Debt and the Effects of Fiscal Policy*

Carlo Favero and Francesco Giavazzi †

May 2009

*We thank Guido Lorenzoni, Olivier Blanchard and Roberto Perotti for very useful comments and suggestions. An early version of this paper circulated as NBER WP 12822, January 2007.

†Favero: IGIER-Bocconi and CEPR. Giavazzi: IGIER-Bocconi, MIT, CEPR and NBER.

1 Introduction

A shift in taxes or in government spending (a "fiscal shock") at some point in time puts a constraint on the path of taxes and spending in the future, since the government intertemporal budget constraint will eventually have to be met. Consider for example a positive shock to government spending. Following the shock the government may respect its budget constraint by adjusting taxes and spending so as to keep the ratio of public debt-to-GDP stable, or it may delay the adjustment and in the meantime let the debt ratio grow. It may even plan to use the inflation tax or to default. The effects of the fiscal shock on taxes, spending, inflation and interest rates are likely to differ depending on the path the government chooses.

This fact is mostly overlooked in empirical analyses of the effects of fiscal shocks. The estimated models fail to keep track of how a fiscal shock and its effects on macro variables determines the evolution over time of the debt-GDP ratio; they also overlook the possibility that taxes, spending and other macro variables, interest rates in particular, respond to the level of the debt. This is surprising because the evidence suggests that governments do care about their budget constraint. Using a century of U.S data, for instance, Bohn (1998) finds a positive correlation between the government surplus and the Federal debt.

This paper explains why omitting the governemnt intertemporal budget constraint results in incorrect estimates of the effects of fiscal policy shocks. We show how to construct correct estimates that keep track of the effects of these shocks on the dynamics of the public debt. We also show why keeping track of the debt dynamics through a linearized budget constraint is not the right solution. Finally we show what difference it makes with reference to two classical papers that study the effects of fiscal shocks on the U.S. economy using different assumptions to identify such shocks: Romer and Romer's (2007) and Blanchard and Perotti (2002).

The observation that the government budget constraint cannot be overlooked when estimating the effects of fiscal shocks suggests that there is a major discrepancy between the dynamic stochastic general equilibrium models used to analyze the effects of such shocks and the VARs used to study the response of the economy to the same shocks. Equilibrium structural models are solved by imposing the government intertemporal budget constraint and are simulated under the equilibrium assumption that the real value of the debt in the hands of the public must equal the expected present value of government surpluses. On the contrary, the VARs used to study the effects of fiscal policy shocks—and to discriminate between competing DSGE models,

or to provide evidence on the stylized facts to include in theoretical models used for policy analysis—do not impose this condition and usually do not even include debt.

An older literature studied the effects of fiscal policy shocks using cross-country evidence and found that such effects might be non-linear and depend (among other factors) on a country's level and/or growth rate of the public debt (Giavazzi and Pagano, 1990, Alesina and Perotti, 1995, Perotti 1999, Giavazzi et al 2000). Empirical models that omit debt and the government budget constraint are obviously mute on this issue. While those papers addressed the identification of fiscal shocks in an unsatisfactory way, the results they found are worth reconsidering with a more robust identification.

2 Estimating the effects of fiscal shocks

Consider the problem of estimating the effects of a fiscal shock in a model without a budget constraint. Let y_t denote output, z_t the interest rate and e_t^T, v_t two (orthogonal) structural shoks. For the time being let's assume that these shocks have been identified without asking how: for instance e_t^T could be the tax shocks identified by the Romer and Romer "narratrive approach"

$$\begin{aligned} y_t &= \beta_{11} y_{t-1} + \beta_{12} z_{t-1} + e_t^T \\ z_t &= \beta_{21} y_{t-1} + \beta_{22} z_{zt-1} + v_t \end{aligned} \tag{1}$$

The effect of an e_t^T shock on y_{t+1} is

$$\frac{\partial y_{t+1}}{\partial e_t^T} = \beta_{11}$$

and in general, if we limit to the response to e_t^T shocks

$$y_t = \Psi(L) e_t^T$$

Now consider the problem of estimaing the effects of a fiscal shock in a model which includes the government's intertemporal (and non-linear) budget costraint (The example does not keep track of taxes and thus omits the governemnt surplus from the budget constraint. This allows us to show the problem is the simplest possible way)

$$
\begin{aligned}
y_t &= \beta_{11} y_{t-1} + \beta_{12} z_{t-1} + \beta_{13} d_{t-1} + e_t^T \\
z_t &= \beta_{21} y_{t-1} + \beta_{22} z_{t-1} + \beta_{23} d_{t-1} + v_t \\
d_t &= (z_t - y_t)\, d_{t-1}
\end{aligned} \tag{2}
$$

where the third equation is the government intertemporal budget constraint.

In this model the effect of an e_t^T shock on y_{t+1} is

$$\frac{\partial y_{t+1}}{\partial e_t^T} = (\beta_{11} - \beta_{13} d_{t-1})$$

How serious is the error one makes by overlooking the budget constraint? Let $\beta_{11} = 0$ for simplicity, that is let's close down the dynamics. Then

$$y_{t+1} = -\beta_{13} d_t e_t^T + e_{t+1}^T$$

with $e_t^T \perp e_{t+1}^T$. Observing d_t, the estimate of β_{13} is

$$\frac{Cov\left(d_{t-1} e_t^T, y_{t+1}\right)}{Var\left(d_{t-1} e_t^T\right)} = \beta_{13}$$

If instead you overlook d_t (and the budget constraint, since to keep track of d_t one must use the intertemporal budget constraint) what you estimate is the product of β_{13} and the covariance between debt and the volatility of the structural shocks.

$$
\begin{aligned}
\frac{Cov\left(e_t^T, y_{t+1}\right)}{Var\left(e_t^T\right)} &= \frac{Cov\left(e_t^T, \beta_{13} d_{t-1} e_t^T + e_{t+1}^T\right)}{Var\left(e_t^T\right)} \\
&= \beta_{13} \frac{E\left(d_{t-1}\left(e_t^T\right)^2\right)}{E\left(e_t^T\right)^2}
\end{aligned}
$$

If $d_t = d_0 \ \forall \ t$, that is if the debt ratio remained constant, the two expressions coincide and omitting the budget constraint would not result in incorrect impulse responses, since in both cases

$$\frac{\partial y_{t+1}}{\partial e_t^T} = -\beta_{13} d_0$$

But in (2) this could happen only if fiscal policy responded simultaneously to tax shocks, so as to cancel their effect of the debt ratio. If instead d_t is not constant,

the true response is $\frac{\partial y_{t+1}}{\partial e_t^T} = -\beta_{13} d_{t-1}$, while the response computed overlooking the budget constraint is

$$\frac{\partial y_{t+1}}{\partial e_t^T} = -\beta_{13} \frac{E\left(d_{t-1}\left(e_t^T\right)^2\right)}{E\left(e_t^T\right)^2}$$

In the data y_{t+1} is affected not by a single shock e_t^T, but by the moving avearge of past shocks $\sum_i \delta^i e_{t-i}^T$. The bias thus depends on the covariance between d_{t-1} and the volatility of tax shocks. Since debt today reflects past shocks, $d_{t-1} = f\left(\sum_i \delta^i e_{t-i}^T, ...\right)$: the bias is non-zero by construction [1]

2.1 Could the budget constraint be linearized?

Leeper and Chung (2007) recognize this problem and address it appending a linearized budget constraint to a fiscal VAR. .They assume that d is stationary, linearize the budget constraint and solve forward imposing the transversality condition

$$\begin{aligned} \ln(d_t) &= \frac{1}{(1-\rho)} \sum_{i=0}^{\infty} \rho^i E_t \Delta ls_{t+i+1} \\ ls_{t+1} &\equiv -\eta \ln(g_{t+1}) + (1-\rho+\eta) \ln(t_{t+1}) \\ &\quad - (i_{t+1} - \pi_{t+1} - \Delta y_{t-i}) + (1-\rho) k \end{aligned}$$

with η, ρ, k linearization parameters, functions of the unconditional meams of macro and fiscal variables.

