Fiscal multipliers : different instruments, different phases of the business cycle, different policies

Fiscal Multipliers: Different Instruments, Different Phases of the Business Cycle, Different Policies

Andreas Zervas

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I declare that this my own work.

Andreas Zervas

To my family, especially my Katherines and Eleanna.

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Abstract

In this thesis I explore the effects of fiscal policy, on the main macroeconomic variables, particularly in the form of fiscal multipliers, mostly from an empirical but also from a theoretical perspective. The second chapter explores several issues concerning the workings of fiscal policy: the first is whether it is possible to identify proper spending shocks, overcoming potential problems caused by anticipation of policy from the private sector; it turns out it is. The second issue is what are the effects of different spending variables on the economy, and it turns out that civilian spending has beneficial effects, while military investment leads to output contraction. The second issue, taken up in chapter three, is to decipher the effects of both government spending and taxes in the different phases of the business cycle. It turns out that useful public spending has positive effects on economic activity, particularly in periods of low growth, and that spending is more powerful to stabilize the economy than taxes. Proper policy action appears to be necessary to make sense of the results. However, the current methods to identify fiscal shocks have several shortcomings, and a method to achieve better identification is proposed in chapter four. The econometric results verify that spending shocks have positive effects on the economic activity, while tax shocks negative, and that the spending multiplier appears to be bigger in absolute value than the tax multiplier, casting doubt on the relevance of several economic theories as well as policy prescriptions. The size of both multipliers depends on policy. In addition, no deterioration over time of the power of spending to stabilize the economy is visible. Finally, in chapter 5 a simulation of a baseline DSGE model gives some guidelines on how policy may affect economic outcomes.

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Chapter 1

Introduction

1.1 Motivation

It is hard to overstate the practical importance of knowing what are actually the effects of fiscal policy in the economy. As the recent crisis has shown, there are limitations to the ability of central banks to stabilize the economy, and important fiscal action was necessary in several countries in order to exit the recession; this is much more evident in the case of EMU, where in some countries the crisis is far from over. However, the way economists and policy makers think about the effects of fiscal policy is not uniform: one may encounter totally different views, all claiming to be correct. In the last decade there was a significant increase in the number of researchers trying to shed light on the issue. It is only the last few years that a consensus seems to form, that fiscal policies may have important effects on the economy and is a policy tool worth trying if needed.

A very important concept in macroeconomics, inherited from Keynesian theory, is the one of the multipliers. It is the change in output generated by the change in the policy variable, spending[1] or taxes. Its size is of extreme importance: are spending multipliers big enough to be worth using active fiscal policies in recessions? Which policy variable has the highest multiplier is an extremely important question - should the government increase spending or cut taxes in recessions? The size is also important to understand how fiscal policy works: for example, a spending multiplier higher than one means that private spending increases after a government spending increase, typically crowding in consumption, while a multiplier lower than one signifies the opposite; a multiplier less

[1] Throughout this thesis spending is the expenditure on goods and services (government consumption and/or investment, including wages), but not transfers, like pensions or unemployment benefits.

than one might mean that the fiscal action under consideration should not be taken, since such an action would probably reduce the welfare of society. These are probably the most important issues in understanding the effects of fiscal policy. Estimating these output multipliers is the most important issue in this thesis, and it is done in ways that differ in several aspects from what has been typically done in the literature so far.

There are many important questions, especially for policy-making, concerning the effects of fiscal policy on the economy, beyond those stated previously. One that has not been answered so far, at least not thoroughly, is the following: what are the effects of different spending variables on the economic activity? This is one of the basic questions this thesis tries to address, and taken up in chapter 2, where several econometric models are used including not only total spending in goods and services, as is customary in the literature, but also its main components. As will become evident there, which spending variable is increased matters a lot: civilian spending of all kinds has strong expansionary effects on the economy; on the contrary defense spending, in particular expenditure for weapons (defense investment in the U.S. data), has recessionary effects on output.

Another issue with fiscal policy is that since fiscal institutions are slow to react, there is plenty of time left to agents to adjust their behavior before the actual change in the spending or tax variables occur. It is argued that one of the reasons typical SVAR techniques find positive effects on spending shocks, especially on consumption, is the existence of fiscal foresight: agents can anticipate spending changes, and adjust their behavior beforehand - they reduce their consumption before the actual spending increase occurs; then what the VAR actually estimates is the positive reaction of consumption, as the economy returns to the long-run equilibrium. The problem of fiscal foresight, if it is present, does not allow reliable estimates of fiscal policy effects, at least in the way it is customarily done in the literature, which uses Structural Vector Autoregressions. This is another issue taken up in chapter 2, where it is shown that this is not a major problem in U.S. data, and therefore SVAR techniques can give reliable results in this case.

Another very important question, especially for policy-making, is whether there are different effects of fiscal policies during different economic conditions. One particular way to put forward this question, of the most important ones admittedly, is to ask what are the effects of fiscal policy during the different phases of the business cycle -

are e.g. spending increases more effective during recessions, as Keynesian theory and common sense (at least among many policy makers) suggest? More specifically, the previous questions about the sizes of fiscal multipliers, both of aggregate variables and their constituents, can be asked over the business cycle. This issue is taken up in chapter 3, where it is shown that important non-linearities exist in the data and that spending multipliers are probably higher than those of taxes, and both are higher (in absolute value) in recessions.

Many of the disputes over the effects of fiscal policy stem from the inability to find proper exogenous shocks, or good enough instruments, to estimate the contemporaneous effects of fiscal policy. This is particularly evident in the case of taxes; it is notoriously difficult to estimate the tax multiplier, because in the data taxes are very highly correlated with GDP, so are mostly driven by the cyclical movements of output. Blanchard and Perotti (2002) were the first who actually developed a convincing methodology to estimate the cyclical movement of taxes based on institutional information outside the model, but after the work of Romer and Romer (2010), the literature has moved toward seeking plausible exogenous instruments to estimate tax effects and multipliers. However, not any of these methods is flawless, as will be shown later.

This issue, along with the underlying one about the size of fiscal multipliers, is the focus of chapter 4. There a different identification method is used, based on the separation of structural shocks hitting the economy in permanent and transitory. This method allows to generate instruments that can be used for the estimation of contemporaneous relations. The results of this econometric analysis suggest that spending multipliers are higher, and they depend on policy. Also, tax multipliers are lower than those of spending, and that the results of several recent papers estimating tax multipliers are not robust.

Another important issue, particularly relevant now days that many countries are trying to reduce debt, is whether it is possible to consolidate without too much pain. In an famous paper, Alesina and Perotti (1995) advocated that a fiscal consolidation based on spending cuts is preferable to tax increases, since the former has a negative effect on interest rates, that lead to increases in private sector's investment and consumption. Naturally, such a view considers government spending as predominantly useless, and reducing it does not deteriorate the equilibrium of the economy. The results in chapters

3 and 4 suggest that this theory is not likely to hold in reality, at least for the part of government spending regarding goods and services; it might hold for transfers and pensions, but this is an issue not taken up in this work.

Further, the stability of the effects of spending and tax policies and of the relevant multipliers, is of particular importance from both a theoretical and a practical point of view. Perotti (2004a) argued that spending multipliers have reduced after 1980, probably because of more aggressive monetary policy towards inflation, but other explanations based on the fall on the number of credit constrained consumers because of financial liberalization or increased openness are possible.

This thesis is also motivated from the opposing views in economic theory about the effects of fiscal policy shocks. There are two fundamental views among academics about the operation of the economy. The first one is the equilibrium - Real Business Cycle approach, for which fiscal policy is ineffective, due to the presence of Ricardian Equivalence, and possibly even leading to bad economic outcomes, especially when the yardstick to measure the policy is individual welfare; the stronger effects of fiscal policy, mostly if taxes are distortionary, may come from the supply side of the economy, by altering people incentives to work and save. On the other hand, Keynesian theory asserts that fiscal policy, and particularly government spending, is a very powerful tool to stabilize the economy, particularly during deep recessions - government should act as the spender of the last resort. These two views are in accord in the issue of output response to government spending increases, which is positive in both cases, but differ in their predictions about the consumption response: RBC theory suggests it is negative because of the negative wealth effect, Keynesian that it is positive.

These models have different assumptions about the transmission mechanism of fiscal policy. The typical neoclassical model, and most of current DSGEs, predict that spending has a multiplier lower than one, since the increase in useless government consumption (that will eventually lead to higher taxes) forces consumption to fall. This is unlike the results of the majority of SVAR studies, which predict that consumption rises after increases in spending. It takes a different mechanism to generate a positive consumption response; most common mechanisms to generate this effect are a) the addition of rule-of-thumb consumers in an NK model in a sufficient proportion to give such an effect, or b) the assumption that government spending generates some positive externality to the

productivity of the private sector, or c) a utility function that assumes non-separability of consumption with either government spending or labor. The tax multiplier naturally depends heavily on the nature of taxes in the model: a lump-sum tax has very different effects compared to a distortionary income tax. This thesis contributes in this discussion by setting up models to replicate the basic estimated effects in the empirical parts of chapters, using non-standard modeling elements to achieve the desired responses. A transmission mechanism used in this thesis to get the desired responses depends on policy: even with a model that deviates only slightly from the basic RBC or NK model in what concerns fiscal policy, the operation of this policy alone, in the form of proper fiscal rules, can go a long way into generating the observed responses. This is a feature that adds realism, and makes some explanations offered so far redundant.

1.2 Literature Review

1.2.1 Different ways to calculate responses to innovations in fiscal policy

1.2.1.1 The exogenous shocks method

The first way to see the effects on the economy required the existence of a variable that constitutes a plausible unexpected / exogenous shock to fiscal policy. Naturally, this kind of variable solves the identification problem that is present in all econometric models. But such shocks are hard to come by. The only big exogenous events are wars, that were scarce in post-WW2 data for developed countries that have trustworthy and long time series, and even these do not capture all aspects of fiscal policy actions.

Assuming such exogenous shocks exist and are observable to the econometrician, one can use fairly standard techniques to assess their effect on the economy. A natural macroeconometric model for this task would be a VARX model, a VAR model augmented with the exogenous shocks variables[2]. Schematically, these models can be described in the following way; estimate a reduced form VARX:

$$\mathbf{Y_t} = \mathbf{A}(L)\mathbf{Y_{t-1}} + \mathbf{B}(L)\mathbf{X_t} + \mathbf{U_t},\ \mathbf{U_t} \sim iid(\mathbf{0}, \Sigma)$$

[2]The interested reader could see the details on good time series books like Lütkepohl (2005), especially chapter 10.

where $\mathbf{Y_t}$ is the vector of n endogenous variables, $\mathbf{X_t}$ is the vector of the m exogenous shock variables, and $\mathbf{U_t}$ the residuals, $\mathbf{A}(L)$ and $\mathbf{B}(L)$ are polynomials in the lag operator with orders p and q respectively; other exogenous or deterministic variables are ignored for expositional purposes. To see the effects of the shocks on the endogenous variables of the system, one can form the augmented companion matrix $\mathbf{A}$ and the impact matrix $\mathbf{B}$ of the system:

$$\mathbf{A} = \left[\begin{array}{cccc|cccc} A_1 & ... & A_{p-1} & A_p & B_1 & ... & B_{q-1} & B_q \\ I_n & \cdots & 0 & 0 & 0 & \cdots & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & I_n & 0 & 0 & \cdots & 0 & 0 \\ \hline & & & & 0 & \cdots & 0 & 0 \\ & & 0 & & I_m & \cdots & 0 & 0 \\ & & & & \vdots & \ddots & \vdots & \vdots \\ & & & & 0 & \cdots & I_m & 0 \end{array}\right], \mathbf{B} = \left[\begin{array}{c} B_0 \\ 0 \\ 0 \\ 0 \\ \hline I_m \\ 0 \\ 0 \\ 0 \end{array}\right]$$

With these matrices, IRFs can be constructed in the same way as those of the shocks to the endogenous variables.

1.2.1.2 The SVAR identification method

When one estimates a VAR, the errors are in general contemporaneously correlated. However, the VAR can be thought of as the reduced form of a more general, structural model which allows for contemporaneous correlation of the endogenous variables, but with shocks uncorrelated both intertemporally and among them during the same period; usually one is interested in the effects of these shocks, the so called structural shocks, to the endogenous variables[3]. Formally, suppose that the true model is:

$$\mathbf{C_0 Y_t} = \mathbf{C}(L)\mathbf{Y_{t-1}} + \mathbf{E_t} = \textstyle\sum_{\mathbf{i=1}}^{\mathbf{p}} \mathbf{C_i Y_{t-i}} + \mathbf{E_t}$$

but since the matrix $\mathbf{C_0}$ will not be known in general, the researcher has to estimate the reduced form VAR and use some restrictions in order to identify the parameters of the true structural model. So one estimates:

$$\mathbf{Y_t} = \mathbf{A}(L)\mathbf{Y_{t-1}} + \mathbf{U_t} = \textstyle\sum_{\mathbf{i=1}}^{\mathbf{p}} \mathbf{A_i Y_{t-i}} + \mathbf{U_t} = \textstyle\sum_{\mathbf{i=1}}^{\mathbf{p}} \mathbf{C_0^{-1} C_i Y_{t-i}} + \mathbf{C_0^{-1} E_t}$$

[3]For the interested reader an excellent exposition of the structural VAR topic is chapter 9 of Lütkepohl (2005).

and imposes some appropriate restrictions in order to estimate the true coefficient matrices and find the effects of the structural shocks. Typically $\mathbf{E_t} \sim iid(\mathbf{0}, \mathbf{I})$ and $\mathbf{U_t} \sim iid(\mathbf{0},\Sigma)$.

The SVAR method mainly rests on imposing enough restrictions to ensure a decomposition of the variance - covariance matrix of the residuals from the VAR - with k variables one needs to impose $\frac{k(k-1)}{2}$ restrictions on $\mathbf{C_0}$ or $\mathbf{C_0^{-1}}$ to identify the "true" shocks, in addition to the covariance restrictions, so that $\mathbf{C_0 U_t} = \mathbf{E_t} \Leftrightarrow \mathbf{U_t} = \mathbf{C_0^{-1} E_t}$ is satisfied; this problem is generally solved by maximizing numerically the log-likelihood of the model where the restrictions are imposed.

The most commonly used restrictions to identify structural errors is the (lower) Cholesky factorization of the variance – covariance matrix of the estimated residuals; so $chol(\Sigma)$=$\mathbf{C}_0^{-1}$, and each column of the generated matrix has the effect of a (hopefully) structural shock to the endogenous variables.

This method imposes a recursive pattern of causality in the same period; the first variable is not affected by any other in a given period of time (but can be affected in the following periods), the second can be affected only by the first in that period, and so on. Off course, this pattern depends on the way the variables are ordered in the VAR, so one can not estimate unique impulse response functions for the fiscal policy shock under any ordering. It is considered quite reliable for spending shocks when the spending variable is ordered first, since government spending is pretty much predetermined within the same period, at least when transfers are excluded so that it only contains spending on goods and services. It is the most commonly used method in the literature. Needless to say, other patterns are possible, but this one is the most common and seems to be quite reasonable for spending shocks.

A more general SVAR model is the (in the terminology of chapter 9 of Lütkepohl (2005)) so called AB model. This model implies this relation between the VAR residuals $\mathbf{U_t}$ and the structural errors $\mathbf{E_t}$: $\mathrm{A}\mathbf{U_t} = \mathrm{B}\mathbf{E_t} \Rightarrow \mathbf{U_t} = \mathrm{A}^{-1}\mathrm{B}\mathbf{E_t} = \overline{\mathrm{B}}\mathbf{E_t}$. Using covariance restrictions, one can only identify $\frac{k(k+1)}{2}$ parameters on matrices A and B, the same number as in the model of the previous paragraphs, so typically one assumes that either A or B is equal to $\mathbf{I}(k)$ and works with a B or an A model or, in the terminology of the previous paragraphs, with $\mathbf{C}_0^{-1}$ or with $\mathbf{C_0}$.

1.2.1.3 The Blanchard and Perotti approach to identification

Another commonly used approach in the estimation of SVAR models in the literature related to the effects of fiscal policy shocks employs an alternative, although very similar, identification method, pioneered by Blanchard and Perotti (2002). This method uses external information in order to identify some of the parameters of $\mathrm{A} = \mathbf{C}_0$ and produce the correct responses to a fiscal policy shock. The exposition below follows Perotti (2004a), who estimated more general versions of the model used in the original Blanchard and Perotti paper.

