Solving Large Scale Models Under Alternative Policy Closures: The MSG2 Multi-Country Model

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1 Introduction

This paper explores a number of issues in the design and use of the MSG2 multi-country model for policy simulation analysis. A brief overview of the MSG2 model is presented in section 2.

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The use of large scale models with rational expectations such as the MSG2 model has required the development of new numerical algorithms. The solution algorithm that is used to solve the MSG2 model, as well as several other multi-country models including the G-Cubed model (see McKibbin and Wilcoxen (1995)), is summarized in section 3. In sections 4 and 5 the impact of alternative assumptions about fiscal and monetary closure rules are explored in more detail. In particular the standard assumptions used in the MSG2 model of a incremental interest payments rule for fiscal are compared to other assumptions frequently used in other global models such as a debt targeting rule and a fiscal conservatism rule. In addition rules for monetary policy such as a fixed stock of money rule, a nominal income rule and an inflation target are compared. Both sets of policy closure assumptions are compared focusing on Australia but the insights generalize across the other countries in the model. It is shown that these assumptions can have some important implications for both the long run and short run impacts of fiscal and monetary policy. A summary is presented in section 6.

2. An Overview of the MSG2 Multi-Country Model

Full documentation of the MSG2 model and an analysis of its properties and tracking performance can be found in McKibbin and Sachs (1991). The model has undergone a number of changes since that earlier version and information on the latest model can be found on the world wide web at http://WWW.MSGPL.COM.AU A summary of the key features of the model are presented in table 1 and the coverage of the model is listed in table 2. The version used in this paper is the "Asia model" version 42I (see McKibbin (1996)).

The MSG2 multi-country model is a fully specified dynamic intertemporal general equilibrium model (DIGEM) with careful treatment of stock-flow relations such as the cumulation of investment into capital stocks and the cumulation of fiscal deficits into net asset stocks. Both the short run demand and supply sides of the major economies are incorporated. In the long run, supply is determined by neoclassical growth theory. The model incorporates a number of financial markets such as share markets and markets for short and long bonds in each of the industrial regions where prices are determined by intertemporal arbitrage relations as well as long run sustainability conditions on fiscal deficits and current account positions. In addition, the assumption of rational expectations in these financial markets as well as some forward looking behavior in real spending decisions means the effects of anticipated policy changes are well handled by this model. The regimes that are included in the model are explicitly modeled and since we use a structural model with rational expectations, the model is essentially immune from the Lucas (1974) Critique. The model version in this paper has regional/country coverage for the United States, Japan, Germany,

Table 1: Main Features of the MSG2 Model

- both the demand and supply side of the major economies are explicitly modelled;

- demand equations are based on a combination of intertemporal optimizing behavior and liquidity constrained behavior;

- the supply side takes explicit account of imported intermediate goods especially the role of imported capital goods in investment in economies;

- major flows such as physical investment, fiscal deficits and current account imbalances cumulate into stocks of capital, government debt and net external debt which in turn change the composition and level of national wealth over time.

- Wealth adjustment determines stock equilibrium in the long run but also feeds back into short-run economic conditions through forward-looking share markets, bond markets and foreign exchange markets.

- Asset markets are linked globally through the high international mobility of capital.

Table 2: Regional Coverage of the MSG2 Model Used in this Paper

(version 42I)

Regions (preceded by country code)

Structural

(U)	United States
(J)	Japan
(G)	Germany
(K)	United Kingdom
(E)	Rest of the EMS (denoted REMS)
(A)	Australia
(R)	Rest of the OECD (denoted ROECD)
(H)	High Income Asia
(Z)	Other Asia

Non-Structural

(O)	oil exporting countries (denoted OPEC)
(L)	non-oil developing countries (denoted LDCs)
(B)	eastern European economies and the former Soviet Union (denoted EFSU).

Sectors

one good in each country/region

the United Kingdom, the rest of the EMS (denoted REMS)[2], Australia, the Rest of the OECD (denoted ROECD)[3], non-oil developing countries (denoted LDCs)[4], high income Asia[5] , other Asia[6], oil exporting countries (denoted OPEC)[7], and eastern European economies including the former Soviet Union[8].

It is important to note that investment and consumption behavior is modeled as a weighted average of intertemporal optimizing behavior (with rational expectations of the future path of the global economy), and backward looking behavior based on current income. Thus expected changes in policy and changes in future stocks of assets leads to an initial (although quite damped) response of households and firms. Investment is based on the cost of adjustment approach of Lucas (1967) and Treadway (1969) which yields a model with investment partially determined by Tobin's q, along the lines of the work of Hayashi (1982). A full derivation of the model can be found in McKibbin and Sachs (1991).

Apart from the shocks and underlying model structure, the results also depend on the

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[2] This block consists of Belgium, Denmark, Ireland, Italy and Luxembourg.

[3] This group of countries consists of Austria, Canada, Finland, Iceland, New Zealand, Norway, Portugal, Spain, Sweden and Switzerland.

[4] Non-Oil Developing countries are based on the grouping in the IMF Direction of Trade Statistics less countries explicitly modelled as noted elsewhere.

[5] This group consists of Hong Kong, Korea, Singapore, Taiwan.

[6] This group consists of China, Indonesia, Malaysia, Philippines and Thailand,

[7] Oil exporting countries are based on the grouping in the IMF Direction of Trade Statistics.

[8] These countries are Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland, Romania, Yugoslavia, and the former USSR.

assumptions about fiscal and monetary closure, or more specifically the fiscal and monetary regimes in place in each economy. In this paper, policy closure assumptions are changed in the Australian module with a given set of plausible fiscal and monetary closure assumptions in other countries. For example, in all other countries, fiscal policy is assumed to be implemented such that all governments maintain a fixed share of government spending to GDP and adjust taxes to service any changes in debt (the incremental interest payments rule discussed below). The fiscal deficit adjusts endogenously to any changes in real activity or interest rates. The details of the alternative policy closures in Australia as discussed in the next section.

3. The MSG2 Solution Algorithm

The MSG2 model (as well as the G-Cubed Model) is solved using software developed by McKibbin (1987) for solving large models with rational expectations on a personal computer.[9] The model version in this paper has approximately 1300 equations in its current form with 26 costate variables. To describe the solution procedure we begin by observing that from a mathematical

$$Z_t = F(Z_t ,S_t ,C_t ,X_t) \qquad (1)$$

$$S_{t+1} - S_t = G(Z_t ,S_t ,C_t ,X_t) \qquad (2)$$

standpoint, the MSG2 model is a system of simultaneous equations which can be written in the form:

[9] For a more detailed description of the algorithm, see Appendix C of McKibbin and Sachs (1991). The software developed for solving this model has been written in the GAUSS programming language.

$$C_{t+1} - C_t = H(Z_t, S_t, C_t, X_t) \qquad (3)$$

where Z is a vector of endogenous variables, S is a vector of state variables, C is a vector of co-state variables, X is a vector of exogenous variables, and F, G and H are vector functions. The first step in constructing the baseline is to use numerical differentiation to linearize (1) though (3) around the model's database (which is for 1987). We then transform the model into its minimal state space

$$S_{t+1} - S_t = G(f(S_t, C_t, X_t), S_t, C_t, X_t) \qquad (4)$$

$$C_{t+1} - C_t = H(f(S_t, C_t, X_t), S_t, C_t, X_t) \qquad (5)$$

representation by using (1) to find a set of equations f() that allow us to eliminate Z from (2) and (3):

The linearized model is then in the form:

$$dS_{t+1} = (I + G_Z f_S + G_S)dS_t + (G_Z f_C + G_C)dC_t + (G_Z f_X + G_X)dX_t \qquad (6)$$

$$dC_{t+1} = (I + H_Z f_C + H_C)dC_t + (H_Z f_S + H_S)dS_t + (H_Z f_X + H_X)dX_t \qquad (7)$$

The eigenvalues of this system of equations are then calculated to ensure that the condition for saddle-point stability is satisfied (that is, that the number of eigenvalues outside the unit circle are equal to the number of costate variables). Following that we compute the model's stable manifold

$$\Gamma = (I + H_Z f_C + H_C)^{-1} \qquad (8)$$

as follows. For convenience, define G:

