A Structural VAR Approach to Estimating Budget Balance Targets

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The Fiscal Responsibility Act 1994 states that, as a principle of responsible fiscal management, a New Zealand government should ensure total Crown debt is at a prudent level by ensuring total operating expenses do not exceed total operating revenues. In this paper a structural VAR model is estimated to evaluate the impact on the government's cash operating surplus (or budget balance) of four independent disturbances: supply, fiscal, real private demand, and nominal disturbances. Based on the distribution of these disturbances, stochastic simulations are undertaken to derive the level of the ex ante cash budget balance needed to achieve an actual cash budget balance, at a given level of probability, at some future time horizon.

1. Motivation and Methodology

Recognition of the dynamic effects of government budget deficits, the importance of policy credibility, timing difficulties associated with discretionary fiscal policy as a result of “inside” and “outside” lags, and difficulties many countries have experienced trying to reverse large fiscal deficits have led to renewed interest in the specification of government budget balance rules. For example, in several US states there exist strict balanced budget rules. For countries participating in stage III of the European Monetary Union, the Maastricht Treaty imposes a deficit ceiling of 3 per cent of GDP (and a debt limit of 60 per cent of GDP) and the Stability and Growth Pact specifies particular circumstances where a deficit can be regarded as excessive. One of the consequences of these developments is that, in the context of counter-cyclical policy, there has been a tendency to assign more weight to monetary policy and automatic fiscal stabilisers at the expense of discretionary fiscal policy (Taylor, 2000; Wren-Lewis, 2000).

These ideas have had a significant influence on fiscal policy in New Zealand. In particular, the Fiscal Responsibility Act 1994 (FRA) specifies that a government

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must achieve operating surpluses every year until a prudent level of debt is achieved. This effectively requires a government to generate cash-flow surpluses in order to reduce debt levels. Although the FRA does not specify a prudent level of debt, the Act does imply that a government must set its fiscal parameters \textit{ex ante} in order to achieve a target budget balance consistent with some desired outcome for public debt.

Therefore, if a government wants to allow automatic fiscal stabilisers to operate unimpeaded over the business cycle without breaching some lower or upper bound for the fiscal balance (such as any bound implied by the Fiscal Responsibility Act), it needs to set fiscal parameters and the \textit{ex ante} budget balance so that they take into account the potential impact of unexpected exogenous shocks to the budget balance. Put another way, to avoid breaching a desired budget balance \textit{ex post}, a government needs to form a judgement about the appropriate \textit{ex ante} budget balance in light of given probabilities of the type and size of exogenous shocks that could impact on the structural and cyclical components of the budget balance.

Various approaches can be used to estimate prudent budgetary margins. Buti, Franco and Ongena (1998) use estimated elasticities of budget deficits to output changes to evaluate the distance a budget deficit would need to be from its target in order to accommodate the impact on the deficit if a country’s output gap was at its historical maximum negative gap. The New Zealand Treasury uses a number of procedures in the analysis of appropriate budgetary margins. A “Ready Reckoner” model is used to provide indicative fiscal tracks in the event of alternative real output growth paths. For the short term, a cyclically adjusted balance model is used to gauge the underlying structural fiscal position. The New Zealand Treasury also uses a long term fiscal model to project the long-term path of fiscal variables under alternative fiscal assumptions and assumptions for GDP growth, interest rates and employment. However, the interaction between these variables and the cash budget balance is not captured and formally estimated probabilities are not assigned to the budget balance forecasts. Further complicating the interpretation of these simulations is the fact that the New Zealand government budget balance has evidently tended to be relatively volatile compared to many other OECD countries (Tam and Kirkham, 2001).

The purpose of this paper is to develop an alternative procedure for estimating an \textit{ex ante} budget balance consistent with a given budget rule. Our approach is to use a structural vector autoregression (SVAR) model to evaluate the probability

\footnote{Specifically, the principles of responsible fiscal management set out in the FRA include: “Reducing total Crown debt to prudent levels .... by achieving operating surpluses every year until prudent levels of debt have been achieved,” and “Maintaining total Crown debt at prudent levels by ensuring that, on average, over a reasonable period of time, total operating expenses do not exceed operating revenues.” (New Zealand Government, 1994).}

\footnote{However, the FRA requires a government to publish its long-term objectives for total Crown debt and the operating balance. This is done in the \textit{Budget 2002 Economic and Fiscal Update} (Minister of Finance, 2002). The FRA also requires a government to illustrate likely progress towards the objectives, as in the \textit{Budget 2002 Fiscal Strategy Report} (Minister of Finance, 2002).}
and impact of different types of shocks to New Zealand government's cash budget balance. By examining the magnitude of past shocks, and their effect on the cash budget balance, the model is used to estimate the level of the ex ante cash budget surplus necessary to achieve a specified cash budget surplus at some future time horizon with a given level of probability. Alternative time horizons are considered because, as the future time horizon is extended, the probability of adverse disturbances to the cash budget balance increases and their propagation effects become more pronounced. Therefore, for a desired probability of continuously avoiding breaching a particular floor (or minimum value) for the cash budget surplus, the appropriate ex ante cash budget surplus increases as the time horizon for that target is extended.

This paper therefore augments existing models by explicitly modelling the interaction between a set of economic variables and the cash budget balance. In addition, this paper presents a different approach to the "risks and scenarios" approach that the New Zealand Treasury undertakes with its set of forecasts. Rather than predicting the behaviour of the cash budget balance under specific, alternative shocks to the economy, we focus on the level of the cash budget balance sufficient to withstand a number of possible shocks and still remain within surplus. In effect, this necessitates forming a judgement on the size and frequency of each particular shock to the economy and their impact on the budget balance.

In order to make this judgement, the approach of this paper is to undertake stochastic simulations based on the SVAR equations that capture the dynamic response of the government's cash budget balance to historical structural disturbances. From this SVAR model, we can derive probabilities of breaching particular cash budget balance targets over alternative horizons. The simulation procedure used to derive these probabilities follows the method proposed by Dalsgaard and de Serres (1999). This paper extends their work by specifying a theoretical macroeconomic model and budget balance function to underpin the SVAR model and to make explicit the theoretical explanations for the structural restrictions imposed on the model.

