

The Identification of Fiscal and Monetary Policy in a Structural VAR*

Mardi Dungey^{††} and Renée Fry^{††}

†CFAP, University of Cambridge

⁺CAMA, Australian National University

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Abstract

Good economic management depends on understanding how shocks from monetary policy, fiscal policy and other sources affecting the economy and their subsequent interactions. This paper presents a new methodology to disentangle such shocks in a structural VAR framework. The method combines identification via sign restrictions, cointegration and traditional exclusion restrictions within a system which explicitly models stationary and non-stationary variables and accounts for both permanent and temporary shocks. The usefulness of the approach is demonstrated on a small open economy where policy makers are actively considering the interaction between monetary and fiscal policies. The results show that over the last 20 years the influence of the fiscal policy stance on output has sometimes been substantial, and generally outweighs the contribution of monetary policy shocks.

Keywords: Identification, Fiscal policy, Monetary policy, SVAR, Permanent and transitory shocks, Sign restrictions.

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1 Introduction

For any country, effective economic management depends on understanding the nature of shocks hitting the economy and their subsequent economic interactions. In particular, interactions of monetary policy shocks with fiscal policy and other variables, fiscal policy shocks with monetary policy and other variables, and macroeconomic shocks with both fiscal and monetary policy are of importance for policy makers. This paper contributes a new methodology for disentangling these effects empirically in a structural vector autoregression framework (SVAR).

Empirical macroeconomic modelling is often undertaken in a SVAR, where identification of policy shocks usually occurs in one of three ways.¹ The first is through traditional normalisation and restrictions on the contemporaneous relationships between variables. This is widely applied to monetary policy (for a review see Bagliano and Favero, 1998) and only recently to fiscal policy using institutional detail and calibrated elasticities as identification tools (Blanchard and Perotti, 2002; Perotti, 2002; Chung and Leeper, 2007; and Favero and Giavazzi, 2007). The second is the newer sign restriction identification method which imposes restrictions on the set of impulse responses to shocks considered acceptable from the possible choice of orthogonal systems (Faust, 1998; Canova and de Nicoló, 2002; and Mountford and Uhlig, 2005). The third approach is to take account of the longer run properties of the model, in one form as a vector error correction model (VECM), or as an extension of Blanchard and Quah (1989), or in the recognition of the correspondence between SVARs and VECMs, see Jacobs and Wallis (2007), which allows the use of cointegrating relationships as a tool of identification as in Pagan and Pesaran (2008).

Here the approach is to build a model containing fiscal, monetary and other macroeconomic variables drawing on elements of these three identification methods. Short-run restrictions on the non-fiscal variables are provided via the existing traditional SVAR restrictions. The fiscal policy shocks are identified using a minimal set of sign restrictions, leaving other relationships to be data determined.² These restrictions are applied in conjunction with information from the cointegrating relationships between the macroeconomic variables to model the long run, allowing for both permanent and

¹In some circumstances VAR methods are inappropriate. Sometimes models cannot be written as a finite order VAR in the first place or are unable to be recovered, or suffer from small sample problems; see Lippi and Reichlin (1994); Cooley and Dwyer (1995); Faust and Leeper (1997); Canova and Pina (2005); Fry and Pagan (2005); Chari et al (2005); Fernandez-Villaverde et al (2007); and Leeper, Walker and Yang (2008) amongst others for discussion.

²Leeper, Walker and Yang (2008) suggest that non-fiscal policy shocks are not well identified by sign restrictions.

transitory components and a mixture of stationary and non-stationary variables. The current paper is the first to combine these three techniques and allows us to make a more structured analysis while still adhering to the VAR tradition of letting the data determine the dynamics in the economy, particularly for the less commonly modelled fiscal policy shocks.

The study of fiscal policy shocks and policy interactions in SVAR models is relatively limited but has largely built on the Blanchard and Perotti (2002) fiscal policy framework: for example Perotti (2002) for a range of OECD countries. More recently, Chung and Leeper (2007) and Favero and Giavazzi (2007) build on Blanchard and Perotti and show the importance of accounting for the level of government debt. Mountford and Uhlig (2005) use the Blanchard and Perotti fiscal variables but an alternative sign restriction based identification scheme. Canova and Pappa (2007) also utilise the sign restriction method for examining fiscal policy in a monetary union. The latter papers all focus on the US.³

The application in this paper is to the small open economy of New Zealand, one of the few countries which has coherent fiscal data available for modelling.⁴ New Zealand was the first country to adopt inflation targeting, in 1990, and consequently has the longest available time series for a small open economy in an inflation targeting environment. It also adopted a Fiscal Responsibility Act in 1994. Further, policy attention in New Zealand is currently focussed on the interactions between fiscal and monetary policy (Finance and Expenditure Committee, 2007). There is a well-established SVAR modelling framework for New Zealand, which has resolved many non-fiscal related model specification issues, and this is drawn on for the short-run restrictions for the non-fiscal variables; see particularly Buckle, Kim, Kirkham, McLellan and Sharma (2007) and references therein.

The rest of this paper proceeds as follows. Section 2 presents a coherent VAR framework in which three types of identification restrictions are simultaneously applied and illustrates how to obtain impulse response functions and historical decompositions under this structure. Section 3 outlines the variables and data properties for the New Zealand example, characterising the stationarity and cointegration results necessary to apply the modelling framework. The specification of the model is described in Section

³Canova and Pappa (2007) also apply their model to Europe.

⁴Common problems with time series of fiscal data are moves from accrual to cash accounts within recent sample periods, lack of seasonally adjusted data, insufficient frequency of data (many series are available only on an annual basis), adjustments for large defense expenditure items, consistent debt data and compatibility of component series - see Blanchard and Perotti (2002) for their approach to the US data.

4 and the results are presented in Section 5 in terms of impulse response functions and historical decompositions. Section 6 discusses the relative influence of monetary and fiscal policy on the macroeconomy. Section 7 concludes.

2 The Empirical Methodology

This section shows how to nest three identification methods in a SVAR. These are specifically, the traditional short-run restrictions, sign restrictions and long-run restrictions. Both permanent and transitory shocks are identified following Pagan and Pesaran (2008).

Consider a standard VAR(p) where the data y_t are expressed in levels,

$$B(L)y_t = \varepsilon_t, \quad (1)$$

where $B(L) = B_0 - B_1L - B_2L^2 - \dots - B_pL^p$. Usually identification proceeds through restrictions on the B_0 and $\Omega = E(\varepsilon_t\varepsilon_t')$ matrices or in the case of Blanchard and Quah (1989) restrictions on long run impact effects. Sign restrictions provide a further alternative. Defining \widehat{S} as containing the estimated standard deviations of the structural residuals along the diagonal with zeros elsewhere, the relationship between the estimated reduced form and structural errors is

$$\begin{aligned} \widehat{e}_t &= \widehat{B}_0^{-1}\widehat{S}\widehat{S}^{-1}\widehat{\varepsilon}_t \\ &= T\eta_t, \end{aligned} \quad (2)$$

where \widehat{B}_0^{-1} is the inverse of the estimated matrix of contemporaneous coefficients, T is designated an impact matrix, and η_t are the estimated shocks with unit variances. The original shocks can be redefined as a function of an orthonormal matrix Q , in this paper the Given's rotation matrix, which by definition has the properties $Q'Q = QQ' = I$ such that

$$\widehat{e}_t = TQ'Q\eta_t \quad (3)$$

$$= T^*\eta_t^*. \quad (4)$$

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

remain orthogonal. The choice of Q is determined by examination of the signs of the impulse response functions. Defining $B_0^* = (T^*S^{-1})^{-1}$, and $B_i^* = B_i$ for all $i \neq 0$, the VAR(p) can be rewritten as

$$B^*(L)y_t = \varepsilon_t, \quad (5)$$

where $B^*(L) = B_0^* - B_1^*L - B_2^*L^2 - \dots - B_p^*L^p$.