Using G we can rewrite (7) to give dC_t in terms of the other variables:

$$dC_t = \Gamma dC_{t+1} - \Gamma(H_Z f_S + H_S) dS_t - \Gamma(H_Z f_X + H_X) dX_t \qquad (9)$$

$$\begin{aligned} dS_{t+1} = (I + G_Z f_S + G_S - \Gamma(H_Z f_S + H_S)) dS_t + (G_Z f_C + G_C)\Gamma dC_{t+1} \\ + (G_Z f_X + G_X - \Gamma(H_Z f_X + H_X)) dX_t \end{aligned} \qquad (10)$$

Substituting (9) into (6) gives:

Applying (9) recursively and using (10) allows us to find an expression for the stable manifold for the costate variables in terms of changes in current state variables and all current and future changes in

$$dC_t = \Phi dS_t + \sum_{i=t}^{T} \Theta_i dX_i + \Omega dC_T \qquad (11)$$

the exogenous variables. The expression will have the following form:

where F, Q_i, and W are matrices of constants. We evaluate F, Q, and W numerically; in general, their closed-form expressions will be quite complicated. Once this is found the model can be solved quickly and easily for different experiments because the new values of the costate variables can be calculated simply by evaluating (11). These values can then be inserted into (1) to calculate the other endogenous variables.

The algorithm also allows for calculation of time consistent close loop optimal policy rules although these are not discussed in this paper[10].

4. Alternative Fiscal and Monetary Closure Assumptions

In this section, the role of the fiscal and monetary closure assumptions are explored in some detail. A number of alternative closures are possible including a full range of optimization assumptions for fiscal and monetary policy following the large literature on the design of optimal fiscal and monetary regimes[11] . Indeed the model used in this paper has contributed to that literature both from the point of view of a single country or region (Argy et al (1989)) as well as from a global perspective (Henderson and McKibbin (1993), McKibbin and Sachs (1988,1991). In this paper rather than focus on optimal rules as in the above studies, the focus is on the impact of simple rules for fiscal and monetary policy on the model properties. In particular three alternative fiscal regimes are considered and what these mean for the impact of changes in monetary policy in the model.

[10] See McKibbin (1987) for an overview of the optimization algorithm.

[11] see for example Bryant Hooper Mann (1993) and Brandsma and Hughes-Hallett (1989) and Kydland and Prescott (1977).

i) Fiscal Regimes

$$DEFN_t = G_t - T_t + i_t B_t \qquad (12)$$

Consider the budget constraint facing a government summarized in equation (12). DEFN is the fiscal deficit ; G is total government spending on goods and services as well as infrastructure investment (which is included in the MSG2 model but unchanged for all simulations below); T is total tax revenue from income taxes, corporate taxes, import duties etc; i is the nominal interest rate and B is the stock of government debt. The last term (iB) is therefore the interest payment on outstanding government debt.

In the MSG2 model, variables are expressed in per efficiency units. In the above expression assuming lower case letters are upper case variables expressed in per efficiency labor units (i.e. g=G/Y) and adjusting the deficit for the inflation component of interest payments on the debt we get

$$defi_t = g_t - t_t + r_t b_t \qquad (13)$$

the following equation:

where r is the real interest rate defined as the nominal interest rate (i) less expected inflation ($r_t = i_t - {}_tp_{t+1}$) . Note that this expression has adjusted each variable in equation (1) by deflating by GDP plus it has subtracted the inflation component of interest payments on government debt .

The link between debt and the fiscal deficit is the familiar relationship

$$dB_t /dt = DEFI_t \qquad (14)$$

To convert this to the same units as above it can be shown that given b=B/Y and assuming a population plus productivity growth rate equal to n, that:

$$db_t /dt = defi_t - nb_t \qquad (15)$$

$$db_t /dt = g_t - t_t + (r_t - n) b_t \qquad (16)$$

thus debt (relative to GDP) in the MSG2 model evolves according to the budget constraint:

$$\lim_{t \to \infty} b_t e^{-(r_t - n)t} = 0 \qquad (17)$$

Imposing the condition that debt has finite value

we can rewrite equation (16) as the intertemporal budget constraint of the government:

$$b_0 = \int_0^{\infty} (t_s - g_s) e^{-(r-n)s} ds \qquad (18)$$

Equation (18) shows that the value of debt (relative to GDP) in period 0 is equal to the integral of the future stream of tax revenue less the future stream of government spending.

What is required to impose this intertemporal budget constraint in any model is a reaction function for either some component of spending or taxes such that (18) is satisfied.

The regimes considered in this paper are dealt with in greater detail in Bryant and Long(1996a,1996b) and the reader is referred to those papers for an analysis of the steady state and dynamic implications of each regime. In this section I summarize the regimes.

The first regime considered is the regime used in the MSG2 model which is referred to in Bryant and Long (1996a) as the **incremental interest payments rule** (IIP). In the following notation a superscript b refers to the baseline value of a variable. Thus r_t^b is the baseline value if r in period t.

$$t_t = t_t^b + r_t b_t - r_t^b b_t^b \qquad (19)$$

This rule is shown in equation (19):

In this rule a lump sum tax (t) is adjusted to any changes in the interest servicing costs relative to baseline during simulation.

From the above summary of the government budget constraint it can be seen that assuming t=rb in equation (16) gives:

$$db_t /dt = g_t - nb_t \qquad (20)$$

$$b_t = g_t /n. \qquad (21)$$

or in the steady state when db/dt=0 we have:

Thus in an economy in which taxes only cover interest costs of the debt, the steady state stock of debt to GDP in the case of the IIP rule is dependent on the steady state level of government spending adjusted by the underlying real growth rate. In terms of the simulations below any change in government spending will lead to a permanent change in the ration of debt to GDP. In the MSG2 model the long run growth rate of population plus labor augmenting technical change is 3% thus a 2 percent of GDP reduction in government spending will eventually reduce government debt by approximately 66% (=100*2/.03)

The second rule is the closure rule assumed in a number of models such as the IMF MULTIMOD model. This is referred to as the **debt targeting rule**.

$$t_t = t_{t-1} + a_1(b_{t+1} - b^T_{t+1}) + a_2((b_{t+1} - b^T_{t+1}) - (b_t - b^T_t)) \qquad (22)$$

The instrument in this rule is the income tax rate (t) rather than tax revenues relative to GDP (t). The current tax rate (t) is set equal to the previous period tax rate plus two terms. The first term in the gap between the actual debt at the end of period t less the desired debt at the end of period t.

Targeted variables are indicated by a T superscript. Note that in this particular implementation we assume that the targeted debt is equal to the baseline debt. The second term is the derivative feedback term, that is the change in the gap between the actual and desired stocks of debt. This last term is also the fiscal deficit plus the term nb when there is underlying real growth in the economy. In the simulations below I assume the same values for a_1 (= 0.04) and a2 (=0.3) as Bryant and Long (1996a). In this rule any changes in the economy that change the fiscal deficit in the short run have not effect on the long run stock of government debt relative to GDP.

The third rule shown in equation (23) is **strict fiscal conservatism** in which the government is assumed to hit a desired debt stock exactly in every period. This is equivalent to equation (22) with

$$b_t = b_t^T \qquad (23)$$

very large feedback coefficients.

ii) Monetary Regimes

Monetary policy in this model is assumed to be implemented with a feedback rule for interest rates on some target variable (either the stock money relative to target, the level of nominal income relative to target, or the rate of inflation relative to target). In this paper we take an extreme value for each feedback coefficient such that the target variables are targeted exactly. An alternative approach is either to use an arbitrary coefficient to capture partial adjustment or one can calculate an “optimal” feedback coefficient such that some objective function written in terms of ultimate target variables is maximized (see McKibbin (1993)). In that earlier paper the “optimal” degree of adjustment for a monetary target rule, given the historically estimate variance covariance matrix of shocks, was found to be exact targeting on money.

