lasts for less than one year, before the economy experiences a period where GDP falls below its trend path. The impact of the government spending shock on net tax is broadly similar to the deterministic specification.

4.2 Diagnostic tests

To assess the stability of parameter estimates, Hansen's (1992) stability test can be used. A key advantage of this test is that it does not require selecting potential structural break points. Moreover, no special treatment of lagged dependent variables is required (Hansen, 1992). However, the test requires variables to be stationary.

The Hansen stability test produces two types of statistic: a joint test statistic and individual test statistics. Individual test statistics represent the stability of each parameter in the reduced-form equations in (1), while the joint test assesses the stability of all the parameters jointly in each of the equations in (1). The null hypothesis of stable estimates is rejected if the individual or joint test statistics are significant, i.e. the p-values are low. The results for the baseline and alternative models, which are reported in Appendix B, show that, overall, the parameter estimates are fairly stable for both the individual and joint tests. Although some parameters are unstable individually, they appear to be stable jointly over time.

To test for model stability we verify the stationary condition of the fiscal VAR models. This formally tests that the impulse responses converge following a fiscal shock. We compute the value of root from the eigenvalues of the companion matrix derived from the parameter estimates. A value of root of greater than one indicates that a model is systematically unstable. The results, also reported in Appendix B, show that the baseline and alternative models are stationary. The values of roots are less than one although they are larger for the deterministic and Hodrick-Prescott models compared to the stochastic trend and first difference models.

To detect possible misspecification of the models we test that the residuals from the reduced-form equations in (1) are normally distributed using Jarque and Bera's (1987) test of normality. The results, reported in Appendix C, show that the equations have normally distributed errors except for the government expenditure equation in the deterministic and the Hodrick-Prescott model.

We also use Ramsey's (1969) RESET test of specification error to determine possible misspecification of the models. The RESET test allows assessing the linearity assumption in the reduced-form equations in (1). The results, also reported in Appendix C, show that the hypothesis of model misspecification is rejected for all equations except for the deterministic model. This finding and the results from the normality tests strongly suggest that the deterministic model does not fit the New Zealand data well. The finding is in line with the unit root tests, which suggest that a model specification that assumes non-stationary variables is more appropriate for New Zealand.

4.3 Alternative ordering of variables and elasticities

In the baseline model, net tax is ordered before government spending. To assess the sensitivity of the impulse responses the ordering is reversed and government spending is placed before net tax. The results, which are plotted in Appendix D, show that the impulse responses from the alternative ordering are similar. For the stochastic and first difference models, there is only a minor difference that the immediate response of each fiscal variable from the shock to the other fiscal variable is somewhat larger when net tax are ordered first.

For the Hodrick-Prescott specification, there are small differences in the immediate response of net tax to a government spending shock, and the immediate response of government spending to a net tax shock. With the alternative ordering, where government spending is placed before net tax, government spending no longer declines following a net tax shock. Moreover, with the alternative ordering net tax immediately declines in response to an increase in government spending. The opposite occurs with the baseline Hodrick-Prescott specification.

To test the sensitivity of the fiscal VAR to the tax-output elasticity, two alternative elasticities of 0.5 and 1.5 are used instead of 1. The tax-output elasticity is a key variable in forming the cyclically adjusted net tax residuals that are used as instrumental variables to estimate the contemporaneous effect of a change in net tax on output. The impulse responses with the alternative elasticities are plotted in Appendix E for the stochastic, first difference and Hodrick-Prescott models. The results show that the impact of increasing the tax-output elasticity from 1 to 1.5 is to marginally increase the impact that a net tax shock has on output for all three models. The result of decreasing the tax-output elasticity from 1 to 0.5 is to reduce the negative impact on GDP over the short term of the net tax shock. Overall, despite substantial changes in the tax-output elasticity, the responses of GDP to the net tax shock are similar.

4.4 Comparison with other models and economies

Finally, we compare the New Zealand results to that from other models and economies. Table 3 summarises the fiscal multipliers estimated from the New Zealand VAR and prior work by Blanchard and Perotti (2002), and Perotti (2004). Contemporaneous, peak and long term responses are reported.[8]

While there is considerable variation between economies in the contemporaneous responses of GDP to fiscal shocks, they are generally positive for government spending and negative for a net tax shock. However, in absolute terms the impact of a government spending shock on GDP tends to be larger than a net tax shock. The peak and long-term responses of GDP to government spending shocks differ substantially across economies, being positive in some countries and negative in others. Results for the United States suggest that the peak and long-term government spending multipliers are sensitive to the time period and whether or not inflation and the 10 year nominal interest rate are included in the VAR model. The peak and long-term tax multipliers are generally negative, although again there is considerably variation across economies.

Note that for Australia and New Zealand, which are both small open economies, the fiscal multipliers are relatively small compared with the larger economies, possibly reflecting the role that imports, private savings, interest and exchange rates play in influencing the way these economies adjust to fiscal shocks.

Table 3 – GDP response to a government spending and net tax shock

Study	Country	Sample	Trend	Spending response of GDP			Net tax response of GDP		
				Impact	Peak**	Long-term*	Impact	Peak**	Long-term*
Blanchard and Perottri (2002)	United States	1960-1997	DT	0.84	1.29 (15)	0.97	-0.69	-0.78 (5)	-0.22
		1960-1997	ST	0.90	0.90 (1)	0.66	-0.70	-1.33 (7)	-1.29
Re-estimated		1974-1997	DT	2.39	2.47 (2)	0.30	-1.04	-1.04 (1)	-0.06
		1974-1997	ST	1.23	1.23 (1)	0.44	-0.80	-1.11 (8)	-1.04
Perotti (2004)***	United States	1980-2000	DT	0.60	-0.60 (1)	-0.10	-0.25	-0.90 (8)	-0.15
	Germany	1980-2000	DT	0.60	-1.70 (1)	-0.20	-0.20	-0.50 (13)	0.25
	United Kingdom	1980-2000	DT	-0.05	-0.50 (4)	-0.45	-0.05	-0.35 (7)	0.05
	Canada	1980-2000	DT	0.05	-1.70 (1)	-0.80	0.10	0.80 (6)	0.30
	Australia	1980-2000	DT	0.30	0.40 (14)	0.20	-0.30	-0.50 (6)	-0.05
Claus, Gill, Lee and McLellan (2006)	New Zealand	1982-2004	DT	0.13	0.37 (3)	0.00	-0.24	-0.24 (1)	0.00
		1982-2004	ST	0.12	0.44 (3)	0.26	-0.25	-0.25 (1)	-0.06
		1982-2004	FD	0.13	0.47 (3)	0.31	-0.25	-0.25 (1)	-0.06
		1982-2004	HP	0.03	-0.26 (5)	0.00	-0.20	0.22 (3)	0.00

* Long-term is taken to be after 20 quarters.