The first stage of this paper involves specification of a theoretical macro model that explicitly incorporates the government's budget balance and its interactions with the rest of the economy. This is presented in section 2 which provides a theoretical basis for identifying the expected short-run and long-run effects of exogenous shocks to the budget balance and other endogenous variables in the model.

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3 The terms “cash budget balance” and “budget balance” are used interchangeably in the text. We use the term “cash budget balance” to refer to the Crown's net cash flow from operations, or cash flow generated from its day to day (or operating) activities. The cash budget balance differs from the “operating balance” reported in the Crown's accounts, in that the operating balance is not measured on a cash basis, but is measured on an accrual basis. See Buckle, Kim and Tam (2001) for further details.

4 For example, see chapter 4 of the Budget 2002 Economic and Fiscal Update (Minister of Finance, 2002).
The second stage, presented in sections 3 and 4, involves estimation of a structural VAR model to determine the effects of exogenous shocks on the cash budget balance and other endogenous variables. We consider four types of shocks: supply, fiscal, real private demand and domestic nominal price shocks. The third stage presented in section 5 involves stochastic simulations of the estimated SVAR equations to build up probabilities of breaching a particular cash budget balance floor over a range of alternative future time horizons. Section 6 provides concluding comments and suggestions for further development.

2. A "sticky-price" macroeconomic model and the budget balance

Our interpretation of the type of disturbances that impinge on the budget balance and whether these disturbances have transitory or permanent effects is based on a traditional sticky-price model of macroeconomic fluctuations. The model is a variant of Fischer's (1977) sticky-price macroeconomic model. Modifications introduced to that model are the specification of a government budget balance function, a private sector demand function, and the explicit treatment of fiscal shocks in the aggregate and private sector demand functions.

The model is specified as follows:

\[ Y_t = -a_1 r_t + a_2 \theta_t + a_3 \delta_t - a_4 \gamma_t; \quad a_1, a_2, a_3, a_4 > 0 \]  
\[ F_t = b_1 Y_t - b_2 r_t + b_3 \gamma_t; \quad b_1, b_2, b_3 > 0 \]  
\[ D_t = d_1 Y_t - d_2 r_t + d_3 \gamma_t; \quad d_1, d_2, d_3 > 0 \]  
\[ M_t - P_t = c_1 Y_t - c_2 r_t; \quad c_1, c_2 > 0 \]  
\[ \bar{Y}_t = \bar{N} + \theta_t \]  

where

\[ r_t = r_{t-1} + e_t^r \]  
\[ \delta_t = \delta_{t-1} + e_t^\delta \]  
\[ \theta_t = \theta_{t-1} + e_t^\theta \]  
\[ M_t = M_{t-1} + e_t^M \]  

The variables \( Y, F, \) and \( D \) denote the logs of realised real output, the government's real budget balance and real private sector demand, respectively. The natural rate of employment is denoted by \( \bar{N} \), \( \theta \) denotes the log of productivity, \( P \) and \( M \) represent the logs of the price level and the money supply respectively, and \( r \) is the real interest rate.
Equation (1) is a reduced form IS function that recognises that real aggregate demand is determined by the real interest rate and exogenous shocks to total private demand and to fiscal policy.

Equation (2) states that the real budget balance comprises four components: a component determined by real income, a real interest rate component, and two exogenous shock components. The parameter $b_1 > 0$ in equation (2) captures the net effect of real output on the budget balance arising from the interaction of output and taxation, transfer payments and government expenditure. The parameter $b_2 > 0$ captures the effect of real interest rates, arising from the need to service public debt. The two exogenous shocks to the real budget balance arise from shocks to private demand ($\delta$) and fiscal shocks ($\gamma$), which are assumed to follow a random walk process.

The inclusion of $b_3 \delta_t$ in the real budget function captures this 'discretionary' stabilisation role of fiscal policy in response to shocks to private demand, in contrast to the 'automatic' role captured by $b_1 Y_t$. The reason for this is as follows. Private demand shocks will tend to cause real private demand to deviate from the natural rate of output and hence either accentuate inflationary pressures or accentuate the size of the output gap. Accordingly, we allow for the possibility of an offsetting (or stabilisation) response by the fiscal authority.

The coefficient $b_2 > 0$ in equation (2) captures this fiscal policy reaction. It implies that, in the presence of a positive real private demand shock, a government will react by increasing the fiscal surplus, thereby moderating the rise in aggregate demand as a consequence of the real private demand shock. Similarly, a negative private demand shock, which will have the potential to increase the output gap and unemployment, is assumed to provoke the converse reaction by a government. In this case, a government will reduce the fiscal surplus with the aim of moderating the decline in real aggregate demand relative to the natural rate of output.

Equation (3) states that aggregate real private demand is a function of realised real income ($Y$), the real interest rate ($r$), productivity and exogenous changes in real private demand ($\delta$). Productivity is allowed to affect aggregate private demand directly. This could occur through investment demand for example, in which case $d_3 > 0$.

Equation (4) is the demand for real money balances. $M$ is assumed to follow a random walk process.

Equation (5) is the production function; it relates output, employment, and productivity. $\bar{Y}$ can be interpreted as the natural rate of output which is the rate of output that is realised when employment is at the natural rate, given the level of productivity, $\bar{\theta}$, which is assumed to follow a random walk process.
The variables $\varepsilon^f, \varepsilon^d, \varepsilon^r, \varepsilon^n$ are serially uncorrelated and orthogonal fiscal, private demand, supply (or productivity) and nominal disturbances, respectively.