The three monetary regimes use in this paper are summarized in equations (24) through (26). Take equation (24) for example. This has that the short term nominal interest rate (i) equal to the baseline nominal interest rate (i^b) plus a coefficient times the gap between the actual stock of money (M) and the target stock of money (M_t^T).

$$i_t = i_t^b + \beta_1 (M_t - M_t^T) \qquad (24)$$

The money target is:

$$i_t = i_t^b + \beta_2 (PY_t - PY_t^T) \qquad (25)$$

The Nominal income (or nominal GDP) target is:

$$i_t = i_t^b + \beta_3 (\pi_t - \pi_t^T) \qquad (26)$$

Inflation target is:

5. The Consequences of Fiscal and Monetary Closures

The results for each of the simulation are contained in figures 1 through 10. For each policy change there are three sets of graphs (with an additional set of graphs for the fiscal shift, discussed below). All variables are expressed as deviations from what otherwise would have occurred along the baseline of the model. The deviation units differ across variables. GDP, employment, output price, nominal effective exchange rate and real effective exchange rate are expressed as percentage deviation from baseline. Inflation, short term nominal interest rates, short term real interest rate and (where they are presented) real and nominal rate of return on ten year bonds are all expressed as percentage point deviation from baseline. Thus a value of 1 is a 100 basis point rise in the variable. The fiscal deficit, government debt stock, current account balance and trade balance are all expressed as percent of baseline GDP deviation from base.

A. The Consequences of the Fiscal Regime for Changes in Monetary Policy

i) Reduction in the targeted price level by 2%

The first simulation is a reduction in the targeted level of prices by 2%. This is implemented by reducing the nominal anchor. In this simulation it is assumed that the money supply is the nominal anchor and it is reduced by 2% immediately in 1996. Over time the price level falls to the desired level 2 percent lower than that which would otherwise have been. Figures 1 through 3 contain the results for this scenario under the three assumptions for fiscal policy outlined above. In the figures, the "rB rule" is the incremental interest payment rule (IIP rule); "B target" is the debt targeting rule and "B fixed" is the fiscal conservatism rule.

In understanding the results for monetary policy it is useful to first focus on the overall adjustment for all three regimes and then focus on the differences between regimes. In doing this it is helpful to first analyse the IIP regime ("rb rule" in the figures) because this the standard fiscal regime in the MSG2 model and is most comparable to other studies with this model.

The outcome for prices can be seen in the bottom right hand panel of figure 1. Prices fall (relative to baseline) by 0.8 percent during 1996 and gradually reach the new desired level by the year 2000. The policy is implemented by raising short term nominal interest rates (figure 3) such that the new target path for money is achieved exactly. The result of the rise in interest rates with sticky wages is to sharply raise real interest rates (figure 3). This appreciates the exchange rate in both real and nominal terms as foreign financial capital flows into the Australian economy attracted by higher real and nominal rates of return. Higher real interest rates dampen private investment directly through a higher cost of funds and also through a tightening of short run liquidity constraints on firms and households. In addition, the rise in the real exchange rate dampens foreign demand for Australian exports. Each factor acts to temporarily reduce GDP. The fall in aggregate demand reduces prices. In addition the appreciation of the exchange rate lowers the cost of imported consumption goods as well as the cost on imported intermediate goods which further reduces inflation (defined in terms of the consumer price index) temporarily. With sticky nominal wages the fall in aggregate demand and rise in the real wage reduces employment proportionately more than the fall in GDP.

The impact of the shock on the balance of payments can be considered in a number of ways. This is also where the fiscal policy assumptions are more important. One way to think through the adjustment process is through the expected theoretical effects on exports and imports which depend on their price and income elasticities. The fall in aggregate demand in Australia should reduce the demand for imports directly. On the other hand the stronger real exchange rate should raise the demand for imports since imported goods become relatively cheaper in Australian dollars. On the export side the effect is clearer. The stronger real exchange rate (i.e the higher the relative price of Australian goods to foreign goods) tends to lower the demand for exports and there are no foreign income effects from the Australia policy change. Thus exports should fall. These factors taken together imply that the results for the trade balance are ambiguous in theory.

An alternative, equally valid but nonetheless useful, way of thinking through the adjustment process is to realize that the current account adjustment will be determined by the shifts in public and private saving and investment in Australia. On the investment side we have assumed that public infrastructure investment spending is constant. Private investment spending falls slightly because of the temporary rise in real interest rates (which raises the real interest rate on 10 year bonds) and the slowdown in economic activity which reduces expected future output in the near term as well as tightening cash flow of firms. Public saving tends to fall since government spending is fixed and the slowdown in economic activity tends to reduce tax revenue thus increasing the budget deficit all other things unchanged. Private saving tends to fall as well as some households attempt to smooth consumption as income falls temporarily. Therefore the effect on the current account is also ambiguous from this approach (as expected given they are two sides of the same story). The key insight is that it is clearer how the fiscal regime can be important when thinking through the saving/investment channel. This is through the effect of the fiscal regime on the response of public saving.

Indeed now consider the differences in results across the fiscal regimes. The results for real GDP do not differ much across these versions of the fiscal regimes. The key point from examining the differences in GDP are that the fiscal conservatism rule leads to a larger output loss in the short run since the tendency to run a budget deficit as revenues fall leads to a rise in tax rates so as to keep government debt unchanged. Thus the monetary contraction is accompanied by an endogenous fiscal contraction, relative to the other fiscal regimes. In the other regimes, in the short run, fiscal policy is allowed to be counter cyclical.

Greater differences can be found in the adjustment of fiscal and trade deficits. From figure 2 it is clear that the incremental interest payments rule (IIP) allows a larger fiscal deficit to emerge than the other rules in the short run. The debt target rule allows a short run increase in the fiscal deficit however this rule returns the debt to the baseline level whereas the government debt is permanently higher under the IIP rule. The implication of this is that the fiscal deficit that emerges under the debt target rule must be reversed by running a fiscal surplus during the period shown which dampens economic activity during that phase of adjustment. The fiscal conservatism rule shows the assumption that the fiscal deficit and the stock of government debt remain unchanged at baseline.

The impacts on the trade balance are quite different under the different fiscal regimes . Under the IIP rule the trade balance deteriorates because public saving falls relative to the regime of fiscal conservatism. Indeed the trade balance improves under the fiscal conservatism rule because public saving is unchanged and the fall in private investment is larger than the fall in private saving. These results are interesting although the magnitudes of the differences are relatively small.

The effect on financial prices are more different than the real effects of the alternative regimes. In particular we find an interesting result in the case of the strict fiscal conservative rule. In this case note that the nominal interest rate does not change. This is because we have held the supply of bonds fixed as well as assuming that domestic and foreign bonds a perfect substitutes (i.e. uncovered interest rate parity holds). Thus with a fixed supply of bonds and an infinitely elastic demand for bonds, the domestic price of bonds (i.e. the inverse of the nominal interest rate) cannot change. This implies through the interest parity condition that the nominal exchange rate jumps to its long run value of a 2% nominal appreciation instantly. The implication from the money demand function is that the nominal transaction variable (in this case nominal GDP) must fall by exactly the fall in the money supply. The other implication of this rapid adjustment of nominal asset prices is that with sticky wages, the fluctuations in prices are manifested in changes in real interest rates and real exchange rates rather than in nominal interest rates and nominal exchange rates.

A final point to note is that there is a small long run depreciation of the real exchange rate in the case of the IIP rule because the earlier build of domestic government debt translates into a small build up of foreign debt which need to be serviced in the long run. This is achieved by having slightly higher exports relative to imports as compared to the baseline. Thus the in the long run there is a real depreciation relative to baseline. This effect is absent from the other two regimes that target debt stocks because the long run stock of government and foreign debt returns to baseline.

ii) Reduction in the targeted Inflation rate of 1%

The results for a change in policy that is a permanent reduction in the targeted rate of inflation of 1% are shown next in figures 4 though 6. The adjustment process is similar to that for the change in the price level target however several points stand out. Firstly, the real GDP and employment reductions are larger (when re-scaled to the initial period change in inflation) and remain below baseline for longer in the case of the inflation target. As expected, prices continue to fall by 1% per year which differs from the first simulation in which prices converged to a new lower level. In addition the changes in fiscal deficits, government debt and current account adjustment is more spread out for the inflation shock.