** Peak is the largest absolute deviation from zero.

*** Model includes 5 variables: government spending, net tax, output, inflation and a nominal interest rate.

DT, ST, FD and HP indicate at a deterministic trend, stochastic trend, first difference and a Hodrick-Prescott trend.

[8] Although Perotti's (2004) estimates of the fiscal response are over a similar time period as for New Zealand the model specification is different as it includes inflation and a 10-year nominal interest rate. For this reason we re-estimate the fiscal response for Blanchard and Perotti (2002)

The contemporaneous response of GDP to fiscal shocks displayed in Table 3 does not capture the dynamic response of GDP to these shocks. Therefore, to compare the dynamic response of GDP to fiscal shocks across the various VAR models, Table 4 reports the cumulative response of GDP after four and twelve quarters. Consistent with prior work, the twelve quarter cumulated response is referred to as the long-run multiplier. Table 4 shows that government spending tends to also have a positive effect on GDP in the medium and long run. However, the immediate negative effect on GDP of a net tax shock does not persist for all countries in the long run. Net tax increases because of an increase in tax revenue and/or a decline in transfer payments. A positive response of GDP to a discretionary net tax shock may therefore be the result of a decline in transfer payments having a positive effect on GDP that more than offsets any negative effects of increased taxation. Alternatively, an increase in net tax may be the result of tax policy reform that has raised tax revenue but at the same time has reduced the distortionary effects of taxation, for example, by broadening the tax base.

In summary, the results from the sensitivity analysis and robustness testing suggest that the fiscal VAR with a specification that assumes non-stationary variables is well specified and appropriate for New Zealand. Moreover, the estimated effects of fiscal policy on output fall within the range of international evidence. In fact, our results suggest that the New Zealand data may actually fit the Blanchard and Perotti (2002) model better than the US data. Performing the same sensitivity analysis and robustness testing for the US model as for the New Zealand fiscal VAR, we found evidence of parameter and model instability and potential model misspecification for the US model. For example, the equations for the US model have non-normally distributed errors, especially for the net tax equation. In addition, we found that the US equations with temporary tax cut dummy variables have unstable estimates for the joint test although the equations become stable once the dummy variables are removed from the equations.[9]

Table 4 – Cumulative GDP response to a spending/tax shock

Study	Country	Sample	Trend	Cumulative response of GDP to a Spending shock		Cumulative response of GDP to a Net tax shock	
				4	12	4	12
Blanchard and Perotti (2002) Re-estimated	United States	1960-1997	DT	2.13	6.63	-2.89	-8.18
		1960-1997	ST	2.09	5.12	-3.60	-14.45
		1974-1997	DT	9.70	20.07	-3.53	-8.48
		1974-1997	ST	3.66	7.34	-2.99	-11.54
Perotti (2004)*	United States	1980-2000	DT	-0.25	-1.02	0.43	2.11
	Germany	1980-2000	DT	0.34	-0.09	-0.02	0.29
	United Kingdom	1980-2000	DT	0.44	-3.47	0.23	0.91
	Canada	1980-2000	DT	-0.22	-0.17	-0.30	-1.81
	Australia	1980-2000	DT	0.12	0.41	0.36	1.16
Claus, Gill, Lee and McLellan (2006)	New Zealand	1982-2004	DT	0.80	-0.09	-0.15	-0.25
		1982-2004	ST	1.04	3.13	-0.35	-0.82
		1982-2004	FD	1.16	3.68	-0.35	-0.82
		1982-2004	HP	0.00	-0.92	0.20	0.55

* Model includes 5 variables: government spending, net tax, output, inflation and a nominal interest rate.

DT, ST, FD and HP indicate at a deterministic trend, stochastic trend, first difference and a Hodrick-Prescott trend.

[9] The results are not reported but available upon request.

5 Contributions of fiscal policy to New Zealand business cycles

In section 3 we investigated the dynamic response of output to net tax and government spending shocks via impulse response analysis. In this section, we use the three variable fiscal VAR to measure the historical contribution of fiscal policy to New Zealand business cycles. The aim is to assess the extent to which fiscal policy has added to or subtracted from GDP growth or percentage deviations in GDP from trend. The section also compares the fiscal VAR measures of fiscal impulse with another indicator of fiscal impulse developed by Philip and Janssen (2002).

5.1 Fiscal policy and New Zealand business cycles

We use the first difference and Hodrick-Prescott specifications, two specifications that are commonly used, to represent business cycles. The Hodrick-Prescott specification measures deviations in GDP from its trend growth path, the output gap. Historical decompositions thus assess the contributions from discretionary net tax and government spending shocks to the output gap. The first difference specification, also known as the growth cycle, measures the effect of discretionary fiscal policy on GDP growth, which is approximated by logarithmic first differences of GDP.

Historical decompositions are derived from the structural shocks and impulse responses as follows:

$$Z_t = \textit{initial conditions} + \sum_{i=0}^{t-1} \sum_{j=1}^{3} \theta_i^j u_{t-i}^j \quad j = T, G, Z \tag{5}$$

In equation (5) Z_t measures the output gap or GDP growth rate at time t, θ_i^j is the i^{th} impulse response associated with the j^{th} structural shock, where the structural shocks correspond to discretionary net tax, government spending and output shocks.

Figure 6 shows the contribution to New Zealand business cycles from net tax and government spending, and the combination of both for the period 1983 to 2005. Results are presented for both the first difference and Hodrick-Prescott specifications. Figure 6 shows that the business cycles for each specification are somewhat different. The volatility of the growth rate tends to be larger than for the Hodrick-Prescott specification. The zero line in each chart represents the point where each respective shock is making no contribution to the business cycles. Therefore, when the grey bars are positive, this implies the respective component is making a positive contribution to the output gap or GDP growth rate.[10]