The procedure is roughly the following. First estimate the reduced form model described above; in most papers time trends and quarterly dummies are added in the specification, as in the original application of the methodology. Suppose $\mathbf{Y}_t = [g_t, t_t, y_t, \pi_t, i_t]'$ (government purchases, taxes less transfers, GDP, inflation and an interest rate – the first three variables in logs), and $\mathbf{U_t} = [u_t^g, u_t^t, u_t^y, u_t^\pi, u_t^i]'$. $\mathbf{U}_t$, the residuals of each equation can be thought of as linear combinations of the residuals from the other equations and the structural residuals for this equation, and in the case of each fiscal variable the structural residual of the other fiscal variable may also affect it. So the residuals can be represented in equation form as (ε_t^i is the structural residual of the *ith* equation):

$$u_t^g = \alpha_{gt} u_t^t + \alpha_{gy} u_t^y + \alpha_{g\pi} u_t^\pi + \alpha_{gi} u_t^i + \varepsilon_t^g$$

$$u_t^t = \alpha_{tg} u_t^g + \alpha_{ty} u_t^y + \alpha_{t\pi} u_t^\pi + \alpha_{ti} u_t^i + \varepsilon_t^t$$

$$u_t^y = \alpha_{yg} u_t^g + \alpha_{yt} u_t^t + \alpha_{y\pi} u_t^\pi + \alpha_{yi} u_t^i + \varepsilon_t^y$$

$$u_t^\pi = \alpha_{\pi g} u_t^g + \alpha_{\pi t} u_t^t + \alpha_{\pi y} u_t^y + \alpha_{\pi i} u_t^i + \varepsilon_t^\pi$$

$$u_t^i = \alpha_{ig} u_t^g + \alpha_{it} u_t^t + \alpha_{iy} u_t^y + \alpha_{i\pi} u_t^\pi + \varepsilon_t^i$$

Naturally, the structural policy shocks should enter directly in the VAR equations for the policy residuals – the fiscal authority knows the shocks. Additionally, assuming a recursive ordering in the three equations for the non–policy variables (so that output is not affected contemporaneously by inflation and interest rates but only by policy shocks and its own structural shock, inflation is affected at a given period by all variables except the interest rate, which is affected by all shocks contemporaneously – however this ordering is immaterial for the calculation of the effects of fiscal policy shocks) these equations can be written as:

$$u_t^g = \alpha_{gy} u_t^y + \alpha_{g\pi} u_t^\pi + \alpha_{gi} u_t^i + \beta_{gt} \varepsilon_t^t + \varepsilon_t^g$$

$$u_t^t = \alpha_{ty} u_t^y + \alpha_{t\pi} u_t^\pi + \alpha_{ti} u_t^i + \beta_{tg} \varepsilon_t^g + \varepsilon_t^t$$

$$u_t^y = \alpha_{yg} u_t^g + \alpha_{yt} u_t^t + \varepsilon_t^y$$

$$u_t^\pi = \alpha_{\pi g} u_t^g + \alpha_{\pi t} u_t^t + \alpha_{\pi y} u_t^y + \varepsilon_t^\pi$$

$$u_t^i = \alpha_{ig} u_t^g + \alpha_{it} u_t^t + \alpha_{iy} u_t^y + \alpha_{i\pi} u_t^\pi + \varepsilon_t^i$$

The key to computing the values of the elasticities in the equations of policy variables is to realize that due to decision and implementation lags, there is no systematic discretionary response within the same quarter, so whatever value these elasticities (of government spending with respect to output, inflation and interest rates, α_{gj}, and those of taxes with respect to these variables, α_{tj}, $j = y, \pi, i$) have is due to the automatic stabilizers – the automatic response of budget components to economic activity, and can be calculated with using external information, e.g. on the tax system; for example, Perotti (2004a) gives the following values for the US: $\alpha_{gy} = \alpha_{gi} = 0$, $\alpha_{g\pi} = -0.5$, $\alpha_{ty} = 1.85$, $\alpha_{ti} = 0$, $\alpha_{t\pi} = 1.25$. As it is evident, the validity of this approach relies critically on the availability of quarterly (or higher frequency) data; with lower frequency data, it is more difficult to defend the assumption of no systematic discretionary response within the same time period. One can then perform the following operation and calculate the cyclically adjusted residuals:

$$u_t^{g,ca} = u_t^g - \alpha_{gy} u_t^y - \alpha_{g\pi} u_t^\pi - \alpha_{gi} u_t^i = \beta_{gt} \varepsilon_t^t + \varepsilon_t^g$$

$$u_t^{t,ca} = u_t^t - \alpha_{ty} u_t^y - \alpha_{t\pi} u_t^\pi - \alpha_{ti} u_t^i = \beta_{tg} \varepsilon_t^g + \varepsilon_t^t$$

Then what is left is to find the values of β_{gt} and β_{tg} in order to achieve exact identification; the solution to this problem is to assume that one of them is zero; in that case the structural error is equal to the cyclically adjusted residual. This structural error can be used as instrument to estimate the relevant β in the other equation; luckily, the values of β_{gt} and β_{tg} turn out to be small, so ordering of fiscal variables makes little difference for the results. Proceeding further, one can use the structural errors as instruments in IV regressions to calculate the elasticities with respect to fiscal shocks in the output equation, then in the inflation equation and finally in the interest rate equation; this

way the elasticities from these estimations are used to form the impact vector for the structural shocks[4]. This identification is written in the general AB framework as:

$$\mathrm{A}=\begin{bmatrix} 1 & 0 & 0 & -\alpha_{g\pi} & 0 \\ 0 & 1 & -\alpha_{ty} & -\alpha_{t\pi} & 0 \\ -\alpha_{\mathrm{yg}} & -\alpha_{\mathrm{yt}} & 1 & 0 & 0 \\ -\alpha_{\pi\mathrm{g}} & -\alpha_{\pi\mathrm{t}} & -\alpha_{\pi\mathrm{y}} & 1 & 0 \\ -\alpha_{\mathrm{ig}} & -\alpha_{\mathrm{it}} & -\alpha_{iy} & -\alpha_{i\pi} & 1 \end{bmatrix}, \qquad \mathrm{B}=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \beta_{\mathrm{tg}} & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}.$$

Afterwards, it is a standard procedure to calculate the impulse response functions and assess the effects of fiscal policy shocks to the macroeconomic variables of the system. Comparing this method with the Cholesky ordering, it is evident that the latter imposes many elasticities of fiscal variables to the rest to be zero. It is also evident that it corresponds to Cholesky identification of the cyclically adjusted residuals.

1.2.1.4 The sign-restrictions approach

The last approach used to identify fiscal policy shocks is due to Uhlig. It is a general approach and rests on imposing restrictions on the sign of the impulse response functions, e.g. that the response of GDP to a tax shock (increase) must be negative. This approach can be summarized in the following way (see Mountford and Uhlig (2009) and Caldara and Kamps (2008)).

First estimate the VAR specification; the assumption is that reduced form and structural residuals are linked by the equation $\mathbf{U_t} = \mathbf{BE_t}$, where $E(\mathbf{U_t}\mathbf{U_t}') = \Sigma$ and $E(\mathbf{E_t}\mathbf{E_t}') = \mathbf{I}$; it is worth noting that $\mathbf{E_t}$ usually has less elements than $\mathbf{U}_t$, meaning that the number of structural shocks is less than that of the reduced form residuals/the number of the variables. Then one has to decompose $\mathbf{B}$ as if $\mathbf{B} = \mathbf{PQ}$, where $\mathbf{P}$ is the lower Cholesky factor of Σ and $\mathbf{Q}$ is any orthonormal matrix such as $\mathbf{QQ}' = \mathbf{I}$. $\mathbf{Q}$ is the crucial matrix; its columns carry the weights needed to identify the structural errors.

The identifying assumptions in Mountford and Uhlig (2009) are that for four quarters after any shock variables have to move in a specific manner: a business cycle shock must comove positively with revenues and output and its components; a monetary policy shock must move in the same direction with the interest rate, but must comove negatively

[4] Alternatively, one can directly estimate their effects on the other variables using (under the assumption of uncorrelated structural shocks) OLS regressions of the residuals on the structural shocks, to get the first 2 columns of the relevant $\overline{\mathrm{B}} = \mathrm{A}^{-1}\mathrm{B}$ matrix.

with reserves and prices; a revenue shock must comove positively with revenue and a spending shock must comove positively with spending. Afterward, one has to bootstrap the model to generate impulse responses, from which he/she will retain the ones that satisfy the sign restrictions by means of minimizing a loss function for the deviations of responses from the restrictions, and by imposing that the identified structural shocks are orthogonal with each other.

However, sign restrictions also have some drawbacks. Fry and Pagan (2005) argue against using such restrictions uncritically, indicating that they constitute weak restrictions and consequently give weak information which may not allow one to actually recover true impulses. In addition, Fry and Pagan (2011) argue that it is not good practice to identify single shocks with sign restrictions, since it is likely that one may mix responses to structural shocks that share some common characteristics - alternatively one might need to use restrictions on many variables and for more periods, a modelling decision that would also raise some concerns; sign restrictions are more likely to work better if one tries to identify several structural shocks, and contemporaneous restrictions are likely to work better in policy issues, where an institutional setting is likely to provide credible contemporaneous restrictions for a single structural shock. Paustian (2007) found that sign restrictions typically work better if a) many shocks are identified at the same time and b) these shocks exert a significant influence on the main variables of the VAR; this latter requirement is less likely to be satisfied in the case of fiscal policy, since fiscal (especially spending) shocks are not expected to exert a significant influence on the main macro variables.

1.2.2 A brief introduction in the literature

1.2.2.1 General

Many studies, most of them quite recent and focusing on U.S., try to estimate the effects of fiscal policy shocks in the economy. Most of these studies estimate some form of a (linear) VAR model; each of these studies follows one of the available methodologies described in the previous section. Each methodology uses a different way to identify fiscal policy shocks; in practice, differences boil down to different ways to extract a shock, since the residuals from the VAR mix "true" shocks with the automatic response of budget variables to the state of the economic activity at a particular period; this is

mostly important for taxes, since most of spending is predetermined, and only transfers (mainly unemployment benefits) vary with the economic activity. A good reference for describing the methodologies is Caldara and Kamps (2008), and a comprehensive survey of the results of all methodologies is Ramey (2011b).

The first identification method rests on exogenous shocks to military spending to identify spending shocks; it was pioneered by Ramey and Shapiro (1998), and followed by Edelberg et al (1999) and Burnside et al (2004); the authors estimate models using dummies for the dates these build-ups started, in particular dummies for the third quarter of 1950 (1950:3 - Korea War), the first quarter of 1965 (1965:1 - Vietnam War), the first quarter of 1980 (1980:1 - Reagan build-up) and the third quarter of 2001 (2001:3 - 9/11) - shocks are just giving the value of one to the dummy. The papers adopting the narrative approach find that in response to a war dummy, output rises significantly and persistently, consumption of non-durables and services is not affected very much, contrary to consumption of durables and residential investment, which fall sharply. Spending shocks cause prices and interest rates to rise.

In addition, Romer and Romer (2010) have compiled a series of tax shocks; their sources are the proceedings of the U.S. legislature - shocks are classified as exogenous, that are legislated for ideological reasons, or endogenous that come as reactions to the economic situation. Higher taxes have a big negative effect on output, especially in consumption of durables, while non-durables and services consumption is not affected that much; taxes imposed to decrease the deficit have smaller contractionary effects. Ramey (2011a) assembles a new dataset for defense spending shocks, constructed in a narrative way similar to the one used in the previous paper, and confirms the results coming from the war dates dummies. As it is evident, the findings of this method for spending increases mostly resemble those of an RBC model. These two series are used in the present work.

The SVAR method mainly rests on imposing enough restrictions to ensure a decomposition of the variance - covariance matrix of the residuals from the VAR, as described in the previous subsection. The seminal papers are Blanchard and Perotti (2002) and Fatás and Mihov (2001), who find that a spending shock increases both output and consumption. Fatás and Mihov find that prices fall after a spending shock, and the real interest rate increases. These results in general have been confirmed by Galí et al (2007),

Caldara and Kamps (2008) and Perotti (2004a and 2007) among others. In addition, Perotti (2004a) has shown that the effect of spending shocks on output diminishes after 1980, possibly due to increased responsiveness of monetary policy to inflation, while the interest rate is not affected much; in addition to the behavior of central bank, Bilbiie et al (2008) attribute some of the effect on the fall of the number of credit constrained consumers because of financial liberalization, while Canzoneri et al (2012) argue that it may be partially explained by the increase in openness. Lately, in an innovative paper, Fisher and Peters (2010), confirmed the results of SVAR methodology using excess stock returns of major U.S. military contractors as instruments.

Some papers have used sign restrictions to identify fiscal shocks; this methodology in essence restricts the shape of the IRFs. Mountford and Uhlig (2009) found that a spending shock has a very small, positive yet significant effect on GDP in the first year that turns insignificantly negative later, but causes no reaction in consumption; it also has a negative effect on inflation and the interest rate. In general their results resemble those of the SVAR approach and give more support to some aspects of the Keynesian model. Forni and Gambetti (2010a) also use this identification method in the context of a dynamic factor model; their results are closer to the typical Keynesian effects (as are their identification restrictions).

Other papers with interesting results are Perotti (2004b), Tenhofen and Wolff (2010) and Caldara and Kamps (2008). In the first the author tries to find whether public investment has stronger positive effects on output compared to public consumption - the answer he gives is negative; especially defense investment[5] seems to have adverse effects. Public consumption is more stimulative for output, perhaps because western countries have too much public infrastructure. In the second paper the authors try to see whether anticipation matters for the effects of government spending on the economy; they find that although defense expenditures have the expected (for non-Keynesians) negative effect on consumption, civilian spending has a positive one, and these effects do not depend, at least qualitatively, on whether anticipation is taken into account. In the third, the authors try to compare the different identifications on similar models for a variety of macroeconomic variables; they find mostly Keynesian effects for government spending that are hard to reconcile with DSGE models, and diverging results for taxes

[5]Here defense investment is used as in U.S. data - it includes weapon purchases.

depending highly on identifying assumptions. In addition, Mertens and Ravn (2010) confirm the conclusion of Tenhofen and Wolf (2010) and Blanchard and Perotti that anticipation does not bias the results of SVARs for fiscal policy.

As mentioned before, the main channel through which government spending shocks operate in the economy in DSGE models is the negative wealth effect on agents: government demands to consume more resources, which it takes from agents; these agents are now poorer and have to work more (if taxes are lump-sum, so they do not affect labor supply decisions) and consume less. If taxes are distortionary (so that the Ricardian equivalence is not active), possible choices to work less (if tax rates increase to finance spending) only work to reenforce the negative wealth effect of spending on the budget constraints of the private sector. Important papers that develop models on these lines are Aiyagari et al (1992) and Linemmann and Schabert (2003). These papers imply that the output multiplier of government spending is less than 1, since private consumption (and probably investment) fall, and could become negative if labor supply falls because higher tax rates induce people to work less.

This need not be the case in general. There are various ways to generate positive consumption responses, if the researcher believes that such an outcome is appropriate. First, government spending may work like a productivity shock, and increase the production of the private sector; notable contributions utilizing this idea are Baxter and King (1993) and Linnemann and Schabert (2006); a similar idea is present in the work of Devereux, Head and Lapham (1996), where the role of productivity is played by the entry of new firms in the economy - as the government spends more, it facilitates more firm entry, increasing the capital stock of the economy and eventually productivity.

These are not the only ways to achieve such an outcome. Galí et al (2007) resort to the presence of non-optimizing agents in the economy that consume all their available income; if their number is big enough, and wages increase for some reason after the spending shock (e. g. non competitive labor markets), then a positive response of consumption is possible. Another way to do it is to force people consume more by specifying their preferences appropriately: if labor or government spending enters the utility function in a non-separable way with consumption, it is possible to generate this effect; Linnemann (2006 and 2009) uses this mechanism. Finally, Ravn, Schmitt-Grohé and Uríbe (2006) manage to get this effect by their deep habit mechanism; this particular

preferences specification generates countercyclical mark-ups that are strong enough to overcome the wealth effect. Theory has provided a lot of different ways to setup a model that generates many kinds of potentially desired effects of government spending shocks.

Lately, some papers have conducted counterfactual experiments comparing the response of more than one DSGEs used by international organizations or central banks - typically these models assume (and calibrate or estimate) that a fraction of population is not optimizing and simply consumes all its income (rule-of-thumb consumers). Coenen et al (2012) give spending multipliers for a temporary spending increase between 1 and 2, depending on the existence of monetary accommodation. Cogan et al (2010) report multipliers to permanent spending increases of less than one, similar to those of the previous paper in the permanent case. Freedman et al (2010), using IMF's GIMF model, report multipliers from 0 to 2 depending on the fiscal instrument used and the presence of monetary accommodation. As it is evident, there is enough theory to accommodate many empirical results.

1.2.2.2 Effects over the business cycle

Lately, because of the recent crisis, the focus turned towards the estimation of nonlinear models that try to estimate the effects of fiscal policy shocks during different regimes. Most of these papers use small threshold VARs (TVARs) with few variables, usually not more than 4, typically including a spending and a tax variable, a variable to describe the economic activity (usually output) and possibly another variable. The length limitations of available quarterly time series data allow the estimation of only 2 regimes[6], even in the US that has the longest time series available. In addition, identification is typically done employing familiar SVAR techniques, like Cholesky decompositions or the Blanchard and Perotti method.