The other major differences can be seen in the financial prices in figure 6. The permanent fall in the targeted rate of inflation and therefore a fall in the expected rate of inflation, has the effect of reducing the nominal interest rate in 1996 compared to the rise in nominal interest rates under the price level target. Indeed as we found above, the rule of strict fiscal conservatism causes nominal interest rates to adjust immediately to there new long run value which in this case is a fall of 1% immediately rather than returning exactly to baseline as for the price level shock.

b) The Consequences for Fiscal policy of the Monetary and Fiscal Regimes

This section explores the impact of a fiscal contraction of 2 percent of baseline GDP that is unanticipated and permanent under a range of assumptions about fiscal and monetary regimes. In figures 7 through 10 results for four regimes are presented. The IIP regime (labeled "rB rule" in the figures) is assumed for fiscal policy under the monetary target, nominal income target and inflation target regimes. In addition these figures contain the money target regime under both the IIP fiscal regime as well as the government debt targeting regime. In the case where the fiscal regime is the debt stock target, it is also assumed that the targeted stock of debt to GDP falls by 20% of GDP when the contraction in fiscal spending is announced.

The difference between results in figures 7 through 10 stand out more than in the earlier figures. That is the monetary and fiscal regimes appear to be important for the impact of fiscal policy. The fiscal contraction is implemented when announced rather than phased in over time. A phasing in would be preferable in this model in order to smooth the adjustment costs in the process of resource reallocation.. A sharp fiscal shock is chosen to make the adjustment clear.

Consider the standard MSG2 closure in which the IIP fiscal regime and money target rule operates. The cut in government spending reduces aggregate demand in the Australian economy. The expected increase in public saving (figure 8) reduces real interest rates and depreciates the real and nominal exchange rates. The movement in financial prices acts to stimulate private investment and net exports but this is insufficient in the short run to offset the direct negative effects of the spending cuts on GDP. The reduction in 10 year bond rates are smaller than the reduction for a comparable (defined in terms of GDP) cut in US fiscal deficits (see Bagnoli and McKibbin (1993)) because Australia is small in global capital markets and the rise in government saving has negligible effects on world interest rates and therefore only temporary effects on Australian real interest rates. Given the assumption of an open capital market, the real interest rate in Australia eventually returns to the world real interest rate. This also happens for a U.S. fiscal consolidation except that the world interest rate does not remain unchanged in the U.S. case.

The fall in aggregate demand in Australia tends to reduce prices but the exchange rate appreciation tends to raise the price of imported intermediate inputs as well as imported final goods so that prices actually rise.

Now consider the role of the monetary regimes in changing this basic adjustment story. As inflation rises through the exchange rate depreciation, the inflation target regime implies a monetary contraction. This worsens the loss in real GDP and employment because the fiscal contraction is accompanied by a monetary contraction. The movement in nominal interest rates in figure 9 show that a policy of unchanged nominal interest rates is consistent with an inflation target. However in the other regimes which have less GDP loss and less loss in employment the nominal interest rate is allowed to fall by up to 120 basis point in the case of a nominal income target. Thus if the goal of the policy regime is in smoothing output as well as inflation fluctuations an appropriate policy response to the fiscal adjustment would be to lower nominal interest rates by between 70 and 120 basis points in 1996 and then gradually reverse this through 1997 onwards. This type of response is induced by a nominal income targeting regime but not by a pure inflation targeting regime.

Figures 7 through 9 also give an indication of the role of the fiscal regimes. The money target can be compared under both the IIP rule and the bond target rule in these figures. The initial output effects under both fiscal rules are similar although by 1998 the debt target rule becomes more expansionary. This is because the contraction in government spending begins to be offset by a tax cut as the ratio of debt to GDP levels out at the new desired level of 20% below baseline. Under the IIP rule the level of debt to GDP continues to fall until it reaches approximately 40% of GDP below what otherwise would have been. This can be seen clearly in figure 8.

5 Conclusion

This paper has presented the model solution technique and considered the interdependence of monetary and fiscal closure rules using a global simulation model although focussing in particular on the Australian economy. It is found that for a policy shift in either fiscal or monetary policy, the fiscal and monetary closure rule in place can have important implications for the outcomes of the policy shift. In the case of monetary policy, the real consequences of the monetary shock appear to be less sensitive than the financial market reactions. Indeed it is shown that with perfect international capital mobility and extreme fiscal conservatism, the short term nominal interest rate is determined independently of the price level target of the monetary authority but is dependent on the inflation target.

The nature of the monetary closure rule in place during a substantial fiscal consolidation is shown to be important. Indeed the results suggest that a strict inflation target is likely to lead to excessive output losses relative to a rule that targets nominal income when there is a significant fiscal consolidation in the Australian economy.

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Figure 1: Consequences of a 2 percent Reduction in the Price Level Target