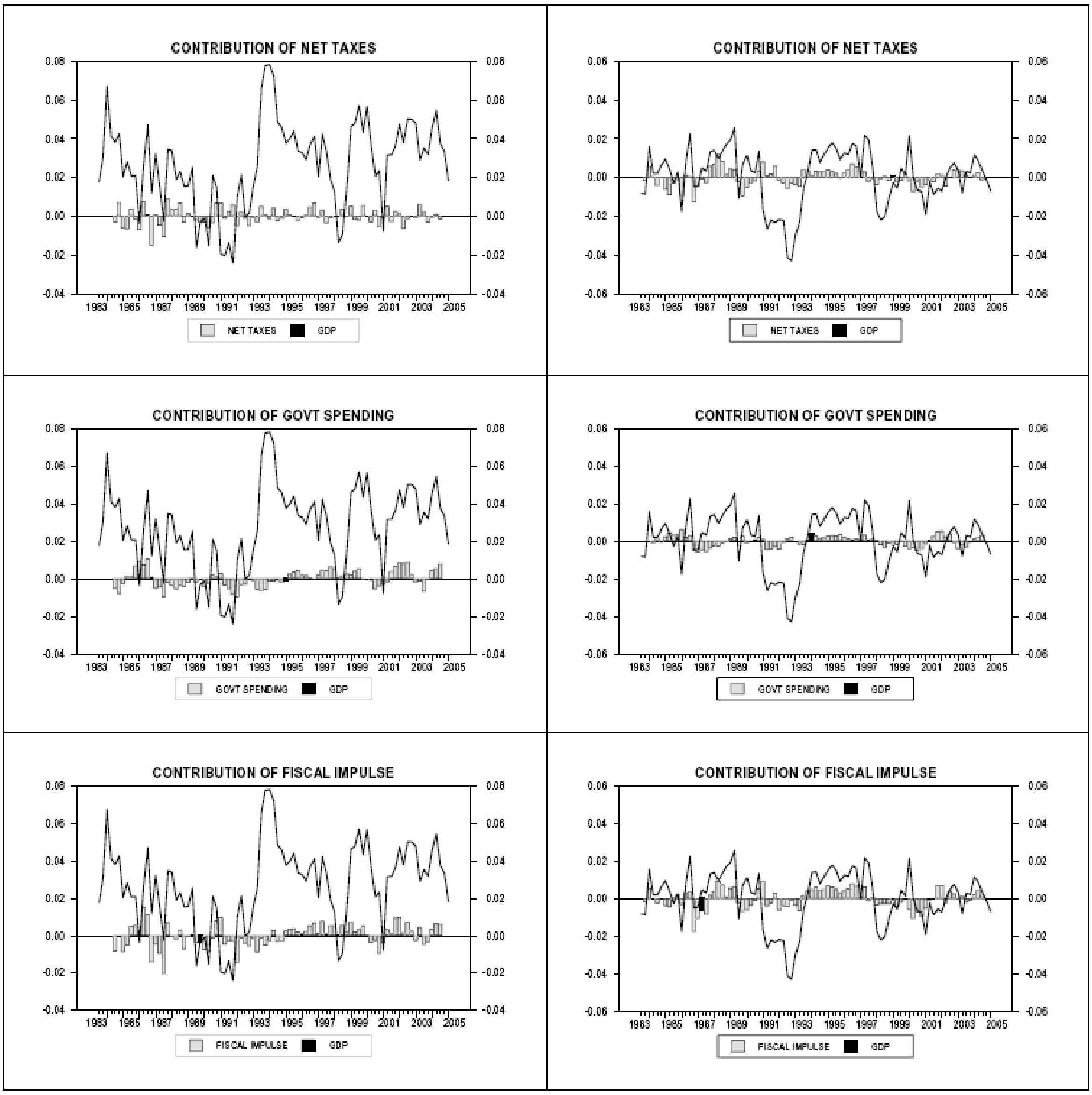
For the first difference specification, which have been presented as the contribution to annual GDP growth to aid interpretation, shows the contribution from net tax to GDP growth is relatively small compared to the contribution of discretionary government spending. Over the period 1983 to 2005 it is difficult to determine whether discretionary changes in government spending were pro- or counter-cyclical. During the recession in the early 1990s the combined contribution of net tax and government spending (i.e. the

[10] At the beginning of the sample period initial conditions may make a substantial contribution to detrended output. However, over time the contribution from initial conditions will converge towards zero. Therefore, the focus of the analysis in from the late 1980s onwards.

total contribution from discretionary fiscal policy) was to generally exacerbate the recession, albeit that the impact was somewhat small. Discretionary fiscal policy tended to add to output growth during the mid- to late-1990s, when New Zealand had relative high growth rates, but again the size of the impact was small. During the past five years, the contribution from discretionary fiscal policy has tended to accentuate movements in output, i.e. fiscal policy has been procyclical.

Figure 6 – Contribution of fiscal policy to New Zealand business cycles

First Difference specification ***Hodrick-Prescott specification***



Note: The series represented by bars on Figure 6 are contributions from net tax, government spending and fiscal impulse. The series represented by lines are deviations in GDP from the Hodrick-Prescott trend and annual GDP growth.

Turning to the Hodrick-Prescott specification, net tax appears to play a greater role, compared with the first difference specification. Furthermore, over the entire period 1982 to 2005, the contribution from net tax is generally pro-cyclical; more so than the pro-cyclicality between the contribution from discretionary government spending and the output gap. Looking at the total contribution from discretionary fiscal policy, during the 1991 to 1992 recession, discretionary fiscal policy accentuated the negative output gap according to the Hodrick-Prescott trend specification. As the economy recovered and the output gap became positive, discretionary fiscal policy made a positive contribution to the output gap. Discretionary fiscal policy contributed little to deviations in output from trend during the 1998 recession, and since then has tended to have a pro-cyclical effect.

5.2 Comparison with Treasury's measure of fiscal impulse

This section compares a measure of fiscal impulse, developed by Philip and Janssen (2002), with those produced by various specifications of the fiscal VAR. We start by noting the conceptual similarities and differences between the alternative measures of fiscal impulse and then compare quantitative estimates.

The Philip and Janssen indicator of fiscal impulse is defined as the change in the estimated structural primary cash balance. The structural primary cash balance is constructed by taking cyclically-adjusted tax receipts and subtracting cyclically-adjusted government spending (which includes some capital items that are deemed to have an impact on aggregate demand) and net interest payments. At a general level (and ignoring net interest payments) this measure of fiscal impulse (FI_t^1) can be denoted as follows:

$$FI_t^1 = T_t^* - T_{t-1}^* - (G_t^* - G_{t-1}^*) \tag{6}$$

where the superscript * indicates the variable has been cyclically adjusted. This indicator of fiscal impulse is seen as measuring whether changes in fiscal policy are adding to, or subtracting from, aggregate demand pressure in the economy (although it is not always specified how aggregate demand is being measured) and is usually estimated using annual data.

This type of measure of fiscal impulse has two widely cited limitations. First, the composition of fiscal policy changes are not taken into account, so for example tax decreases and government spending increases are treated symmetrically in terms of their impact on aggregate demand. Second, at best, this type of indicator only captures the first round impacts of changes in fiscal policy, and not additional dynamic effects.

Interpreting measures of fiscal impulse from VAR models depends on the trend specification adopted. To see this, first denote fiscal impulse (FI^2) from the Hodrick-Prescott fiscal VAR specifications as follows:

$$FI_t^2 = T_t^M - T_t^* - (G_t^M - G_t^*) \tag{7}$$

where the superscript M indicates model-adjusted government spending and net tax (adjusted to isolate the discretionary components of fiscal policy) and the superscript * indicates the time or Hodrick-Prescott trend in net tax and government spending. In this specification fiscal impulse arises from discretionary changes in fiscal policy in which net tax and government spending deviate from their long-run growth paths (as measured by their Hodrick-Prescott trends) and is estimated using quarterly data.