The first paper that sought to find whether fiscal policy has different effects during low and high interest rates was the one by Choi and Devereux (2005). They used TVARs for US data and found that significant nonlinearities exist, especially for interest rates and inflation; they do not allow for endogenous regime switching and no output multipliers are reported. With low real interest rates expansionary fiscal policy (spending) raises output, consumption and taxes, while in a high real interest rate environment

[6] An exception is Choi and Devereux (2005) who use 3 regimes.

expansionary fiscal policy does not stimulate much, and may even have negative effects. Interest rates rise after a spending shock only in the low interest rate regime, while they fall in the high rate environment; inflation rises after a spending shock only in the low interest rate regime.

The closest papers in spirit to the present work (specifically with the work in chapter 3) is the one by Auerbach and Gorodnichenko (2010) and Baum and Koerster (2011). In the first paper, the authors try to answer essentially the same question for the US employing a different technique - they use Bayesian methods to estimate their Smooth Transition Vector Autoregressive model, a recursive identification and a mixture of linear Impulse Response Functions (IRFs) to look at the effects during recessions and expansions. They find important nonlinearities on the effect of fiscal policy (spending) shocks over the cycle – spending shocks are considerably more effective during recessions (bigger multipliers), and the multiplier can reach even 1.5 in their baseline model. They use forecasts of fiscal policy variables, the inclusion of which in the specification increases the size of multipliers. In the second paper they also use similar techniques, but for German data, and find that spending increases are more effective during recessions (multiplier > 1 and rising with the magnitude of the spending shock), while it is rather ineffective during expansions; tax policy is not that effective, but it is slightly more effective during expansions.

Candelon and Lieb (2010) and Fazzari, Morley and Panovska (2010) also try to estimate the effects of fiscal policy shocks during expansions and recessions for the US. The authors of the first paper use a threshold VECM and find that spending is more effective than taxes during recessions in stimulating output; spending drives output, consumption and wages up but prices and interest rates down – investment falls shortly; additionally, tax shocks decrease output, consumption and investment in recessions but do not react in booms; prices go up. The authors of the second paper find typical SVAR effects in both regimes: after a spending shock output and consumption increase, but investment does not fall – it increases in both regimes; government spending affects output more during recessions – consumption rises more during these periods – investment increases also during recessions; additionally, a tax cut raises output, consumption and investment in low regime, and these variables rise by less in the high regime; however, their model is a fiscal SVAR for each regime, with no endogenous switching between states.

Some more papers use the same methods in several countries. Similarly to the previous papers (and the present work), Batini et al (2012) and Baum et al (2012) try to look for the effects of spending and taxes, in expansions and recessions and find higher multipliers in recessions. Both find that tax multipliers are lower than the ones of spending, suggesting that fiscal consolidations in recessions concentrated on spending are likely to be a bad idea since they are likely to suppress output even more; if necessary, it is best to implement them gradually and not frontloading the spending cuts. Both papers find high heterogeneity across countries in their estimated multipliers, suggesting that other things like openness or the extent of automatic stabilizers may affect results; in most cases they find higher spending multipliers than those of taxes, reaching values close to 2 in several cases in recessions, and higher multipliers of both policy variables in recessions.

Finally, two more papers try to estimate the effects of fiscal policy shocks in different regimes, where the regimes are defined in a different way. Afonso, Baxa and Slavic (2011) look at the effects of fiscal policy during periods of financial stress. They find positive effects of government spending shocks; the effects are similar in both regimes, multipliers are generally low but higher during the 2008-09 crisis – the multipliers increased in general after 1990 (more important financial crises). Deàk and Lenarčič (2010) try to find how the economy reacts when the government debt is high or low; in the low-debt regime spending drives output up while taxes drive it down; on the contrary, in the high-debt regime spending drives output down and taxes drive it up; however, their chosen threshold variable (debt-to-GDP ratio) is so slow moving and does not change regimes often, so it should make their model behave more like a structural break model, with the threshold variable replacing time.

Some recent theoretical papers trying to explain the higher multipliers in recessions. Christiano et al (2011) develop a model in which spending multipliers are larger when the interest rate has hit the zero lower bound. Canzoneri et al (2011) develop a model based on the asymmetry generated by financial frictions over the business cycle - these countercyclical frictions make the consumption of borrowers rise more after a spending shock during recessions, and create big multipliers. Another paper that tries to explain the apparent non-linearities of the business cycle is Eggertsson and Krugman (2012), where the forced deleveraging during recessions help to explain the empirical findings.

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Chapter 2

The Effects of Government Spending Components

2.1 Introduction

There are many important questions, especially for policy-making, concerning the effects of fiscal policy on the economy. One that has not been answered so far, at least not thoroughly, is the following: what are the effects of different spending variables on the economic activity. This is the basic question this chapter tries to address. This is done by using several SVAR models, in which the relevant spending variable is not only total spending in goods and services, as is customary in the literature[1], but also its main components. As will become evident later on, which spending variable is increased matters a lot: civilian spending of all kinds has strong expansionary effects on the economy; on the contrary defense spending, in particular expenditure for weapons (defense investment in the U.S. data), has recessionary effects on output. Typically, economists do not expect such reactions, even when public spending is useless. To show a possible way to generate such an effect, I develop a DSGE to account for the most important results.

A potential problem of econometric models of fiscal policy is the so called fiscal foresight: since fiscal institutions are slow to react, there is plenty of time left to agents to adjust their behavior before the actual change in the spending or tax variables occur;

[1] A short summary of the available evidence on the effects of fiscal policy is available in section 1.2.2.1 in introduction.

therefore, agents can anticipate spending changes, and adjust their behavior beforehand - e.g. they reduce their consumption before the actual spending increase occurs, so what the VAR actually estimates is the positive reaction of consumption, as the economy returns to the long-run equilibrium. This is one of the major arguments against using SVAR techniques for fiscal policy. To this end, I use a recently proposed method by Forni and Gambetti (2010b) that essentially tries to find whether these shocks are forecastable when agents can use all the available information. It turns out that this is not a major problem in U.S. data.

The remaining of the chapter is structured in the following way. Section 2.2 describes the data, and presents the tests for the sufficiency of the information contained in the structural shocks generated by each identification method. Section 2.3 presents the effects of the different spending variables in the U.S. economy. In section 2.4 a DSGE model is developed and calibrated to account for the basic results. Section 2.5 concludes.

2.2 Assessing the appropriateness of fiscal shocks

2.2.1 The data

The data used are for the U.S.; the data frequency is quarterly; the sample covers 1960q1 to 2006q4. The choice of the sample is made in the light of the discussion in Blanchard and Perotti (2002) who argue that the 50's are not expected to be from the same stochastic process as the rest of the series because of the Korean war and the large increase in taxes to finance that war, and especially Perotti (2007) who discusses about the effects of including the Korean War on the results under different identification assumptions. Consistently with this paper, Caldara and Kamps (2008) find that different identification methods produce similar results, once differences in sample and included variables are eliminated. For these reasons, I have opted to use similar specifications that always include some basic macroeconomic variables, and the aforementioned common sample.

Most data series come from the National Income and Product Accounts (NIPA) tables, published by the Bureau of Economic Analysis[2]; additional sources are St Louis FED's FRED® database[3] for the interest rate, unemployment and the wage rate.

[2]Available at http://www.bea.gov/national/nipaweb/index.asp.
[3]Available at http://research.stlouisfed.org/fred2/.

In particular the following series from the NIPA tables are used. At first the main macro variables, namely real total output, real total private consumption and real total private investment. The main government spending variable[4] is total government spending on goods and services, in particular total government consumption and investment (includes federal defense and and non-defense spending and state and local spending, but excludes transfers); additionally, I use two more spending variables, total civilian (non-defense, without transfers) and total defense spending (both include government consumption and investment) on good and services. Furthermore, I split government spending to total consumption and its civilian and defense counterparts, as well as total, civilian and defense government investment. The tax variable is total net taxes, calculated as the sum of personal taxes, taxes on production and imports, corporate taxes and social security contributions minus transfers, for total government (federal and state and local). Inflation is the annualized quarterly GDP inflation rate (first difference of log GDP deflator), and the nominal interest rate is the federal funds rate. The labor market variables are the unemployment rate and the real compensation per hour in the non-farm business sector. All the above variables (except unemployment, wage, inflation and the interest rate) are in logs of the real per capita relevant variables, where the deflator used is the relevant deflator for each variable, except the fiscal variables, which are deflated by the GDP deflator. Population has been calculated by dividing nominal GDP by nominal per capita GDP. All series are seasonally adjusted at annual rates by the source.

In the following sub-sections, I use the first 10 principal components from U.S. data. The data used for calculating these principal components come from Stock and Watson (2008)[5], and have been transformed to quarterly frequency; in addition, several quarterly variables have been added to the dataset, including output components, deflators, major spending and tax variables from the NIPA tables.

2.2.2 Ways to assess the usefulness of fiscal shocks

In a series of recent papers Forni and Gambetti (2010a,b) proposed a procedure to test whether a VAR can be used to recover the structural shocks of interest or not. The

[4]The government spending and tax variables are similar to those used by Perotti (2004).
[5]Available at: http://www.princeton.edu/~mwatson/publi.html.

method is based on the fact that a VAR model is limited in its capacity to include information - with 4 lags, the typical length in quarterly data, one can hardly use more than 6 - 8 variables in the model; after this point, the estimates are likely to be problematic with the current post-war macroeconomic datasets. However, there are many variables omitted, and these variables may contain useful information.

In this view, the first thing a researcher should do is to assess the information sufficiency of the model; in practice, this means to check whether important variables are omitted. Since this is difficult to do with each specific variable, the authors suggest to use the principal components estimated from the large datasets available: if (some of) these factors Granger-cause the endogenous variables, then the equations for these variables do not contain all the relevant information. This condition has nothing to do with identification - to identify "true" shocks, one has to be sure that at least the model contains all the relevant information. If it is rejected, then the researcher can estimate a dynamic factor model or a FAVAR (a VAR augmented with factors). A natural objection to this procedure would be that it is very likely that the model still contains a lot of variables and coefficients, and that with the factors one is not absolutely certain what he/she estimates - factors give good summaries of the data for forecasting, but not explanations.

However, even in situations in which informational sufficiency is rejected, it may still be possible that a subset (one or more) of the structural shocks can be recovered. This happens when the structural shock(s) is orthogonal to the lagged factors, which means that the structural shock is unforecastable. This implies a simple testing procedure for a particular shock: perform the desired SVAR analysis to get the A and B matrices of structural coefficients of the (more general structural model now) similarly to the previous chapter; then obtain the structural shock of interest - $\mathrm{A}\mathbf{U_t} = \mathrm{B}\mathbf{E_t} \Rightarrow \mathbf{E_t} = \mathrm{B}^{-\mathbf{1}}\mathrm{A}\mathbf{U_t}$. Then if one regresses the *jth* structural shock (the *jth* row of $\mathbf{E_t}$) on the lagged factors, the significance of the F statistic from this regression allows one to see the whether the structural shock is forecastable - an insignificant F statistic does not reject the null of orthogonality, and the researcher can use the estimated structural shock for inference.

In a similar context, this is the way Ramey (2011) used to assess the suitability of the VAR residuals from the spending equation to be used as structural shocks - instead

of factors, she used the news shocks she constructed[6] from the Survey of Professional Forecasters. Perotti (2011) argues forcefully against the suitability of these news shocks for the intended purpose, by noting that these forecasts are essentially useless, so the news shocks are simply the growth rate of spending and should be expected to be correlated with the VAR residuals from the spending equation. Nevertheless, Mertens and Ravn (2010), Tenhofen and Wolf (2010) and Blanchard and Perotti (2002) all conclude that anticipation is not likely to be a major problem for spending shocks.

2.2.3 Identification Assumptions

In this Chapter I use most of the identification methods described in section 1.2.1, and in particular I use a Cholesky decomposition of the variance - covariance matrix of residuals, with government spending ordered first, the Blanchard - Perotti method, and I also use Ramey's (2011) exogenous defense shock series; in the next section it will be shown that forecast errors for spending from the Survey of Professional Forecasters (SPF) do not constitute proper fiscal shocks, so I will not use them in section 2.3 to draw conclusions.

When I utilise the exogenous defense spending shocks, the augmented companion and impact matrices of section 1.2.1.1 are used. The Cholesky identification implies a B model (in the terminology of Chapter 9 of Lütkepohl (2005), $\mathbf{U}_t = \mathrm{B}\mathbf{E}_t$, since A = I($k$)) with the following pattern for a model with 6 variables and spending ordered first:

$$\mathrm{B}=\begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & b_{66} \end{bmatrix}.$$

The first column of the B matrix has the initial responses to the spending shock (since the latter has a unit variance). The Blanchard - Perotti identification implies an AB model $\mathrm{A}\mathbf{U}_t = \mathrm{B}\mathbf{E}_t$ that (for a model with 6 variables with spending ordered first, taxes

[6]These government spending news shocks are the difference between the forecasts and the actual spending in the next period.

second, output third, inflation fourth and 2 other variables) leads to a matrices with the same pattern as in section 1.2.1.3, and specifically the following ones:

$$\mathrm{A} = \begin{bmatrix} 1 & 0 & 0 & -\alpha_{g\pi} & 0 & 0 \\ 0 & 1 & -\alpha_{ty} & -\alpha_{t\pi} & 0 & 0 \\ -\alpha_{\mathrm{yg}} & -\alpha_{\mathrm{yt}} & 1 & 0 & 0 & 0 \\ -\alpha_{\pi\mathrm{g}} & -\alpha_{\pi\mathrm{t}} & -\alpha_{\pi\mathrm{y}} & 1 & 0 & 0 \\ -\alpha_{5\mathrm{g}} & -\alpha_{5\mathrm{t}} & -\alpha_{5y} & -\alpha_{5\pi} & 1 & 0 \\ -\alpha_{6\mathrm{g}} & -\alpha_{6\mathrm{t}} & -\alpha_{6y} & -\alpha_{6\pi} & -\alpha_{65} & 1 \end{bmatrix}, \mathrm{B} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \beta_{\mathrm{tg}} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}.$$

I did not use sign restrictions to identify spending shocks, for the reasons mentioned in section 1.2.1.4. In short, sign restrictions are expected to work better when one tries to identify many shocks, especially ones that explain a significant portion of the variance of residuals. However, in this case I want to identify a single shock (a spending shock) for which there is a clear institutional setting that leads to enactment lags and implementation lags, making the assumption that government spending in goods and services is predetermined relative to other variables a reasonable one. In addition, this variable in not expected to explain a big portion of output fluctuations. Therefore, it seems reasonable not to use sign restrictions in this case[7].

2.2.4 Do the shocks coming from the different identification methods constitute proper fiscal shocks?

To see whether the shocks coming from the various identification methods constitute proper fiscal shocks, one first has to define the models from which these shocks come. I have run a variety of VARs from which I extract the spending shocks. As mentioned in section 2.2.2, the idea is that a shock is considered structural if it is unforecastable with the information agents have before it is realized. I also test the exogenous shocks mentioned in the literature in the same way. I do not try to estimate models that are informationally sufficient as defined in the sense of Forni and Gambetti - no reasonable model is likely to be anyway. I only want to focus on the effects of fiscal shocks, so I consider only these shocks.

The test is very simple. For all the shocks, I run a regression of the chosen shock on 2 lags of it; to these regressors I add those from the first two lags of the first 10 principal

[7]However, in Appendix A, the interested reader can find some results using sign restrictions; these results indicate why one should be cautious using such restrictions in a setup like the current one.

components of the U.S. data that give the best model according to the Hannan-Quinn criterion - all combinations are automatically run to choose the best one. Then I check whether the F-statistic from the regression is significant. This procedure is implemented in order not to have many unnecessary regressors in the model, and consequently accept the null of no significance of the regression more often.

The VAR models have the following specifications: the first class of VARs (model 1) includes a spending variable, output, net taxes, inflation, the federal funds rate and consumption; the second class of models (model 2) takes out inflation and adds total investment (without inventories) at the end; the last class (model 3) has a spending variable, output, net taxes, the federal funds rate, unemployment and the real wage as defined above. A time trend is always added, and all specifications have 4 lags of the endogenous variables. All models have many variables - although many more variables could be included in them, the variables included should ensure a quite accurate description of the basic aspects of the U.S. economy.

Various spending variables are used; these are total spending, total government consumption and investment, and their military and civilian counterparts. Government wages are not used separately, since they are the biggest part of government consumption (and give essentially the same results with it). As it is evident, many models are produced by these combinations; for each model, spending shocks are constructed, and the procedure described above is implemented to give the best regression model. In the Cholesky case, the spending variable is always put first, output second and taxes third, while in the Blanchard and Perotti[8] case the spending variable is always put first, taxes second and output third. Additionally, when inflation is not present in the model, the Blanchard - Perotti spending shock is identical to its Cholesky counterpart, since the procedures to obtain each of these two shocks are virtually the same - however, for completeness both are reported.