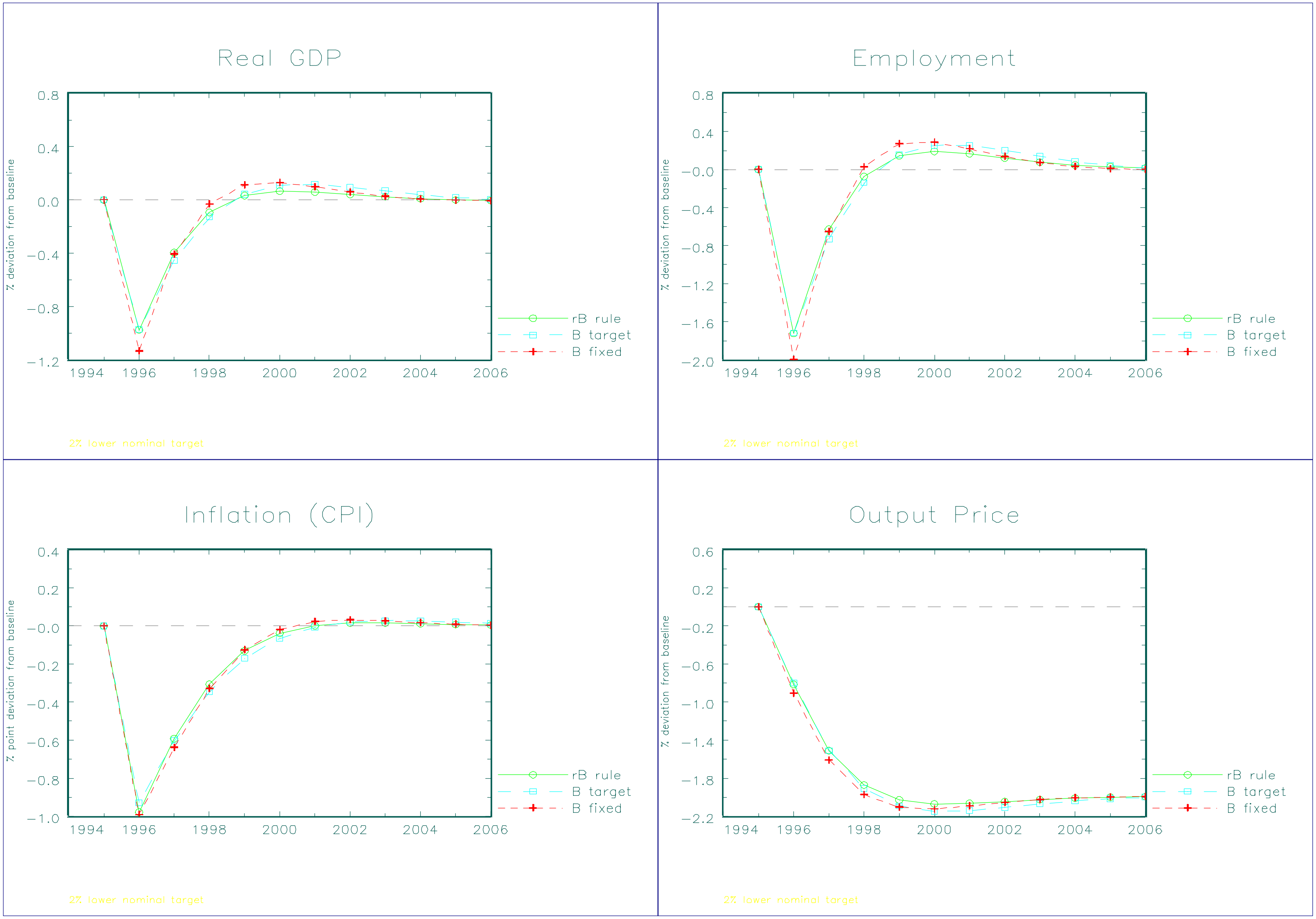

Figure 2:Consequences of a 2 percent Reduction in the Price Level Target

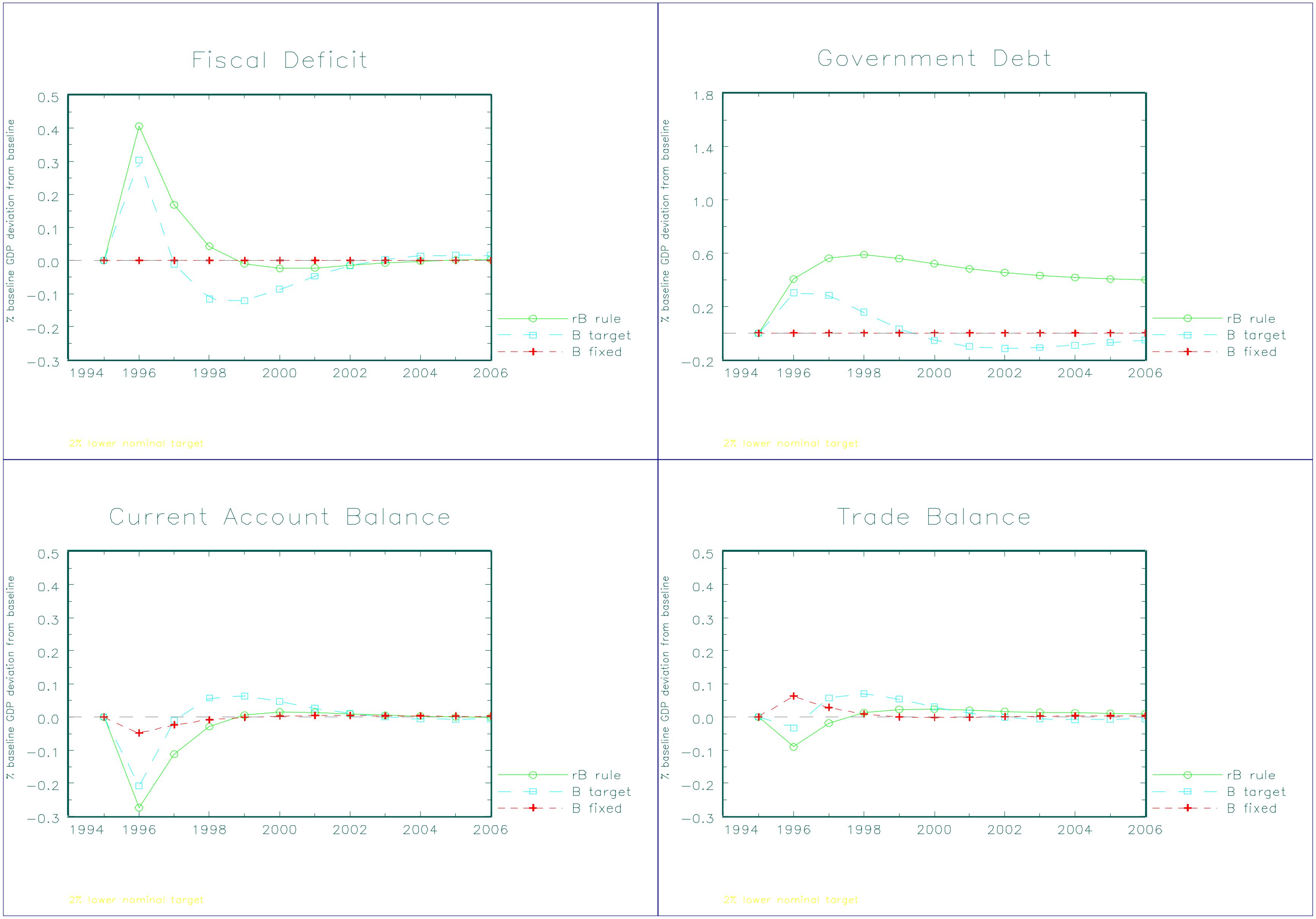

Figure 3:Consequences of a 2 percent Reduction in the Price Level Target

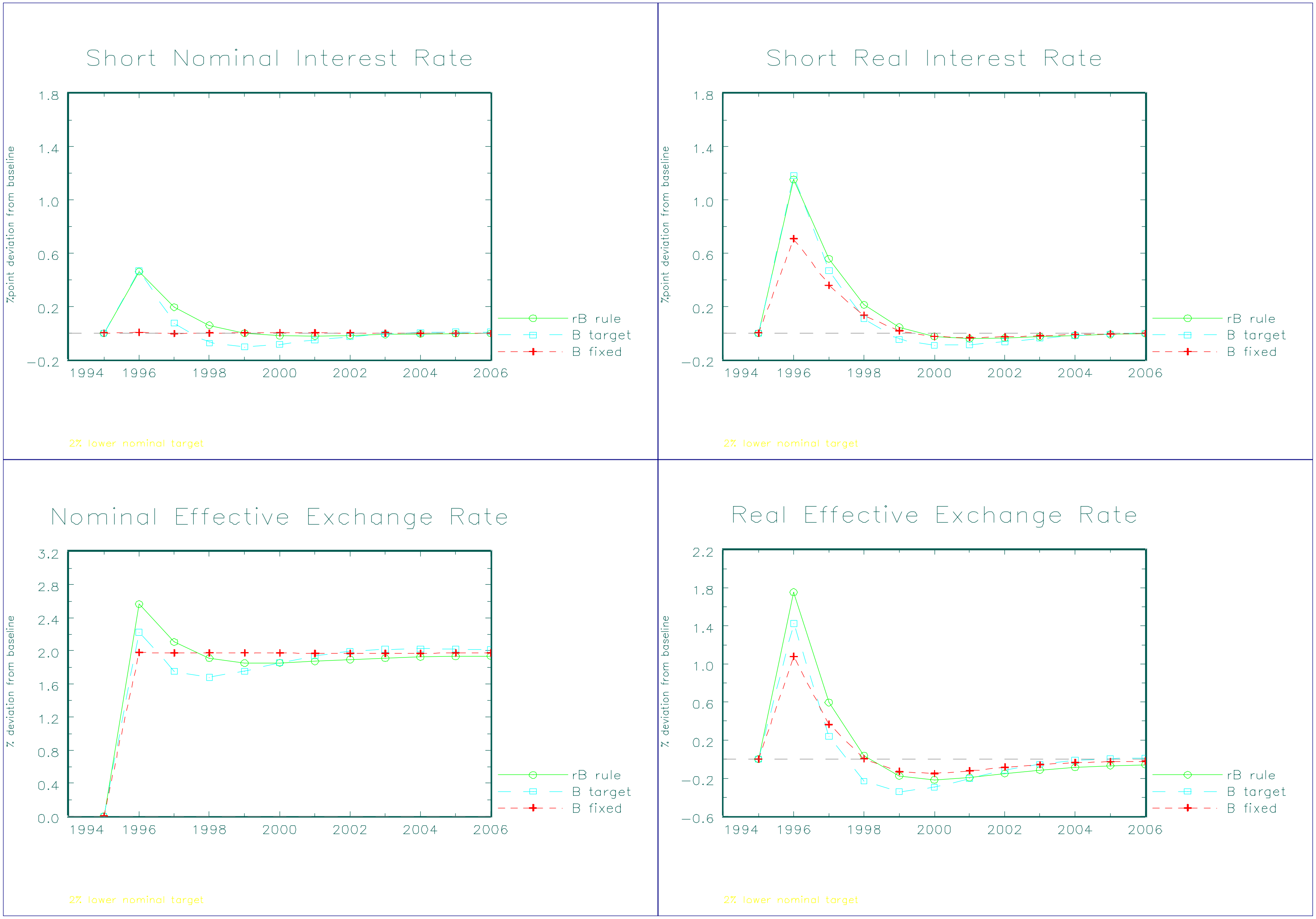