This model can be reduced to a four equation system by using equation (4) to derive an expression for the real interest rate ($r$) and eliminating it from equations (2) and (3). The result is a four-equation system for $Y_t, F_t, D_t$ and $\bar{Y}_t$, where the new coefficients ($y_t, f_t$ and $z_t$) are complex functions of the original coefficients ($a_i, b_i, c_i$, and $d_i$):

$$Y_t = y_1 (M_t - P_t) + y_2 \theta_t + y_3 \delta_t - y_4 Y_t$$

(10)

$$F_t = f_1 Y_t + f_2 (M_t - P_t) + f_3 \delta_t + \gamma_t$$

(11)

$$D_t = z_1 Y_t + z_2 (M_t - P_t) + z_3 \theta_t + \delta_t$$

(12)

$$\bar{Y}_t = \bar{N} + \theta_t$$

(13)

The model assumes that monopolistic firms set prices for period $t$ at the end of period $t-1$ at a level that is expected to make the quantity demanded equal the to natural rate of output, ie. to achieve $E_{t-1}(Y_t - \bar{Y}_t) = 0$. This is used to solve for $Y_t, F_t, D_t$ and $P_t$. The solutions for these endogenous variables imply the following growth paths for real output, the real budget balance, real aggregate private demand and prices:

$$\Delta Y_t = e_{t-1}^s + y_2 (e_t^s - e_{t-1}^s) - y_4 (e_t^f - e_{t-1}^f) + y_3 (e_t^d - e_{t-1}^d) + y_1 (e_t^n - e_{t-1}^n)$$

(14)

$$\Delta F_t = \left[ f_1 - f_2 (y_2 - 1) \right] e_{t-1}^s + f_1 y_2 (e_t^s - e_{t-1}^s) + e_t^f + f_3 (e_t^d - e_{t-1}^d) + f_2 (e_t^n - e_{t-1}^n)$$

(15)

$$\Delta D_t = z_3 e_t^s + \left[ z_1 + \frac{z_2 (y_2 - 1)}{y_1} \right] e_{t-1}^s + z_2 y_2 (e_t^s - e_{t-1}^s) + z_1 y_4 (e_t^f - e_{t-1}^f) + z_2 y_3 (e_t^d - e_{t-1}^d) + (z_1 \gamma_t + z_2 \delta_t) (e_t^n - e_{t-1}^n)$$

(16)
In this form, the model implies five long-run restrictions: three in equation (14) and one in each of equations (15) and (16). The presence of nominal price rigidities in the short run means the model predicts that positive real private demand disturbances ($\epsilon^d$) and nominal disturbances ($\epsilon^n$) will raise real output in the short run, but these effects disappear in the long run. Similarly, positive fiscal shocks ($\epsilon^f$) will lower real output in the short run, but the effect disappears in the long run. In the long run, only supply (that is, productivity) disturbances ($\epsilon^s$) affect output.

However, the long-run effect of real private demand shocks on the real budget balance in equation (15) is ambiguous. It will depend on whether $f_3 - f_2 y_4$ is less than or greater than zero. $f_3$ is the direct effect of private demand shocks on the real budget balance (government’s offsetting reaction to private demand shocks). $f_2 y_4$ is the indirect effect of private demand shocks on the budget balance arising from consequential changes in real money balances and hence the real interest rate.

It is not clear which of these two influences dominate. Moreover, it is unrealistic to allow the real budget balance to change permanently in response to real private demand shocks. Therefore we will assume the total long-run effect is zero. Accordingly, this leaves us with six long-run restrictions that are imposed on the SVAR model specified in section 3.

The short-run and long-run response of real output, the fiscal balance, real private demand and inflation to the four disturbances implied by this theoretical dynamic model are summarised in Table 1.

The model predicts that in the short run the budget balance will rise in response to positive supply, real private demand and nominal shocks. The short-run response to fiscal shocks is unclear because there are offsetting forces arising from the direct impact on the budget balance of a fiscal shock and the induced fall in real output that lowers net taxation revenue. It seems likely however that $f_1 y_4 < 1$, in which case a positive fiscal shock will raise the budget balance in the short run. In the long run, supply and fiscal shocks permanently affect the budget balance while real private demand and nominal shocks are neutral.

Positive supply, real private demand and nominal shocks raise real private demand in the short run. The impact of positive fiscal shocks on real private demand is negative. This occurs because a positive fiscal shock lowers real aggregate demand and realised output, which in turn reduces real private demand.
Table 1: Theoretical Impulse Responses

| Response of output level | 0 | 1 | ... | ∞ |
|-------------------------|---|---|-----|---|
| $\varepsilon^s$         | + | + | ... | + |
| $\varepsilon^f$         | - | 0 | ... | 0 |
| $\varepsilon^d$         | + | 0 | ... | 0 |
| $\varepsilon^n$         | + | 0 | ... | 0 |

| Response of real budget balance | 0 | 1 | ... | ∞ |
|---------------------------------|---|---|-----|---|
| $\varepsilon^t$                | + | ? | ... | ? |
| $\varepsilon^f$                | ? | + | ... | + |
| $\varepsilon^d$                | + | 0 | ... | 0 |
| $\varepsilon^n$                | + | 0 | ... | 0 |

| Response of real private demand | 0 | 1 | ... | ∞ |
|---------------------------------|---|---|-----|---|
| $\varepsilon^t$                | + | ? | ... | ? |
| $\varepsilon^f$                | - | + | ... | + |
| $\varepsilon^d$                | + | ? | ... | ? |
| $\varepsilon^n$                | + | 0 | ... | 0 |

| Response of inflation rate     | 0 | 1 | ... | ∞ |
|---------------------------------|---|---|-----|---|
| $\varepsilon^t$                | 0 | ? | ... | ? |
| $\varepsilon^f$                | 0 | - | ... | - |
| $\varepsilon^d$                | 0 | + | ... | + |
| $\varepsilon^n$                | 0 | + | ... | + |

$+$ = rise; $-$ = fall in the level of the endogenous variable in response to a positive shock.
In the long run, the response of real private demand to positive supply shocks and real demand shocks is ambiguous, because there is a positive impact of these shocks on private demand, but there is also a possible negative effect arising from a fall in real money balances and a rise in the real interest rate. The long-run effect of positive fiscal shocks is positive via the “crowding in” effect of a fall in real interest rates. The long-run impact of nominal shocks on real private demand is neutral, even though these are random walk shocks, i.e., permanent shocks. The reason for this is that the price level changes, so that real money balances are unchanged in the long run.

The model therefore incorporates a dichotomy between the long-run effects of demand and supply shocks. While this is common practice, there are many reasons to think that demand and fiscal disturbances could have long-run effects on output. These include the presence of increasing returns, of learning by doing, and the possibility that fiscal policy may affect the savings rate, and subsequently the long-run capital stock.

Despite these possibilities, it is common practice to assume these long-run effects are small compared to those of supply disturbances. Thus, distinguishing between the long-run effects of real demand, nominal and fiscal shocks and the long-run effects of supply shocks has important implications for their related long-run effects on real private demand, inflation and the budget balance.