The VAR(p) expressed in either equation (1) or (5) depending on whether sign restrictions are imposed, can be written in a corresponding reduced form in differences as follows (for convenience the notation assumes the imposition of sign restrictions, but to remove them simply impose $B^*(L) = B(L)$):

$$\Psi(L)\Delta y_t = -\Pi y_{t-1} + e_t, \quad (6)$$

where $e_t = B_0^{*-1}\varepsilon_t$ and $\Psi(L) = (I_n - \Psi_1 - \Psi_2 - \dots - \Psi_{p-1})$ with Ψ_j being the appropriate transformation of the structural parameters.⁵ In the case where all variables in y_t are $I(1)$ and there are $r < n$ cointegrating relationships between them, the matrix Π will be rank deficient and in the usual notation $\Pi = \alpha'\beta$ where α and β are of full rank.⁶

The inclusion of $I(0)$ variables in y_t is relatively straightforward by simply recognising that the k $I(0)$ variables are treated in exactly the same way as the n $I(1)$ variables, but with the matrix β on the lagged levels effects (y_{t-1}) defined as

$$\beta = \begin{bmatrix} \beta_n & 0 \\ 0 & -I_k \end{bmatrix}. \quad (7)$$

When the system contains fewer cointegrating vectors than $I(1)$ variables it is useful to identify which of the shocks in the system are transitory, and which are permanent; see Levtchenkova, Pagan and Robertson (1998) and Jacobs and Wallis (2007). By definition all shocks corresponding to the $I(0)$ variables are transitory. In a common trends representation

$$\Delta y_t = F(L)e_t = F(L)(B_0^*)^{-1}\varepsilon_t, \quad (8)$$

where $F(L) = I_{n+k} + F_1L + F_2L^2 + \dots$ and $F(1) = F$ is given by

$$F = \beta_{\perp} [\alpha'_{\perp} \Psi(L) \beta_{\perp}] \alpha_{\perp}^{-1}, \quad (9)$$

with $\alpha'_{\perp}\alpha = 0$, $\beta'_{\perp}\beta = 0$, $F\alpha = 0$ and $\beta'F = 0$. The matrix α'_{\perp} corresponds to the H matrix used in Levtchenkova, Pagan and Roberston (1998) to partition permanent

⁵For example, in the case of a VAR(3) in levels the appropriate transformations are $\Pi = (B_0^*)^{-1}(B_0^* - B_1^* - B_2^* + B_3^*)$, $\Psi_1 = (B_0^*)^{-1}(B_3^* - B_2^*)$ and $\Psi_2 = -(B_0^*)^{-1}B_3^*$.

⁶Greater orders of integration are prevented via the assumption that the eigenvalues of $(B_0^*)^{-1}B_i^*$ exist for all i , and lie inside the unit circle.

and temporary shocks. Here we can say more about its properties following Pagan and Pesaran (2008). If the first $(n - r)$ shocks are permanent then

$$\Delta y_t = F(L) (B_0^*)^{-1} \begin{pmatrix} \varepsilon_{1jt} \\ \varepsilon_{2jt} \end{pmatrix}, \quad (10)$$

for the shocks in the second group, ε_{2jt} , to be transitory requires

$$FB_0^{*-1} \begin{pmatrix} 0_{(n-r) \times r} \\ I_{r+k} \end{pmatrix} = 0, \quad (11)$$

which is equivalently

$$FB_0^{*-1} \begin{pmatrix} 0_{(n-r) \times r} \\ I_{r+k} \end{pmatrix} = F\alpha = 0. \quad (12)$$

Premultiplying by $B_0^*F^{-1}$ leaves

$$\begin{pmatrix} 0_{(n-r) \times r} \\ I_{r+k} \end{pmatrix} = B_0^*\alpha = 0. \quad (13)$$

The right hand side of equation (13) can be multiplied by an arbitrary non-singular matrix R

$$\begin{pmatrix} 0_{(n-r) \times r} \\ I_{r+k} \end{pmatrix} = B_0^*\alpha R = \alpha^*R = \begin{pmatrix} \alpha_1^*R \\ \alpha_2^*R \end{pmatrix}. \quad (14)$$

Satisfying this equation requires that $\alpha_1^*R = 0$, and consequently that $\alpha_1^* = 0$. The importance of this for the estimation of such a system is that it precludes the inclusion of error correction terms in structural equations which contain permanent shocks, but the error correction terms enter where there are transitory shocks. This provides extra instruments for identification, although this turns out not to be relevant in the overidentified system investigated in the current paper. For the stationary variables, the error correction terms can be thought of as additional adjustment mechanisms.

Impulse response functions To extract impulse response functions for a system of $I(1)$ and $I(0)$ variables with cointegrating relationships and a combination of permanent and temporary shocks a further reformulation of the VECM system to a SVAR is useful. The permanent components in the system may be written as a Beveridge-Nelson decomposition

$$\Delta\gamma = \zeta_t, \quad (15)$$

where ζ_t is white noise. Then denote the permanent component of a series y_{it} as y_{it}^p which in general can be written as $y_{it}^p = J\gamma_{it}$ where

$$J = FB_0^{*-1}. \quad (16)$$

This consequently means that $\beta'J = 0$.

Using the permanent and temporary components of the system the VECM can be transformed into a so-called gaps SVAR form as in Dungey and Pagan (2008), who explicitly recognise that a number of existing models which use this do not specifically include the remaining lags of the permanent variables, thus missing an important aspect of the transformation. Denote the transitory component of the variables as $\omega_t = (y_t - y_t^P)$, the correct transformation of the SVECM into a SVAR is

$$B^*(L)\Delta\omega_t = \Pi\omega_{t-1} + \sum_{j=1}^{p-1} B_j^* \Delta y_{t-j}^P + \varepsilon_t. \quad (17)$$

Rearranging and recognising that $\Delta y_t^P = J\varepsilon_t$ means the system can be written as

$$\tilde{B}(L)y_t = \Pi y_{t-1} + -\tilde{B}(L)J\varepsilon_t + (B_0^*)^{-1} \varepsilon_t, \quad (18)$$

where $\tilde{B}(L) = I_n - \tilde{B}_1L - \tilde{B}_2L^2 - \dots - \tilde{B}_pL^p$. Rewriting (18) as a moving average in ε_t provides the expression

$$G(L)y_t = J(L)\varepsilon_t, \quad (19)$$

and impulse responses are computed in the usual manner. The long run effects are apparent through the presence of the J matrix. The responses in variable y at horizon j to a shock in ε_{kt} is represented as

$$\frac{\partial y_{t+j}}{\partial \varepsilon_{kt}} = \frac{\partial \omega_{t+j}}{\partial \varepsilon_{kt}} + \frac{\partial y_{t+j}^P}{\partial \varepsilon_{kt}} = \frac{\partial \omega_{t+j}}{\partial \varepsilon_{kt}} + J. \quad (20)$$

Historical decompositions Historical decompositions are a reorganisation of information in the impulse response functions. From the moving average form of any variable as given in equation (18), it is possible to attribute the change in any variable in the system at any given point in time to the cumulation of all previous shocks and initial conditions. From (18) this has the form

$$\Delta\omega_t = \text{initial conditions} + \sum_{i=0}^t C_i \varepsilon_{t-i} + J, \quad (21)$$

where the C_i are the impulse responses at each horizon. The distribution of the permanent effects over the time horizon of the decomposition is not explicit, and as the changes at each point in time are of interest, the effect of J in this form of the analysis is largely ignored.

3 The Data

The data consist of 12 individually linearly detrended endogenous variables in y_t ordered as

$$y_t = \{y_t^*, px_t, pm_t, g_t, tax_t, gne_t, debt_t, gdp_t, hpinf_t, inf_t, short_t, twi_t\}, \quad (22)$$

where y_t consists of foreign output (y_t^*), the price of exports (px_t), the price of imports (pm_t), real government expenditure (g_t), real taxation revenue less transfers (tax_t), absorption (represented by real gross national expenditure) (gne_t), the ratio of sovereign issued debt to GDP ($debt_t$), real GDP (gdp_t), house price inflation ($hpinf_t$), consumer price inflation (inf_t), the short term interest rate ($short_t$) and the trade weighted exchange rate for the New Zealand dollar (twi_t).⁷

Data are available from 1983:2, and the current dataset extends to 2006:4. New Zealand implemented a number of important changes in macroeconomic policy during this period, including the adoption of formal inflation targeting in 1989, and the use of the Monetary Conditions Index (MCI) based on inflation and exchange rate movements as a reference for monetary policy decisions between 1994 and 1997.⁸ On the fiscal policy side New Zealand experienced a period of rapidly rising debt over the 1980s, which led to a focus on debt reduction and the adoption of the Fiscal Responsibility Act in 1994 and the Public Finance Act in 1989 (amended in 2004), where the Government was charged with following principles of responsible fiscal management, including ensuring that Government debt be maintained at prudent debt levels. All variables are in natural logarithms except for the interest rates and inflation rates which are in percentages.⁹ Figure 1 presents a present a plot of the data for all variables including the exogenous variables of climate and the international interest rate. Full definitions of the variables are given in Appendix 1.