They then estimate the system (including the budget constraint to which they append a shock) imposing the cross-equation restrictions implied by the linearized budget constraint, and compute impulse responses under the assumption that the debt ratio is stationary.

But if the budget constraint is linear the effects of structural shocks can be estimated simply from $y_t = \Psi(L) e_t^T$: as discussed in Section 2, there is no need to keep track of the dynamics of d. Moreover, as we shall see, for three decades (1950 to 1980) the debt-GDP ratio in the U.S. had a trend thus defying the assumption of stationarity.

[1] This could also be shown using a Montecarlo simulation: generate the data using model (2); then compare the two estimators.

2.2 How to estimate the effects of fiscal shocks keeping track of the budget constraint

Estimating the effects of fiscal policy shocks keeping track of the government's intertemporal budget constraint requires preseving its non-linearity and appending it to a VAR that includes the fiscal variables (that's where the shocks come from) and at least the macro variables that enter the budget constraint: output, inflation and interest rates, that is

$$\begin{aligned} \mathbf{Y}_t &= \sum_{i=1}^{k} \mathbf{C}_i \mathbf{Y}_{t-i} + \boldsymbol{\gamma}_i d_{t-1} + \mathbf{u}_t \\ d_t &= \frac{1+i_t}{(1+\pi_t)(1+\Delta y_t)} d_{t-1} + \frac{\exp(g_t) - \exp(t_t)}{\exp(y_t)} \end{aligned} \tag{3}$$

where $\mathbf{Y}_t' = \begin{bmatrix} g_t & t_t & y_t & \pi_t & i_t \end{bmatrix}$, d_t is the debt-to-GDP ratio, i_t is the nominal rate of interest (the average cost of debt financing), Δy_t is real GDP growth, π_t is inflation, t_t and g_t are, respectively, (the logs of) government revenues and government expenditure net of interest. (We use logs because it is the log of output, taxes and spending that enters $\mathbf{Y}$).

(3) differs from a traditional fiscal VAR (one that omits the budget constraint and assumes $\boldsymbol{\gamma}_i = 0$) in two aspects. First, all variables in $\mathbf{Y}$ are allowed to respond to the level of the debt. This is simply a multivariate extension of the univariate specification of the fiscal reaction function estimated in Bohn (1998). As observed in the Introduction, Bohn finds a significant response of the primary surplus to debt fluctuations and shows that U. S. fiscal policy satisfyies the intertemporal budget constraint. Second, we endogeneize the debt, and we do so via an intertemporal relation that does not contain an error, as our VAR contains all variables relevant to determine the debt-deficit dynamics. identity. Finally note that since we treat the budegt constraint as an identity, the number of shocks is the same as in a VAR that does not include the budget constraint, so that the identification problem remains unaffcted. Also, since there are no parameters to be estimated in the debt dynamics equation, (3) can be estimated excluding that equation.

Finally, the presence of the intertemporal budget constraint makes computing the responses of the variables in $\mathbf{Y}_t$ to innovations in $\mathbf{e}_t$ different from computing impulse responses in a standard VAR. Impulse responses comparable to those obtained from the traditional moving average representation of a VAR can be constructed going through the following steps:

- generate a baseline simulation for all variables by solving (3) dynamically forward (this requires setting to zero all shocks for a number of periods equal to the horizon up to which impulse responses are needed),
- generate an alternative simulation for all variables by setting to one–just for the first period of the simulation–the structural shock of interest, and then solve dynamically forward the model up to the same horizon used in the baseline simulation,
- compute impulse responses to the structural shocks as the difference between the simulated values in the two steps above. (Note that these steps, if applied to a standard VAR, would produce standard impulse responses. In our case they produce impulse responses that allow for both the feedback from d_{t-i} to $\mathbf{Y}_t$ and for the debt dynamics),
- compute confidence intervals.[2]

3 Does it make a difference?

To illustrate the empirical relevance of keeping track of the budegt constraint, we use (3) to analyze the effects of fiscal shocks identified in two classical studies of U.S. fiscal policy: Romer and Romer's (2007) where fiscal shocks are identified from the narrative record, and the approach to identification followed by Blanchard and Perotti (2002) and based on a structural VAR. Before doing this we describe our data.

3.1 Data

We use quarterly data for the U.S. economy since 1960:1, the sample analyzed in Blanchard and Perotti (2002) and extended to 2006:2 in Perotti (2007). Our approach requires that the debt-dynamics equation in (3) tracks the path of d_t accurately: we thus need to define the variables in this equation with some care.

The source for the different components of the budget deficit and for all macroeconomic variables are the NIPA accounts (available on the Bureau of Economic Analysis

[2]Bootstrapping requires saving the residuals from the estimated VAR and then iterating the following steps: a) re-sample from the saved residuals and generate a set of observation for $\mathbf{Y}_t$ and d_t, b) estimate the VAR and identify strucutral shocks, c) compute impulse responses going thorough the steps described in the text, d) go back to step 1. By going thorugh 1,000 iterations we produce bootstrapped distributions for impulse responses and compute confidence intervals.

website, downloaded on December 7th 2006). y_t is (the log of) real GDP per capita, Δp_t is the log difference of the GDP deflator. Data for the stock of U.S. public debt and for population are from the FRED database (available on the Federal Reserve of St.Louis website,also downloaded on December 7th 2006). Our measure for g_t is (the log of) real per capita primary government expenditure: nominal expenditure is obtained subtracting from total Federal Government Current Expenditure (line 39, NIPA Table 3.2) net interest payments at annual rates (obtained as the difference between line 28 and line 13 on the same table). Real per capita expenditure is then obtained by dividing the nominal variable by population times the GDP chain deflator. Our measure for t_t is (the log of) real per capita government receipts at annual rates (the nominal variable is reported on line 36 of the same NIPA Table).

The average cost servicing the debt, i_t, is obtained by dividing net interest payments by the federal government debt held by the public (FYGFDPUN in the Fred database) at time $t-1$. The federal government debt held by the public is smaller than the gross federal debt, which is the broadest definition of the U.S. public debt. However, not all gross debt represents past borrowing in the credit markets since a portion of the gross federal debt is held by trust funds–primarily the Social Security Trust Fund, but also other funds: the Trust Fund for Unemployment Insurance, the Highway Trust Fund, the pension fund of federal employees, etc.. The assets held by these funds consist of non-marketable debt.[3] We thus exclude it from our definition of federal public debt.

Figure 1 reports, starting in 1970:1 (the first quarter for which the debt data are available in FRED), this measure of the debt held by the public as a fraction of GDP (this is the dotted line). We have checked the accuracy of the debt dynamics equation in (3) simulating it forward from 1970:1 (this is the continuous line in Figure 1). The simulated series is virtually super-imposed to the actual one: the small differences are due to approximation errors in computing inflation and growth rates as logarithmic differences, and to the fact that the simulated series are obtained by using seasonally adjusted measures of expenditures and revenues. Based on this evidence we have used the debt dynamics equation to extend d_t back to 1950:1. (A quarterly series for d_t extending back to 1950:1 will become necessary when we compare our results with those in Romer and Romer (2007) whose sample starts just after World War II.) Figure 1 shows that this series tracks the annual debt level accurately, at least up to

[3] Cashell (2006) notes that "this debt exists only as a book-keeping entry, and does not reflect past borrowing in credit markets."

the early 1950's. [4]

[Insert Figure 1]

4 Fiscal shocks identified from the narrative record

Romer and Romer (2007) (R&R in what follows) use the U.S. narrative record–presidential speeches, executive-branch documents, and Congressional reports–to classify the size (defined as the estimated revenue effect of a new tax bill), timing, and principal motivation for all major postwar tax policy actions.[5] They then identify, among all documented tax actions, those that could be classified as "exogenous", as opposed to those that were countercyclical, *i.e.* motivated by a desire to return output growth to normal. Tax changes aimed at correcting the effects of a previous spending shock are considered endogenous. Exogenous tax changes are further divided into two groups: those that appear to be motivated by a desire to raise the potential growth rate of the economy, and those aimed at reducing a budget deficit inherited from previous administrations.