In table 2.1 the results for the forecastability of spending shocks are shown. As it is evident from the table, there is very little evidence that spending shocks identified by the typical Blanchard - Perotti or Cholesky identifications are forecastable; they seem to be truly structural shocks, in the sense of Forni and Gambetti, and inference coming

[8]In this case all the elasticities of spending are 0 except the elasticity of spending with respect to inflation, which is set at -0.5, as in Perotti (2004a).

Table 2.1: Regressions including spending shocks

	F statistic			probability F			$\overline{R^2}$			Number of additional regressors		
	model 1	model 2	model 3	model 1	model 2	model 3	model 1	model 2	model 3	model 1	model 2	model 3
total spending	0.85	0.64	0.92	0.427	0.529	0.400	0.003	0.001	0.004	0	0	0
civilian spending	0.46	0.49	0.18	0.633	0.612	0.838	-0.000	-0.000	-0.003	0	0	0
defense spending	0.90	1.84	1.07	0.407	0.140	0.346	0.004	0.019	0.006	0	1	0
total consumption	0.84	0.89	1.16	0.431	0.411	0.317	0.004	0.004	0.007	0	0	0
civilian consumption	1.48	0.36	1.57	0.219	0.692	0.197	0.013	-0.001	0.015	1	0	1
defense consumption	0.94	0.84	1.32	0.389	0.433	0.269	0.004	0.003	0.009	0	0	0
total investment	0.03	2.18	0.08	0.967	0.072	0.921	-0.005	0.030	-0.004	0	2	0
civilian investment	0.03	0.43	0.15	0.969	0.652	0.859	-0.005	-0.001	-0.004	0	0	0
defense investment	0.05	0.14	0.13	0.949	0.87	0.878	-0.005	-0.004	-0.004	0	0	0

(a) Regressions including Cholesky spending shocks

	F statistic			probability F			$\overline{R^2}$			Number of additional regressors		
	model 1	model 2	model 3	model 1	model 2	model 3	model 1	model 2	model 3	model 1	model 2	model 3
total spending	0.78	0.64	0.92	0.459	0.529	0.400	0.003	0.001	0.004	0	0	0
civilian spending	1.21	0.49	0.18	0.304	0.612	0.838	0.009	-0.000	-0.003	1	0	0
defense spending	0.95	1.84	1.07	0.389	0.140	0.346	0.004	0.019	0.006	0	1	0
total consumption	0.35	0.89	1.16	0.701	0.411	0.317	-0.001	0.004	0.007	0	0	0
civilian consumption	0.12	0.36	1.57	0.883	0.692	0.197	-0.004	-0.001	0.015	0	0	1
defense consumption	0.82	0.84	1.32	0.443	0.433	0.269	0.003	0.003	0.009	0	0	0
total investment	0.02	2.18	0.08	0.979	0.072	0.921	-0.005	0.030	-0.004	0	2	0
civilian investment	0.04	0.43	0.15	0.956	0.652	0.859	-0.005	-0.001	-0.004	0	0	0
defense investment	0.04	0.14	0.13	0.963	0.87	0.878	-0.005	-0.004	-0.004	0	0	0

(b) Regressions including Blanchard-Perotti spending shocks

Table 2.2: Regressions including exogenous shocks

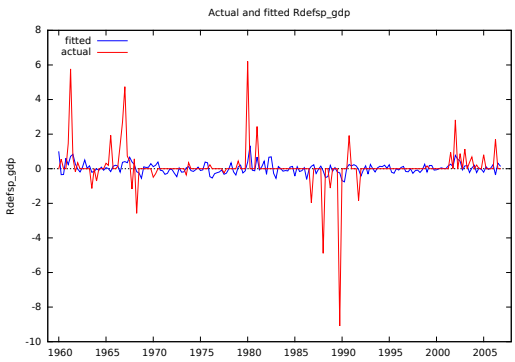
	F statistic	probability F	$\overline{R^2}$	Number of additional regressors
Defense News Shock	3.19	0.014	0.049	2
SPF Forecast shock	5.38	0	0.155	4

from these two approaches concerning the effects of government spending shocks seems to be valid. As it will become evident later, they are also very similar shocks - their only difference comes from the adjustment for inflation in the Blanchard - Perotti case, which produces a positive correlation between these shocks and the residuals from the inflation equation.

In table 2.2 the results for the forecastability of the exogenous spending shocks used in Ramey (2011) are shown. As it is evident from this table, the only shock that might qualify as a truly structural one is the Ramey's defense spending news shock; though it seems to be somewhat forecastable, in practice it is very difficult to forecast the big and infrequent changes to forecasts of defense spending. What is more important is that the forecast error of the SPF forecasts for spending variables, a variable used in some papers and also one that is supposed to forecast residuals from spending equations is quite forecastable and cannot be considered a true structural shock. This conclusion is evident if one takes a look on the graphs of actual vs fitted values from the best model, presented in figure 2.1.

Figure 2.1: Actual vs fitted values from best models of exogenous shocks

(a) Defense news shock



(b) SPF forecast error

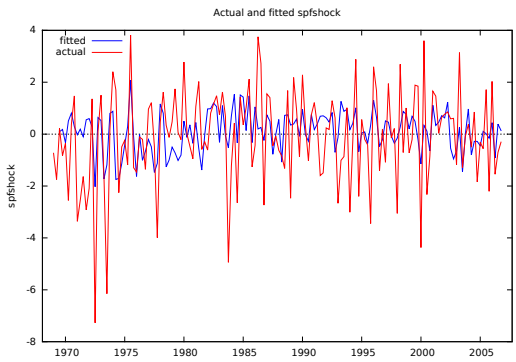
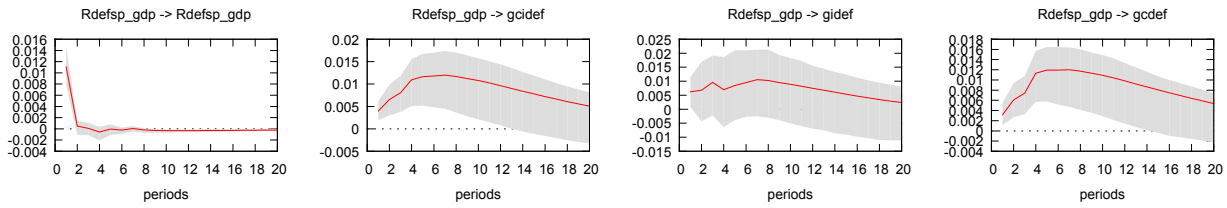
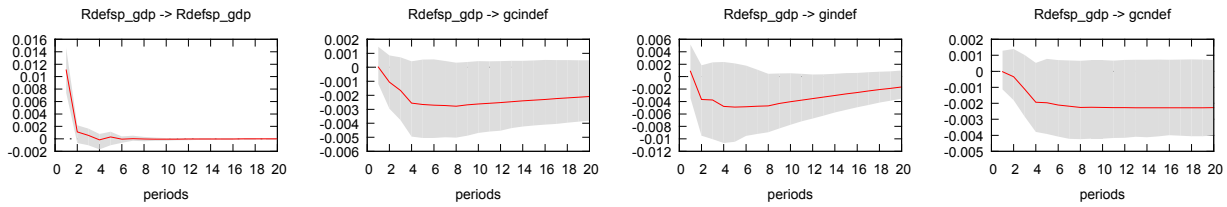


Figure 2.2: The effects of defense news shocks on the various spending variables (90% C.I.);

(a) Defense spending variables



(b) Civilian spending variables



Rdefsp_gdp: Ramey's shock; gcidef: total defense spending; gidef: defense investment; gcdef: defense consumption; gcindef: total civilian spending; gindef: civilian investment; gcndef: civilian consumption.

2.2.5 What part of the budget do the exogenous fiscal shocks really affect?

To be sure that the defense news shocks are truly such shocks, and to gain further understanding on what these shocks actually move, it is important to see the effects of these shocks on the major budget categories. To this end, I will perform the following exercise: 2 VARs are run for the defense news spending shock and the major spending categories, one for defense and another non-defense spending variables. Then the system is shocked in the shock variable, by using a recursive ordering with the shock variable placed first.

The IRFs for shocks in the defense news shocks (with 90% confidence intervals) are shown in figure 2.2. As it is evident, the defense news shocks increase defense spending variables, and insignificantly decrease civilian ones; importantly, they increase defense consumption significantly, meaning that their biggest effect is on military personnel wages (that also includes their effect on the number of military personnel).

2.3 The effects of fiscal shocks in US economy

2.3.1 The baseline models

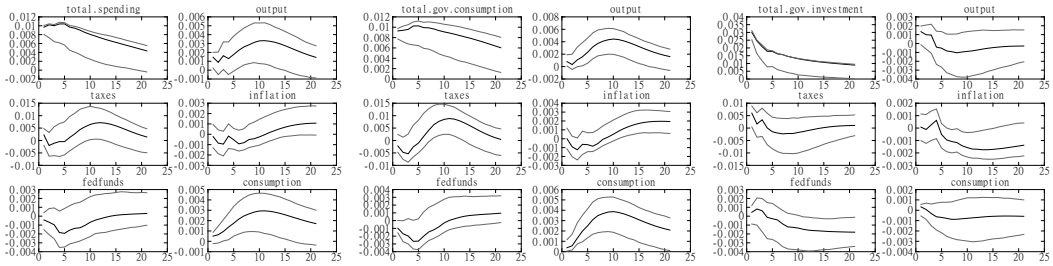
As mentioned above, the baseline models consist of a spending variable, taxes, output (or output and then taxes in the Cholesky case), inflation, the federal funds rate and consumption. The spending variable is either total spending, government consumption or government investment, total or broken into the relevant civilian and military series. So we have 9 different spending variables, and three different identifications. When the exogenous shocks are used, they are placed as exogenous variables in the model. All models have 4 lags of the endogenous variables, and the ones that use the exogenous shocks have lags 0-4 of these shocks; a constant and a time trend is always added; in all graphs 90% confidence intervals are plotted.

Figure 2.3 presents the results for the responses of the baseline models (the ones that include output, inflation, the federal funds rate and consumption) to shocks on the basic government spending aggregates - total spending on goods and services, total government consumption and total government investment - or to defense news shocks. As it is evident from the graphs included in this figure, shocks to total government spending and government consumption lead to increases in output and consumption and to decreases in the federal funds rate, in both the Cholesky and the Blanchard-Perotti (BP) cases; taxes also follow a similar pattern in both cases: first they fall, but in the medium term they rise above baseline. The differences in these two identifications lie in the responses of inflation: in the Cholesky case they are negative, while in the BP case inflation rises; as mentioned before, the positive reaction of inflation in the BP case is mechanically generated by the cyclical adjustment of spending residuals with those from the inflation equation[9], as described in section 2.2.4.

Overall, these responses are more compatible with a Keynesian view of the economy; the Cholesky case is very compatible with the story told by some recent DSGE models that allow government spending to have a positive externality to the private sector production function (e.g. Baxter and King (1993) or Linnemann and Schabert (2006)), effectively to be a kind of a productivity shock; the reduction of inflation is particularly

[9]The residuals from inflation equation are added to those of the spending equation creating a positive correlation of the structural spending residuals with inflation, a correlation that is absent in the unadjusted residuals, which can also be considered structural.

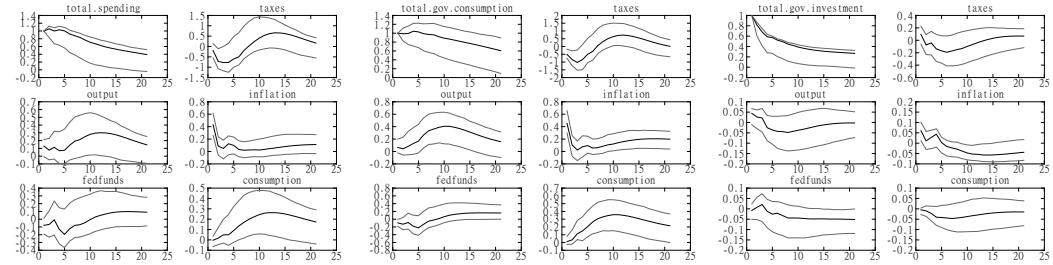
Figure 2.3: Baseline models, spending shocks from all identifications, models that include total government spending (90% C.I.)



(a) Cholesky identification, total spending

(b) Cholesky identification, government consumption

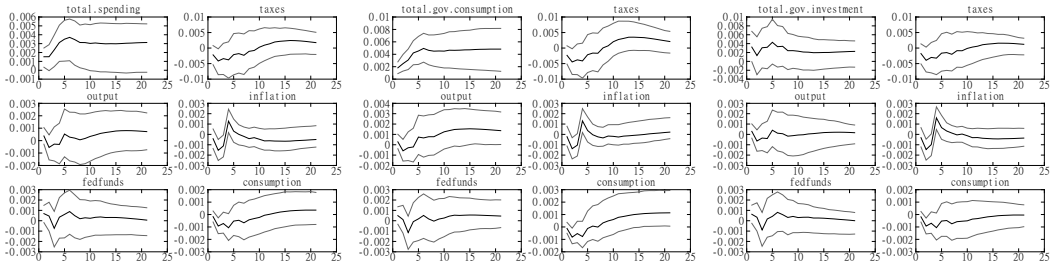
(c) Cholesky identification, government investment



(d) B-P identification, total spending

(e) B-P identification, government consumption

(f) B-P identification, government investment



(g) Exogenous shock identification, total spending

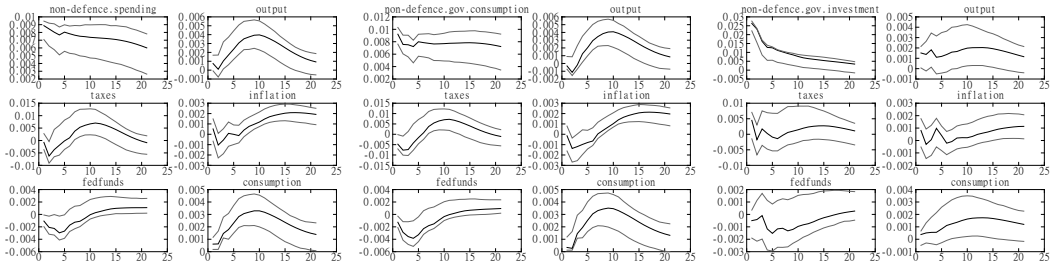
(h) Exogenous shock identification, government consumption

(i) Exogenous shock identification, government investment

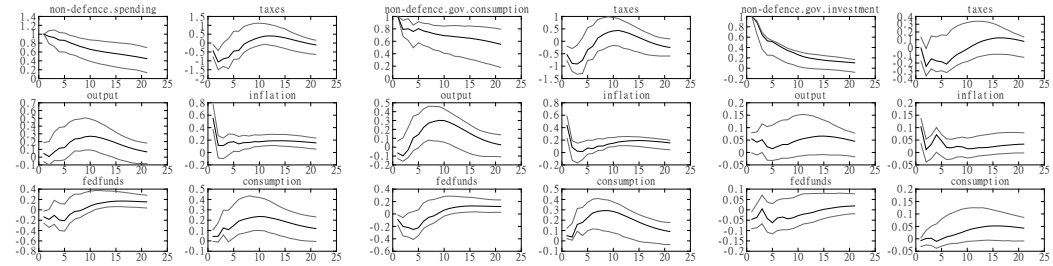
compatible with such a story. The BP case is more similar to Keynesian view of the economy - again the (positive in this case) inflation response is crucial for this.

The responses of these variables to government investment shocks are not significant, but some puzzling features reappear, as in Perotti (2004b): in particular, government investment leads to a fall in consumption - but how can the not so useful on a priori grounds government consumption give rise to significant positive output and consumption responses, while the generally considered more useful government investment not affect output and lead to negative consumption responses? Can the same institutions do a good job in one part of fiscal policy (government consumption choices) and fail in the other part (government investment choices)? An answer will be suggested later.

Figure 2.4: Baseline models, spending shocks from Cholesky and BP identifications, models that include government civilian spending (90% C.I.)