Figure 4:Consequences of a 1 percent Reduction in the Target Rate of Inflation

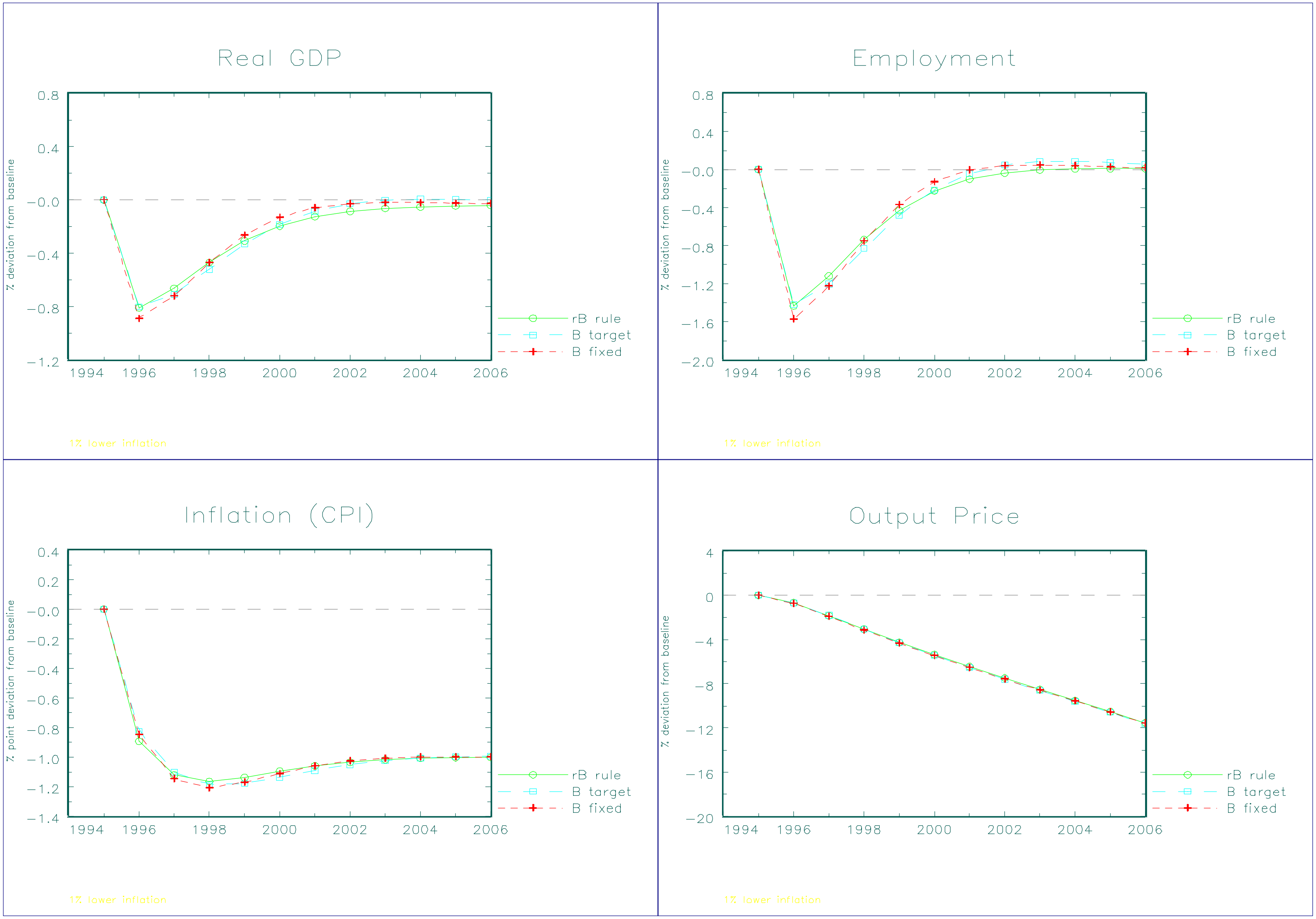

Figure 5:Consequences of a 1 percent Reduction in the Target Rate of Inflation

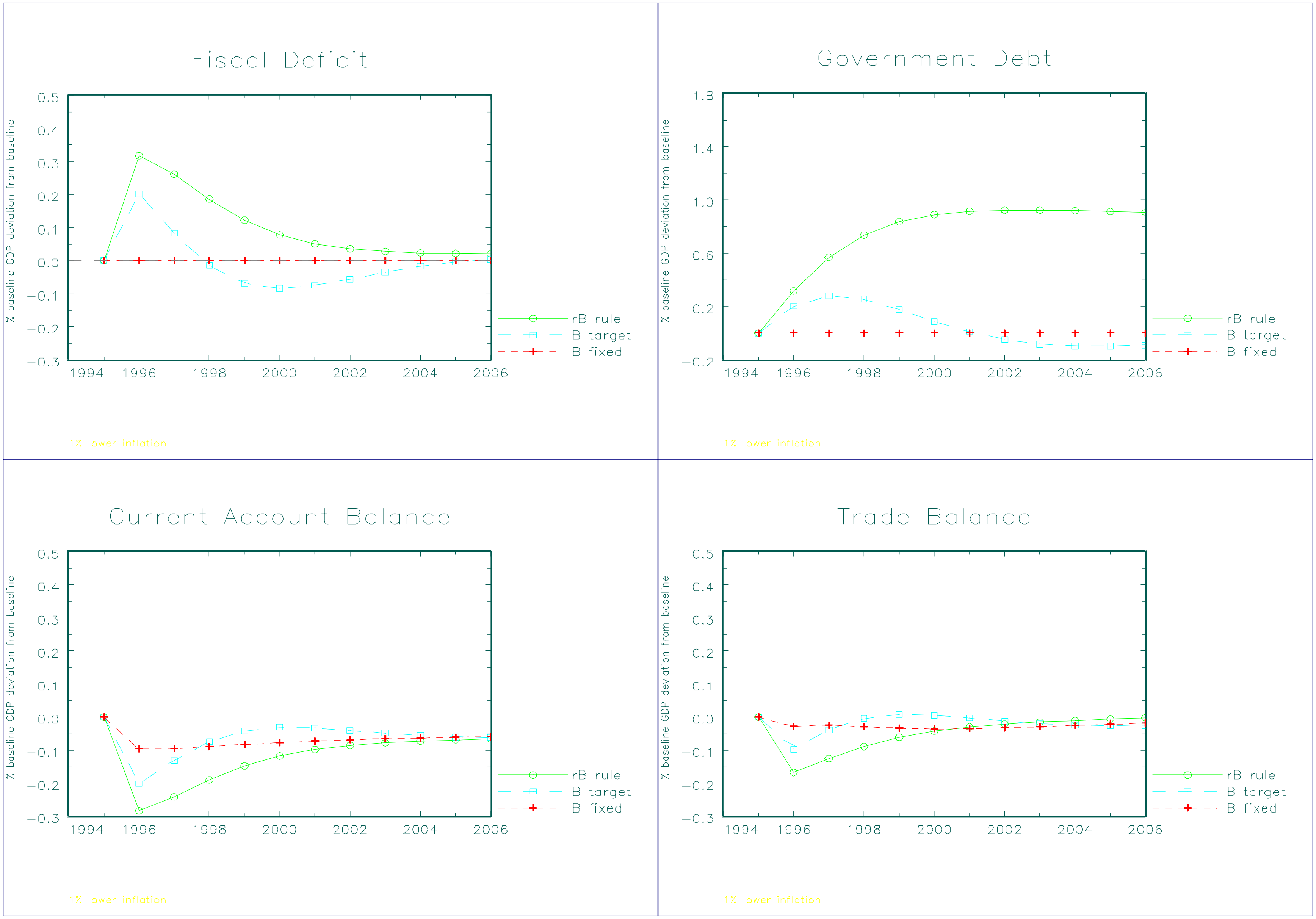

Figure 6:Consequences of a 1 percent Reduction in the Target Rate of Inflation