Since 1947 U.S. Federal laws changed taxes in 82 quarters. A number of these quarters had tax changes of multiple types. Among the 104 separate quarterly tax changes identified, 65 are classified as exogenous. In this Section we use these 65 tax changes (the R&R exogenous tax shocks) and ask what difference it makes if the debt channel is, or is not, included in the transmission mechanism.

R&R assess the impact of tax shocks on output [6] estimating

$$\Delta y_t = \beta_0 + \sum_{i=1}^{12} \beta_i \frac{\Delta T_{t-1}^{ex}}{Y_{t-1}} + e_t \tag{4}$$

where Δy_t is real quarterly output growth, $\frac{\Delta T_{t-1}^{ex}}{Y_{t-1}}$ are the tax shocks, measured as

[4] We are unable to build the debt series back to 1947:1, the start of the Romer and Romer sample, because data for total governemnt spending, needed to buld the debt series, are available on a consistent basis only from 1950:1.

[5] Early attempts at applying to fiscal policy the methodology proposed by Romer and Romer (1989) to identify monetary policy shocks were Edelberg, Eichenbaum and Fisher (1999), Burnside, Eichenbaum and Fisher (2004), Ramey (2006). These papers used a dummy variable which identifies characterizes episodes of significant and exogenous increases in government spending (typically wars).

[6] They estimate the effects of tax shocks on the individual components of GDP, on unemployment and inflation.

a percent of nominal GDP [7]

We assess the importance of omitting the government budget constraint by computing impulse responses to the R&R tax shocks ε^T [8] in

$$\begin{aligned} \mathbf{Y}_t &= \sum_{i=1}^{k} \mathbf{C}_i \mathbf{Y}_{t-i} + \boldsymbol{\gamma}_i \left(d_{t-1} - d^*\right) + \epsilon_t^T \\ d_t &= \frac{1+i_t}{\left(1+\pi_t\right)\left(1+\Delta y_t\right)} d_{t-1} + \frac{\exp\left(g_t\right) - \exp\left(t_t\right)}{\exp\left(y_t\right)} \end{aligned} \tag{5}$$

(5) differs from (3) for the hypothesis that the variables in $\mathbf{Y}$ respond to the deviation of d from a target, d^*. We take 0.35 as a reference value for d^*: this is the average debt ratio used as a reference value by Bohn (1998).

We find that the R&R shocks are indeed structural shocks to taxes because they are uncorrelated with all lags of the variables included in the VAR's and are significant only in the equation for t. Thus they satisfy the properties that exogenous shocks identified in a structural VAR should fulfill. [9]

4.1 Is U.S. fiscal policy stabilizing?

Before computing impulse responses to the R&R shocks we report in Table 1 the estimated coefficients on $(d_{t-1} - d^*)$ for each on the five variables in $\mathbf{Y}$ (taxes, spending, output, inflation and the cost of debt service) dividing our data into two sub-samples: 1950:1-1979:4 and 1980:1-2006:2. We do this beacuse Perotti (2007) finds that the response of fiscal policy is very different before and after 1980—and in fact we find strikingly different responses.

[7] They also experiment introducing additional controls: lags of Δy_t, monetary policy shocks, government spending, oil prices. If the tax shocks were truly exogenous these controls should not affect the esimate of the $\beta_i's$, and in fact they do not.

[8] R&R scale their shocks by the level of GDP. We scale them by taxes to allow direct comparability of the effects of these shocks with those identified in a SVAR. In a SVAR tax shocks are extracted from a specification in the logarithms of the levels of real variables. Innovations thus have the dimension of a percentage change in taxes. A one per cent change in taxes is much smaller than a one per cent shock in the tax-to-GDP ratio. The re-scaling affects the size of the effects but not the shape of the impulse responses.

[9] Including the R&R tax shocks in a VAR is a natural way of computing the dynamic response of macro variables to shocks identified outside the VAR because what matters are the impulse responses generated by the different shocks, not the correlation of the shocks themselves.VAR's have been used to compute impulse responses to shocks identified outside the VAR in the analysis of the effects of monetary shocks in Bagliano and Favero (1999).

TABLE 1						
Feedbacks from d_{t-i} (st. err in paren)						
		g_t	t_t	y_t	π_t	i_t
d_{t-1}	*1960:1—1979:4*	−5.83 (5.14)	−3.55 (2.17)	−1.59 (2.17)	−0.88 (0.71)	0.079 (0.25)
	1980:1—2006:2	−3.94 (2.58)	1.63 (4.27)	0.83 (1.06)	0.13 (0.34)	0.62 (0.32)
d_{t-2}	*1960:1—1979:4*	5.90 (5.11)	4.18 (5.89)	1.75 (2.16)	0.87 (0.72)	−0.049 (0.25)
	1980:1—2006:2	3.82 (2.60)	−1.59 (4.30)	−0.85 (1.06)	−0.14 (0.34)	−0.63 (0.33)
Δd	*1960:1—1979:4*	**−6.12** (5.04)	**−6.07** (6.22)	−2.21 (2.19)	−0.84 (0.70)	**−0.038** (0.27)
	1980:1—2006:2	**−6.48** (2.50)	**2.44** (3.97)	0.25 (0.99)	−0.12 (0.32)	**0.56** (0.30)

In all the equations, the restriction that the two coefficients are of equal magnitude and of opposite sign cannot be rejected, which suggests that the five variables respond to the lagged change in the debt ratio. The last two rows in the table report the coefficients (and their standard errors) when this restriction is imposed. For instance, government spending is reduced when the lagged change in the debt ratio is positive. The gap between the actual primary surplus (as a fraction of GDP) and the surplus that would stabilize d is measured as $(d_{t-1} - d_{t-2})$. The magnitude of the coefficient indicates that the gap between the surplus that would stabilize the debt ratio and the actual surplus acts as an error correction mechanism in the fiscal reaction-function, that is, current expenditures are decreased when the last period's primary surplus is below the level that would have kept the debt ratio stable.

The response of g_t to a change in the debt-ratio is significant after 1980, but not before. Taxes do not respond significantly to a change in the debt ratio; however, the difference between the point estimates for the two sub-periods is close to being significant, and the response is stabilizing only after 1980. The average interest cost of debt also depends on the difference between the actual surplus and the debt-stabilizing surplus. This result is particularly strong in the second sub-sample. Finally, the direct effect of lags in d_t on inflation and output is never significant in any of the samples.

In summary, before 1980, U.S. fiscal policy does not seem to have been aimed at stabilizing the debt-to-GDP ratio. This fact probably reflects the will of the government to reduce the debt ratio from the high initial level inherited after World War

II. Only after 1980 does U.S. fiscal policy become stabilizing. Using the coefficients estimated up to 1980 to simulate the effects of a current fiscal policy shock is thus inappropriate, since such a shock would put the debt ratio on a diverging path, driven by the coefficients that have been estimated on a sample characterized by a decreasing debt ratio.