3. Specification of the structural VAR model

In this section, we construct and estimate a four variable structural VAR model in order to decompose fluctuations in the government budget balance into the four structural (or economic) disturbances identified in the model described in section 2, i.e., $\varepsilon^s$, $\varepsilon^f$, $\varepsilon^d$, and $\varepsilon^n$.

The model can be represented by a $4 \times 1$ vector of endogenous variables $\Delta Z$ (comprising $\Delta Y$, $\Delta F$, $\Delta D$, and $\Delta P$) with the moving average representation given by

$$\Delta Z_t = A(L)\varepsilon_t, \quad (18)$$

where $A(L) = \sum_{i=0}^{\infty} A_i L^i = A_0 + A_1 L + A_2 L^2 + \ldots$ is a $4 \times 4$ matrix of polynomials in the lag operator $L$ and $\varepsilon_t$ is a $4 \times 1$ vector of white noise disturbance terms $\varepsilon^s$, $\varepsilon^f$, $\varepsilon^d$, and $\varepsilon^n$. We assume that $A_0$ has 1’s along its diagonal and that $\varepsilon_t \sim (0, \Sigma_\varepsilon)$ and $\Sigma_\varepsilon$ is diagonal (that is, the structural shocks are mutually orthogonal). The variables in $\Delta Z$ are all stationary. (If any of the variables are non-stationary, it should be further differenced to make it stationary provided the variables are not
The $E_t$'s are structural disturbances, and we are interested in estimating the response of elements of $Z$ to innovations in the elements of $e$. For example, we are interested in the response of the budget balance to four different structural disturbances. A plot of the row $i$, column $j$ element of $A_s$ as a function of $s$ is called the impulse response function. It describes the response of $\Delta Z_{it+s}$ to a one-time one-unit impulse in $e_{jt}$.

It is convenient to define the matrix $H$ such that $HH' = \Sigma_e$; the diagonal elements of $H$ are the standard errors of the elements of $e$. Then equation (18) can be rewritten as

$$\Delta Z_t = A(L)e_t = A(L)HH^{-1}e_t = \widetilde{A}(L)\tilde{e}_t,$$

where $\widetilde{A}(L) = A(L)H$, and $\tilde{e}_t = H^{-1}e_t$ is the vector of structural shocks measured in one standard deviation units. Note that

$$E\tilde{e}_t\tilde{e}_t' = (H^{-1})(Ee_te_t')(H^{-1})' = H^{-1}HH'(H^{-1})' = 1.$$

The $ij$-th element of $\widetilde{A}_s$ represents the response of $\Delta Z_{it+s}$ to a one-time one standard deviation impulse in $e_{jt}$.

One way to summarise the information contained in our $\Delta Z$ data is to estimate the VAR representation of appropriate order $k$:

$$b(L)\Delta Z_t = u_t, \text{ where } b(L) = I - B_1L - B_2L^2 - \ldots - B_kL^k.$$

Since $\Delta Z$ is stationary, the roots of $b(L)$ are all greater than 1. Therefore the VAR representation can be inverted into $\Delta Z_t = C(L)u_t$, where $C(L) = B(L)^{-1}$ and $c(0) = I$. In terms of (13), $C(L) = A(L)A(0)^{-1}$ and $u_t = A(0)e_t$. Thus in order to recover estimates of the structural disturbances, $E_t$, from the estimated VAR residuals, $u_t$, it is necessary to estimate $A(0)$.

The covariance matrix of the VAR residuals, $\Sigma_u$, is related to $A(0)$ and $\Sigma_e$ by

$$\Sigma_u = A(0)\Sigma_e A(0)' = A(0)HH'A(0)'.$$

Since $\Sigma_u$ is symmetrical, equation (21) provides $n(n + 1)/2$ restrictions, where $n$ is equal to four. But we have to estimate $n^2$ elements in $A(0)$ and $H$. Therefore, $n^2 - n(n + 1)/2 = n(n - 1)/2$ additional restrictions are necessary for complete
identification. For the four variable system we consider, six additional restrictions are required.

Such identifying restrictions have taken a variety of forms in the literature. One approach achieves identification by imposing a priori restrictions on the contemporaneous interactions among the variables in the system. These restrictions take the form of exclusion restrictions i.e., zero restrictions on some of the elements of \( A(0) \). These include the recursive structure popularised by Sims (1986) and the simultaneous equations approach by Bernanke (1986), Blanchard and Watson (1986), and Blanchard (1989).

An alternative approach to identification relies on restrictions on long-run effects implied by an underlying theoretical model. As shown by Blanchard and Quah (1989), this can be translated into a restriction on the dynamic system that may aid in the identification of model parameters.

The lag polynomial \( C(L) \) that is obtained by inverting the VAR representation is defined by

\[
C(L)A(0) = A(L).
\]

(22)

Assume that economic theory implies that certain structural disturbances have no long-run impact on some elements of \( Z \). This imposes zero restrictions on the elements of \( A(1) \). In this case, the restrictions imposed by

\[
C(1)A(0) = A(1)
\]

(23)

together with restrictions implied by (21) may allow \( A(0) \) to be estimated. This is the approach taken by Blanchard and Quah (1989). Examples of the application of long-run identifying restrictions to estimate SVAR models for the New Zealand macroeconomy are Conway (1998), Fisher (1996) and Fisher, Fackler and Orden (1995). Some studies like Gali (1992) apply combinations of contemporaneous and long-run restrictions by imposing zero restrictions on some of the elements of both \( A(0) \) and \( A(1) \).

In this paper, only long-run restrictions are imposed. This allows the data to determine the short-run dynamics. The theoretical model developed in Section 2 suggests it may be appropriate to impose restrictions on the contemporaneous reaction of prices to structural disturbances. However, the model is estimated using annual data and, although goods prices would be expected to display inertia, according to recent research the duration of prices is typically significantly less than one year. Buckle and Carlson (1995) estimate the average duration of prices set by NZ manufacturing, building, merchant and service firms was approximately 4.7 months during the high inflation in the 1970s and 1980s and was approximately 8.5 months during the 1990s when inflation was much lower.