The fiscal variables are government expenditure, taxation revenue and the debt to GDP ratio. Government expenditure includes real total government consumption and real total government investment consistent with Blanchard and Perotti (2002) and Claus et al (2006) for New Zealand. Real net taxation revenue, denoted herein simply as taxation is total government revenue less transfer payments as in Claus et al

⁷Note that linear detrending is equivalent to the approach taken in many New Keynesian DSGE models (see Lubik and Schörfheide, 2005). In contrast Buckle et al (2007) use a HP filter to detrend their data, however it is not clear how to retain the long run cointegrating relationships in this case.

⁸Buckle et al (2007) find that accounting for the MCI period makes little difference to outcomes in their SVAR.

⁹Other fiscal SVAR models use either levels or per capita data. In this case per capita data essentially involves the use of a common detrending variable. Levels data aids our interpretation, particularly when comparing fiscal and monetary policies.

(2006) and Mountford and Uhlig (2005). The debt to GDP ratio is included following work showing the importance in avoiding the ‘incredible debt to GDP ratios’ which can occur in systems without this variable; see Favero and Giavazzi (2007) and Chung and Leeper (2007).

The data are of mixed order of integration, see Dungey and Fry (2007) for the complete set of unit root tests. Foreign and domestic output, government expenditure and taxation revenue are $I(1)$ processes. House price and consumer price inflation and interest rates are treated as $I(0)$. The trade weighted index is statistically $I(1)$ using both the Augmented Dickey-Fuller and Phillips-Perron tests as guides, while the evidence is mixed for the price of exports and the price of imports. All three are treated as $I(1)$ for the purposes of this paper. Application of the unit root tests to a longer time series on the price of exports and the price of imports supports this view. Although there are some difficulties with viewing the trade weighted index as $I(1)$ this turns out to be a useful specification here, partly because as in Dungey and Pagan (2008), it allows a mechanism by which balance of payments adjustments can occur, as otherwise there is no mechanism other than domestic income adjustment to shocks which change the demand or supply of the export sector. Secondly, the trade weighted index turns out to be an integral part of understanding the long term relationships between the variables in the system.

Of the 12 variables, 8 are non-stationary, and there are 3 cointegrating vectors.¹⁰ Empirical examination of the cointegrating relationships amongst the non-stationary series using the Engle-Granger two-step procedure confirms a cointegrating vector between $\{ g_t \text{ tax}_t \text{ gne}_t \text{ gdp}_y \text{ twi}_t \text{ y}_t^* \}$ and a further relationship between $\{ twi_t \text{ px}_t \text{ pm}_t \}$. The results of these tests are summarised in Table 1. A further cointegrating vector [1 -1] between government expenditure and tax is chosen, essentially keeping the debt to GDP ratio stable.¹¹ Note, that the relationship between the first set of variables

¹⁰Using the Johansen test we identified 1 cointegrating vector from the maximum eigen value test and 3 using the trace test. On the basis of the eigen value test we tested for a cointegrating relationship between the $I(1)$ variables using the Engle Granger 2 step method and found evidence of the cointegrating relationships given in the text. One of the possible reasons for difficulties in establishing the relationships between the variables in the New Zealand framework is a potential structural break associated with the Fiscal Responsibility Act (1994) affecting the behaviour of the fiscal variables from 1994 onwards. We experimented with including a dummy variable in the cointegrating relationships involving government expenditure and tax to represent this change but it made no qualitative difference to the results presented here.

¹¹There is a substantial literature testing for fiscal sustainability as a cointegrating relationship between taxation revenue and government expenditure, with mixed results. Here we err on the side of imposing the more policy acceptable fiscal sustainability by imposing the cointegrating relationship between government expenditure and tax. The classic article setting forth the arguments for nonstationarity as a measure of sustainability is Hamilton and Flavin (1986). More recently Bohn (2007)

absorption coinciding with the quarters prior to announced increases to the GST rate (see Buckle et al, 2007).

The debt variable enters as the seventh variable in the system and is contemporaneously dependent on each of the fiscal variables and absorption as an indicator of cyclical pressure. As in Chung and Leeper (2007) the presence of debt without a specific budget constraint is sufficient to avoid problems with debt to GDP ratios found in Favero and Giavazzi (2007), and additionally contributes to the stability of the system; see Fry and Pagan (2005) on the role of stock variables in VAR models.

Domestic GDP is modelled as a function of the contemporaneous and lagged fiscal policy variables, debt and absorption, as well as all lags of the short interest rate and exchange rate. It also responds to the contemporaneous and lagged exogenous variables of foreign output (y_t^*) and the climate variable.

House price inflation is included as a control for asset price behaviour in New Zealand. It is modelled as a function of contemporaneous and lagged domestic demand and output, its own lags, lagged inflation and the interest rate. Consumer price inflation itself encompasses a Phillips curve type specification, where contemporaneous and lagged domestic demand are key. Pass through effects from imported inflation are accounted for through the inclusion of the lagged exchange rate. The two GST dummy variables discussed in relation to the absorption equation above, as well as lags of the climate variable are also included.

The short interest rate adopts a Taylor rule form, containing contemporaneous and lagged domestic demand and inflation and the lagged interest rate. The exchange rate responds to all variables in the model, with the exception of house price inflation, given that the housing stock is an essentially non-internationally tradeable commodity.

While traditional SVAR identification such as outlined so far has been successfully applied to modelling monetary policy, untangling fiscal policy is more difficult; see Blanchard and Perotti (2002). A standard VAR or VECM has difficulty differentiating that an increase in taxes ought to be associated with a fall in GDP while an increase in government expenditure ought to be expansionary.¹² The solution adopted here is to specifically incorporate the direction of these hypothesized fiscal relationships using the sign restrictions methodology; see for example Mountford and Uhlig (2005) and Canova and Pappa (2007).¹³ This method has the advantage that the same model can

¹²The specification in Muscatelli, Tirelli and Trecroci (2004) uses the budget deficit as a measure of fiscal stance to avoid the problem with separately identifying taxation revenue and government expenditure.

¹³Blanchard and Perotti (2002) solve this problem using institutional details; see also Perotti (2002), Claus et al (2006), Chung and Leeper (2007) and Favero and Giavazzi (2007).

Q^d matrix is used to calculate the impulse response functions. In this application $d = 1,000$.

To disentangle the impulses and to assign them to particular shocks, three levels of criteria are examined.

Criterion 1: pure sign criterion The first criterion is purely sign based. For a positive Government expenditure shock (Gt), both government expenditure and GDP respond positively for j periods such that

$$\begin{aligned} C_{g,j}^{Gt,\tau} &\geq 0, & \forall j \\ C_{gdp,j}^{Gt,\tau} &\geq 0, & \forall j, \end{aligned} \quad (26)$$

for either of $\tau = 4$ or $\tau = 5$, where $\tau = 4, 5$ denote the fourth and fifth set of impulses respectively. The signs of the remaining impulses in τ are unconstrained and free to take on any sign. In the empirical example, $j = 1$.

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

$$\begin{aligned} C_{tax,j}^{T,\tau} &\geq 0, & \forall j \\ C_{gnc,j}^{T,\tau} &\leq 0, & \forall j, \end{aligned} \quad (27)$$

for either of $\tau = 4$ or $\tau = 5$. Again, the signs of the remaining impulses in τ remain unconstrained.