The measure of fiscal impulse (FI_t^3) that emerges from the first difference specification of the fiscal VAR can be denoted as follows:

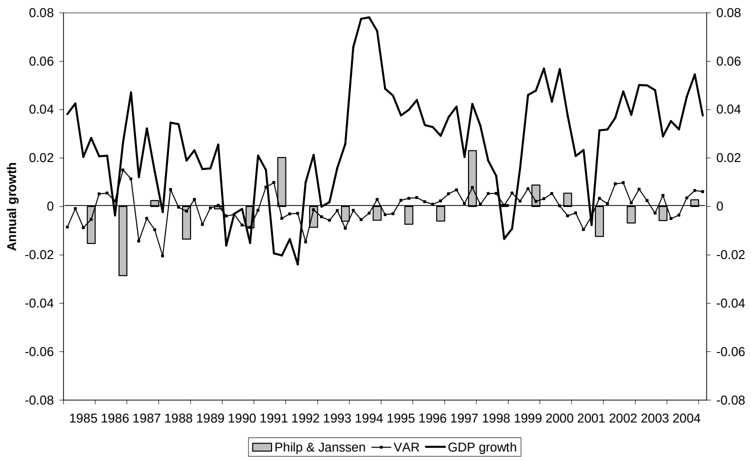
$$FI_t^3 = T_t^M - T_{t-1}^M - (G_t^M - G_{t-1}^M) \tag{8}$$

In this specification fiscal impulse arises because of changes in taxes and government spending. This measure of fiscal impulse gauges the contribution of fiscal policy to GDP growth.

The VAR measures of fiscal impulse overcome the two main limitations of indicator type measures of fiscal impulse. First, the VAR measures of fiscal impulse account for changes in the composition of fiscal policy. This is because they feed through a system of equations that allows for different impacts of tax and spending changes on GDP. Second, because dynamic interactions are specifically modelled within the VAR model, second round effects are captured.

Figure 7 – Alternative measures of fiscal impulse

First difference specification



Hodrick-Prescott specification

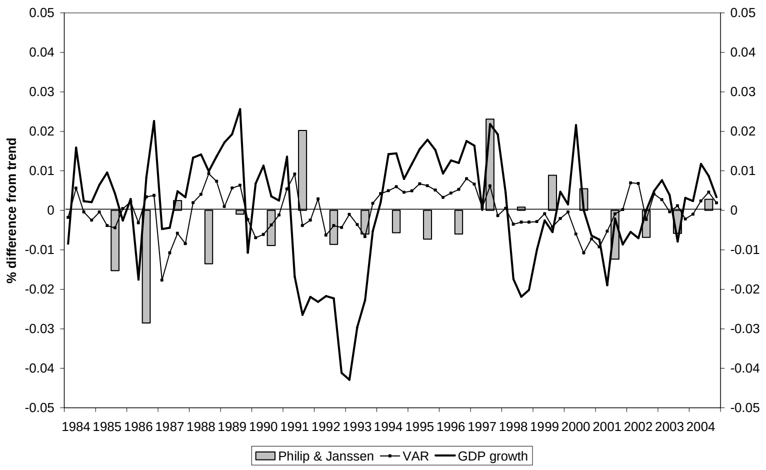


Figure 7 shows the two measures of fiscal impulse from the first difference and Hodrick-Prescott specifications of the fiscal VAR and compares them with the Philip and Janssen indicator measure of fiscal impulse. The first chart of Figure 7 corresponds to the first difference fiscal VAR specification and shows the contribution of fiscal impulse to annual GDP growth. The second chart of Figure 7 corresponds to the Hodrick-Prescott fiscal VAR specification and shows the contribution of fiscal impulse to deviations in GDP from trend (that is, the output gap). The Philip and Janssen measure of fiscal impulse has been inverted, compared to the way it is usually presented, to aid comparison with the fiscal VAR measures of fiscal impulse. Because initial conditions can make substantial contributions to GDP growth or deviations in GDP from trend this analysis focuses from the mid-1980s onwards.

Figure 7 suggests that in general the sign and magnitude of the first difference fiscal VAR specification and the Philip and Janssen measures of fiscal impulse are similar, although there are periods where there are differences. It is interesting to note that Treasury's current measure of fiscal impulse tends to display larger absolute changes than the measure of fiscal impulse from the first difference fiscal VAR model.

In the late 1980s both measures of fiscal impulse suggest that fiscal policy was acting to dampen GDP growth; this was more so for the Philip and Janssen measure of fiscal impulse. During the 1991 and 1992 recession, the measure of fiscal impulse from the first difference fiscal VAR suggests that fiscal policy made a larger negative contribution during this period, than is suggested by the Philip and Janssen measure of fiscal impulse. Throughout the remainder of the 1990s both measures are in broad agreement about the contribution of fiscal policy to GDP growth (although the stimulus from fiscal policy in 1997 is considerably larger for the Philip and Janssen measure compared to the VAR measure of fiscal impulse). In the period from 2002, at least until more recently, the two measures suggest different impacts of fiscal policy on GDP growth.

In general, there has also been some degree of congruence between the measure of fiscal impulse produced from the Hodrick-Prescott VAR specification and the Philip and Janssen measure of fiscal impulse, particularly over the last five years. However, one period where the two measures noticeably differ is in the mid-1990s, when the Philip Janssen measure suggests discretionary fiscal policy was subtracting from positive deviations in GDP from trend, whereas the fiscal VAR measure suggests fiscal policy was adding to positive deviations in GDP from trend.

6 Conclusions

This paper has examined the dynamic effects of fiscal policy on New Zealand GDP using a structural VAR model. Following the modelling procedures developed and implemented by Blanchard and Perotti (2002) and Perotti (2004), the impact of government spending (purchases of goods and services), taxes and transfers on GDP was identified by assuming that discretionary fiscal policy is unable to respond to GDP shocks within one quarter. Institutional information on the tax and transfer system are therefore used to quantify the automatic effects of changes in GDP on government spending, taxes and transfers.

Results showed that an increase in government spending led to an increase in GDP in the short term, while an increase in net tax reduced GDP in the short-term. The size of the response in GDP to changes in government spending and net tax was dependent on the trend specification adopted. The estimated impact of increases in government spending or net tax on New Zealand GDP was smaller than the estimated effects of changes in government spending or net tax on GDP for the United States. In this respect, results for New Zealand are similar to those for Australia and most likely reflect the small, open nature of both economies. When the fiscal VAR model was estimated with the net tax variable separated into taxes and government transfers, impulse responses revealed that a tax revenue shock lowered GDP (although the decline was small), while a government transfer shock lead to an increase in GDP in the short-term, but a decline in GDP over the medium-term.