The results in Table 1 prompt a question. We argue that traditional VARs are mis-specified because they overlook the possibility that fiscal policy reacts to the level of the debt ratio. In other words, the mis-specification would arise from the omission of a low-frequency variable. But according to Table 1, what matters is the change in the debt ratio, which is a high-frequency variable. However, the omission of d_t is still relevant for the following reason: the first difference of d_t is itself a (non-linear) function of d_t. Taking the first difference of the debt dynamics equation, we obtain

$$\Delta d_t = \frac{(i_t - \Delta p_t - \Delta y_t - \Delta y_t \Delta p_t)}{(1 + \Delta p_t)(1 + \Delta y_t)} d_{t-1} + \frac{\exp(g_t) - \exp(t_t)}{\exp(y_t)}. \tag{6}$$

The change in the debt ratio is equal to the difference between the actual surplus-to-GDP ratio and the ratio that would keep debt stable, which is a function of the level of the debt. Hence, the change in the debt ratio depends on the level of debt via a time-varying relationship, because the first term on the right hand side of teh equation above, the ratio of the average cost of debt financing to nominal GDP growth, varies over time. Figure 3 shows that this time variation is empirically relevant over the sample we consider. In other words, our empirical model is an error-correction model consistent with cointegration between the primary surplus and the debt-stabilizing surplus.[10] Therefore, including the change in d in a VAR is virtually equivalent to

[10] This cointegrating relation is different from those experimented with in standard SVARs. In particular, the cointegrating relation implied by (6) is different from the cointegrating relation between g_t and t_t, with a cointegrating vector $(1, -1)$, proposed in the Blanchard and Perotti (2002) robustness check. This could explain why estimating a cointegrated model, or a simple model specified in first differences, makes no substantial difference for the evidence they reporte. Of course, if the debt-stabilizing surplus were stationary, the data would support—up to a logarithmic transformation—their cointegrating vector, but the long-run solution of their cointegrating system would still be different from the one implied by a system in which there is a tight relation between the actual surplus and the debt-stabilizing surplus. The cointegrating relation implied by (6) is also different from the error-correction model proposed in Bohn (1998): Bohn includes the level of the debt ratio in the fiscal reaction function but does so without allowing for the time variation of the coefficient on the debt level.

augmenting the VAR with a time-varying function of the level of the debt-to-GDP ratio, which indeed is a slow moving variable.[11]

We now turn to the results.

4.2 The effects of fiscal policy shocks identified from the narrative record

Figures 2 and 3 show the impulse response of output to an exogenous R&R tax shock equivalent to 1% of taxes in the two susamples. The difference between the responses obtained with and without keeping track of the budget constraint is significant, particularly in the second sub-sample. This is not surprising in view of our finding that after 1980 U.S. fiscal policy has stabilized the debt-GDP ratio.

[Insert Figures 2 and 3]

5 Fiscal shocks identified in a structural VAR

We next consider the effects of the fiscal shocks identified in Blanchard and Perotti (2002) and extended in Perotti (2007) (B&P in what follows) and obtained from a structural VAR of the form

$$\mathbf{Y}_t = \sum_{i=1}^{k} \mathbf{C}_i \mathbf{Y}_{t-i} + \mathbf{u}_t \tag{7}$$

where $\mathbf{Y}$ includes the same variables that appear in (3). The government budget cosntrained and d are omittied.

Comparison of (7) with (3) riases a question.. $\mathbf{Y}$ already contains all the variables that enter the government intertemporal budget constraint that appears in (3): isn't this good enough ? Do we need to insert the debt level directly? Why are the impulse responses biased if the model does not explicitly include d and the identity describing its evolution over time?

The reason why d cannot be dropped is that it is unlikely that the short lags of g, t, π, Δy and i that enter (linearly) a VAR that does not include d and the budget

[11] As a robustness check, we have re-estimated (5), by augmenting it with the debt-stabilizing surplus-to-GDP ratio lagged once and twice. The coefficients on the two lags were of the same sign and their sum was not statistically different from the coefficient on the first difference of d, our proposed model.

constraint can trace the evolution of the debt ratio accurately enough. To convince yourself notice that d_t is the result of a long and non-linear lag dynamics

$$\begin{aligned} d_t &= \sum_{i=0}^{K} \left(\frac{\exp(g_{t-i}) - \exp(t_{t-i})}{\exp(y_{t-i})} \right)^i \prod_{i=o}^{K} \left(\frac{1+i_{t-i}}{(1+\pi_{t-i})(1+\Delta y_{t-i})} \right) + \\ &+ \prod_{i=o}^{K} \left(\frac{1+i_{t-i}}{(1+\pi_{t-i})(1+\Delta y_{t-i})} \right) d_{t-K-1} \end{aligned}$$

5.1 Identification

SVAR's identify fiscal shocks imposing restrictions that allow the two structural fiscal shocks (to taxes and government spending, respectively) to be recovered from the reduced form residuals, $\mathbf{u}$. The innovations in the reduced form equations for taxes and government spending, u_t^g and u_t^t, contain three terms: *(i)* the response of taxes and government spending to fluctuations in macroeconomic variables, such as output and inflation, that is implied by the presence of automatic stabilizers; *(ii)* the discretionary response of fiscal policy to news in macro variables and *(iii)* truly exogenous shifts in taxes and spending, the shocks we wish to identify. B&P exploit the fact that it typically takes longer than a quarter for discretionary fiscal policy to respond to news in macroeconomic variables: at quarterly frequency the contemporaneous discretionary response of fiscal policy to macroeconomic data can thus be assumed to be zero. To identify the component of u_t^g and u_t^t which corresponds to automatic stabilizers they use institutional information on the elasticities of tax revenues and government spending to macroeconomic variables. They thus identify the structural shocks to g and t by imposing on the $\mathbf{A}$ and $\mathbf{B}$ matrices in $\mathbf{Au} = \mathbf{Be}$ the following structure [12]:

$$\begin{bmatrix} 1 & 0 & a_{gy} & a_{g\Delta p} & a_{gi} \\ 0 & 1 & a_{ty} & a_{t\Delta p} & a_{ti} \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^t \\ u_t^y \\ u_t^{\Delta p_t} \\ u_t^i \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \begin{bmatrix} e_t^g \\ e_t^t \\ e_t^1 \\ e_t^2 \\ e_t^3 \end{bmatrix}$$

[12] Mountford and Uhlig (2002) identify government spending and revenue shocks by imposing restrictions on the sign of impulse responses. Fatas and Mihov (2001) rely on a simple Choleski ordering.

where e_t^i $(i = 1, 2, 3)$ are non-fiscal shocks and have no structural interpretation. Since a_{gy}, $a_{g\Delta p}$, a_{gi}, a_{ty}, $a_{t\Delta p}$ and a_{ti} are identified using external information [13], there are only 15 parameters to be estimated. As there are also 15 different elements in the variance-covariance matrix of the 5-equation VAR innovations, the model is just identified. The e_t^i $(i = 1, 2, 3)$ are derived by imposing a recursive scheme on the bottom three rows of $\mathbf{A}$ and $\mathbf{B}$; however, the identification of the two fiscal shocks–the only ones that we shall use to compute impulse responses–is independent of this assumption. Finally, the identification assumption imposes $b_{12} = 0$. [14] [15]

5.2 Debt dynamics implied by the B&P shocks in a model without BC

To assess the importance of omitting d, we start with a simple exercise. After having estimated the parameters $\mathbf{C}_i$ in (7), that is with no debt and budget constraint, we use the identity that describes debt accumulation to simulate the system out-sample for 80 quarters, starting from the conditions prevailing in the last observation of the

[13] The elasticities of taxes and government spending with respect to output, inflation and interest rates used in the identification have been updated in Perotti (2007) and are

Elasticities of government revenues and expenditures						
	a_{gy}	$a_{g\Delta p}$	a_{gi}	a_{ty}	$a_{t\Delta p}$	a_{ti}
Entire sample	0	-0.5	0	1.85	1.25	0
1960:1-1979:4	0	-0.5	0	1.75	1.09	0
1980:1-2006:2	0	-0.5	0	1.97	1.40	0

[14] B&P provide robustness checks for this assumption by setting $b_{21} = 0$ and estimating b_{12}. We have also experimented with this alternative option. In practice, as the top left corner of the $\mathbf{B}$ matrix is not statistically different from a diagonal matrix, the assumption $b_{12} = 0$ is irrelevant to determine the shape of impulse response functions.