Criterion 2: magnitude restriction In certain draws, it is not possible to disentangle the two shocks using (26) and (27) alone. This occurs: (i) in the case of a government expenditure shock occurring in impulses τ when the response of taxation in the same set of impulses is negative ($C_{tax,j}^{Gt,\tau} \leq 0, \forall j$); (ii) in the case of a taxation shock in impulses τ where the response of government expenditure in the same set of impulses is positive ($C_{g,j}^{Gt,\tau} \geq 0, \forall j$). In this case a further rule is applied where if in a set of impulses τ , the magnitude of the response of government expenditure is greater than the magnitude of the response of taxation

$$C_{g,j}^\tau > C_{tax,j}^\tau, \forall j, \quad (28)$$

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

Criterion 3: relative magnitude restriction Occasionally after criterion 2 is imposed there are cases where both sets of impulses ($\tau = 4$ and $\tau = 5$) appear to be the same shock (either both government expenditure or both taxation shocks). Rather than discarding these draws, the impulses are disentangled by examining the ratio of the absolute value of the contemporaneous response of government expenditure to the contemporaneous response of taxation in impulses τ . If

$$abs\left(\frac{C_{g,1}^4}{C_{tax,1}^4}\right) \geq abs\left(\frac{C_{g,1}^5}{C_{tax,1}^4}\right), \quad (29)$$

then the fourth set of impulses is a government expenditure shock and the fifth set is a taxation shock and vice versa. If the two are equal, then it is assumed that the shock is a government expenditure shock.

Long run restrictions Amongst the 8 non-stationary variables there are 3 cointegrating relationships leaving 5 permanent shocks to be identified. The external sector shocks corresponding to international output, the price of exports and the price of imports are identified as two sources of permanent shocks. The remaining 2 permanent shocks within the domestic economy are chosen to be those corresponding to *gne* and *gdp*.¹⁷ When testing the convergence of the SVAR these were the shocks in which the ECM term entered to give stability in the model, see Pagan and Pesaran (2008).

Identifying permanent shocks in both foreign and domestic GDP suggests some deviation between the world technology shock and a New Zealand technology shock. There is evidence for different rates of trend growth in the international and New Zealand output series. The evidence is less strong for a difference between GDP and absorption, but during the sample period there is substantial divergence between the paths of the two which may be responsible for the behaviour being found here. The absorption shock can be regarded as a change in preferences for imports over domestic goods. The behaviour of export and import prices shows that there is higher growth in export prices over the period than the price of imports. This divergence represents the increased foreign preference for commodity products over the period. This is akin to allowing for a permanent shift in the terms of trade in the favour of New Zealand exports in this period.

¹⁷There is a strong case for the *g* and *tax* shocks to be transitory. In the case of a government expenditure shock Ricardian equivalence should hold. With a temporary government expenditure shock it is not feasible to have a permanent tax shock without implying an unstable debt to GDP ratio.

inflation (see Figure 2). The budget deficit (taxation less government expenditure) response is in the opposite direction to that of the short term interest rate, echoing the substitutability result in Muscatelli, Tirelli and Trecroci (2004). The relatively long lived effects of monetary policy decisions are apparent in the figures. This result arises from the imposition of the Pagan and Pesaran (2008) distinction between temporary and permanent shocks, without this, other models (including previous drafts of this model) find that the effects of monetary policy shocks can dissipate within 18 months to 2 years; see for example Buckle et al (2007). The movement in the exchange rate (not shown) as in most of the scenarios explored here, reflects the changes in the real interest rate relative to unchanging international real interest rates.

Fiscal policy shocks Figure 3 gives the impulse responses for seven of the domestic variables to temporary shocks originating in government expenditure (column 1), taxation revenue (column 2) and the debt to GDP ratio (column 3).

For the government expenditure shock, the impact of the increased government expenditure is reflected in higher output (panel e), consistent with the results in Blanchard and Perotti (2002), Perotti (2002, 2007) for a range of countries, and the preferred specification in Claus et al (2006). However, absorption falls initially (panel c). This result may reflect some of the debate about the nature of the private consumption response to higher government expenditure in terms of potential crowding out as in Canova and Paustain (2007). The higher government expenditure also results in a fall in taxation revenue (panel b), as it does in the majority of the results in Favero and Giavazzi (2007). The fall in absorption may be part of the mechanism for this via consumption tax revenue. The debt variable rises (panel d) and is resolved in the longer term by lower government expenditure. Inflation (panel f) falls, consistent with the existing US based studies of Chung and Leeper (2007), Mountford and Uhlig (2005) and most of the Favero and Giavazzi (2007) results. In these papers the interest rate declines in response to the government expenditure shock, although Mountford and Uhlig (2005) find an initial rise when expenditure is delayed for a year. Here, interest rates initially rise (panel g) associated with the higher GDP but quickly become negative stimulating a recovery in GNE and higher inflation.¹⁸

The temporary taxation shock in the second column of Figure 3 results in higher government expenditure (panel h), although the increase in taxation is sufficient to lower the debt to GDP ratio over the first 2 years of the impulse horizon (panel k).

¹⁸Canova and Paustain (2007) identify their government expenditure shock by a positive sign restriction whereby only draws where inflation rises in response to a government expenditure shock are retained.

This result is consistent with increased taxation through a consumption tax, resulting in lower absorption, and a redistribution of government spending through investment goods. This is something that may well be a suitable characterisation of the New Zealand economy over the sample period which includes both the introduction and increases in the rate of GST and a change in policy towards government investment expenditure over the period. As in Hall and Rae (1998), a comparison of the results in columns 1 and 2 show that a decrease in taxation leads to a greater GDP effect than the equivalent increase in government expenditure. The taxation shock is associated with lower inflation (panel m). Favero and Giavazzi (2007) similarly find that inflation falls in response to a taxation shock and interest rates respond with a fall, while Mountford and Uhlig (2005) find a rise in prices. In the current model, the short term interest rate declines in response to lower inflation.

The immediate effect of a temporary shock to the debt to GDP ratio in column 3 is a decrease in government expenditure and a slightly delayed rise in taxation revenue in order to bring the ratio back towards its initial value (panels o and p). The higher taxation and lower government expenditure combine for continued lower GDP (panel s). The effects of this 3.7% positive shock to the debt to GDP ratio, while resulting in a 0.6% fall in government expenditure and 0.3% rise in taxation revenue at their respective minima and maxima, has only a relatively small effect on absorption and GDP. The emergence of inflation (panel t) leads to higher interest rates (panel u), which act to reduce the recovery in output. In this case both the fiscal and monetary policies seem to be working to decrease growth in their aims to both contain inflation and return to the previously pertaining debt to GDP equilibrium. This provides a very good reason to think carefully about the sources of shocks to a debt to GDP ratio. Forcing the shock to be temporary seems to have output costs. The interactions between the fiscal and monetary policy shocks are more fully explored in Section 6.

Historical decompositions of inflation, the interest rate and GDP Figure 4 presents the historical decomposition of inflation over the sample period, with each panel showing the contribution of a particular shock to inflation. Inflation is determined mainly by own-shocks, although each of absorption, export and import prices and the exchange rate also have a discernible effect.

The historical decomposition of the short term interest rate is given in Figure 5. This shows that the major contributor to the short term interest rate, other than own innovations, is domestic inflation. The Reserve Bank of New Zealand is clearly responding to domestic price conditions, and not international or asset price inflation

(as represented here by house price inflation). It is also worth noting that shocks to government expenditure and taxation do not have a marked impact on either inflation or interest rate outcomes over the period compared with other influences.

The historical decomposition of GDP is shown in Figure 6. The most important source of shocks lies with GDP itself, followed by shocks to absorption (*gne*) and international output (y^*). Absorption shocks have an important role in offsetting negative own shocks particularly during the recovery from the recession in the early 1990s and slowdown in the early 2000s period.

The contribution of the policy variables to GDP are shown in greater detail in Figure 7. The government expenditure shocks are approximately counter-cyclical. They make positive contributions to output prior to the Fiscal Responsibility Act in 1994, and in the post-Asian crisis period and during the slowdown of 2000. Since about March 2003 government expenditure shocks act negatively on output. As in Claus et al (2006) the contributions of government expenditure and taxation to GDP are roughly equivalent in their scale. The contribution of the short term interest rate to output is largely negative post the early 1990s. In Section 6 where feedback effects to policy variables are controlled for, a different picture emerges.

Taxation shocks generally contribute negatively to output, as is expected with the fiscal consolidation occurring over the period. Two periods of positive contribution stand out in the figures. The first is immediately post the increase in the rate of the GST in 1989. The second is the most recent period from mid 2005. Prior to the Fiscal Responsibility Act, when the debt to GDP ratio is climbing, the effects of debt to GDP shocks are almost entirely negative. In more recent periods, a more benign debt outlook contributes positively to output.