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5 If \( A(L) = A_0 + A_1L + A_2L^2 + \cdots \), then \( A(1) = A_0 + A_1 + A_2 + \cdots \) equals the sum of the lag coefficients.
The long-run restrictions are as follows. Three restrictions arise because fiscal, real private demand, and nominal shocks do not have permanent effects on real output, but supply shocks can have a permanent effect. Two further restrictions are that real private demand shocks and nominal shocks do not have long-run effects on the government budget balance. The sixth restriction is that nominal shocks have a permanent effect on the aggregate price level but do not have a permanent effect on any other variable in the system. These long-run restrictions imply that

\[
a_{12}(L) = a_{13}(L) = a_{14}(L) = a_{23}(L) = a_{24}(L) = a_{34}(L) = 0,
\]

where \( a_{ij}(L) \) is the \( ij \)-th element of \( A(L) \). This provides us with six restrictions, which is just enough to identify the model. Thus \( A(L) \) has the form:

\[
\begin{bmatrix}
a_{11}(L) & 0 & 0 & 0 \\
a_{21}(L) & a_{22}(L) & 0 & 0 \\
a_{31}(L) & a_{32}(L) & a_{33}(L) & 0 \\
a_{41}(L) & a_{42}(L) & a_{43}(L) & a_{44}(L)
\end{bmatrix},
\]

which is lower triangular. Noting that \( C(1)u_t = A(L)\varepsilon_t \), where \( C(L) \) is the matrix of estimated long-run multipliers from the VAR,

\[
C(1)\Sigma_u C(l)' = A(l)\Sigma_e A(l)' = A(l)HH'A(l)'.
\]

Since \( C(l) \) and \( \Sigma_u \) are available from the estimation of a standard VAR representation, the estimate of the lower triangular matrix \( \tilde{A}(L) = A(L)H \) can be obtained as the Cholesky factor of \( C(l)\Sigma_u C(l)' \). Once \( \tilde{A}(L) \) is estimated, the estimate of \( \tilde{A}(0) = A(0)H \) is obtained from equation (18) as \( C(l)^{-1}\tilde{A}(L) \). Since the diagonal elements of \( A(0) \) equal 1, we can recover estimates of \( A(0) \) and \( \Sigma \) from an estimate of \( \tilde{A}(0) \).

4. Data, model estimation and impulse responses

To estimate the SVAR system, data were required for the four endogenous variables: real output, the real government budget balance, real private demand, and the general price level. The annual data used to estimate the model included:

\( Y: \) Log of real GDP;
F: Central Government's net cash flows from operations as a ratio to nominal GDP;
D: Log of the sum of real private consumption and real private investment;
P: GDP deflator.

The longest sample period available was 1971 – 1999. A full description of the data is available in the Appendices to Buckle, Kim and Tam (2001). These data were compiled from various New Zealand Treasury and Statistics New Zealand data sources and from series available in Dalziel and Lattimore (1999). Y, D and P are available on a March year basis throughout the sample period whereas F is only available on a March year basis until 1989, thereafter it is measured on a June year basis. An in-built lag between F and the other three endogenous variables will therefore already partially exist. This should be taken into consideration when interpreting the impulse responses. Whether these four variables are able to successfully capture the four disturbances can be evaluated by examining the impulse responses.

Unit roots and co-integration

In order for the methodology described in Section 3 to be valid, all the variables included in the SVAR system should be stationary. If a variable is non-stationary, it should be differenced until it becomes stationary. For real output, the real budget balance and real private demand in level form, and for the first difference of the GDP deflator, the Augmented Dickey-Fuller (ADF) unit root test fails to reject the null hypothesis of a unit root. In each case, however, first differencing of the real variables and second differencing of the GDP deflator induces stationarity. The ADF statistics (where lag lengths were chosen by the Bayesian Information Criterion) are respectively -2.96, -4.92, -3.27, -5.26 where the 5 percent and 1 percent critical values are -2.89 and -3.51 respectively.

While the unit root test suggests that the variables are non-stationary in level form when considered individually, it is possible that these variables share a common non-stationary trend. In this case, a stationary linear combination of the variables may be found, and the variables are said to be co-integrated. When variables are co-integrated, estimating a SVAR model where the series are expressed in first differences would be inappropriate. One reason is that first-

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6 As we define our real budget balance variable to be the nominal net cash flow from operations as a ratio to nominal GDP, hereafter the term "real budget balance" will refer to the ratio specified above.

7 The data set runs from 1971 to 1999 and covers a period in which there may have been structural changes to the New Zealand economy. If so, there may be an argument to use Perron's test for unit roots in the presence of structural change. However, the small sample size, means it is not feasible to adopt this approach.
differencing would remove important information about the behaviour of the variables contained in the common trend.

We checked for the possibility that the four-variable system might be co-integrated. Vector co-integrating regressions do not indicate stationary residuals using the ADF test suggested by Engle and Granger (1987). In particular, the ADF statistics from the levels regression normalised to either real GDP, the real budget balance, private real demand, or the inflation rate are –2.40, –2.81, –2.42, –2.71 respectively, where the 5 percent critical value is –4.22.

Based on these findings, we estimate the SVAR model in first differences.

Lag Order

Lag order determination constitutes a well-known problem when it comes to implementing a SVAR model. Typically the issue is handled by performing likelihood ratio tests. However, we have an extremely small sample size. The likelihood ratio test is based on asymptotic theory, which may not be useful for the small sample size of this study. Instead, we used multivariate generalisations of the Akaike Information Criterion (AIC) and Hannan Quinn Information Criterion (HQ).

Both criteria select a model that includes 3 lags in the VAR, with a time trend. However, a time trend is difficult to justify theoretically. When the time trend is excluded, the AIC suggests a model with 3 lags while the HQ suggests a model with 2 lags. The AIC for 2 lags is 6.7278 and for 3 lags 6.7225. The HQ for 2 lags is 7.1966 and for 3 lags 7.3996. We therefore estimated the model and generate impulse responses and stochastic simulations based on a 3rd order SVAR model.

Impulse Responses

Impulse responses from the VAR estimation are presented in Figure 1. Since no restrictions other than the six long-run identifying restrictions are imposed on the effects of the shocks, it is possible to check whether the identified shocks behave in a way which is consistent with the implications of the theory discussed in Section 2. The confidence bands around the impulse responses are typically wide.

Although this is not an unusual result, we nevertheless need to be cautious in the interpretation of these results.

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8 The Johansen (1988) method is another way by which the possibility of co-integration can be checked. However, that procedure is based on the maximum likelihood method, which may not be reliable in view of the short sample period over which the model in this paper is estimated.