The structural VAR model was also used to analyse the historical contributions of fiscal policy to New Zealand business cycles. Two measures of fiscal impulse were examined: one based on a first difference VAR specification and the other based on detrending data using the Hodrick-Prescott filter. The fiscal impulse measure based on the first difference specification showed that fiscal policy dampened GDP growth in the early 1990s, while adding to growth in the mid-to-late 1990s. Since 2001 fiscal policy has tended to add to GDP growth. The fiscal impulse measure based on the Hodrick-Prescott trend specification showed that fiscal policy subtracted from positive deviations in GDP from trend in the early 1990s, but made a positive contribution during the period 1993 to 1998. Since 1998 fiscal policy tended to subtract from positive deviations in GDP from trend. Although there is a reasonable degree of congruence between the Philip and Janssen measure of fiscal impulse and the alternative structural VAR measures (especially for the first difference specification), there are periods where the measures differ significantly on the contribution of fiscal policy to GDP.

This paper provides a basis for further work on fiscal policy and the New Zealand economy. One area of work is to disaggregate government spending and tax data to analyse the differential effect of changes in different spending and tax categories on GDP. A further area of work is to explicitly incorporate the government budget constraint. Another extension of this work is to include fiscal variables in a larger structural VAR model of the New Zealand economy (for example, the structural VAR model developed by Buckle, Kim, Kirkham, McLellan and Sharma, 2002) to measure the effect of changes in fiscal policy on other economic variables, such as inflation, interest and exchange rates, and private sector output. This larger model could also be used to examine the impact of exogenous shocks on the fiscal balance and, using techniques developed by Buckle, Kim and Tam (2001), the ex-ante fiscal balance required to maintain some specified lower or upper bound for the fiscal balance.

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Appendix A: Augmented Dickey-Fuller unit root tests

Appendix Table 1 – Unit root test results

	Fiscal Balance	Net Tax	Government Spending	GDP
None	-3.279	-0.629*	0.594	3.300
Intercept	-3.055	-1.262*	-0.683*	0.440*
Intercept and Trend	-2.754*	-2.183*	-1.315*	-1.564*

* Indicates statistically significant unit root.

Appendix B: Stability tests

Appendix Table 2 – Stability test results for equations and individual parameters

Table B-1. Stability Test Results for Equation and Individual Parameter

	Deterministic Specification			Stochastic Specification			Hodrick-Prescott Specification			First Difference Specification		
Test	Tax stats (p-val)	G.E. stats (p-val))	GDP stats (p-val)	Tax stats (p-val)	G.E. stats (p-val))	GDP stats (p-val)	Tax stats (p-val)	G.E. stats (p-val))	GDP stats (p-val)	Tax stats (p-val)	G.E. stats (p-val))	GDP stats (p-val)
Joint	3.47 (1.00)	3.32 (1.00)	2.85 (1.00)	2.84 (1.00)	3.16 (1.00)	1.76 (1.00)	3.22 (1.00)	2.96 (1.00)	2.02 (1.00)	2.75 (1.00)	3.13 (1.00)	1.75 (1.00)
Individual												
Variance	0.50 (0.04)*	0.17 (1.00)	0.12 (1.00)	0.61 (0.02)*	0.39 (0.08)*	0.13 (1.00)	1.08 (0.00)*	0.23 (1.00)	0.12 (1.00)	0.63 (0.02)*	0.34 (0.11)*	0.13 (1.00)
Constant	0.07 (1.00)	0.03 (1.00)	0.05 (1.00)	0.19 (1.00)	0.32 (0.13)*	0.16 (1.00)	0.06 (1.00)	0.05 (1.00)	0.09 (1.00)	0.17 (1.00)	0.35 (0.10)*	0.18 (1.00)
Net Tax{1}	0.10 (1.00)	0.06 (1.00)	0.09 (1.00)	0.15 (1.00)	0.05 (1.00)	0.12 (1.00)	0.14 (1.00)	0.12 (1.00)	0.16 (1.00)	0.15 (1.00)	0.04 (1.00)	0.11 (1.00)
Net Tax{2}	0.09 (1.00)	0.06 (1.00)	0.07 (1.00)	0.08 (1.00)	0.04 (1.00)	0.02 (1.00)	0.03 (1.00)	0.14 (1.00)	0.06 (1.00)	0.08 (1.00)	0.02 (1.00)	0.02 (1.00)
Net Tax{3}	0.11 (1.00)	0.05 (1.00)	0.06 (1.00)	0.10 (1.00)	0.13 (1.00)	0.03 (1.00)	0.14 (1.00)	0.05 (1.00)	0.05 (1.00)	0.11 (1.00)	0.10 (1.00)	0.04 (1.00)
Net Tax{4}	0.12 (1.00)	0.03 (1.00)	0.06 (1.00)	0.02 (1.00)	0.09 (1.00)	0.20 (1.00)	0.11 (1.00)	0.13 (1.00)	0.10 (1.00)	0.02 (1.00)	0.07 (1.00)	0.20 (1.00)
G.E.{1}	0.07 (1.00)	0.02 (1.00)	0.06 (1.00)	0.19 (1.00)	0.14 (1.00)	0.04 (1.00)	0.06 (1.00)	0.07 (1.00)	0.10 (1.00)	0.17 (1.00)	0.19 (1.00)	0.05 (1.00)
G.E.{2}	0.08 (1.00)	0.02 (1.00)	0.06 (1.00)	0.06 (1.00)	0.23 (0.11)*	0.05 (1.00)	0.21 (1.00)	0.31 (0.14)*	0.07 (1.00)	0.07 (1.00)	0.20 (1.00)	0.04 (1.00)
G.E.{3}	0.08 (1.00)	0.02 (1.00)	0.06 (1.00)	0.04 (1.00)	0.34 (0.16)*	0.05 (1.00)	0.09 (1.00)	0.10 (1.00)	0.12 (1.00)	0.04 (1.00)	0.38 (0.08)*	0.06 (1.00)
G.E.{4}	0.09 (1.00)	0.02 (1.00)	0.06 (1.00)	0.05 (1.00)	0.29 (1.00)	0.03 (1.00)	0.49 (0.05)*	0.15 (1.00)	0.04 (1.00)	0.05 (1.00)	0.24 (0.20)*	0.04 (1.00)
GDP{1}	0.08 (1.00)	0.03 (1.00)	0.05 (1.00)	0.08 (1.00)	0.12 (1.00)	0.11 (1.00)	0.06 (1.00)	0.12 (1.00)	0.11 (1.00)	0.08 (1.00)	0.19 (1.00)	0.11 (1.00)
GDP{2}	0.08 (1.00)	0.03 (1.00)	0.05 (1.00)	0.20 (1.00)	0.34 (0.11)*	0.12 (1.00)	0.05 (1.00)	0.38 (0.08)*	0.10 (1.00)	0.23 (1.00)	0.19 (1.00)	0.15 (1.00)
GDP{3}	0.08 (1.00)	0.03 (1.00)	0.05 (1.00)	0.24 (0.20)*	0.29 (1.00)	0.23 (1.00)	0.05 (0.20)*	0.27 (0.18)*	0.25 (0.19)*	0.16 (1.00)	0..04 (1.00)	0.13 (1.00)
GDP{4}	0.08 (1.00)	0.03 (1.00)	0.05 (1.00)	0.12 (1.00)	0.12 (1.00)	0.03 (1.00)	0.15 (1.00)	0.14 (1.00)	0.06 (1.00)	0.17 (1.00)	0.08 (1.00)	0.04 (1.00)
Dummy{1}	0.08 (1.00)	0.15 (1.00)	0.11 (1.00)	0.08 (1.00)	0.06 (1.00)	0.19 (1.00)	0.09 (1.00)	0.17 (1.00)	0.10 (1.00)	0.07 (1.00)	0.05 (1.00)	0.20 (1.00)
Dummy{2}	0.25 (1.00)	0.20 (1.00)	0.10 (1.00)	0.24 (1.00)	0.43 (0.06)*	0.03 (1.00)	0.12 (1.00)	0.29 (0.16)*	0.19 (1.00)	0.23 (1.00)	0.45 (0.06)*	0.03 (1.00)
Dummy{3}	0.11 (1.00)	0.16 (1.00)	0.04 (1.00)	0.16 (1.00)	0.17 (1.00)	0.07 (1.00)	0.11 (1.00)	0.19 (1.00)	0.05 (1.00)	0.16 (1.00)	0.20 (1.00)	0.08 (1.00)
Time	0.12 (1.00)	0.03 (1.00)	0.05 (1.00)	-	-	-	-	-	-	-	-	-
Time square	0.13 (1.00)	0.02 (1.00)	0.05 (1.00)	-	-	-	-	-	-	-	-	-