[15] Although we use the same identifying assumptions, our choice of variables differs slightly from those used in B&P, because, as discussed above, we need to use variables that allow the debt dynamics equation to track the path of d_t accurately. In particular, our measure of i is the average cost of debt financing rather than the yield to maturity on long-term government bonds used in B&P. Our definitions of g and t are also slightly different: we follow the NIPA definitions by considering net transfers as part of government expenditure, rather than subtracting them from taxes. To check that our slight differences in data definitions do not change the results we have first estimated a VAR without a budget constraint, as in B&P. The impulse responses we have obtained are consistent with those reported in B&P.

estimation period. The path for d_t so construced reveals the steady-state properties of the estimated empirical model.

When the model is estimated over the first sub-sample (1960:1–1979:4), the simulated out-of-sample path for d_t diverges (Figure 4). When it is estimated over the second sub-sample (1980:1–2006:2) the simulated debt ratio tends, eventually, to fall below zero.

This exercise naturally raises a number of questions and observations:

- does the apparent instability depend on the underlying behavior of the government, or is it simply the result of a mis-specified model? Debt stabilization requires that the primary budget surplus reacts to the accumulation of debt, but such a reaction—if it were in the data—would not be captured by a VAR that omits d and the budge constraint. Hence the simulated path may very well be the result of a mis-specification of the empirical model rather than a description of the actual behavior of the government;

- it is obviously difficult to interpret impulse-response functions when these are computed along unstable paths for the debt ratio, as these will eventually diverge. Ustable dynamics become particularly problematic when the effects of fiscal shocks are computed over relatively long horizons, or when identification is obtained by imposing long-run restrictions on the shape of impulse responses. This is not the case in the identification by B&P, that is achieved by imposing restrictions on the simultaneous effects of fiscal policy shocks. However, the interpretation of the responses to shocks along an unstable debt path remains problematic;

To better address these questions, we now turn to the model described in (5).

[Insert Figure 4]

5.3 Debt dynamics implied by B&P shocks with a BC

Figure 5 reports out-sample simulations of d_t obtained from (5). In the second sub-sample, allowing $\mathbf{Y}_t$ to respond to past debt growth stabilizes the path of d_t. This is not the case in the first sub-sample, though this is not surprising, since in Table 1 we have found that the feedbacks from d_t to g_t and t_t only become significant after 1980.

Thus, omitting feedback from the debt level to fiscal policy can result in impulse responses to fiscal shocks that are based on biased estimates and are computed along

implausible paths for the debt ratio. Whether including such a feedback effect is sufficient to produce stable debt paths obviously depends on the size of the feedback effects. If they are too small—as they were in the United States up to the early 1980s—unstable debt paths will not be eliminated.

[Insert Figure 5]

5.4 The effects of fiscal shocks identified by B&P

Figures 6 and 7 compare the impulse responses obtained from a SVAR that keeps track of the effects of the shocks on d, and one that does not [16]

Figure 6.a refers to the first sub-sample, 1960:1–1979:4; Figure 7 refers to 1980:1–2006:2 In each figure, the left-hand panels refer to a 1 percent shock to g; while the right-hand panels refer to an equivalent shock to t. In each column, the graphs show, from top to bottom, the impulse response of g, t, y, inflation, and the average cost of debt service. Dotted lines refer to the model *with* the budegt constraint, the continuous line refers to the model *without* a budget constraint. The reported 95 percent confidence bounds are for the impulse responses *with* a budget constraint.

Before 1980, when U.S. fiscal policy does not respond to d

- following a shock to g, or t, keeping track of the effect of the shock on debt results in a larger response of interest rates (outside the 95 percent confidence bounds)
- positive shocks to g have a positive (temporary) effect on output. Positive shocks to t have a negative and more persistent effect on output. But the effects of these shocks is not significantly different in the two models

These effects are not surprising since we found that in this sub-sample U.S. fiscal policy was not stabilizing. Where absence of stabilization should make a difference is on interest rates, and in effect it does.

After 1980, when fiscal policy is stabilizing

- in the model with a budget constraint g shocks are less persistent

[16] The response of the variables in $\mathbf{Y}_t$ to the level of debt may be non-linear. This the finding of the literature cited in the introduction. To allow for this possibility we have experimented with a specification in which $(d_t - d^*)$ is replaced by $(1 + \exp(d^* - d_t))$.The results, reported in the last two Figures of the paper, are not very different from those obtained assuming linearity.

- t respond to shocks to g so as to stabilize the debt: an increase in g (left panel) is accompanied by an icresae in t, but the effect is not signiifcantly different in the two models

- this is not the case for the response of g to a t shock. Keeping track of the budget constraint results in a stronger stabilizing response of g (although spending only rises over time), statiscally different from the case when the budget constraint is omitted

- following a positive shock to g, output rises. The effect on output of t shocks is not signiifcant. .

Table 2 complements the result in Figures 4 by computing the cumulative response of interest rates and aggregate output to a fiscal shock over three time horizons, (4, 12, and 20 quarters) and comparing these results with the responses estimated in the absence of a debt feedback effect.

The main difference between a model with and without a feedback is observed in the first sub-sample, when fiscal policy is not stabilizing: following a 1 percent g shock,the response of interest rates, accumulated over 20 quarters, is 0.118 in the model with a feedback effect, 0.032 without. The response of output to the same g shock is positive and significant when you overlook the budget constraint, not significant when you keep track of the effect of the g shock on d—possibly because of the larger reposnse of interest rates..

[Insert Figures 6 and 7]

[Insert table 2]

6 Conclusions

We have analyzed the effects of fiscal shocks keeping track of the effects of such shocks on macro variables and on the accumulation of public debt. We have shown that overlooking the government budget constraint, or linearizing it, can result in incorrect estimates of the effects of fiscal shocks.

7 References

Alesina, A. and R. Perotti [1995]: “Fiscal Expansions and Adjustments in OECD Countries”, *Economic Policy*, October 1995

Bagliano, Fabio and C. Favero [1999]: "Information from financial markets and VAR measures of monetary policy", *The European Economic Review*, 43, 825-837.

Blanchard, Olivier and R. Perotti [2002]: "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*

Bohn, Henning [1998]: ”The Behaviour of U.S. public debt and deficits”, *Quarterly Journal of Economics,* 113, 949-963.

Burnside, Craig, M. Eichenbaum and J.D.M. Fisher [2003]: “Fiscal Shocks and Their Consequences”, NBER Working Paper No 9772

Cashell, Brian W. [2006]: "The Federal Government Debt: its size and economic significance" CRS Report for Congress.

Chung Hess and D.Leeper [2007] "What has financed government debt?" NBER WP 13425

Edelberg, Wendy, M. Eichenbaum and J. D.M. Fisher [1999]: ”Understanding the Effects of a Shock to Government Purchases”, *Review of Economics Dynamics*, pp.166-206, 41

Fatás, Antonio and I. Mihov [2001]: ”The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence”, mimeo, INSEAD

Giavazzi, Francesco and M. Pagano [1990]: "Can Severe Fiscal Contractions Be Expantionary? Tales of Two Small European Countries", *NBER Macroeconomics Annual*, 1990, pp. 75-122.

Giavazzi, Francesco, T. Jappelli and M. Pagano [2000]: "Searching for Non-Linear Effects of Fiscal Policy: Evidence from Industrial and Developing Countries", *European Economic Review*, 44, no. 7, June.