6 The Influence of Monetary and Fiscal Policy

The dynamics of the model represented in the impulse response functions and the historical decompositions consist of a combination of both direct and indirect effects of policy variables in response to shocks. To isolate the pure policy effects from those which arise from the result of feedback of policy responses through to other variables in the economy, the coefficients of the non policy variable lags in an equation are set to zero, and the decompositions recalculated. This allows the construction of indices of the impact of monetary and fiscal policy shocks from the historical decomposition; see for example Dungey and Pagan (2000) and Buckle et al (2007). The difference between the historical decompositions of GDP with and without feedback effects in the interest

rate equation is a measure of the impact of monetary policy on the economy, and when added to the direct impact of interest rate shocks forms a monetary policy indicator (*mpi*). The effects of government expenditure, taxation and debt policy are constructed similarly, and aggregated to form fiscal policy indicators for government expenditure (*gpi*), taxation revenue (*tpi*), and debt (*dpi*).

The contributions of pure monetary and fiscal policy to GDP over the sample period are shown in Figure 8. The monetary policy indicator clearly makes a much smaller contribution than the fiscal policy indicators. From September 1989 to June 1995 monetary policy acts in a contractionary fashion. This is the period of the introduction of inflation targeting and monetary policy is clearly aimed at lowering inflation, but one consequence is that monetary policy is contractionary for GDP during a period of below average growth. Monetary policy is slightly expansionary from mid-1995 to June 1997, and then again resumes a contractionary stance. This latter episode is well-documented in the literature as associated with the period when the Reserve Bank of New Zealand based its anti inflationary target on a monetary conditions index (MCI) weighted equally across domestic inflation and exchange rate changes. A direct consequence was that to maintain the MCI policy stance during the East Asian crisis the Reserve Bank raised domestic interest rates in order to offset exchange rate movements, with unpleasant consequences for the real economy. In the figure the contractionary effect of monetary policy outlasts the MCI period and continues until mid-2003. For 2006 the monetary policy indicator returns to a contractionary stance.

The combination of the fiscal policy indicators is counter cyclical during each of the recession of the early 1990s, the slowdown associated with the Asian crisis and the drought in the late 1990s. However, this is not always the case. Fiscal policy is contractionary during the long recovery of the early 1990s and from mid-2005, in the midst of a period of sustained high growth in New Zealand output, the tax policy and the debt policy indicators in particular show an expansionary fiscal stance. Only for the period of 2000-2003 are each of the three fiscal policy indicators acting in the same direction. The tax cuts introduced over the period 1997 and 1998 are apparent in the positive innovations from the tax policy indicator over this period. The results of the Fiscal Responsibility Act and reduction in debt to GDP ratio are also evident in the debt policy indicator in the figure. From about mid-1995 there is a positive stimulus to the economy from the enhanced prospects for future growth with a lower debt to GDP ratio.

The combination of shocks which make up the GDP historical decomposition (Figure 6) suggest that the *mpi* and fiscal policy indicators are complementary in the sense

of Muscatelli, Tirelli and Trecroci (2004) only during the period of December 1991 to September 1994; further the complementarity comes from the *tpi*, a refinement not available in their analysis. In the RBNZ (2007) submission to the inquiry into the future of monetary policy framework, the Reserve Bank suggests that the last few years, fiscal expenditure is stimulatory (p.14 of their submission) and contributes to cyclical fluctuations. The results here suggest for the period from mid-2005, net taxation and debt to GDP policy shocks are contributing to output pressure, while government expenditure shocks are not. Potentially, the contribution of the debt to GDP ratio represents the greater confidence about the economy's ability to fund future growth with its currently historically relatively low debt to GDP ratio.¹⁹

7 Conclusions

This paper has contributed a new approach to the empirical estimation of the interactions between monetary policy, fiscal policy and other economic shocks using a SVAR framework. The strengths of three different identification methods were exploited within a single modelling framework with an application to a small open economy. The existing traditional short-run coefficient restrictions were used to identify non-fiscal shocks. Sign restrictions were used to separate government expenditure and taxation shocks. The third element was to formally model the long run via the cointegrating relationships between the macroeconomic variables, and account for both permanent and transitory shocks in a model with both stationary and nonstationary data.

The methodology was illustrated by an application to New Zealand, the economy with the longest history of inflation targeting and a well-constructed fiscal data set. Additionally, New Zealand is currently considering the structure of its macroeconomic policy making, and specifically the interactions between monetary and fiscal policy. The model incorporated elements of previous SVAR modelling for this economy in the short-run coefficient restrictions, building on Buckle et al (2007). New features included the incorporation of the fiscal and debt variables, and the adoption of a SVARX form, where climate and international interest rates are incorporated as exogenous variables. The important role of debt in empirical models of fiscal policy has been emphasized in the recent work of Chung and Leeper (2007) and Favero and Giavazzi (2007). An

¹⁹The positive contribution of taxation shocks is a conglomerate of taxation receipts and transfer payments. Changes to the transfers system, and anticipation of lower income tax rates are likely to be part of the explanation, and a further decomposition would be a useful future area for further research.

important addition to the model was incorporating the long run behaviour, where the cointegrating relationships were derived from both the empirical characteristics of the data and theoretical concepts regarding fiscal sustainability.

The model characterised the behaviour of output in New Zealand over the last 20 years, and showed that in general fiscal policy shocks have been larger than monetary policy shocks. Taxation and debt policy shocks have been more substantial than government expenditure shocks. Most of the behaviour in output arising over the sample period was clearly not a result of policy shocks; other influences, often own shocks, were dominant. However, a decomposition of monetary policy shocks showed that it mainly responded to inflationary shocks, providing a heartening validation of the conduct of monetary policy in New Zealand. The conduct of fiscal policy had both counter and pro-cyclical elements, and the three elements associated with government expenditure, taxation and debt policy were frequently acting in different directions. With respect to the current debate in New Zealand, the results showed that at the end of the sample period, net taxation policy was contributing to higher demand, while government expenditure policy was not. A useful avenue for future research would be to separate the effects of taxation and transfers from the net tax variable.

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A Data Definitions

All data are provided by the New Zealand Treasury, further details are available in Dungey and Fry (2007).

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

Exchange rate: Nominal trade weighted index, average of 11 am observations from RBNZ (RTWI11am).

Export prices: Domestic current price export price index, all merchandise.

Foreign interest rate: Time varying GDP-weighted 90 day interest rate consisting of US, Japanese, German and Australian interest rates.

Foreign output: Real foreign output index from New Zealand Treasury, 2000Q1=100 made up of industrial output indices weighted by export value share.

Government debt: The ratio of government debt to GDP. The debt data was interpolated from annual data using the method of Chow and Lin (1971) for the period to September 1994.

Government expenditure: Real central government consumption plus real government investment (both s.a. \$NZm, chain volume in 1995/1996 prices) smoothed through the application of a moving average filter of the current and three lags of observations. The series are purged of purchases of frigates in 1997 and 1998 and investment by state owned enterprises.

Gross domestic product: Real GDP(P) s.a. \$NZ m., chain-volume expressed in 1995/96 prices.

Gross national expenditure: Real GNE s.a. \$NZ m., chain-volume expressed in 1995/96 prices.

House price inflation: Annualised quarterly change in the nominal house price index base of March 2000=100.

Import prices: Domestic current price import price index, total merchandise imports.

Inflation: Annualised quarterly rate of the New Zealand CPI - All groups.

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

Taxation: Real taxation (direct plus indirect taxation with intra-government GST removed) minus real transfers (both are s.a. \$NZm). The series is deflated by the GDP(E) implicit price deflator s.a. based at 1995/1996=100 and smoothed through the application of a moving average filter of the current and three lags of observations.

Table 1:
Engle-Granger two-step cointegration tests 1983Q2 to 2006Q4.*

Variable	Coefficients in the cointegrating regressions								test statistics on residuals
	<i>y*</i>	<i>px</i>	<i>pm</i>	<i>g</i>	<i>tax</i>	<i>gne</i>	<i>gdp</i>	<i>twi</i>	
<i>g</i>	-0.692				0.304	1.480	-0.554	-0.172	-2.487
<i>g</i>					1				n.a.
<i>twi</i>		-0.200	-1.016						-4.419

*The ADF tests are performed on the errors of the cointegrating equations. The MacKinnon (1996) 5% critical value is -1.944.