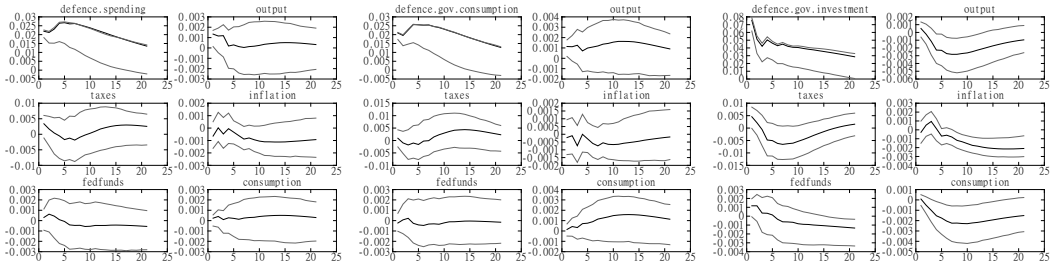
(a) Cholesky identification, total civilian spending (b) Cholesky identification, civilian government consumption (c) Cholesky identification, civilian government investment



(d) B-P identification, total civilian spending (e) B-P identification, civilian government consumption (f) B-P identification, civilian government investment

The last row of figure 2.3 has the responses of the previous models to the exogenous defense spending news shocks. In responses to such shocks, all parts of the major budget categories rise permanently; government consumption is the spending variable that rises more strongly and significantly. It is probably worth to point out that shapes of the government spending responses are quite different in this case: unlike the SVAR case, where government spending takes its peak value on impact and then falls (as the stable roots of the model force the system to go back to equilibrium), in the exogenous shocks case spending variables are permanently set in a higher level - government investment immediately, government consumption shortly after the shock. Output and taxes do not move significantly - output does not move at all, while taxes fall somewhat. Inflation goes in a negative path for the first few periods and federal funds rate is not affected. Lastly, consumption falls. Another thing to point out is the similarity of responses in all variables, except spending ones, across models. These reactions are somewhat consistent with a baseline NK model with price rigidities (like the one of Linnemann and Schabert (2003)) - output does not move much, inflation falls slightly, the FED does not move the target rate much, consumption falls; these results are also reminiscent of Ramey's (2011) results and explanations; in her work, a defense spending news shocks give similar results

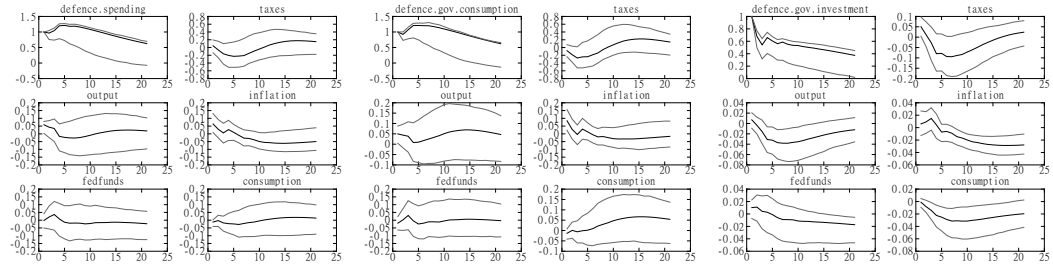
Figure 2.5: Baseline models, all identifications, models that include government defense spending (90% C.I.)



(a) Cholesky identification, total defense spending

(b) Cholesky identification, government defense consumption

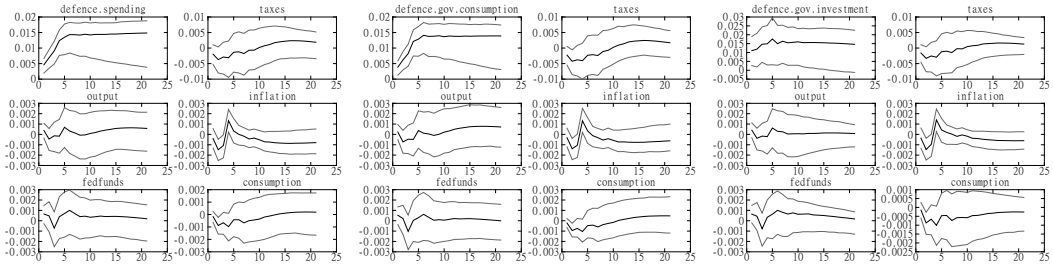
(c) Cholesky identification, government defense investment



(d) B-P identification, total defense spending

(e) B-P identification, government defense consumption

(f) B-P identification, government defense investment



(g) Exogenous shock identification, total defense spending

(h) Exogenous shock identification, government defense consumption

(i) Exogenous shock identification, government defense investment

in VARs with mostly real variables - a difference is that she obtains a strong positive output response and a clear negative consumption response.

In figure 2.4 the results from the models that have only civilian spending are presented. The identifications used are only the two SVAR variants - the defense news spending shocks are not used, since they primarily affect defense variables, as shown is section 2.2.5. Leaving aside the responses of inflation, which continue to be different according to the identification method as described before, in all cases taxes fall initially and recover in the second half of the forecast period, the federal funds rate falls and both consumption and output increase strongly. The first important result is that shocks to civilian government investment have positive effects on output and consumption, as

one would expect. The second one is that civilian government consumption has strong positive effects on output and consumption; since the major component of government consumption is public sector wages, this means that by hiring more people the U.S. government was able to affect positively the economy.

Figure 2.5 presents the responses to spending shocks in the models with defense spending variables. I will not discuss the responses in the exogenous shocks cases, since they are very similar to those in figure 2.3; the only thing worth looking at is the strength of the responses of spending variables to the exogenous news shocks. In what concerns the two SVAR cases, leaving aside the issue of inflation, there are some common findings: taxes tend to fall and the federal funds rate does not move. Total defense spending has minor effects on all variables. Additionally, government defense consumption has positive effects on output and consumption, although these are not particularly strong and are not very precisely estimated; these results suggest that government consumption expenditures of all kinds have similar effects, something not that surprising if one recalls that they also have the same nature - they mostly reflect wages. The most important result however comes from the graphs depicting the responses to military investment shocks: military investment, which includes purchases of armament in U.S. data, has strongly recessionary effects on output, and consequently reduces taxes and consumption. The effects on output and consumption are particularly strong and significant. All these happen despite the fact that U.S. military procurements are mainly manufactured in the country and not imported from abroad.

Lastly, an important thing is to quantitatively assess the effects of these variables on output. In table 2.3 the output multipliers of all cases of spending shocks described previously in this section are presented. The multipliers in the models with civilian variables and identification using the defense news shocks are not presented, since these spending variables are not particularly affected by these exogenous shocks. There are several results worth mentioning, and these are consistent with the visual inspection of the figures.

I start with the SVAR cases. The first thing to notice is that for all cases civilian spending has a higher multiplier than total spending and defense spending; between the last two, total spending has higher multiplier. Civilian spending of all kinds has a big multiplier - 2 or more on average in the Cholesky case, more than 1.3 in the BP case;

Table 2.3: Output multipliers to spending shocks

	Cholesky identification				Blanchard-Perotti identification				Exogenous shocks			
	mean	period 0	period 4	period 8	mean	period 0	period 4	period 8	mean	period 0	period 4	period 8
total spending	1.11	0.675	0.69	1.02	0.93	0.65	0.46	0.74	0.27	1.22	-0.10	0.09
civilian spending	2.07	0.67	0.16	2.27	1.35	0.36	0.62	1.35				
defense spending	0.43	0.93	0.53	0.32	0.20	0.89	0.27	0.01	0.20	1.24	0.10	0.10
total consumption	1.48	0.53	0.77	1.51	1.31	0.40	0.60	1.28	0.70	0.96	-0.03	0.56
civilian consumption	1.97	-0.36	0.43	2.35	1.36	-0.693	0.13	1.66				
defense consumption	0.98	0.98	0.82	0.87	0.67	0.90	0.50	0.47	-0.03	1.06	-0.45	-0.18
total investment	-0.09	1.18	0.56	-0.22	-0.44	1.17	0.22	-0.71	-0.57	2.40	-1.23	-0.80
civilian investment	4.50	2.17	2.89	3.89	3.25	2.05	1.95	2.35				
defense investment	-3.56	0.73	-2.24	-4.14	-3.66	0.76	-2.36	-4.29	0.73	4.04	0.42	-1.20

particularly big is the multiplier of civilian investment, which is 4.5 on average in the Cholesky case and 3.25 in the BP case, a lot bigger that any value reported in Perotti (2004b). Defense investment has a very negative effect on output - the multiplier is less than -3.5 in both SVAR cases. It is evident that different spending categories affect the economy in very different ways.

The results in the exogenous spending shocks suggest that the values of spending multipliers are totally different from those in the SVAR cases; especially the positive value of the defense investment multiplier on impact strikes out. Given the very similar patterns in all IRFs in this case, maybe it is pointless to talk for other multipliers than those to total defense spending; the nature of these spending shocks seems to make it impossible to isolate the effects of different defense spending variables - they give a combined effect. In addition, the shapes of the IRFs are totally different from those of the SVAR cases, making it hard to compare these effects.

2.3.2 Extensions

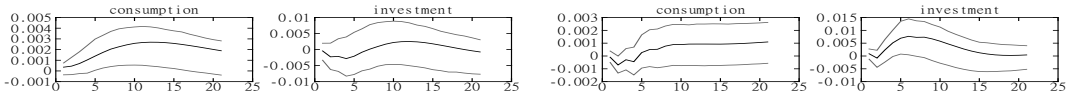
In order to see more clearly the effects of the various spending shocks in the economy, a further set of models has been estimated. The first set, under the general name model 2, seeks to explore the effects on investment. From the baseline set of models inflation is dropped and total private investment is added in the last place. The variables are: the government spending variable, output, taxes, the federal funds rate, consumption and investment.

Furthermore, I seek to find the effects on labor markets. To gain further insight on this issue, I estimate a third set of models, under the general name model 3; from the specification of model 2 I drop consumption and investment and add at the end unemployment and wage, in this order.

In these models the BP identification method is not used - no inflation is present in the model, so for the spending shocks the two SVAR methods will give the same results since there is not any adjustment for inflation. The results from the other two identification methods are presented though - in figure 2.6 the responses of investment are presented, while in figure 2.7 those of unemployment and wages.

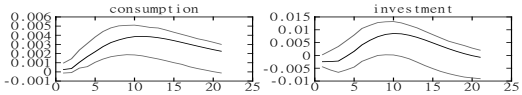
As it is clear, in all cases the exogenous shocks generate a positive effect in investment - this is insignificant in most cases; such a response is consistent with a simple

Figure 2.6: Responses of investment to Cholesky and Exogenous spending shocks (90% C.I.)

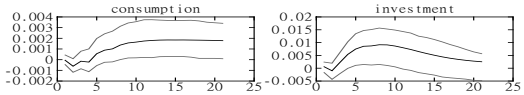


(a) Total spending, Cholesky identification

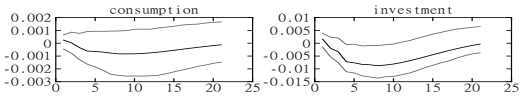
(b) Total spending, exogenous shock



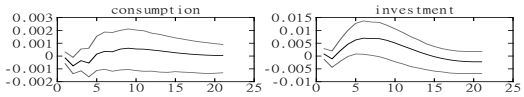
(c) Total government consumption, Cholesky identification



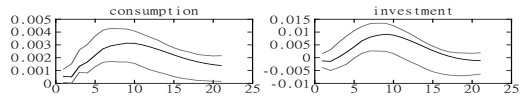
(d) Total government consumption, exogenous shock



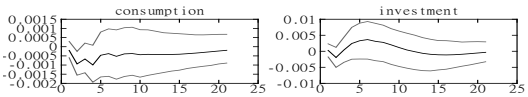
(e) Total government investment, Cholesky identification



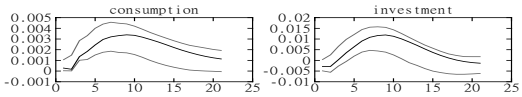
(f) Total government investment, exogenous shock



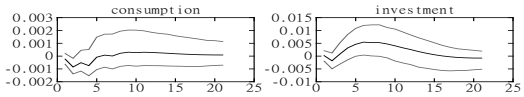
(g) Total civilian spending, Cholesky identification



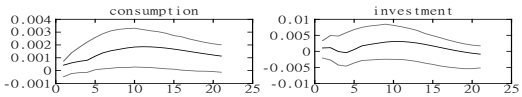
(h) Total civilian spending, exogenous shock



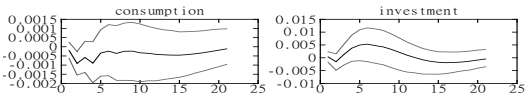
(i) Total civilian government consumption, Cholesky identification



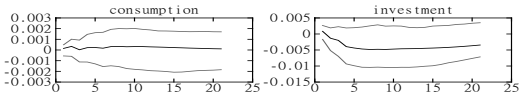
(j) Total civilian government consumption, exogenous shock



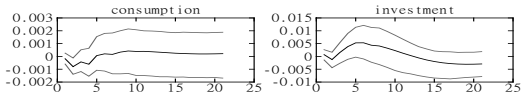
(k) Total civilian government investment, Cholesky identification



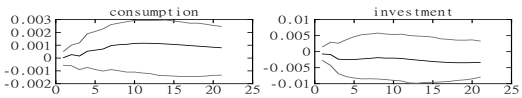
(l) Total civilian government investment, exogenous shock



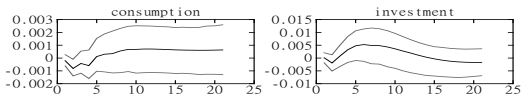
(m) Total defense spending, Cholesky identification



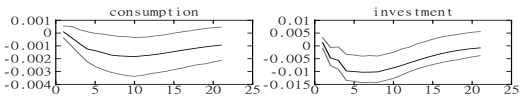
(n) Total defense spending, exogenous shock



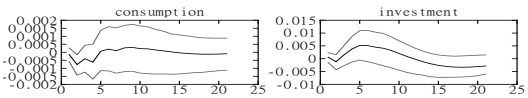
(o) Total defense government consumption, Cholesky identification



(p) Total defense government consumption, exogenous shock

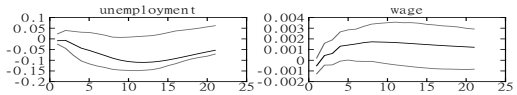


(q) Total defense government investment, Cholesky identification

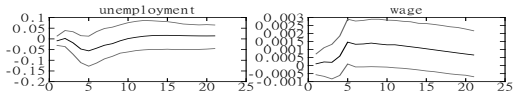


(r) Total defense government investment, exogenous shock

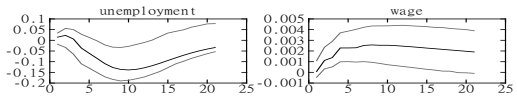
Figure 2.7: Responses of unemployment and wages to Cholesky and Exogenous spending shocks (90% C.I.)



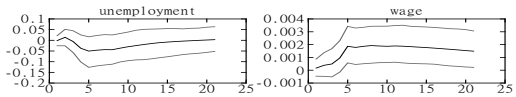
(a) Total spending, Cholesky identification



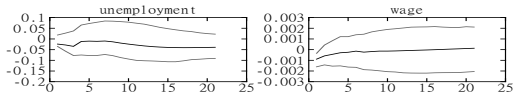
(b) Total spending, exogenous shock



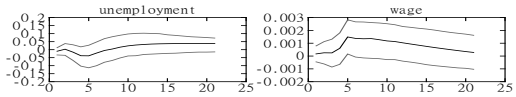
(c) Total government consumption, Cholesky identification



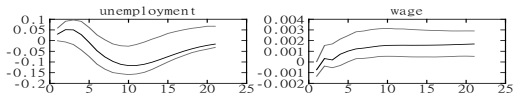
(d) Total government consumption, exogenous shock



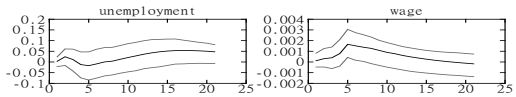
(e) Total government investment, Cholesky identification



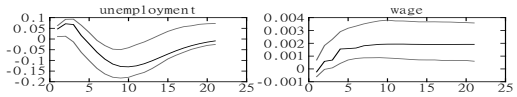
(f) Total government investment, exogenous shock



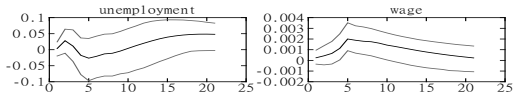
(g) Total civilian spending, Cholesky identification



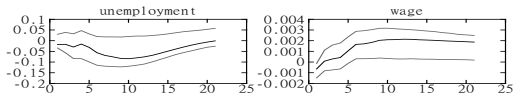
(h) Total civilian spending, exogenous shock



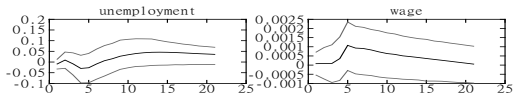
(i) Total civilian government consumption, Cholesky identification



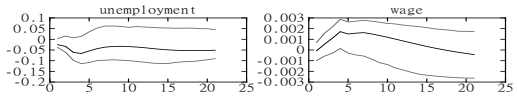
(j) Total civilian government consumption, exogenous shock



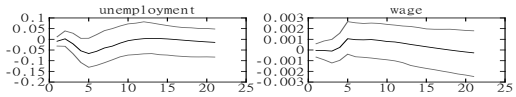
(k) Total civilian government investment, Cholesky identification



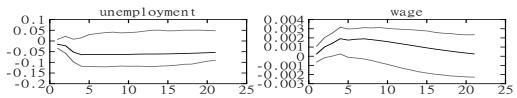
(l) Total civilian government investment, exogenous shock



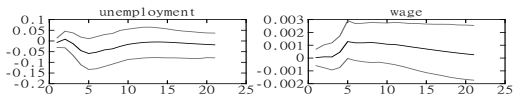
(m) Total defense spending, Cholesky identification



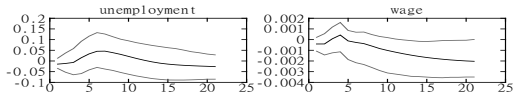
(n) Total defense spending, exogenous shock



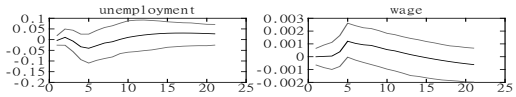
(o) Total defense government consumption, Cholesky identification



(p) Total defense government consumption, exogenous shock



(q) Total defense government investment, Cholesky identification



(r) Total defense government investment, exogenous shock

DSGE-RBC model if the real interest rate does not respond to spending shocks, so that the negative wealth effect drives people to increase saving. In the SVAR case, the responses of investment generally follow those of consumption; government consumption and especially civilian consumption increases investment - only defense consumption leaves private investment unaffected; defense investment depresses private investment, in line with the other recessionary effects of this variable.