* Indicates statistically significant unstable estimates

* Tax = Net tax and G.E. = Government Expenditure

Appendix Table 3 – Stability test results for the fiscal VAR model

Deterministic	Stochastic	Hodrick-Prescott	First Difference
0.219	0.273	0.132	0.233
0.352	0.273	0.365	0.233
0.444	0.503	0.507	0.483
0.444	0.503	0.637	0.483
0.477	0.527	0.637	0.516
0.477	0.527	0.685	0.516
0.514	0.534	0.690	0.519
0.691	0.534	0.690	0.519
0.691	0.609	0.690	0.610
0.779	0.609	0.690	0.610
0.886	0.690	0.718	0.691
0.886	0.690	0.718	0.691

Appendix C: Normality and linearity tests

Appendix Table 4 – Test results for normality of residuals

	Net Tax		G.E.		GDP	
	Statistics	P-Value	Statistics	P-Value	Statistics	P-Value
Deterministic	0.111	0.946	19.387	0.000*	2.001	0.368
Stochastic	2.377	0.305	3.206	0.201	3.641	0.162
Hodrick-Prescott	1.651	0.438	19.453	0.000*	3.728	0.155
First Difference	1.700	0.427	4.593	0.101	4.763	0.092

* Indicates statistically significant non-normal distribution of residuals

Appendix Table 5 – Test results for linearity

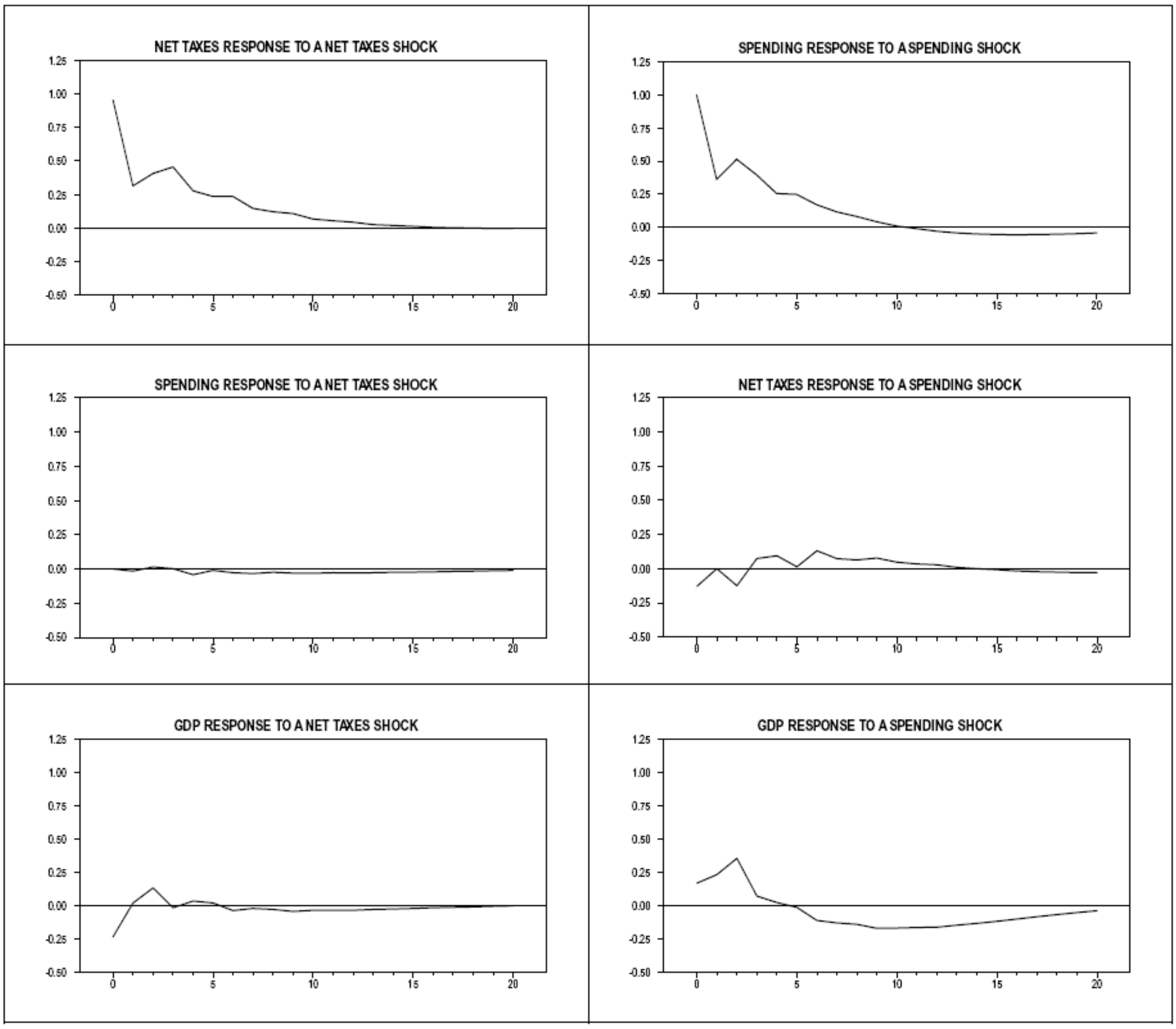
			D.T.	S.T.	H.P.	F.D.
Net Tax	Powers = 2	Statistics	0.702	0.185	0.027	0.233
		P-Value	0.405	0.669	0.869	0.631
	Powers = 2,3	Statistics	4.176	1.392	0.029*	1.417
		P-Value	0.020*	0.256	0.972	0.250
	Powers = 2,4	Statistics	2.763	1.122	0.448	1.099
		P-Value	0.049*	0.346	0.720	0.356
G.E.	Powers = 2	Statistics	0.340	1.898	0.067	3.139
		P-Value	0.562	0.173	0.797	0.081*
	Powers = 2,3	Statistics	0.173	1.177	0.046	1.872
		P-Value	0.841	0.314	0.955	0.162
	Powers = 2,4	Statistics	0.166	0.935	0.030	1.276
		P-Value	0.919	0.429	0.993	0.290
GDP	Powers = 2	Statistics	105.813	0.385	0.008	1.247
		P-Value	0.000*	0.537	0.931	0.268
	Powers = 2,3	Statistics	150.911	0.470	0.057	1.007
		P-Value	0.000*	0.627	0.945	0.371
	Powers = 2,4	Statistics	99.604	0.558	0.082	0.694
		P-Value	0.000*	0.644	0.969	0.559