Table 2:
Sizes of one-standard deviation shocks to the model.

Variable	Size	Variable	Size
<i>y*</i>	0.00729	<i>debt</i>	0.03765
<i>px</i>	0.03176	<i>gdp</i>	0.00597
<i>pm</i>	0.03490	<i>hpin.f</i>	1.94017
<i>g</i>	0.00536	<i>inf</i>	0.82783
<i>tax</i>	0.01080	<i>short</i>	0.98216
<i>gne</i>	0.01266	<i>twi</i>	0.01507

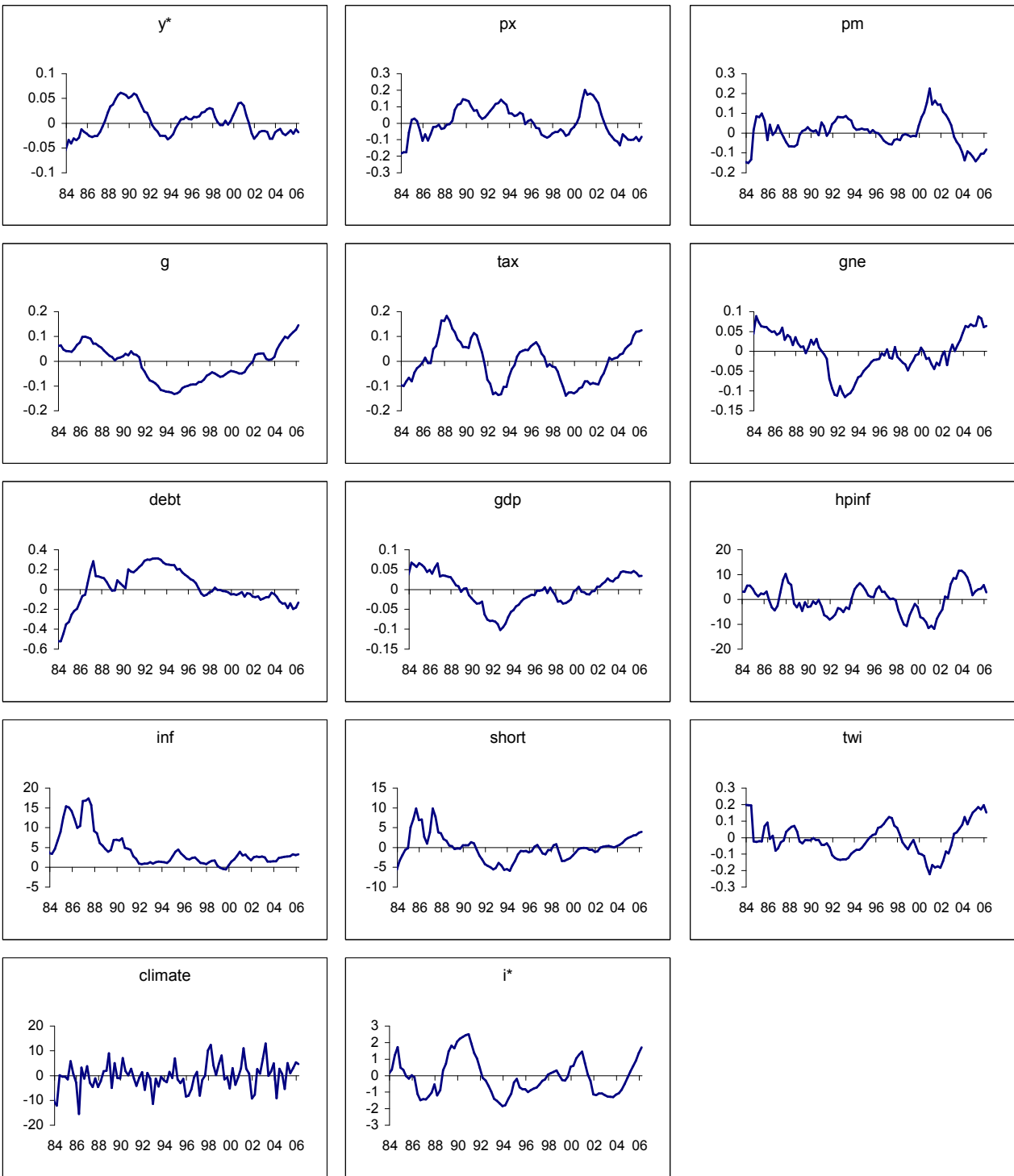


Figure1: Plots of the New Zealand data. With the exception of the interest rates, inflation rates and the climate variable, the original data were detrended using a linear trend.