The effects of exogenous spending shocks on the labor market are again uniform - unemployment falls insignificantly, while wage rises, insignificantly in most cases, significantly in the models using total and civilian government consumption; again these results are not very consistent with a baseline DSGE-RBC model - people work more, which is what they would do in such a model, but that should result in falling wages.

The effects of the SVAR models in the labor market have a strong Keynesian flavor: unemployment falls and wage rises, suggesting strong effects on labor demand, more strongly when civilian spending and especially civilian government consumption is used. But there is one important exception - in response to shocks in (total and) military investment, unemployment rises and wages fall, although insignificantly, a manifestation of the negative output effects of government investment.

2.4 A model to account for the results

2.4.1 The basic results the model should explain

The positive effects of civilian spending and the negative effects of military investment are similar to those obtained by Perotti (2004b) and Tenhofen and Wolff (2010). What this paper has done in the econometric work was to analyze more thoroughly the U.S. data and check whether these results still apply. However, in both papers the authors give some tentative explanations. What I will do in this section is to develop a DSGE model that will account for the most important results.

In this point I will repeat the important results of the empirical analysis. The first is that civilian consumption and investment have strong positive effects on economic activity - the response of the FED does not seem to be the main reason for that in the Cholesky case, meaning that the actions of a central bank that lowers interest rates to accommodate fiscal policy decisions do not seem to produce these effects; one can say

the opposite in the BP case; in any case, the effects on the real variables are similar in both cases (though the lower inflation in the Cholesky case seems to increase the output multipliers), implying that the biggest part of the explanation is likely to be a real factor (as opposed to a passive FED reaction to spending shocks), and this route I will follow.

All these results of government consumption can potentially be explained in the framework of a DSGE model if government hires labor to produce a public good, which raises the productivity of the private sector, working in a way similar to Linnemann and Schabert (2006); this is the mechanism adopted here. It also explains the increase in output, consumption, investment and wages and the fall in unemployment after government consumption shocks. I will deal with the explanation of the effects of government consumption here, since the effects of government investment have been explained by Baxter and King (1993).

The second crucial result is that defense investment spending leads to contractionary output effects; this result is in stark contrast with both major economic schools of thought - in both, even useless government spending increases output, regardless of its effect on consumption. The explanation I suggest is that military equipment is produced by an inferior production function. This may sound and extreme assumption, especially given that in military equipment the cutting edge of technology is used, but it has some truth: companies that operate in the defense business are less exposed in competition - e.g. in U.S. presently only two companies manufacture military airplanes; certainly, defense contractors are rarely exposed to foreign competition. Often they are required to keep their production lines open and ready for operation without actually producing, because military contracts are infrequent and big - this definitely costs. In addition, these companies are famous for exceeding budgets and timetables; the fairness in the methods they use to compete is often questionable; these characteristics are indicative of an industry that does not operate in a competitive manner. Then the basic effects of government investment are also explained - when government decides to buy more weapons, in practice it shifts resources towards the less efficient sector, leading to a fall in total output; this contraction in output forces consumption, investment and wages to fall.

The previous two paragraphs give the basic results the model should explain. Basically, the model explains the effects of the main spending variables. I do not attempt to

estimate the model here so that its IRFs match those of the VAR as much as possible - I only try to indicate a mechanism to explain the basic results. Importantly, the model is real - no attempt to explain the inflation and interest rate responses is undertaken, since they are not as clear as the ones of real variables, and do not seem that important for the explanations of the reactions of the real variables.

2.4.2 The model

2.4.2.1 Households

The economy is inhabited by numerous households that belong to the interval [0,1]. The representative household maximizes the intertemporal utility (1) subject to the budget constraint (2).

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(ln(C_t) - \frac{\kappa L_t^{1+\theta}}{1+\theta} \right) \tag{2.1}$$

$$C_t + K_{t+1} - (1-\delta)K_t + T_t = (1-\tau^w)W_t L_t + (1-\tau^k)(R_t K_t + D_{2t}) \tag{2.2}$$

C_t is consumption, L_t is the labor supplied in a period, K_t is capital owned by the household, T_t is the (real) lump-sum taxes/transfers, W_t the real wage, τ^w and τ^k are the tax rates on wage and capital income, the later including income both from lending capital $R_t K_t$ to firms and from dividends D_{2t}. The household can choose C_t, K_{t+1} and L_t and takes the rest of the variables as given.

The solution of this problem gives rise to the usual Euler equations for consumption (EL1) and labor supply (EL2).

$$\frac{1}{C_t} = E_t \frac{1}{C_{t+1}}(1 + (1-\tau^k)R_{t+1} - \delta),\ (EL1); \quad W_t = \frac{\kappa L_t^{\theta} C_t}{1-\tau^w},\ (EL2)$$

2.4.2.2 Firms

There are two sectors in the economy, one that produces consumption goods and one that produces goods that are consumed by government. In the first sector there are many firms belonging in the interval [0,1], each producing the same consumption good under perfect competition, while in the second sector there is only one firm.

For firms in the consumption sector the problem is to minimize cost, $W_t L_{1t} + R_t K_{1t}$, subject to the production function (3), which is a standard Cobb-Douglas one, with a modification: G_{1t}, a good produced by the government, affects the labor productivity, so it has an externality, and its exponent, γ, controls the size of this externality; A_1 is the level of technology, R_t the real return to capital. As it is typical in competitive sectors, each firm employs labor L_{1t} and capital K_{1t} up to the point where the factor price equals the marginal product as shown in equations (4) and (5), price equals marginal costs and profits are zero.

$$Y_{1t} = A_1 K_{1t}^{\alpha} (G_{1t}^{\gamma} L_{1t})^{1-\alpha} \tag{2.3}$$

$$R_t = \alpha A_1 K_{1t}^{\alpha-1} (G_{1t}^{\gamma} L_{1t})^{1-\alpha} = \alpha \frac{Y_{1t}}{K_{1t}} = MPK_t \tag{2.4}$$

$$W_t = (1-\alpha) A_1 K_{1t}^{\alpha} G_{1t}^{\gamma(1-\alpha)} {L_{1t}}^{-\alpha} = (1-\alpha) \frac{Y_{1t}}{L_{1t}} = MPL_t \tag{2.5}$$

An important thing to notice is that this is the big sector in the economy. This has the consequence that factor prices, the rental rate of capital R_t and the real wage W_t are determined in this sector. The other sectors are price takers. Additionally, all capital is produced in this sector (but rented to both sectors after its production).

The monopolist that produces government consumption goods (military equipment) has the objective to maximize profits, and it can actually obtain economic profits. Since this is a small sector in the total economy, it takes factor prices as given. One thing to notice is the different production function (6) of this firm: it is the same as the one of the firms in competitive sector, but with one difference: A_2, the level of technology, is lower in this sector. Solving a cost minimization problem like the previous gives the factor demands (7) and (8) for this firm, as well as the total and marginal cost functions (9) and (10).

$$Y_{2t} = A_2 K_{2t}^{\alpha} (G_{1t}^{\gamma} L_{2t})^{1-\alpha} \tag{2.6}$$

$$K_{2t} = \frac{1}{A_2} \left(\frac{\alpha}{1-\alpha} \frac{W_t}{R_t} \right)^{1-\alpha} G_{1t}^{\gamma(\alpha-1)} Y_{2t} \tag{2.7}$$

$$L_{2t} = \frac{1}{A_2}\left(\frac{\alpha}{1-\alpha}\frac{W_t}{R_t}\right)^{-\alpha} G_{1t}^{\gamma(\alpha-1)} Y_{2t} \tag{2.8}$$

$$TC_{2t} = \frac{1}{A_2} W_t \left(\frac{\alpha}{1-\alpha}\frac{W_t}{R_t}\right)^{-\alpha} G_{1t}^{\gamma(\alpha-1)} Y_{2t} \tag{2.9}$$

$$MC_{2t} = \frac{1}{A_2} W_t \left(\frac{\alpha}{1-\alpha}\frac{W_t}{R_t}\right)^{-\alpha} G_{1t}^{\gamma(\alpha-1)} \tag{2.10}$$

However, being a monopolist, this firm can set its price - assuming that the government has a demand function for this product that belongs to the constant elasticity of demand category, e.g. $Y_{2t} = CP_{2t}^{-\varepsilon}$ (where P_{2t} is the relative price for this good), the solution of the profit maximization problem leads to pricing as a constant mark-up over marginal cost (11) and real profits given by (12).

$$P_{2t} = \frac{\varepsilon}{\varepsilon - 1} MC_{2t} \tag{2.11}$$

$$D_{2t} = P_{2t}Y_{2t} - W_t L_{2t} - R_t K_{2t} \tag{2.12}$$

2.4.2.3 Government

The government collects taxes and buys a) labor services L_g to produce the government service to the private sector G_1 using production function (13) and b) products from the government producing sector G_2. As mentioned before, the largest part of government consumption is wages, so in the model what the fiscal authority buys is simply labor services, at the market wage rate, in a setup similar to Linnemann (2009). To simplify the problem there is no debt - the government budget (14) is always balanced - and tax rates are constant, so varying the lump-sum taxes/transfers T ensures the equality between taxes and spending.

$$G_{1t} = L_{gt}^{\xi} \tag{2.13}$$

$$W_t L_{gt} + P_{2t} G_{2t} = \tau^w W L_t + \tau^k (R_t K_t + D_{2t}) + T_t \tag{2.14}$$

Lastly, the two variables the government chooses to buy from the private sector follow simple AR(1) processes (15 and 16). Variables with a bar on top denote steady state values, e_{lgt} and e_{g2t} are iid shocks.

$$L_{gt} = (1-\rho_{lg})\overline{L}_g + \rho_{lg}L_{g,t-1} + e_{lgt} \ (2.15); \quad G_{2t} = (1-\rho_{g2})\overline{G}_2 + \rho_{g2}G_{2,t-1} + e_{g2t} \ (2.16)$$

2.4.2.4 Market Clearing and Equilibrium

To clear the markets, demand must equal supply in all of them; this leads to the following identities. These denote the equilibrium in capital market (17), in labor market (18), in government consumption sector (19), in consumer goods sector (20) and the GDP identity (21).

$$K_t = K_{1t} + K_{2t} \ (2.17); \quad L_t = L_{1t} + L_{2t} + L_{gt} \ (2.18); \quad Y_{2t} = G_{2t} \ (2.19)$$

$$Y_{1t} = C_t + K_{t+1} - (1-\delta)K_t \ (2.20); \quad Y_t = Y_{1t} + Y_{2t} \ (2.21)$$

The equilibrium is defined by solving the system that is defined by equations (EL1) and (EL2), (2) - (5), (7), (8), (10) - (12), (13) - (16), (17) - (19) and (21).

2.4.2.5 Steady state

From (EL1) one can calculate the steady state (ss henceforth) value of the real interest rate: $\overline{R} = \frac{1/\beta-1+\delta}{1-\tau^k}$. From *MPK* (equation (4)) one has the output to capital ratio $\overline{\frac{Y_1}{K_1}} = \frac{\overline{R}}{\alpha}$ in consumption sector; then, after calculating the ss value of $\overline{G}_1 = \overline{L}_g^{\xi}$ using (13), dividing the production function of Y_1 (3) by K_1 allows one to calculate the steady state value of the capital to labor ratio in this sector: $\overline{\frac{K_1}{L_1}} = \left(\frac{\overline{R}}{\alpha A_1}\right)^{1/(\alpha-1)}\overline{G}_1^{\gamma}$. Using this ratio in (5) makes it possible to calculate the value of wage: $\overline{W} = (1-\alpha)\overline{\frac{Y_1}{L_1}} = (1-\alpha)\overline{\frac{Y_1}{K_1}\frac{K_1}{L_1}} = \frac{1-\alpha}{\alpha}\overline{\frac{K_1}{L_1}}\overline{R}$.

From the ss shares of consumption and government consumption sectors and the respective production functions (3) and (6) one can do the following operations: $\overline{\frac{Y_2}{Y_1}} = \overline{\frac{G_2}{Y_1}} = \overline{\frac{Y_2}{Y}}/\overline{\frac{Y_1}{Y}} = \frac{A_2\overline{K}_{2t}^{\alpha}(\overline{G}_{1t}^{\gamma}\overline{L}_{2t})^{1-\alpha}}{A_1\overline{K}_{1t}^{\alpha}(\overline{G}_{1t}^{\gamma}\overline{L}_{1t})^{1-\alpha}}$. Since factor prices are the same in both sectors, one

Table 2.4: Parameters used in calibration and their values; bars over a variable denote steady state values.

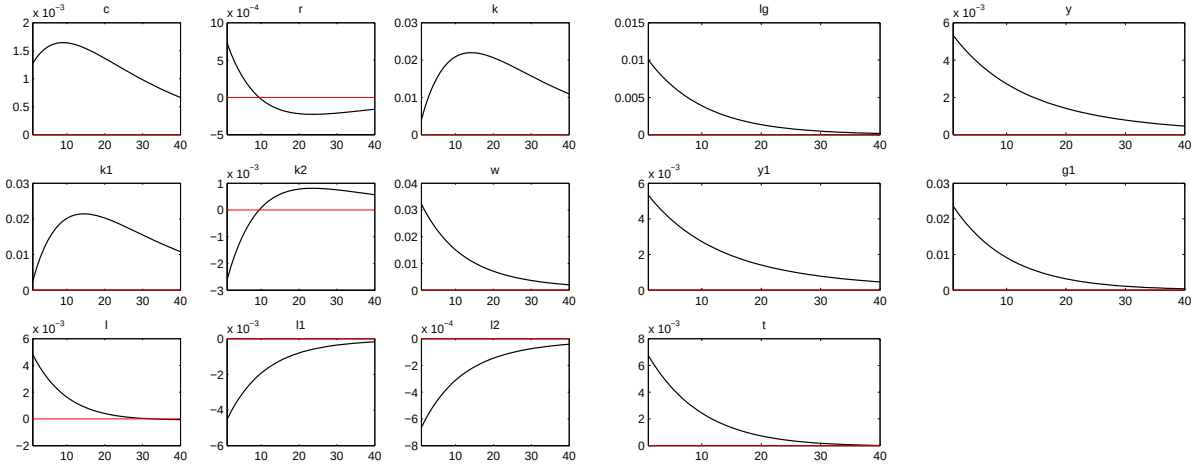
Parameter	Value	Description
β	0.99	Time discount factor
δ	0.02	Depreciation of capital
θ	2	Frisch elasticity of labor supply
τ^k	0.3	Tax rate on capital income (capital and dividends)
τ^w	0.2	Tax rate on labor income
κ	$\frac{\overline{W}(1-\tau^w)}{\overline{L}^\theta \overline{C}}$	Normalization factor for disutility of labor
α	0.3	Share of capital
γ	0.4	Value of externality of government services
ξ	0.5	Productivity of government workers
A_1	1	Level of technology in consumption sector
χ	0.7	Relative level of technology in government consumption sector
A_2	χA_1	Level of technology in government consumption sector
ε	4	Elasticity of substitution of government demand
ρ_{lg}	0.9	Autoregressive coefficient of L_g
ρ_{g2}	0.9	Autoregressive coefficient of G_2
σ_{lg}	0.01	Variance of e_{lg}
σ_{g2}	0.01	Variance of e_{g2}
$\overline{L}$	0.3	Steady state level of employment
$\overline{L}_g$	$0.15\overline{L}$	Steady state level of government employment
$\frac{\overline{Y_1}}{\overline{Y}}$	0.95	Steady state share of consumption sector output in GDP
$\frac{\overline{Y_2}}{\overline{Y}}$	0.05	Steady state share of government consumption sector output in GDP

can write: $\frac{\overline{W}}{\overline{R}} = \frac{1-\alpha}{\alpha}\frac{\overline{K_2}}{\overline{L_2}}$, so the capital to labor ratio must be the same in both sectors. This allows to write the previous equation as: $\frac{\overline{L_2}}{\overline{L_1}} = \frac{A_1}{A_2}\left(\frac{\overline{Y_2}}{\overline{Y}}/\frac{\overline{Y_1}}{\overline{Y}}\right) = \frac{1}{\chi}\left(\frac{\overline{Y_2}}{\overline{Y}}/\frac{\overline{Y_1}}{\overline{Y}}\right)$; since $\overline{L}_1 + \overline{L}_2 = \overline{L} - \overline{L}_g = (1-0.15)\overline{L}$, one has two equations for two unknowns, the ss values L_1 and L_2; solving one gets the following values: $\overline{L}_2 = \frac{(1-0.15)\overline{L}}{1+\chi\frac{\overline{Y_1}}{\overline{Y_2}}}$ and $\overline{L}_1 = \frac{\overline{Y_1}}{\overline{Y_2}}\chi\overline{L}_2$. The rest ss values of the variables can be trivially calculated using the relevant equations.