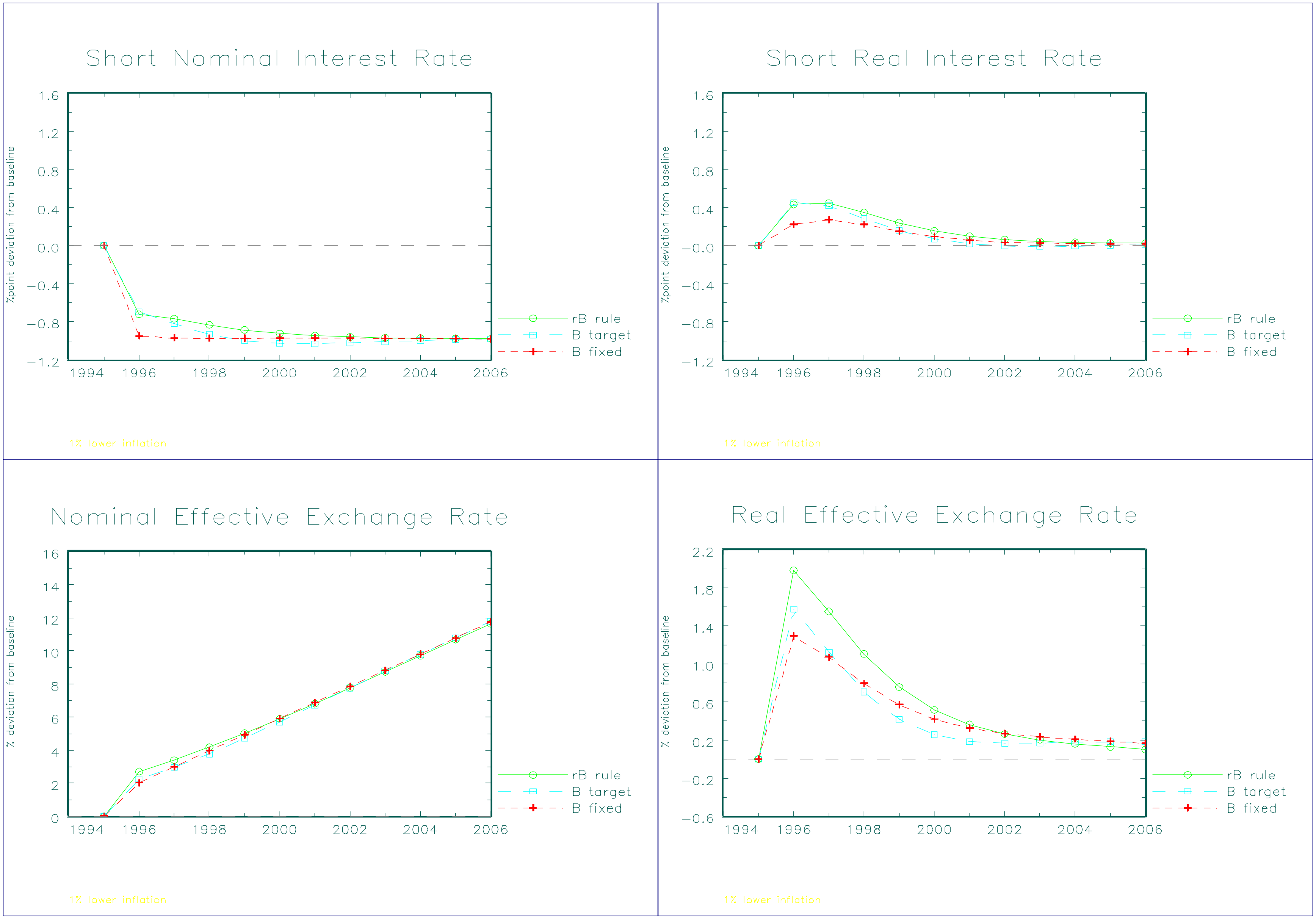

Figure 7: Consequences of a Permanent 2% of GDP Reduction in Government Spending on Goods and Services

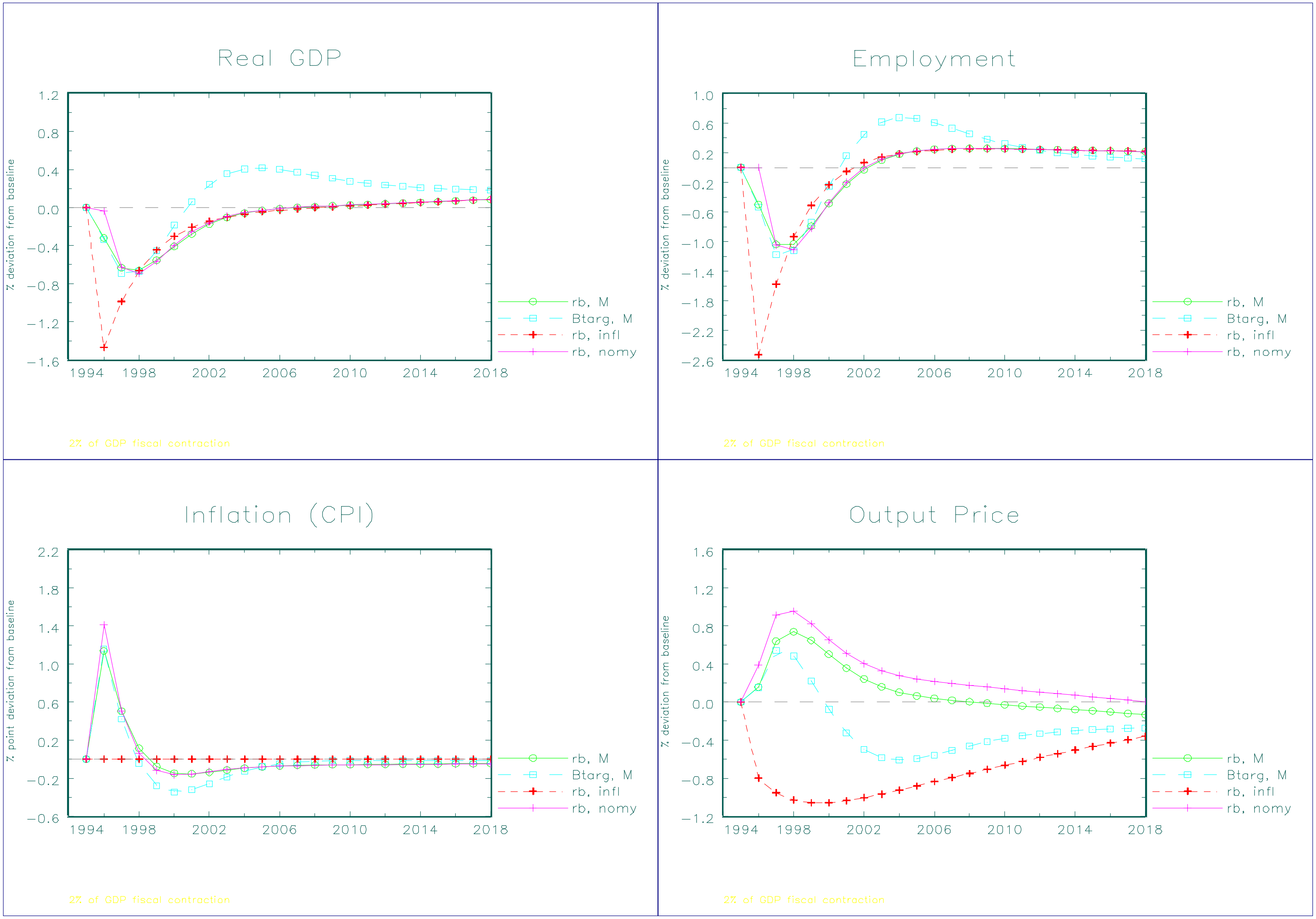

Figure 8: Consequences of a Permanent 2% of GDP Reduction in Government Spending on Goods and Services