* Indicates significant non-linearity
* D.T. = Deterministic, S.T. = Stochastic, H.P. = Hodrick-Prescott and F.D. = First Difference

Appendix D: Alternative ordering

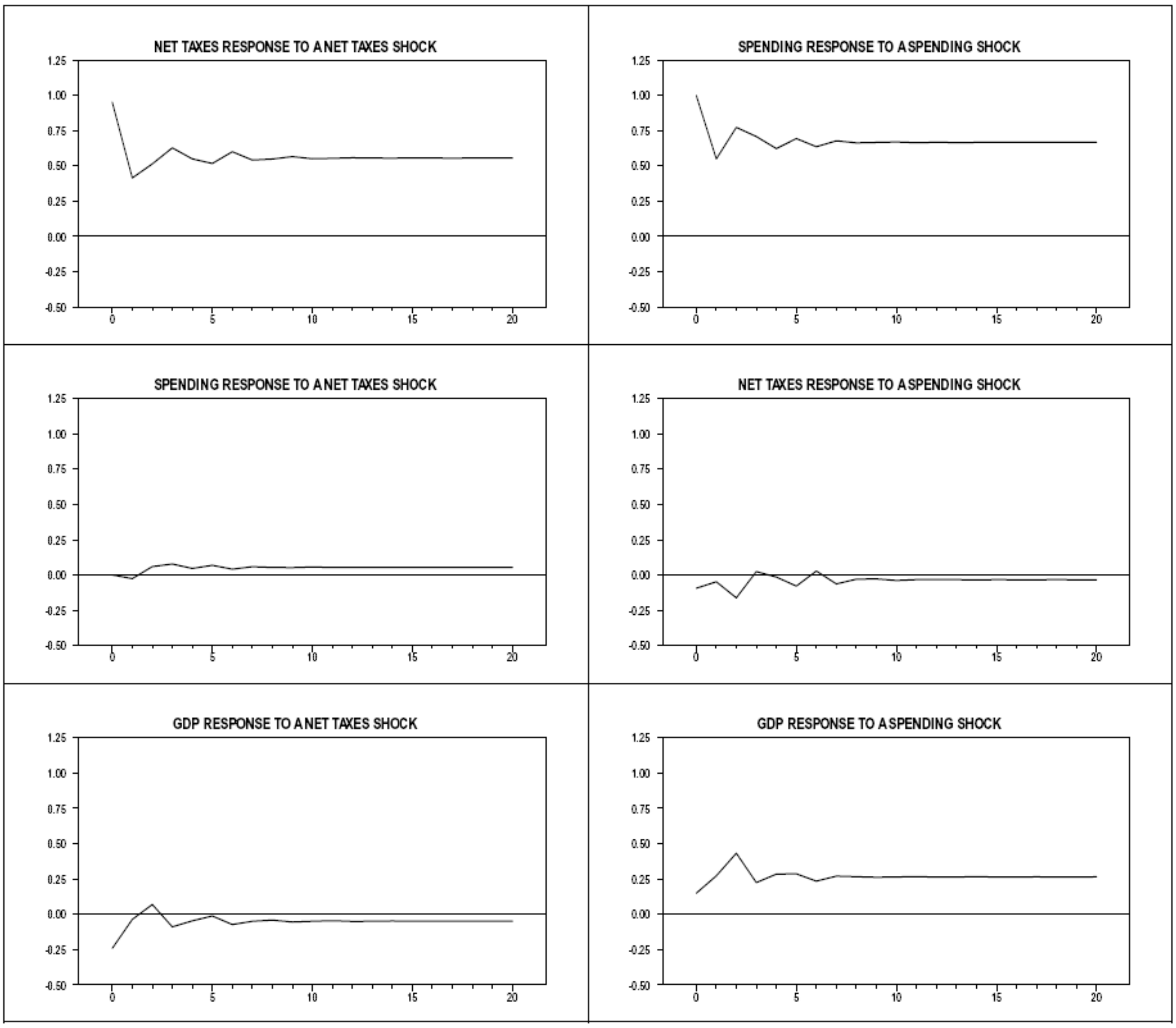
Appendix Figure 1 – Alternative ordering of net tax and government spending for the deterministic trend specification

Net tax shock ***Government spending shock***



Appendix Figure 2 – Alternative ordering of net tax and government spending for the stochastic trend specification