2.4.3 The IRFs

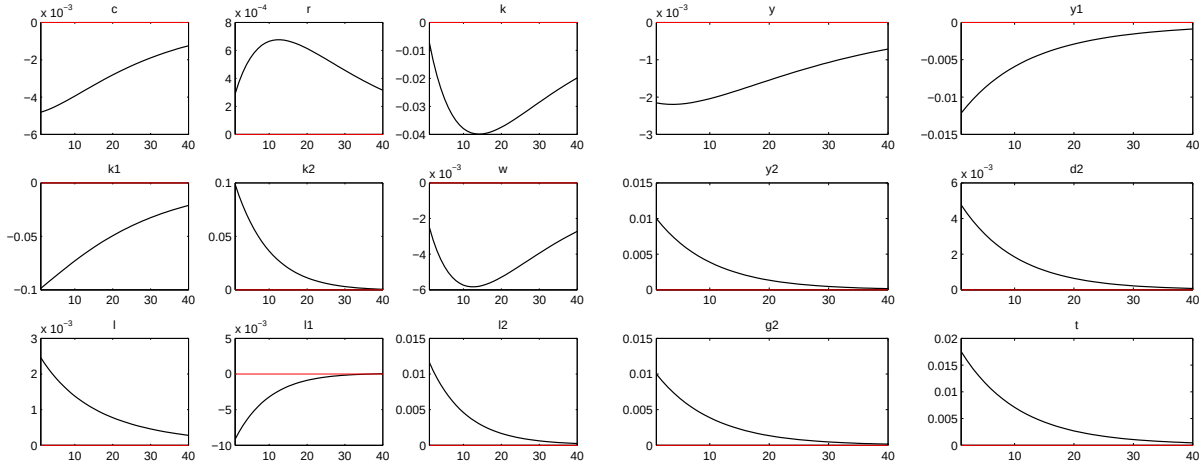
To generate the impulse responses to the two fiscal shocks, the system is linearized around the deterministic steady state using typical linear methods; the values used in the calibration are presented in table 2.4; the time period is assumed to be one quarter. There are not many things to discuss about the values of the parameters: most are typical in the literature, and for those that are not (like γ or ξ or χ) there is scarce or no guidance at all - the choice of values was based on the desire not to have a big externality (in case of γ) or productivity of government employed labor (ξ is less than $1-\alpha$), and not to have huge differences in the relative technology levels (in case of χ);

Figure 2.8: IRFs of theoretical model



(a) Responses to government labor shock part A

(b) Responses to government labor shock part B



(c) Responses to government military equipment shock part A

(d) Responses to government military equipment shock part B

the government is assumed to employ 15% of people (or actually 15% of working hours in the model - $\overline{L}_g$) in steady state.

As it is evident from figure 2.8, the model is quite successful in replicating the effects of civilian wages and military equipment purchases on the main macroeconomic variables. The positive reactions of output, wages, consumption and investment after civilian government employment shocks are present, as well as the negative responses of output, consumption and investment to military equipment shocks. The proposed setup, that is to allow to different parts of spending to affect the economy in a different ways seems to be able to generate the desired responses of the basic macroeconomic variables.

2.5 Conclusions

There are several ways to think about fiscal policy, especially about spending increases that are the focus of this analysis, and there is still no clear consensus on their effects. What this work has done is to carefully examine some aspects of them. First, I have documented that the popular SVAR identification methods are successful into producing proper spending shocks - for these shocks, the typical inference conducted is valid, at least with the U.S. data.

Another contribution in this chapter is that I have carefully examined the differences between identification methods. It has been shown that typical SVAR techniques are not equivalent to those using exogenous shocks. One of the major differences between them, apart of the shape of the IRFs, is that in SVARs one has a chance to isolate effects of components of spending aggregates, while in the exogenous shocks cases this is impossible; in the later case one is only able to estimate the effects of the typical policy mix, e.g. the combination of military personnel hires and defense equipment purchases or the combination of tax increases that have been used on average. The other is that exogenous shocks can be used in a way that can minimize any effects stemming from anticipation of fiscal actions, but this does not seem to be a major problem in the spending shocks generated by SVAR analysis of the dataset at hand, confirming previous work of Blanchard and Perotti (2002) and especially Mertens and Ravn (2010) and Tenhofen and Wolf (2010).

The third contribution of the chapter is to show in a thorough way the differences in the effects of the various government spending aggregates, combining and extending the work of Perotti (2004b) and Tenhofen and Wolff (2010), under a variety of identifying restrictions, as in Caldara and Kamps (2008). I have shown in detail that civilian spending has a beneficial effect on economic activity; this spending category resembles to a kind of productivity shock, giving some supportive evidence to papers advocating this explanation for the positive effects of government spending on economic activity; civilian consumption seems to affect private consumption and investment particularly strongly, while civilian investment has the highest output multiplier; a big effect of fiscal policy comes from labor market, through an effect that seems to affect labor demand and supply. These results comply with those obtained in the SVAR literature, in e.g

Blanchard and Perotti (2002), Fatás and Mihov (2001) or Perotti (2004a). However, military spending does not seem to affect the economy so positively; especially government investment seems to have a particularly negative effect on economic activity, like a negative productivity shock. This later effect is not predicted by any standard theory.

Finally a DSGE is proposed to account for the basic effects. Its key property is the disaggregation of the budget variables and allowing these to have quite distinct effects, as in reality. In particular, government consumption - hires are assumed to work in a manner similar to a productivity shock. Military equipment purchases work in the opposite way, because they are produced by an inferior production function - shifting resources towards this unproductive sector lowers the overall production of the economy. The mechanism is successful in replicating qualitatively the responses of the basic macroeconomic variables that are obtained from the SVAR models.

This work can be extended in several ways. A natural one seems to repeat this analysis using the various tax variables and shocks, which are available at least for the U.S. economy. The other is to repeat a similar analysis in other countries, preferably those that have long quarterly time series data. These routes are left for future research.

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Chapter 3

The Effects of Fiscal Policy during the Business Cycle

3.1 Introduction

A very important question, especially for policy-making, is whether there are different effects of fiscal policies during different economic conditions; this question has been taken up recently by a number of authors, who have tried to answer this question from different perspectives. One particular way to put forward this question, of the most important ones admittedly, is to ask what are the effects of fiscal policy during the different phases of the business cycle - are e.g. spending increases more effective during recessions, as Keynesian theory and common sense (at least among many policy makers) suggest? In addition, a related and extremely important question is which is the policy tool of choice during recessions - governments should increase spending or reduce taxes?

I try to address these questions using regime switching models, namely Threshold Vector Autoregressions (TVAR), and a variety of identification restrictions. A significant difference from other papers utilizing a similar technique is that I use models with more variables, in an effort to describe the economy more accurately, more identification methods and that I try to look at the effects of different categories of spending, as well as those of taxes, while the literature concentrates on spending; importantly, to my current knowledge, this is the first paper that utilizes the recently compiled exogenous tax shock series and explores their effects in a regime switching framework. In this paper, robustness of results is sought, something not always guaranteed in potentially

fragile models like those employing regime switching. I also try to sketch a model that reproduces the basic results.

The basic results from the various specifications confirm the basic findings from the SVAR methodology, and the papers undertaking similar analysis[1]: in response to a spending shock, economic activity (measured by output) is higher, and the effect is likely to be higher during recessions. Importantly, the spending shock has a positive effect on consumption, suggesting that the simple neoclassical model is not consistent with the data. A tax shock seems to have a negative effect on economic activity, though this result is not as clear-cut as the one for spending shocks; consumption, and in most cases output too, fall. In addition, inflation and the federal funds rate are more likely to fall in response to fiscal shocks. Investment is more likely to follow the output pattern. Unemployment responds in the expected manner to fiscal shocks: falls with more spending, rises with more taxes. Furthermore, the composition of spending matters a lot: civilian spending is expansionary, while military spending the opposite.

An important finding is that spending multipliers are probably higher than the ones of taxes in recessions, at least when non-military spending (the bulk of government expenditures) is used. The main policy implication of the findings is that a fiscal stimulus package concentrated in spending is more likely to work, as a Keynesian would assert. Another useful finding is that in most models output responses to taxes are negative in recessions and very small, yet positive in expansions; negative output responses to taxes is a pattern not so easy to replicate with linear VARs and conventional identification methods, and suggests that important nonlinearities exist in the data, and not all theoretical and policy analysis should be based on linear models. In addition, not all spending categories are good to stimulate the economy in recessions - civilian spending is to be preferred as a policy instrument. Also, there is no sign of falling spending multipliers after 1980, contrary to the findings of Perotti (2004).

Finally, a theoretical model is developed to account for most of the results. The key insight of this model is that some simple and expected nonlinearities are capable of reproducing most of the basic results from the econometric analysis, without resorting to consumer heterogeneity or some form of unconventional utility function.

The remaining of the chapter is structured in the following way. Section 3.2 presents

[1]The interested reader should read section 1.2.2.2 in introduction for a brief review of related work.

the methodology and the identification assumptions. Section 3.3 discusses the results from the different specifications. Section 3.4 discusses the DSGE that explains some aspects of the results. Section 3.5 concludes. In Appendix B I describe the data and present the tests for threshold effects for both the individual time series and the VAR systems, as well as graphs omitted from the main text.

3.2 Methodology

3.2.1 Threshold VARs

The model used in this chapter is the Threshold Vector Autoregression (TVAR). In this model there are a number of regimes, and the switch between regimes depends on the (usually lagged) value of the threshold variable, which can be a function of either an endogenous or an exogenous variable and must be stationary. This model has several attractive features, from the practitioner's point of view. First, it is a regime switching model, so it can provide evidence about what happens in different circumstances - regimes. Secondly, it is easy to estimate, since it is just OLS. Thirdly, the regime change does not depend on some latent variable, about which one has no clue, but on an observable variable with a clear economic meaning. On the downside, it is not that easy to test for the existence of threshold effects; additionally, producing forecasts and Impulse Response Functions (IRFs) is a rather complicated and time consuming issue, since it involves a bootstrap or monte-carlo procedure.

Alternative multivariate regime switching models commonly used in the literature are Markov switching VAR models or Smooth Transition VARs. Compared to the first, a threshold VAR has two basic advantages: it is much easier and faster to estimate, as it does not require any numerically expensive optimization of an objective function and regime change depends on an observed variable, not a latent one which might not have a clear economic explanation[2]. Compared to the second, a Threshold model retains the (smaller in this case) advantage of estimation simplicity; additionally, one has to observe that a Smooth Transition models should present strong regime switching effects mainly when it is close to a Threshold model (so that it resembles an abrupt transition model,

[2]However, once estimated, it is much easier to simulate the Markov switching model in order to produce forecasts and IRFs.

despite being called smooth[3]).

Assuming that Y_t and X_t represent vectors of endogenous and exogenous variables respectively and w_t the threshold variable and d its lag, a general TVAR model in which both the coefficients as well as the variance - covariance matrices are allowed to change across regimes can be represented as:

$$Y_t = \mathbf{C_i} + \sum_{j=1}^{p_i} \mathbf{A_{i,j}} Y_{t-j} + \sum_{h=0}^{q_i} \mathbf{D_{i,h}} X_{t-h} + U_{t,i}, \quad \text{if } \mathrm{r_{i-1}} < \mathrm{w_{t-d}} \leq \mathrm{r_i}$$

The model is estimated by OLS by splitting the sample according to the value of the threshold variable for all combinations of threshold values and its delay. The chosen model (a vector $\hat{\vartheta}$ containing the estimates) is the one that minimizes the determinant of the variance-covariance matrix of the estimated residuals $\hat{\Sigma} = \frac{1}{T}\sum_{t=1}^{T} U_t U_t'$ - formally $\hat{\vartheta} = \underset{\vartheta \epsilon \Theta}{\text{argmin}} \det(\hat{\Sigma}(\vartheta))$; this choice corresponds to ML estimation under the assumption of normality of residuals, but other choices, like minimizing the trace of the variance - covariance matrix of the estimated residuals are possible. In practice, for a 2 regime threshold model, one forms a grid for the different values of the threshold variable (and possibly of d), leaving out enough observations at both ends of the vector of the threshold variable so that there are enough observations to estimate the system, and then loops over this grid to pick the threshold value and split the sample accordingly; in univariate 2-regime threshold models, it is typically suggested to leave 10% - 15% of observations at each end out of the estimation - for the VAR, I leave out 20% of observations to get more precise estimates. After splitting the sample, one performs OLS in each sub-sample and stores the determinant of the variance-covariance matrix or the trace; when the loop is finished, the threshold value that gives the minimum value for the minimand is chosen. In this work, the break occurs only in the coefficients of the equations and not the variance-covariance matrix, for reasons that will be discussed in section 3.3.1.

Testing for linearity is a difficult issue; the main reason for this is, similarly to the case of testing for structural break models, the presence of nuisance parameters caused by the fact that there are parameters not identified under the null hypothesis of linearity.

[3]In fact, Auerbach and Gorodnichenko (2010) who use a Smooth Transition VAR mention (in p. 6 footnote 8) that when they estimate all parameters simultaneously, their estimate of the parameter that controls the curvature of the exponential function used to weigh the regimes is quite high, making their model similar to a Threshold VAR.

This means that the distribution of the test statistic is not standard and is dependent on the specific data set.

To test for linearity, I employ several methods. The first was developed by Hansen (1996) for the regression case, and extended by Hansen and Seo (2002) for VECMs with one cointegrating vector (so it is readily applicable in the VAR case). The test consists on computing the supremum of Wald[4] (or LM or LR) statistics (supWald) for each threshold value in the threshold region, and generate p-values for this statistic using a fixed regressors bootstrap, which gives the correct asymptotic distribution; one can also calculate average or exponential Wald[5] statistics (aveWald or expWald) for all possible threshold values - the latter two statistics may be more robust. The bootstrap to calculate the p-values is done in the following way (see Hansen and Seo (2002) p. 303-304): take the residuals from a baseline linear VAR and multiply them with N(0,1) variables; then regress the variable generated by the regressors coming from the TVAR model, for all possible threshold combinations; calculate and store the supWald (and/or aveWald and expWald statistics); repeat this process many times; compare the results from the baseline calculation with those obtained from the bootstrap to get the p-values as the percentage that the baseline statistics do not exceed the outcomes from the bootstrap.

The second way to test for linearity comes from Tsay (1998) and is based on the concept of arranged regression. The mechanics of threshold models are similar to those of structural break models, where the latter have a time trend as the threshold variable. So one starts by arranging the data according to the values of the threshold variable, where d (the lag of the threshold variable) and p (the autoregressive lag) are assumed known. Then one estimates the model with recursive least squares (expanding the ordered sample for one observation at a time) and calculates the predictive residuals (the residuals from the next period observation using the estimates from the current period). Under the null hypothesis of linearity, those residuals are uncorrelated with the regressors. The test is based on the regression of the (standardized) predictive residuals on the regressors, and is actually testing whether a significant relationship between the

[4]the formula for the Wald is: $W = (\mathrm{Rvec(B)})'(\mathrm{R}((\mathrm{X}'\mathrm{X})^{-1} \otimes \Sigma)\mathrm{R}')^{-1}(\mathrm{Rvec(B)})$, where R is a $0 - \pm 1$ matrix of restrictions, B is the coefficient matrix, X is the regressors matrix and Σ the variance covariance matrix from the TVAR.

[5]The formula for the expWald statistic is: $expW = ln(1/I \sum_{i=1}^{I} exp(W(i)/2))$, where I is the number of different threshold values used.

residuals and the regressors exists. This test has a χ^2 distribution under the null of no relationship (linear model).