Mountford, Andrew and H. Uhlig [2002]: ”What Are the Effcets of Fiscal Policy Shocks?” CEPR Discussion Paper 3338

Perotti, Roberto [1999], "Fiscal Policy in good and Bad Times", *Quarterly Journal of Economics*, November 1999

Perotti, Roberto [2007]: “In Search of the Transmission Mechanism of Fiscal policy"; *NBER Macroeconomic Annual*, forthcoming

Ramey, Valerie [2006]: "Identifying Government Spending Shocks: It's All in the Timing", revised, July 2008

Romer, Christina and David H. Romer [1989]: "Does Monetary Policy Matter? A new test in the spirit of Friedman and Schwartz" in Blanchard, O. and S. Fischer, (eds.), *NBER Macroeconomics Annual*, Cambridge, MIT Press, 4, 121-170

Romer, Christina and David H. Romer [2007]: The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks", NBER WP 13264, July .

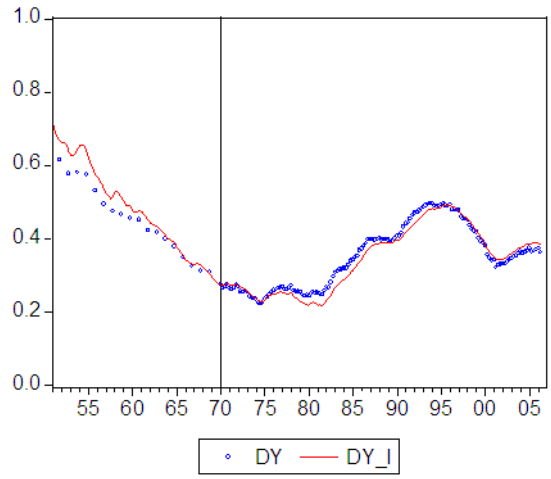


Figure 1:

Debt-GDP ratio: actual and simulated

Actual data (dotted line) at quarterly frequency from 1970 onward, at yearly frequency before 1970. Simulated data (continuous line) built using the government intertemporal budget constraint with actual data and initial conditions given by d in 1970:1.

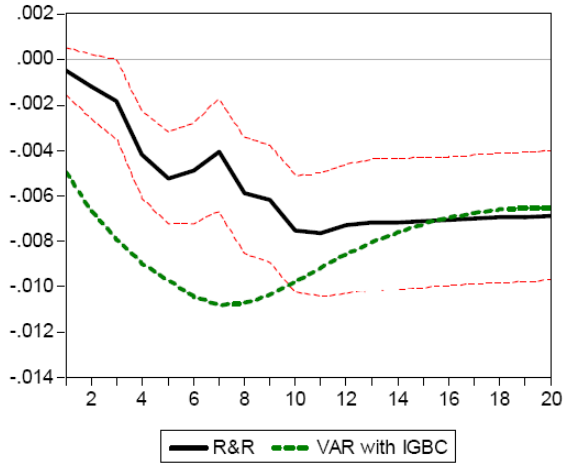


Figure 2:

Response of output to an R&R tax shock with (dotted line) and without (continuous line) a budget constraint: 1950:1-1980:4 (top panel) and 1981:1-2006:2 (bottom panel)

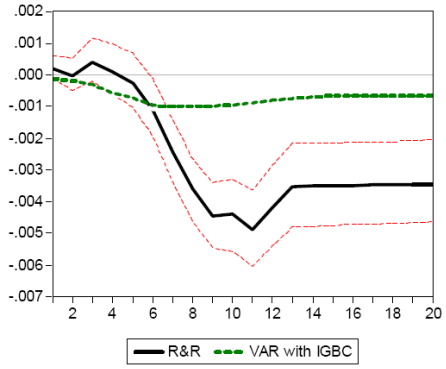


Figure 3:

Response of output to an R&R tax shock with (dotted line) and without (continuous line) a budget constraint: 1981:1 - 2006:2

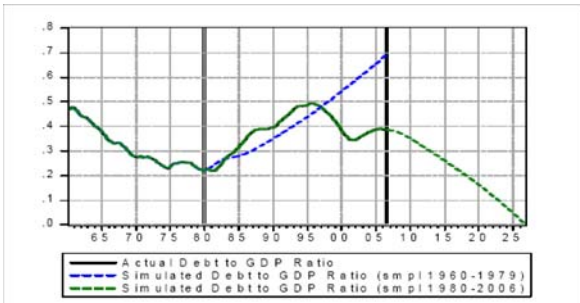


Figure 4: Actual and Simulated out-of sample (starting from conditions in 1980:1, and in 2006:2) debt-GDP dynamics. Simulation are based on BP SVARs without the IGBC estimated on 1960-1979 and 1980-2006

Figure 4:

Out-of-sample debt dynamicsOut-of-sample debt dynamics

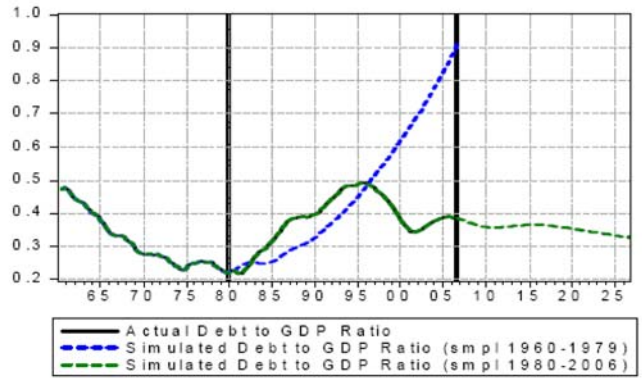


Figure 5: Actual and Simulated out-of sample (starting from conditions in 1980:1, and in 2006:2) debt-GDP dynamics. Simulation are based on BP SVARs with the IGBC estimated on 1960-1979 and 1980-2006

Figure 5:

Linear feedback

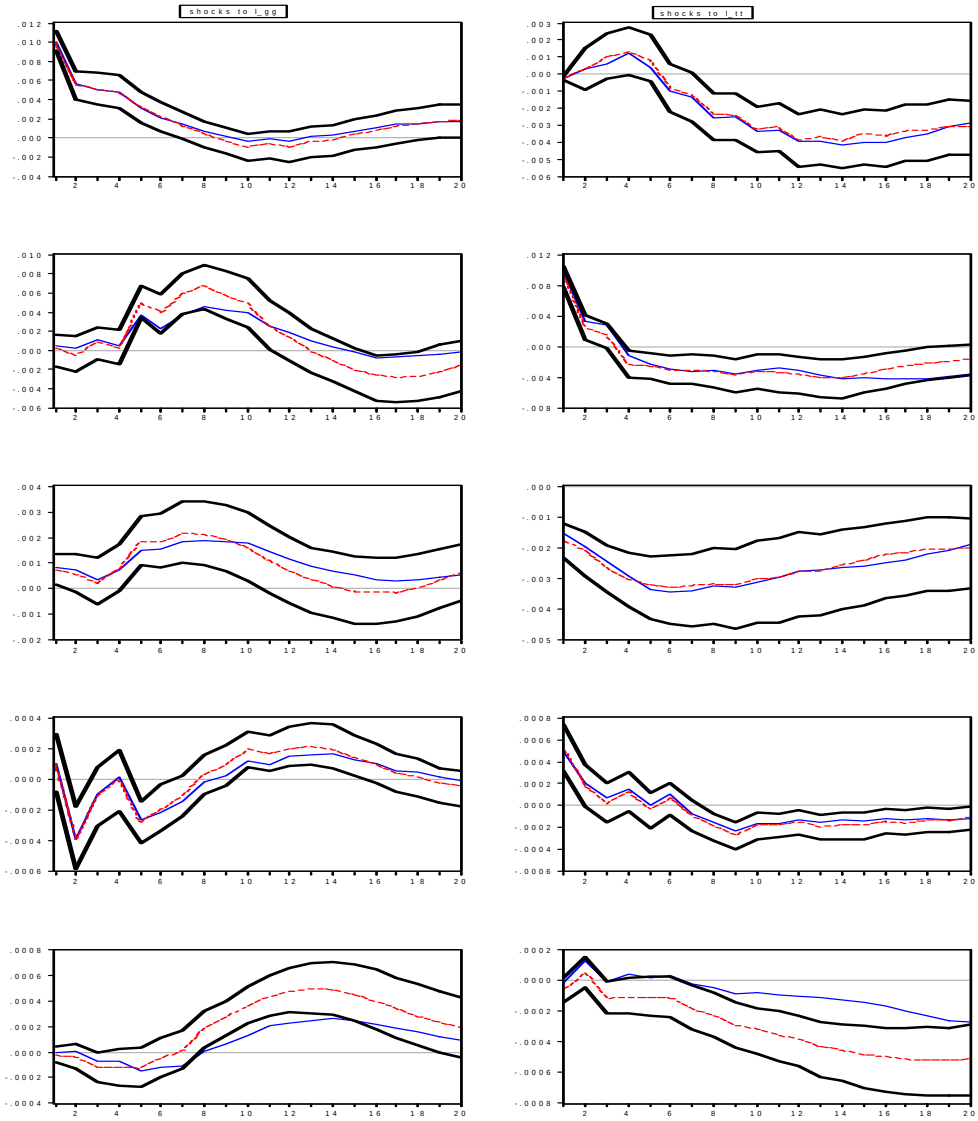


Figure 5.1: Fiscal shocks identified from a SVAR (solid line) and in model with feedbacks (dotted line). Sample 1960:1 1979:4. The first column shows responses to shocks to g_t; the second column to shocks to t_t.The responses reported along the rows refer, respectively, to the effects on g_t, t_t, y_t, Δp_t, i_t.

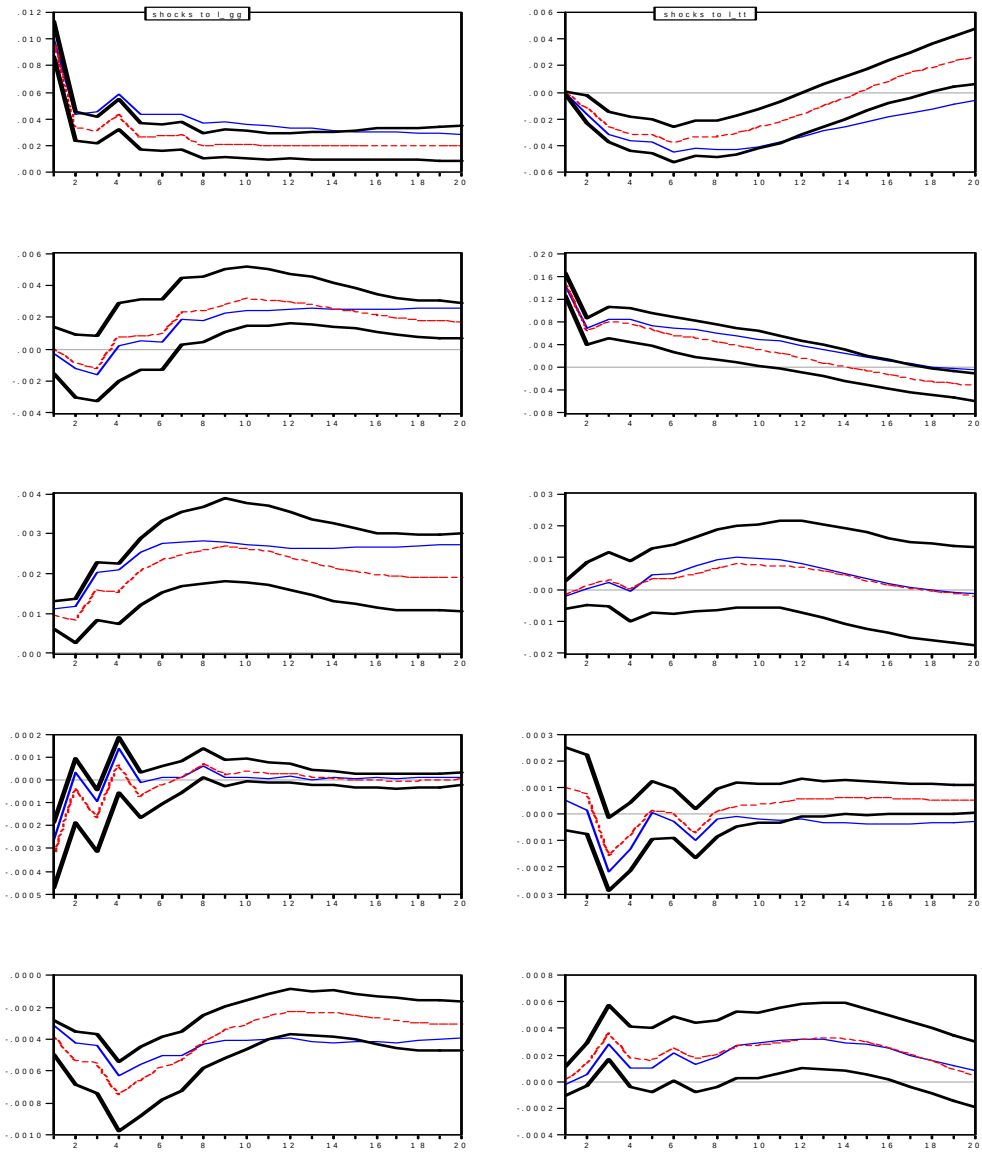
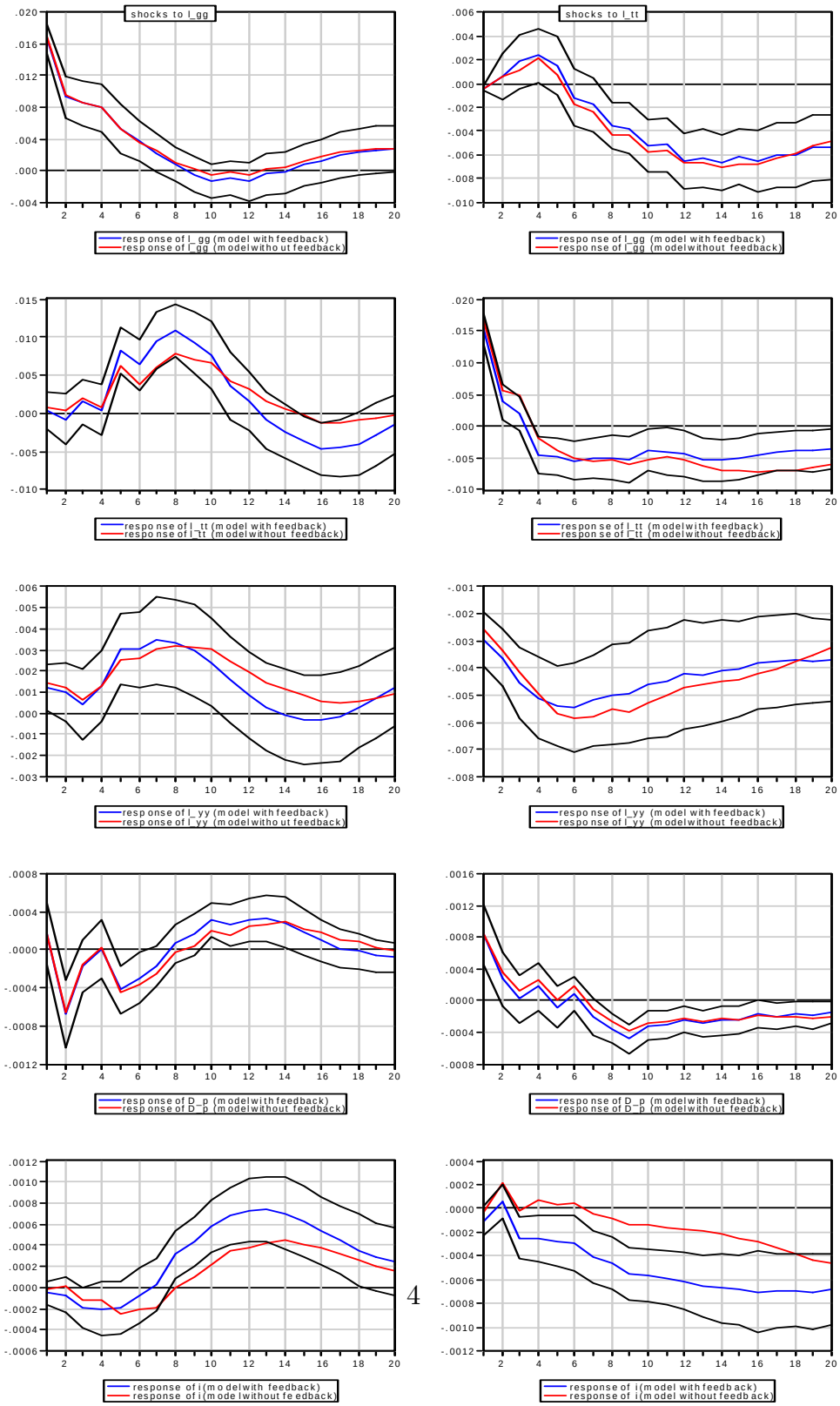
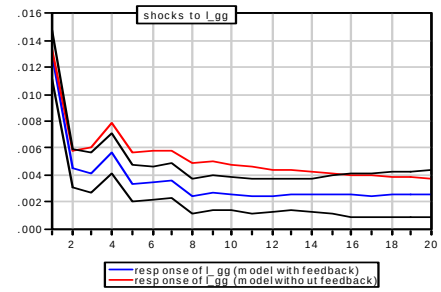
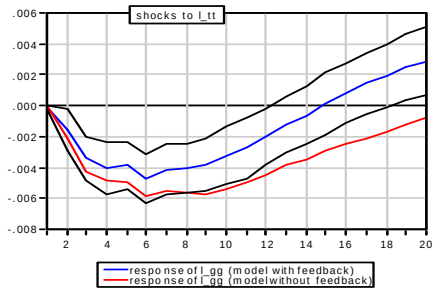