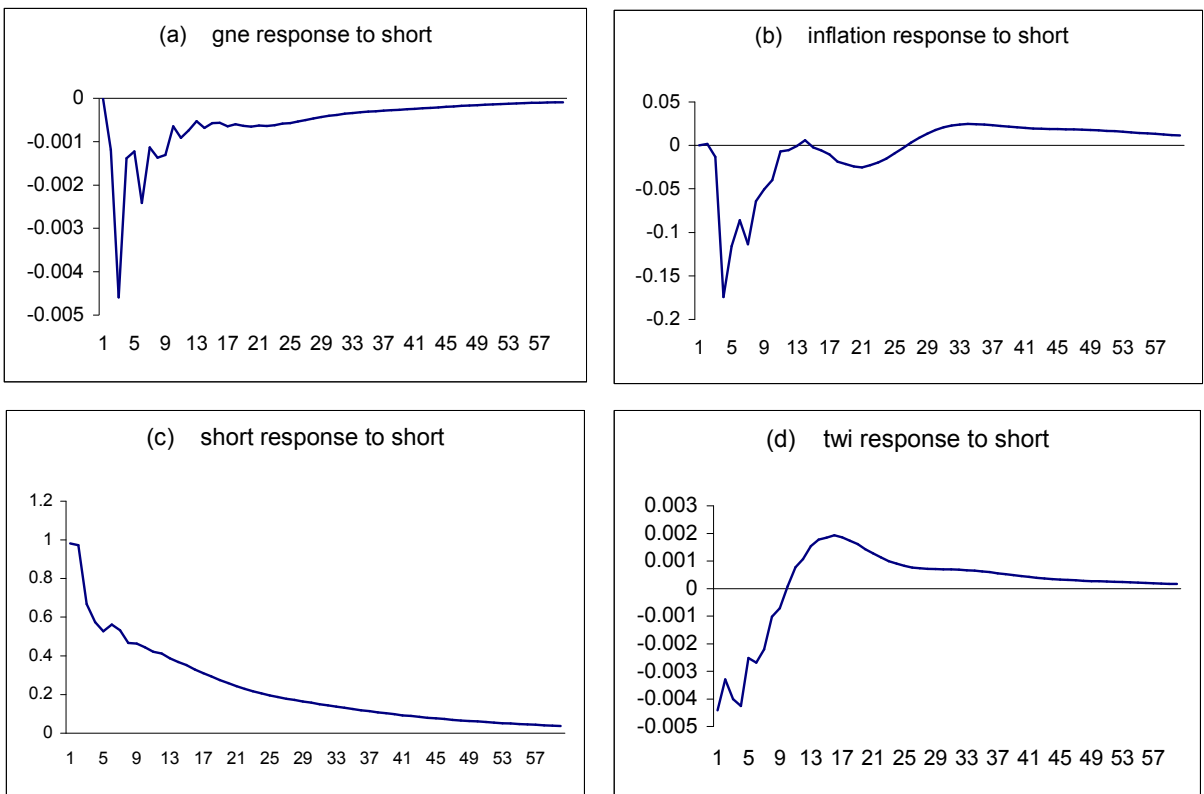


Figure 2: Impulse responses to a shock to the short interest rate

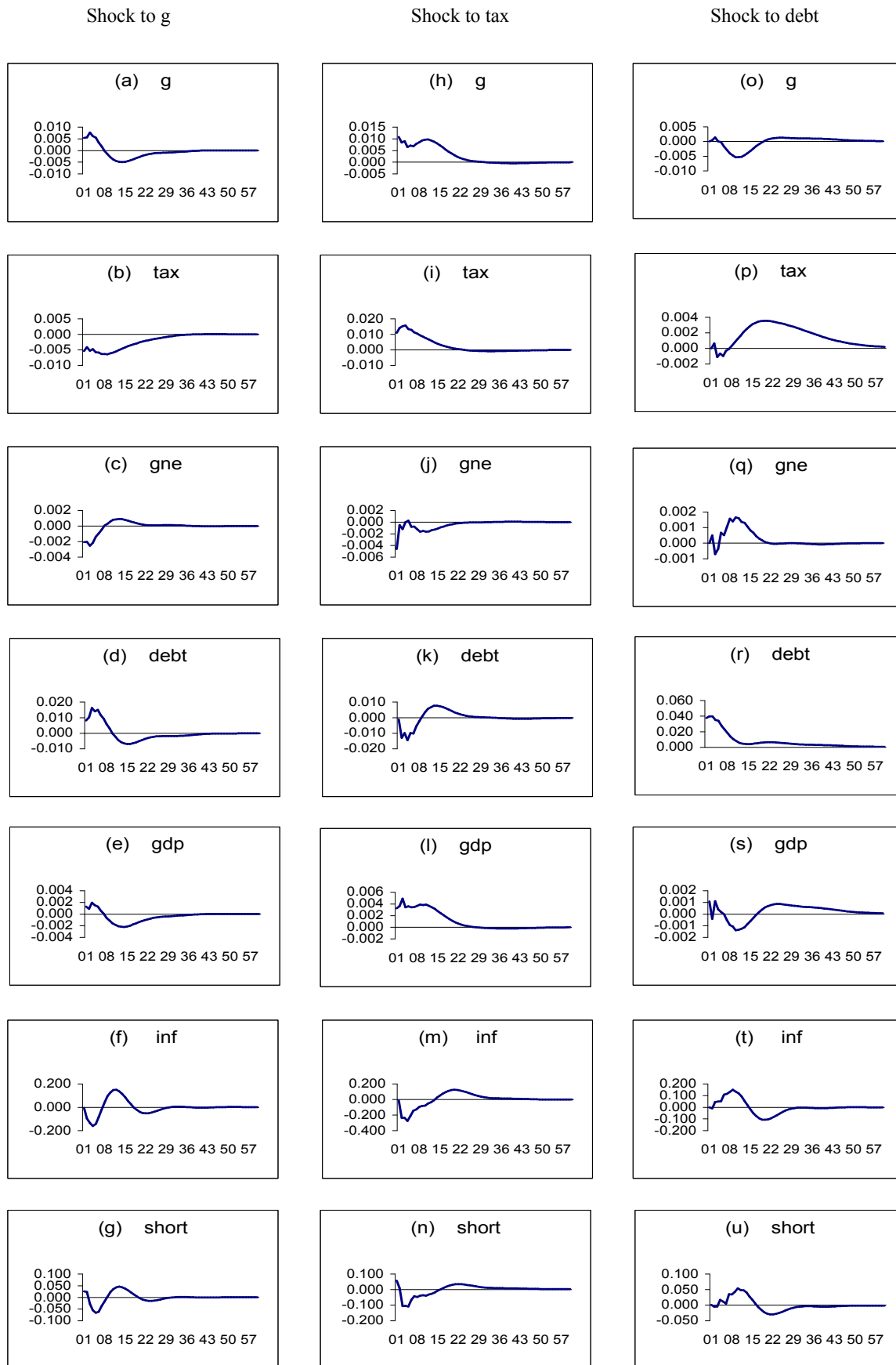


Figure 3: Impulse Responses to a Shock to g, tax and debt

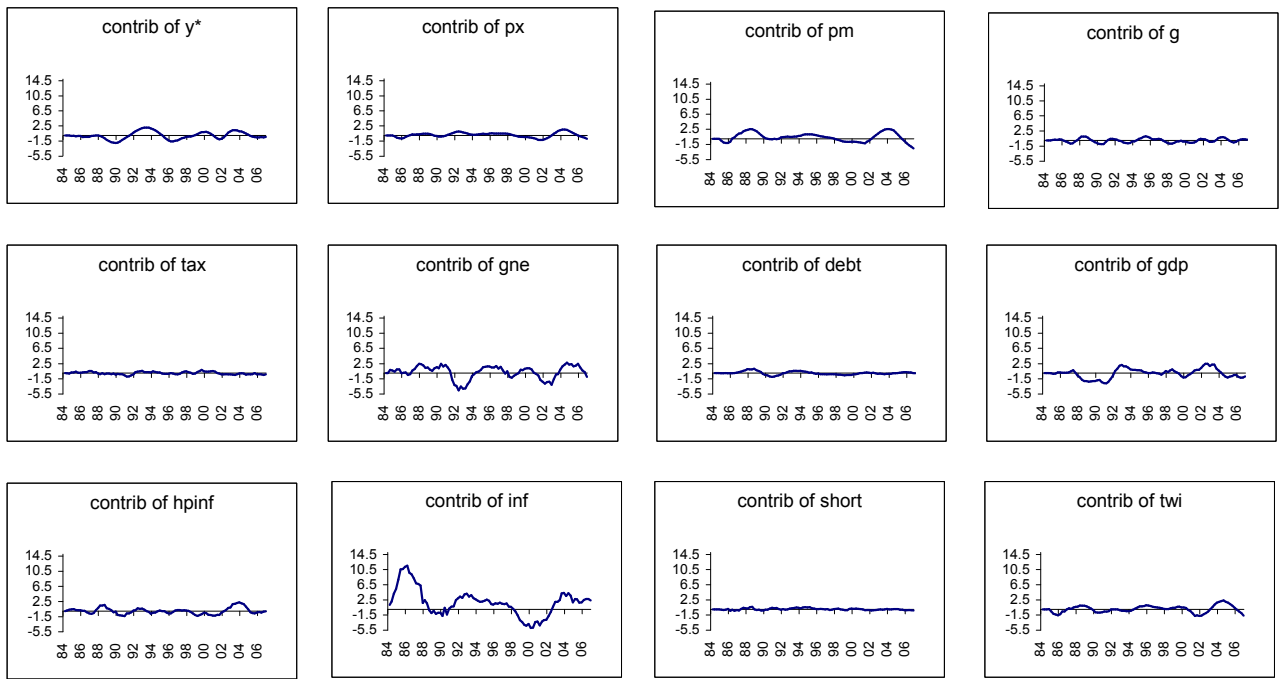


Figure 4: Historical decomposition of inflation

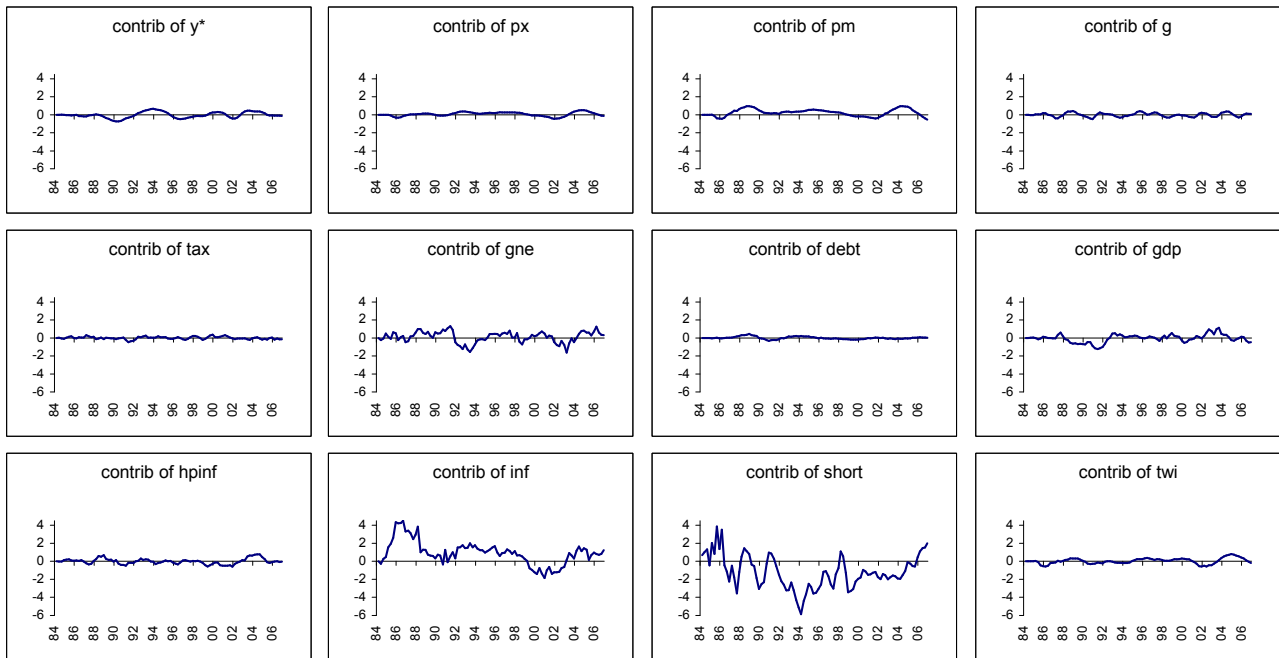


Figure 5: Historical decomposition of short term interest rates.