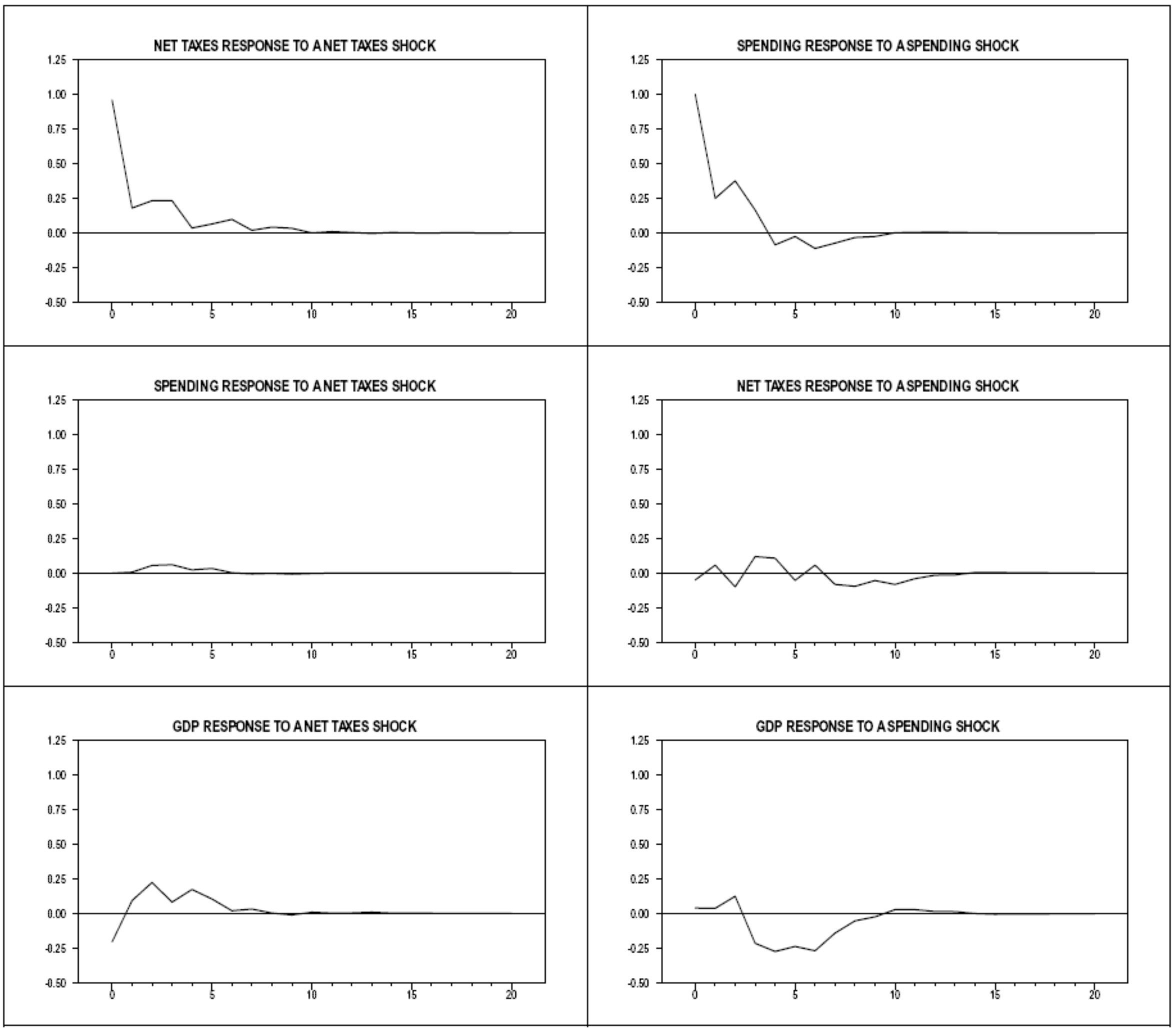
Net tax shock ***Government spending shock***



Note: The figure for the first difference trend specification is not reported, as it is almost identical to the one for stochastic trend specification. However, it is available upon request.

Appendix Figure 3 – Alternative ordering of net tax and government spending for the Hodrick-Prescott specification

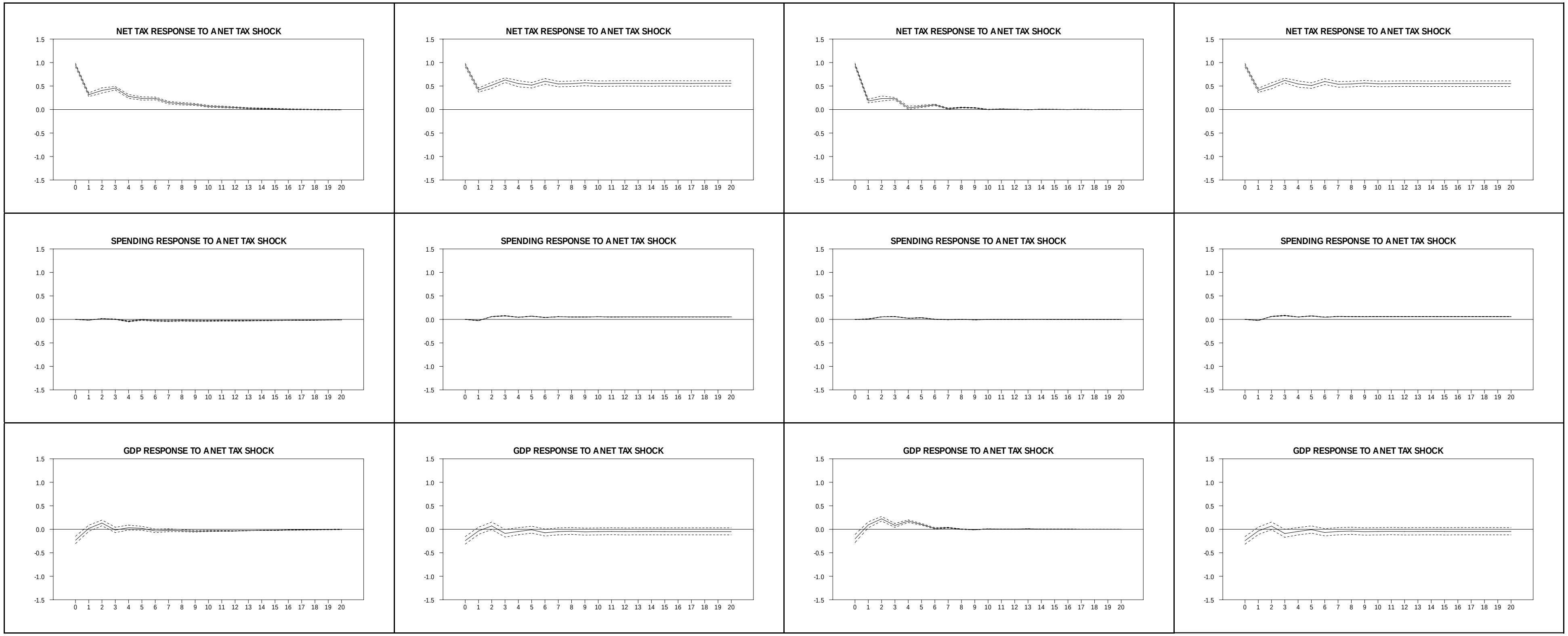
Net tax shock ***Government spending shock***



Appendix E: Alternative elasticities

Appendix Figure 4 – Sensitivity tests for the impulse responses to net tax shock

Deterministic Trend ***Stochastic Trend*** ***Hodrick-Prescott*** ***First Difference***



Appendix Figure 5 – Sensitivity test for the impulse responses to a government spending shock

Deterministic Trend ***Stochastic Trend*** ***Hodrick-Prescott*** ***First Difference***