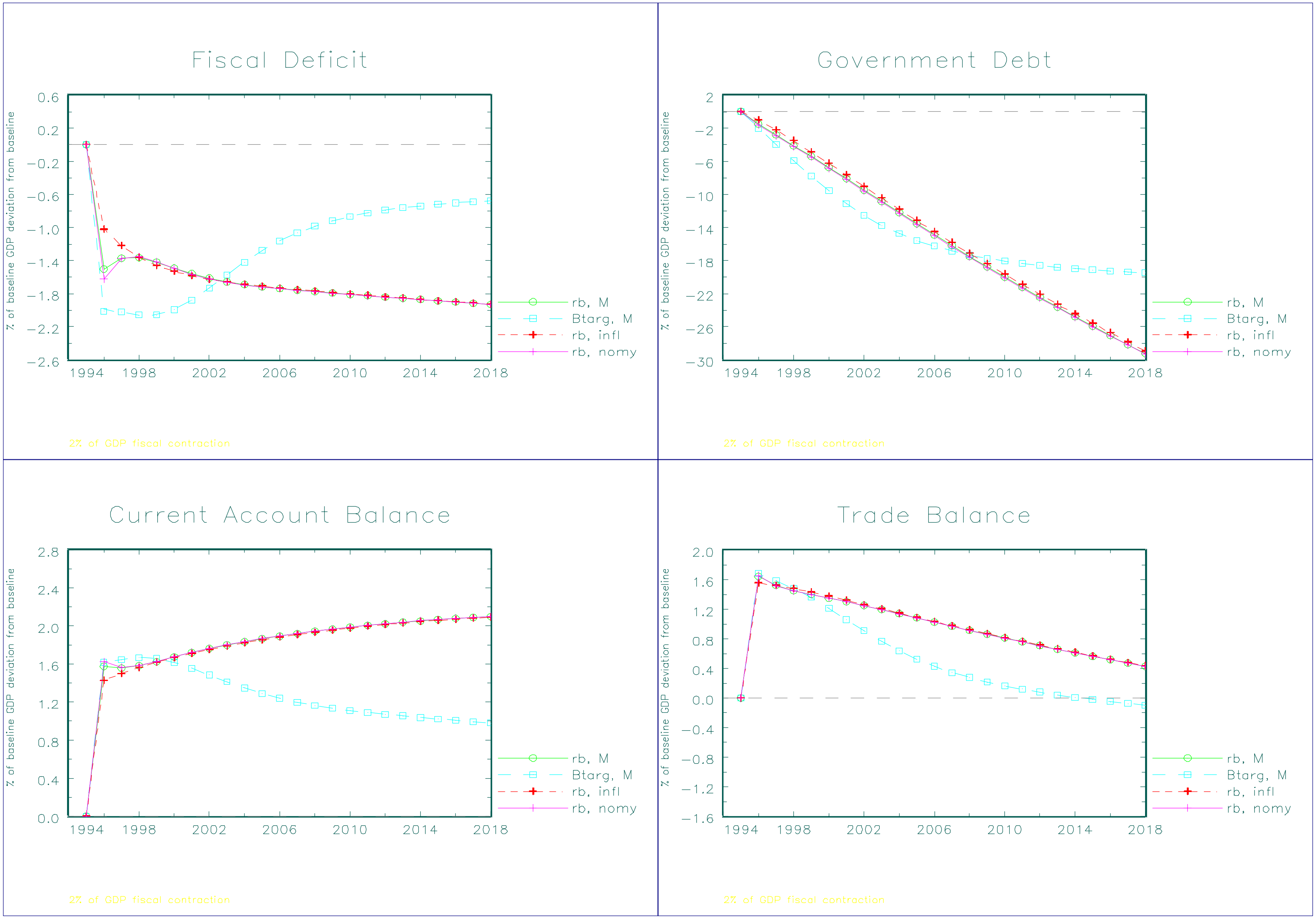

Figure 9: Consequences of a Permanent 2% of GDP Reduction in Government Spending on Goods and Services

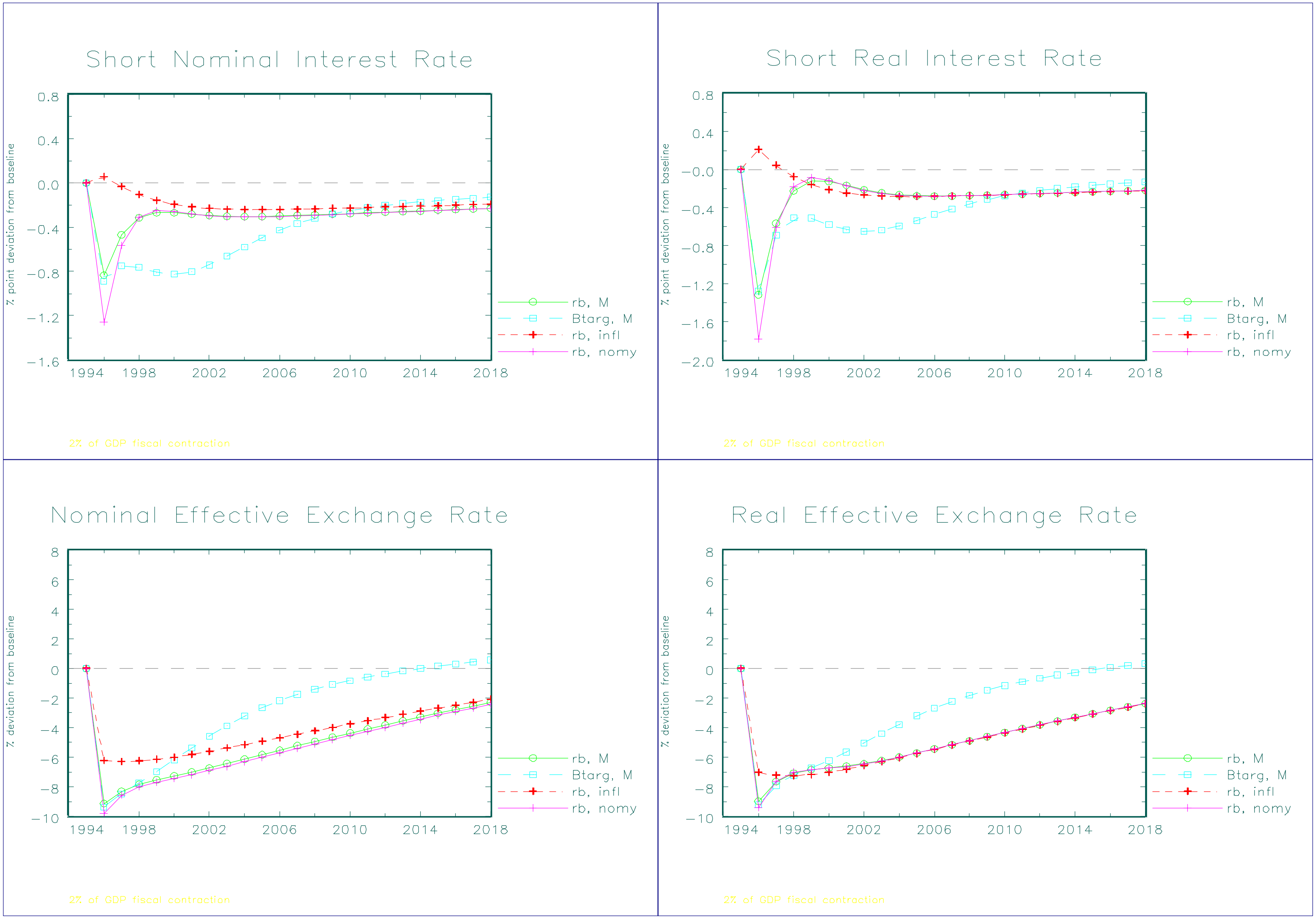

Figure 10: Consequences of a Permanent 2% of GDP Reduction in Government Spending on Goods and Services