9 80% confidence bands were calculated using a bootstrapping technique. In general these bands are quite wide and in two cases the impulse responses fall outside the bands. We think these results are likely to be due to the small sample size which reflects the limited availability of suitable data.
The real budget balance responds to the four disturbances in the estimated model in a manner consistent with our theoretical model, with the exception of the immediate reaction to a nominal shock. A positive supply shock raises the budget balance in the short run and in the long run. The short-run reaction of the fiscal balance to supply shocks could in fact be consistent with the theoretical model. Note that, since the rise in GDP is greater than the rise in the budget balance, the real budget balance (which is the ratio of the budget balance to GDP) falls in the short run and in the long run, as Figure 1 illustrates.

Turning to the other components of our model, the reactions of real output, real private demand and inflation are for the most part consistent with our theoretical model. Real output responds positively in the short run to positive supply, real private demand and nominal shocks. The positive supply shocks generate the expected positive long-run effects on real output and the impact of real private demand and nominal shocks on real output disappear in the long run. Similarly, the impact of fiscal shocks on real output disappear in the long run. In the short run however, positive fiscal shocks raise real output, which is not a result anticipated by our theoretical model.

Real private demand rises in the short run and in the long run in response to positive supply and positive real private demand shocks. The short-run reactions are consistent with the theoretical model. The long-run reactions are also consistent since the signs for the theoretical model are ambiguous. The long-run reaction of real private demand to nominal shocks is neutral which is also consistent with the theoretical model. The immediate response of real private demand in response to a positive fiscal shock is positive, which is not predicted by the theoretical model. The long-run effects, although small, are positive which is consistent with the theoretical model.

The long-run reactions of inflation to positive supply, fiscal and nominal shocks are consistent with our theoretical model results. According to our theoretical model, the long-run reaction of inflation to a positive productivity shock depends on two opposing forces. Productivity has an ambiguous effect on inflation because it can induce a change in real output and a change in real demand. The rise in demand could be direct (via the reaction of investment to the rise in productivity) and indirect as a result of the rise in real output inducing further increases in real private demand. Figure 1 shows that in the short run, inflation falls in response to a positive supply shock (implying the supply effect dominates in the short run) but rises in the long run (implying the direct and induced demand effects dominate in the long run). The long run effects of private demand shocks are slightly negative which is not a result we expected.

Our theoretical model also implies that, due to prices being set one period ahead, there will be no immediate reaction of actual prices to any of the former disturbances. The SVAR impulse responses show however an immediate change of inflation in response to all four shocks. There are at least two possible reasons for this result. First, the data are likely be capturing the fact that not all prices are necessarily rigid in the short run. Second, as explained in Section 3, even if most
prices are sticky in the short run the average duration of prices for many types of output in New Zealand is significantly shorter than one year (which is the frequency of the data used to estimate the SVAR model). Accordingly, impulse responses based on annual data could be expected to reveal significant price reactions even if many prices are pre-set.

**Forecast Error Variance Decomposition**

The relative importance of the contribution of the four shocks to the variance of each endogenous variable can be deduced by decomposing the forecast error variance. Table 2 provides this information. In the short run, supply shocks account for most of the variance of real GDP. Fiscal shocks account for about 13 percent. Because of the long-run identifying restriction, the relative importance of fiscal shocks declines as the forecasting horizon increases. Supply shocks contribute about two-thirds of the variance of real private demand in the short run and long
Figure 1: Impulse Response Functions New Zealand, Annual, 1976 to 1999

Response of output level to:

Supply shock

Real private demand shock

Fiscal shock

Nominal shock

Response of fiscal balance to:

Supply shock

Real private demand shock

Fiscal shock

Nominal shock
Figure 1 cont.: Impulse Response Functions New Zealand, Annual, 1976 to 1999

Response of real private demand to:

- Supply shock
- Real private demand shock
- Fiscal shock
- Nominal shock

Response of fiscal balance to:

- Supply shock
- Real private demand shock
- Fiscal shock
- Nominal shock
Table 2: Forecast Error Variance Decomposition

**Decomposition of Variance for Real GDP**

| Forecasting Horizon | Supply Shock | Fiscal Shock | Real Private Demand Shock | Nominal Shock |
|---------------------|--------------|--------------|---------------------------|---------------|
| 1                   | 83.64        | 12.92        | 0.58                      | 2.85          |
| 2                   | 85.77        | 8.75         | 3.46                      | 2.02          |
| 3                   | 83.08        | 12.47        | 3.21                      | 1.24          |
| 4                   | 84.75        | 11.73        | 2.68                      | 0.85          |
| 8                   | 89.53        | 7.73         | 2.13                      | 0.61          |
| 16                  | 94.12        | 4.31         | 1.23                      | 0.35          |

**Decomposition of Variance for Real Budget Balance**

| Forecasting Horizon | Supply Shock | Fiscal Shock | Real Private Demand Shock | Nominal Shock |
|---------------------|--------------|--------------|---------------------------|---------------|
| 1                   | 0.43         | 95.27        | 1.55                      | 2.75          |
| 2                   | 0.75         | 94.40        | 1.45                      | 3.39          |
| 3                   | 1.54         | 95.08        | 1.11                      | 2.27          |
| 4                   | 1.49         | 95.62        | 0.86                      | 2.03          |
| 8                   | 1.34         | 95.88        | 1.17                      | 1.61          |
| 16                  | 0.73         | 97.59        | 0.73                      | 0.94          |

**Decomposition of Variance for Real Private Demand**

| Forecasting Horizon | Supply Shock | Fiscal Shock | Real Private Demand Shock | Nominal Shock |
|---------------------|--------------|--------------|---------------------------|---------------|
| 1                   | 64.16        | 14.37        | 21.38                     | 0.09          |
| 2                   | 60.26        | 14.82        | 24.70                     | 0.22          |
| 3                   | 51.88        | 22.90        | 24.58                     | 0.64          |
| 4                   | 49.97        | 27.19        | 22.32                     | 0.52          |
| 8                   | 62.54        | 21.08        | 15.86                     | 0.53          |
| 16                  | 68.98        | 16.26        | 14.44                     | 0.32          |

**Decomposition of Variance for Inflation Rate**

| Forecasting Horizon | Supply Shock | Fiscal Shock | Real Private Demand Shock | Nominal Shock |
|---------------------|--------------|--------------|---------------------------|---------------|
| 1                   | 6.78         | 3.60         | 1.06                      | 88.56         |
| 2                   | 4.62         | 2.26         | 0.65                      | 92.48         |
| 3                   | 8.68         | 2.01         | 1.41                      | 87.90         |
| 4                   | 15.59        | 3.16         | 1.20                      | 80.05         |
| 8                   | 15.20        | 8.91         | 1.39                      | 74.51         |
| 16                  | 15.63        | 11.36        | 0.95                      | 72.05         |
run. Fiscal and real demand shocks explain the remaining third. The variance of inflation is dominated by nominal shocks in the short run and the long run, although the importance of supply and fiscal shocks increase in the long run. Fiscal shocks are the dominant contribution to the variance of the budget balance in the short run and the long run.