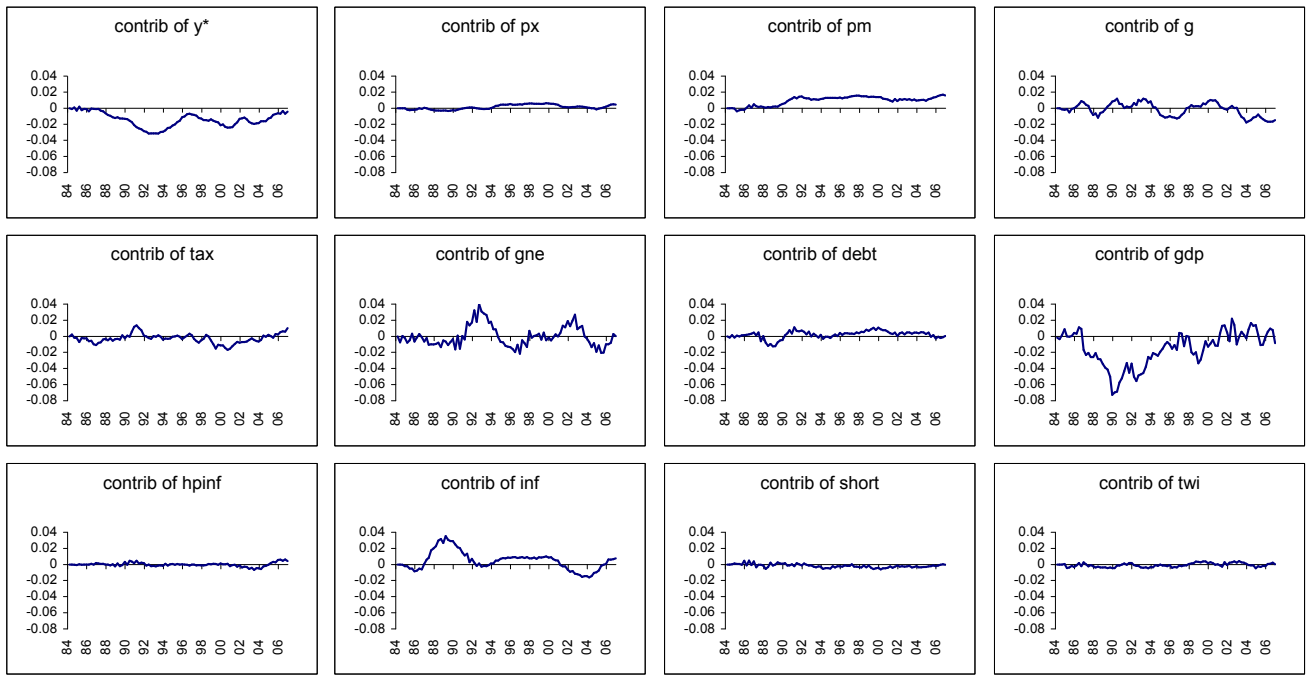


Figure 6: Historical decomposition of output (GDP).

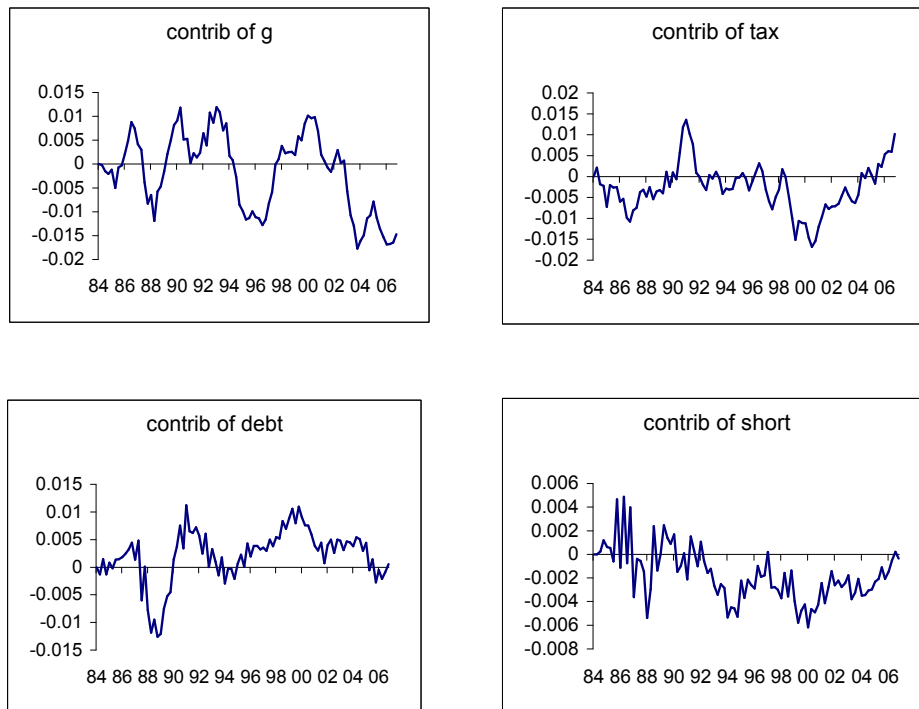


Figure 7: Historical decomposition of GDP by policy instruments

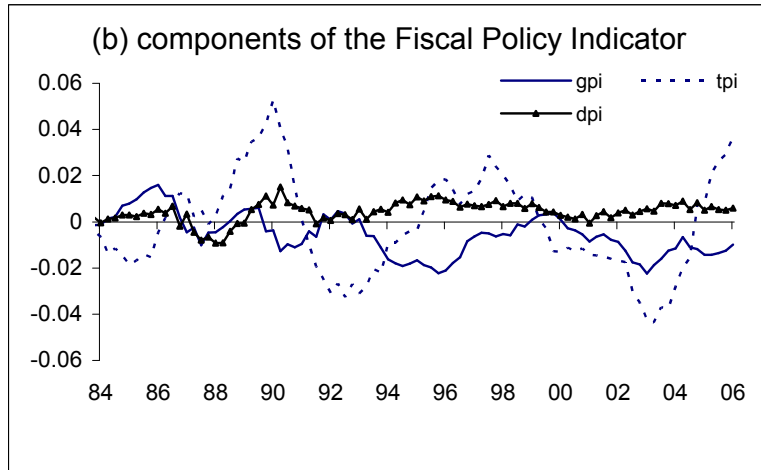
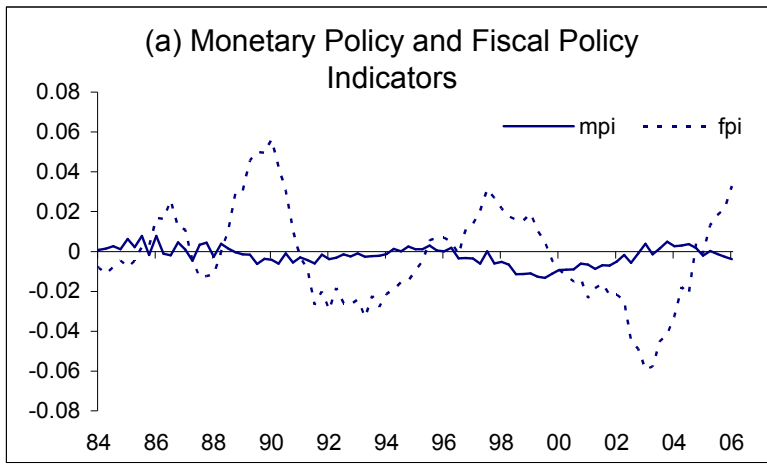


Figure 8: Monetary policy and fiscal policy indicators for GDP.