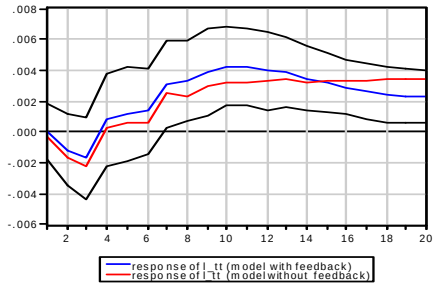
Figure 5.2: Fiscal shocks identified from a SVAR (solid line) and in model with feedbacks (dotted line). Sample 1980:1 2006:3. The first column shows responses to shocks to g_t; the second column to shocks to t_t.The responses reported along the rows refer, respectively, to the effects on g_t, t_t, y_t, Δp_t, i_t.

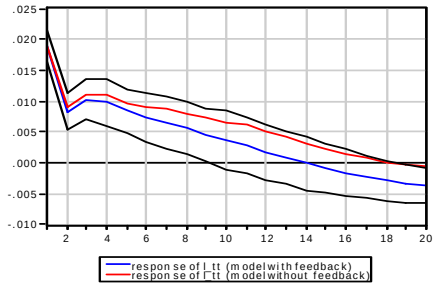
Non-Linear feedback

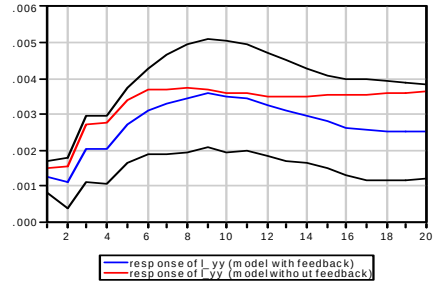

shocks to l_gg
response of l_gg (model with feedback)
response of l_gg (model without feedback)
shocks to l_tt
response of l_gg (model with feedback)
response of l_gg (model without feedback)
response of l_tt (model with feedback)
response of l_tt (model without feedback)
response of l_tt (model with feedback)
response of l_tt (model without feedback)
response of l_yy (model with feedback)
response of l_yy (model without feedback)
response of l_yy (model with feedback)
response of l_yy (model without feedback)
response of D_p (model with feedback)
response of D_p (model without feedback)
response of D_p (model with feedback)
response of D_p (model without feedback)
response of i (model with feedback)
response of i (model without feedback)
response of i (model with feedback)
response of i (model without feedback)

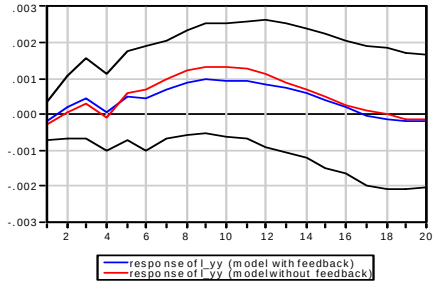

shocks to l_gg
response of l_gg (model with feedback)
response of l_gg (model without feedback)

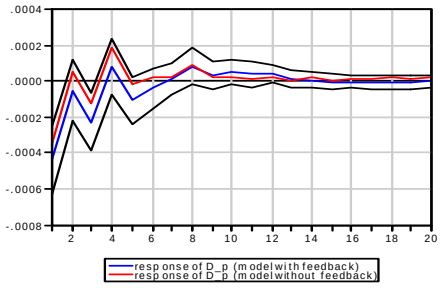

shocks to l_tt
response of l_gg (model with feedback)
response of l_gg (model without feedback)

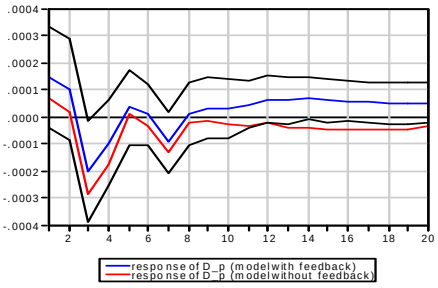

response of l_tt (model with feedback)
response of l_tt (model without feedback)

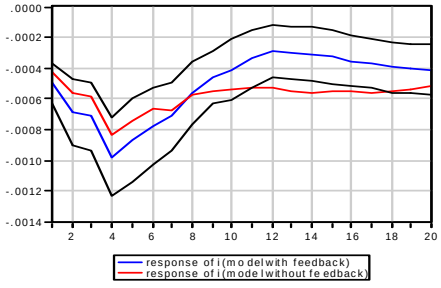

response of l_tt (model with feedback)
response of l_tt (model without feedback)

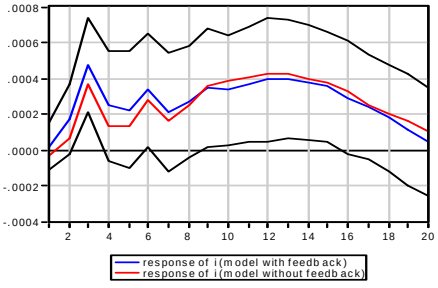

response of l_yy (model with feedback)
response of l_yy (model without feedback)


response of l_yy (model with feedback)
response of l_yy (model without feedback)


response of D_p (model with feedback)
response of D_p (model without feedback)


response of D_p (model with feedback)
response of D_p (model without feedback)


response of i (model with feedback)
response of i (model without feedback)


response of i (model with feedback)
response of i (model without feedback)