5. Stochastic simulations and implied budget targets

The SVAR model captures most of the key properties of the theoretical macro model. The next stage is to use the model to generate stochastic simulations to assess the risk of breaching an ex post real budget balance target over different time horizons. Each stochastic simulation generates a hypothetical path for the four variables of the model. These hypothetical paths are functions of two determinants: structural disturbances to the economy and the propagation mechanism of the economy.

The process of using the SVAR analysis of historical data to specify those determinants and generate these simulated paths is similar to the procedure used by Dalsgaard and de Serres (1999). This process involves the following steps:

1. Assuming that the structural shocks to the economy are distributed as $N(0, \Sigma_e)$. That is, structural shocks are mutually independent and are normally distributed. The estimate of $\Sigma_e$ is obtained from the SVAR estimation explained in section 3;
2. Replacing the third diagonal element of $\Sigma_e$ with zero in the first simulation so that the variance of the fiscal shock is identically equal to zero. This is to exclude autonomous changes in the real budget balance and to capture the pure effects from induced changes to the real budget balance. These results are shown in Figure 2;
3. Incorporating autonomous changes in the real budget balance in the second simulation by including the impact of fiscal shocks. These results are shown in Figure 3;
4. Assuming that the propagation mechanism of the economy is captured by the estimate of $A(L)$ obtained from the SVAR estimation.
Figure 2: Ex Ante Budget Targets: with fiscal shocks excluded
New Zealand, Annual, 1976 to 1999

Figure 3: Ex Ante Budget Targets: with fiscal shocks included
New Zealand, Annual, 1976 to 1999
Once the distribution of fundamental shocks and the propagation mechanism of the economy are specified, the stochastic simulation is done through the following steps:

1. Values of simulated structural shocks are drawn randomly, at each time period, from their distribution.
2. The simulated time series of structural shocks, together with the assumed initial values of the variables, are fed into the non-deterministic part of the estimated SVAR system. This generates hypothetical time paths for the four variables. The initial values for all variables are taken to be zero because the procedure simulates the non-deterministic components of the model i.e., the stochastic components which have a mean value of zero.\(^\text{10}\)
3. Large numbers (in this case we used 1000) of simulated data sets are generated by repeating steps 1 and 2.
4. For each simulated path of the real budget balance, find the minimum value during a particular time horizon considered.
5. These minimum values are ranked in ascending order to form a distribution for each time horizon.
6. Percentiles calculated from this distribution are used to assign a confidence level that the minimum real budget balance will be reached during that time horizon. For example, the 10th percentile in the distribution can be interpreted as the minimum real budget balance that may be reached with a 90 per cent confidence level.
7. For each confidence interval, if the relevant percentile breaches the specified lower bound by say \( x \)%, the initial value of the real budget balance is adjusted upward by \( x \)% This adjusted initial value of the real budget balance is the \( \text{ex ante} \) real budget surplus required for not breaching the specified lower bound at a given confidence interval during the time horizon considered.
8. Steps 4, 5, 6, and 7 are repeated for various time horizons.

This procedure is equivalent to simulating the response of the non-deterministic or stochastic component of the fiscal balance. The reason is that the simulations show how various macroeconomic shocks are propagated into the stochastic component of the fiscal balance. Accordingly, the simulations show how the budget balance would fluctuate around its trend value in response to unexpected shocks. Therefore, the simulations provide a basis for determining the size of the buffer required in order to avoid unexpected shocks driving the budget balance below some specified lower bound.

The first simulations exclude autonomous changes in the real budget balance. This procedure assumes that while supply, private demand and nominal shocks are assumed to be independent of fiscal policy, fiscal shocks are at the discretion of Government. The results for different time horizons and levels of confidence are shown in Figure 2. They can be interpreted as follows. Suppose the fiscal target the

\(^{10}\) This means that the results are not dependent on the stage of the business cycle.
government wishes to achieve with 95 percent confidence is a lower bound of zero for the real budget balance. According to Figure 2, the average annual ex ante budget balance for New Zealand should therefore be set at a surplus of close to 1.0 percent of GDP if the fiscal planning horizon is one year. As the planning horizon is extended to two years the appropriate average annual ex ante surplus rises to approximately 1.1 percent of GDP, for three years it rises to 1.25 percent of GDP, and for a five-year horizon it increases to about 1.5 percent of GDP.\(^\text{11}\)

The appropriate ex ante budget surplus increases as the planning horizon increases because the probability of adverse shocks to the real budget balance increases and the propagation process becomes more pronounced as the planning horizon is extended outward. Similarly, as the desired probability of not breaching a lower bound for the budget balance is raised, the appropriate ex ante budget surplus is increased.

These results for New Zealand can be compared to results obtained by Dalsgaard and de Serres (1999) who used a similar procedure to estimate appropriate budget targets for several EU countries. The purpose of their exercise was to determine the budget balance target that would ensure, at a given probability, that the three percent deficit limit required by the Maastricht Treaty was not breached over a particular time horizon.

By appropriate scaling of the Dalsgaard and de Serres results we can deduce their implied ex ante budget surpluses required to ensure, for a given confidence level, that a zero lower bound for the budget balance is not breached. For example, the results estimated for the UK using bi-annual data for the period 1965 to 1996 and for a 95 percent confidence level are approximately: 2 percent for a one-year planning horizon; 3.5 percent for a three-year planning horizon; and 4 percent for a five-year horizon. Corresponding results for Germany (estimated using data from 1961 to 1997) are: 1.8 percent for a one-year planning horizon; 2 percent for a three-year planning horizon; and 2.5 percent for a five-year horizon. For Austria (estimated using data from 1966 to 1995): 1.5 percent for a one-year planning horizon; 2.2 percent for a three-year planning horizon; and 2.5 percent for a five-year horizon.

Our results for New Zealand can also be used to derive the probability that the net cash flows from operations forecast by New Zealand governments, such as in the Budget 2002 Economic and Fiscal Update (Minister of Finance, 2002), will not breach a zero floor. For example, the forecast for the net cash flow from operations for the year ended June 2003 is NZ$2,711 million or approximately 2.2 percent of forecast nominal GDP. From Figure 2, this forecast cash flow has a very high probability of not breaching a zero floor for the year to June 2003. The ex ante forecast for the net cash flow from operations for the year to June 2004 is

\[^{11}\text{The different time horizons are in reference to the duration of time under which the corresponding simulation is performed. For example, if the planning horizon is 2 years, an ex ante budget surplus of 1.1 percent of GDP means that the average annual balance should be 1.1 percent for the two-year period. It does not mean that the budget surplus must be maintained at 1.1 percent throughout the entire two-year period.}\]
NZ$3,097 million or approximately 2.4 percent of forecast GDP. This implies that the mean net cash flow from operations for the two years to June 2002 is approximately 2.3 percent of GDP [i.e., (2.2 + 2.4)/2]. Figure 2 that on the basis of the current budget forecasts for the two years to June 2004, there is a very high probability that the average annual net cash flow from operations will not be less than zero for the two-year period.

The second set of simulations incorporates fiscal shocks and therefore it includes autonomous changes in the real budget balance. The forecast error variance decomposition shown in Table 2 showed that the presence of fiscal shocks was the dominant explanation of the variance for the real budget balance. We can therefore expect the inclusion of fiscal shocks to have a significant influence on the ex ante budget balance targets compared to those derived in the first simulations, which excluded fiscal shocks. The results for different time horizons and levels of confidence are shown in Figure 3. They confirm our expectation.

Incorporating fiscal shocks generates substantially larger ex ante budget balance targets required to avoid a budget deficit for a given level of probability. For example, by including fiscal shocks, the ex ante budget balance required to avoid a budget deficit at 95 percent level of confidence over a one-year planning horizon, increases from a surplus of just under 1.0 percent of GDP to about 3.5 percent of GDP. For a two-year horizon, the ex ante surplus increases from approximately 1.1 percent of GDP to about 4.5 percent of GDP. For a five-year horizon it increases from 1.5 percent to about 6.5 percent of GDP.

The inclusion of a fiscal shock lowers the probability of not breaching a zero floor. Without fiscal shocks, Figure 2 implied there was a very high (close to 100 percent) probability of the net cash flow from operations for the year ended June 2003 not breaching a zero floor. With fiscal shocks included, Figure 3 implies that this probability falls to about 85 percent. Figure 2 also suggested that there was a very high (close to 100 percent) probability that the net cash flow from operations for the two years to June 2004 would not breach the zero floor. Figure 3 suggests this probability also falls to about 80 percent when fiscal shocks are included.

The acceptability of incorporating fiscal shocks will depend, as is assumed for the other shocks, on whether past unexplained fiscal changes are likely to be representative of the type of fiscal shocks that could occur in the future. The introduction of the Fiscal Responsibility Act 1994 may render that assumption inappropriate if it has significantly changed the way in which fiscal policy decisions are made.

6. Conclusions

This paper endeavours to tackle a practical fiscal management problem. If government wants to allow automatic fiscal stabilisers to operate unimpeded over some specified future time horizon (such as the length of a business cycle for example) without breaching some lower or upper bound for the fiscal balance (such as any bound implied by the Fiscal Responsibility Act for example), it needs
to set fiscal parameters and the *ex ante* budget balance to take into account the potential impact of possible future exogenous shocks to the budget balance. This paper develops a procedure for identifying the probability of future shocks to the budget balance, their impact on the budget balance, and the size of the *ex ante* budget balance that will satisfy that requirement.

The approach developed in this paper is to estimate a structural vector autoregressive (SVAR) model of components of the New Zealand economy and the fiscal balance to quantify the likelihood of different shocks to the economy, based on the last 30 years experience. Information from this model is used to assess the *ex ante* cash budget position that should be targeted, in order to absorb potential shocks without breaching a particular lower bound for the budget balance. The size of the *ex ante* budget cash position will depend on the fiscal planning horizon and on how certain the policy maker wishes to be that potential shocks will be able to be absorbed without breaching the specified lower bound. It will also obviously depend on the specified size of the lower (or upper) bound for the budget balance.

The degree of certainty is based on the frequency and magnitude of past supply, fiscal, real private demand and nominal shocks to the New Zealand economy, and the historical responses of macroeconomic variables to these shocks. There are several potential directions in which the work in this paper could be further developed that may improve the accuracy of identifying the probability of shocks, their impact on the budget balance, and the appropriate *ex ante* fiscal stance. A more explicit treatment of open economy features using for example the open economy SVAR model recently developed by Buckle, Kim, Kirkham, McLellan and Sharma (2002) would provide richer information and identification of domestic and international shocks to the budget balance.

Improvements on the fiscal side could be achieved by separation of the government expenditure and revenue components of the budget balance function in a manner undertaken for example by Blanchard and Perotti (2002), if suitable data can be constructed. In view of the importance of fiscal shocks in explaining the past variance of the budget balance and the likelihood of significant differences in the dynamic impact of government expenditure and revenue changes, this would seem to be a priority for future work on this topic. Inclusion of the stock-flow relationship between budget balances and public debt would also seem to be a worthwhile development, although that may require a different modelling approach to that used in this paper.

The Fiscal Responsibility Act 1994 specifies that operating surpluses must be run to reach a prudent level of debt, and then to maintain that prudent level of debt. Although this paper has primarily concentrated on the level of the *ex ante* budget balance necessary to ensure the *ex post* budget balance is not less than zero, the results can be applied to any lower or upper bound simply by appropriate scaling. This paper does not attempt to determine the appropriate lower bound for the budget balance. Nor does it attempt to determine the optimal level of public debt or public debt to GDP ratio. These are issues for further research. In an operational
sense, this paper assists the policy maker to specify the appropriate ex ante budget balance, once a desired lower bound for the ex post budget balance is derived and specified.

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