Two more ways to test for threshold effects are used. The first one is based on the efficient bounds proposed by Altissimo and Corradi (2002 - for the regression case) and is formulated as in Galvão (2006). This approach utilizes a variant of the supWald (supLM) statistic, but from a model selection approach. Calculate for all possible threshold and threshold lag combinations the following Wald (LM) statistics for the null model (ϑ_0) and the alternative (ϑ)

$$W(\vartheta) = \mathrm{T}\left(\frac{\mathrm{SSR}(\vartheta_0) - \mathrm{SSR}(\vartheta)}{\mathrm{SSR}(\vartheta)}\right); \qquad LM(\vartheta) = \mathrm{T}\left(\frac{\mathrm{SSR}(\vartheta_0) - \mathrm{SSR}(\vartheta)}{\mathrm{SSR}(\vartheta_0)}\right)$$

where SSR is the sum of the sum of squared residuals from all equations. Take the supWald (or supLM) statistic and reject the null if the following condition holds:

$$BWald \quad = \quad \left[\frac{1}{2ln(ln(T))}\left[supW(\vartheta)\right]^{1/2}\right] \quad > \ 1$$

Finally, one can employ a pure model selection approach: chose the model that minimizes the model selection criteria - AIC, BIC, HQ - although these criteria may not have all the properties of the linear case; Gonzalo and Pitarakis (2002) advocate the use of BIC or variants of it in the regression case, while Kapetanios (2001) proposes the use of HQ in the same case; however, in both papers the best performing model when the data are generated by a threshold model is AIC, rendering the choice of criterion quite uncertain - here I present all of them, and take all into account.

3.2.2 Generalized IRFs

In what concerns the output - forecasts or impulse responses - from nonlinear models like the TVARs, the main issue with such models is that their IRFs are not unique and may depend on the regime, the past history, the size and even the sign of the shocks. For this reason, generating IRFs or forecasts is a complicated process, that takes a lot of time and is highly computationally intensive, since it involves integrating the effects of all other factors that might affect the IRFs except the one under consideration, and are called generalized impulse response functions (GIRFs); formally, the GIRF of a vector process Y_t to a shock v_t at horizon $n \leq N$ conditional on the history I_t can

be represented as: $GIRF_Y(n, v_t, I_t) = E(Y_{t+n} \mid v_t, I_t) - E(Y_{t+n} \mid I_t)$. The shock can incorporate identification restrictions, and in this implementation it does, so it is a structural one, as will be explained in the next section. The algorithm to produce the GIRFs in the present work is the following (for details see Koop et al (1996) or Galvão (2003)):

1. Pick a shock v_t^i (if there are many shock possibilities) and pick one particular history I_t^i.

2. Draw a sample of size $N + 1$ by bootstrapping from the residuals of the model, $U_t^{i,N+1}$.

3. Solve the the model forward using $U_t^{i,N+1}$ and I_t^i. These are the responses absent the shock.

4. Solve the the model forward using $U_t^{i,N+1}$ and I_t^i, adding the shock in the first period. These are the responses when the shock is present. Take the difference between the two responses. This is the response to the shock in the current replication.

5. Repeat steps 2 - 4 many times, to compute the dynamic effect of the shock for history I_t^i.

6. Repeat steps 2 - 5 for all possible (or desired) histories.

7. Calculate the mean response for all variables of Y_t. These are the GIRFs to shock v_t^i.

8. [If applicable] Pick another shock v_t^j and repeat steps 2 - 7, until all shock possibilities are exhausted. Calculate the mean responses to all shocks. These are the GIRFs conditional on all shocks and all possible histories.

At step 5, 200 replications per different history are used in this paper. The forecast horizon is 20 dates (after the impulse date). In the present work, step 8 is not implemented. I do not present results from negative shocks, as it is customary in the relevant literature - usually they are almost symmetrical around x-axis with the ones shown, indicating that nonlinearities caused by the sign of the shock are not important.

3.2.3 Identification methods

In the structural VAR literature several identification methods have been proposed. In what concerns the fiscal VARs, several have been applied, and will be shown in the context of a VAR including government spending, taxes, output, inflation and an interest rate with this ordering, except when a Cholesky identification scheme is used. In this work I use the following methods, in order to get results that are as robust as possible.

The first method, and the most widely applied is the Cholesky decomposition of the variance-covariance matrix of the VAR, with government spending ordered first, since this variable is unlikely to react within the same period, once transfers like unemployment benefits have been taken out from the spending variable. In my implementation, government spending is ordered first, followed by GDP, taxes, inflation, the interest rate and the rest of the variables in the specification.

A very popular method is the one proposed by Blanchard and Perotti (2002), which is equivalent to a Cholesky decomposition of the residual variance-covariance matrix, once these residuals have been "purified" by extracting the automatic response of fiscal variables to changing economic conditions, the latter having been calculated using information on the institutional settings for the conduct of fiscal policy or the tax system. These two methods result in a B matrix in the first case and an A matrix in the second (in the SVAR terminology - look at section 1.2.1 for details) with the forms presented in table 3.1 for the 5 variables mentioned in the previous paragraph (in that order).

Table 3.1: Cholesky and Blanchard - Perotti identifying restrictions

a) Cholesky decomposition					b) Blanchard and Perotti				
$b_{1,1}$	0	0	0	0	1	0	0	$-b_{g,p}$	0
$b_{2,1}$	$b_{2,2}$	0	0	0	$-a_{2,1}$	1	0	0	0
$b_{3,1}$	$b_{3,2}$	$b_{3,3}$	0	0	$-a_{3,1}$	$-b_{t,y}$	1	$-b_{t,p}$	0
$b_{4,1}$	$b_{4,2}$	$b_{4,3}$	$b_{4,4}$	0	$-a_{4,1}$	$-a_{4,2}$	$-a_{4,3}$	1	0
$b_{5,1}$	$b_{5,2}$	$b_{5,3}$	$b_{5,4}$	$b_{5,5}$	$-a_{5,1}$	$-a_{5,2}$	$-a_{5,3}$	$-a_{5,4}$	1

In the Blanchard and Perotti identification method, $b_{g,p}$, $b_{t,y}$ and $b_{t,p}$ are the elasticities of spending with respect to price and taxes with respect to output and prices, and are calibrated using outside information. In this paper I use the values reported by Perotti (2004) for the U.S. for these scalars, namely $b_{g,p}$ = -0.5, $b_{t,y}$ = 1.85 and $b_{t,p}$ = 1.25 respectively; for further details check the construction of the elasticities there. The $b_{i,j}$ and $a_{i,j}$ entries (i,j numbers) are estimated.

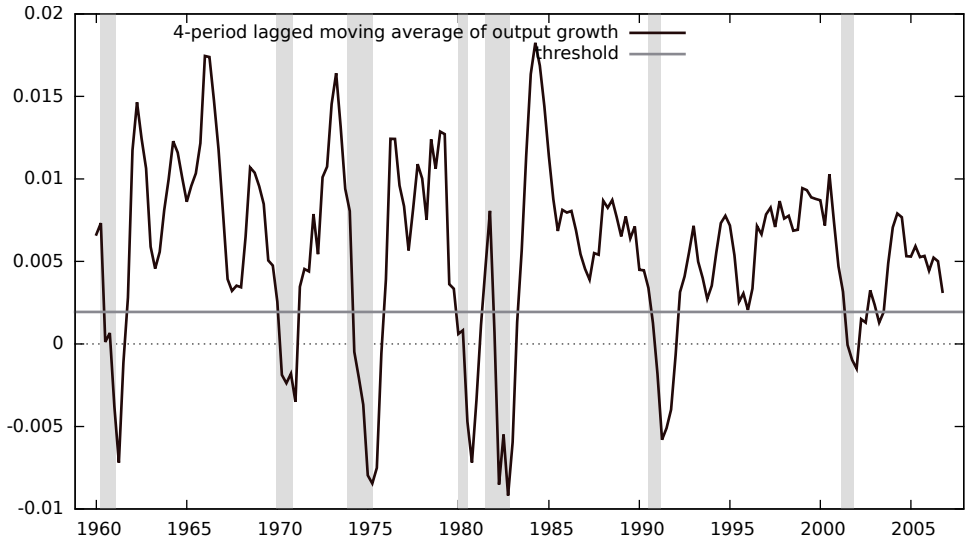
Another method used to understand the reaction of the main macro variables to fiscal policy shocks is to find some good exogenous shock and calculate the reactions of the variables of the model to this shock. It is the lack of good such shocks that leads to the use of the SVAR methodology. For fiscal policy, the exogenous shocks proposed so far, only for the U.S., are the following: first, the war dates by Ramey and Shapiro (1988). Secondly, in Ramey (2011) two more shock series are proposed: the increases in defense spending forecasts as they were published in the news and the change in the forecasts of the forecasters included in the SPF survey. In what concerns taxes, the exogenous shock proposed by Romer and Romer (2010) is based on the motivation for the legislated change in the U.S. tax code - this means that the change in the tax code is not enacted as a response to output movements. I use these exogenous tax shocks (without retroactive effects) as exogenous variables in some specifications and simulate the responses to such shocks; the SPF shock series has fewer observations and its usefulness is debated (see Perotti 2007 and 2011 and chapter 2), while the other tax shock variables are not guaranteed to be exogenous - Romer and Romer base their findings on this exogenous series. These exogenous shocks, measured in percent of GDP, are placed as exogenous variables in the TVAR, and their effects are estimated - only the contemporaneous value of the shocks is used, and these effects are restricted to be the same in both regimes, because there are very few observations in the recession regime. Then, these vectors serve as the impulse to 1% (or 3%) increase in taxes. In addition, in a specification where defense spending is used as the spending variable, I use Ramey's exogenous military spending shocks in a similar manner; this variable is not used in the other models, as in chapter 2 it is shown that it does not move civilian spending variables significantly.

3.3 Results

3.3.1 Baseline model – all identifications

The baseline model includes total spending in goods and services (defense and non-defense, consumption and investment), taxes, output, inflation, the federal funds rate and consumption; one lag of the endogenous variables is used in each regime. Alternative models, discussed later in this section, replace either the spending variable with civilian or military spending, or consumption with investment or unemployment. The threshold

Figure 3.1: Threshold variable and business cycle



Shaded areas are NBER recessions. Threshold value of baseline model.

variable in all cases is a 4-period (backwards) moving average of output growth rate, lagged once, and the threshold splits the sample (1960:1 - 2006:4) in high and low growth regimes; as it is evident in figure 3.1, the chosen threshold variable is a natural business cycle indicator. Details on the data are available in Appendix B.1. In Appendix B.2 linearity tests for the individual time series are presented. The linearity tests supporting the choice of the model(s) are available in Appendix B.3. Figures with the GIRFs of the other models are included in Appendix B.4.

Shocks, in all cases except when the exogenous shocks are used, are normalized to give an initial 1% increase in spending or taxes, and big shocks give a 3% increase in spending or taxes. In the figures, IRFs from big shocks are scaled down by a factor of 3. In all cases, the starting values of the shocks are the same, implying no change in the variance covarinace matrix of the residuals; there are very few observations (41) to estimate both the coefficients (9 in each equation[6]) and the variance-covariance matrix of the low growth regime (with 21 parameters); additionally, it would be too risky to estimate different responses to exogenous structural shocks in the low growth case, since few exogenous shocks observations occur in recessions (6 the case of exogenous tax shocks, 11 in the case of Rameys defense spending shocks); therefore, consistency across the different identification assumptions necessitated the assumption of no break in residuals.

[6] Apart from one lag of the 6 endogenous variables, a constant, a time trend and a squared time trend are added in the equations.

In addition, assuming a common variance-covariance matrix in both regimes, meaning having the same starting values in both of them, shifts the focus on the endogenous reaction of the system, as opposed to differences caused by the breaks in the process that generated the residuals[7].

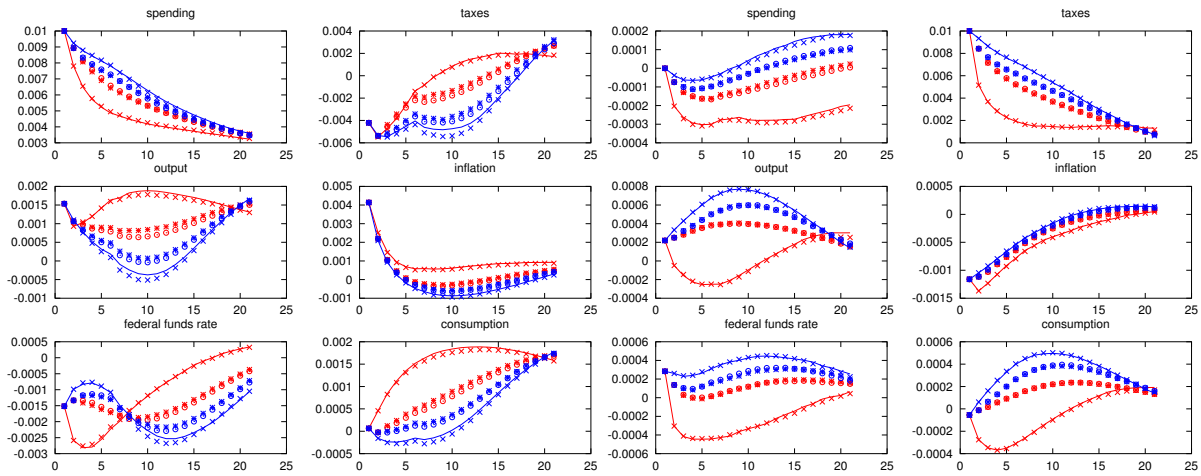
In figure 3.2 the responses to spending and tax shocks for the baseline model under the different identifying assumptions are presented. A first thing to notice is that the Blanchard - Perotti (BP) and the Cholesky (Ch) methods identify quite similar spending shocks, which are also very similar across regimes and histories. The same thing happens in the reaction of taxes to tax shocks (in all three cases). In all cases the responses of spending and taxes have a smaller persistence in the case of recession history (when starting values for the forecasting are from recessions only).

In the BP case, a spending increase leads to a fall in taxes, suggesting the existence of a deficit bias of the fiscal authority; output and consumption go up, more during recessions despite the lower spending increase, inflation goes up but the interest rate down - here the spending shock looks like a Keynesian demand shock and FED seems to accommodate fiscal policy. In the Cholesky case, the reactions to the spending shock differ in the case of inflation which is negative, something that suggests the transmission of spending increase through lower markups as in some DSGEs that deal with fiscal policy issues; additionally, here taxes rise, leading one to think that the fiscal authority does not change the tax rates and the output expansion increases tax receipts. Generally history appears less important to the reactions to spending shocks in this case compared to the BP case.

A tax increase under BP identification drives spending down by little - more intensely so during recessions, suggesting that the fiscal authority raises taxes and cuts spending when the latter has gone too far. There is a small negative response of inflation and a tiny positive response of the federal funds rate during expansion (does not move from the starting values) - but the latter clearly falls during recessions. Output and consumption clearly fall during recessions once history from that regime is used, as most models and common sense would suggest, but, curiously, there is a positive response of output and consumption during expansions (or in recession when the full history is used). The

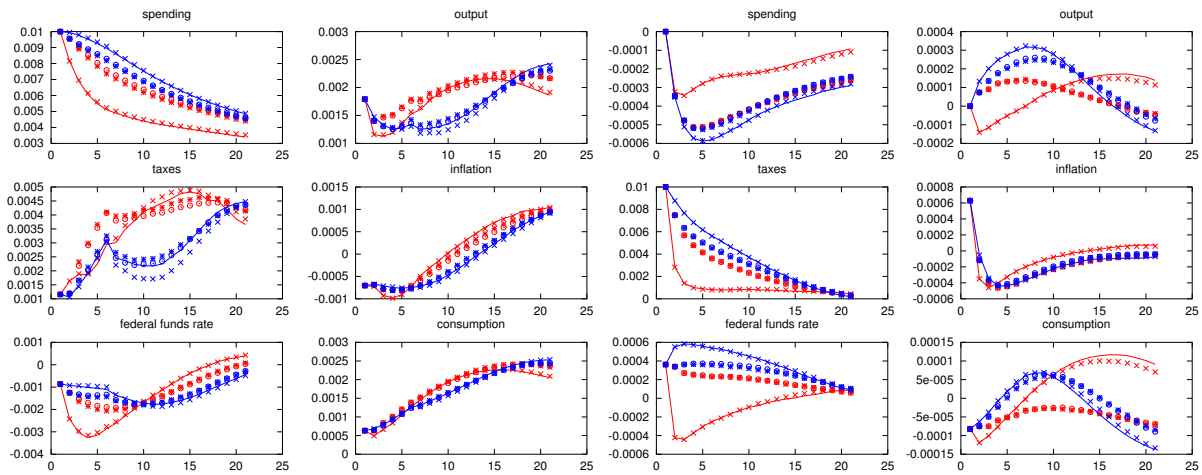
[7] In section B.5 of the Appendix some results from models where the variance-covariance matrix is allowed to change are presented - there it will be shown that proper handling of structural breaks does not alter the main results even in case of breaks in variance-covariance matrix.

Figure 3.2: Baseline model, various identifications.



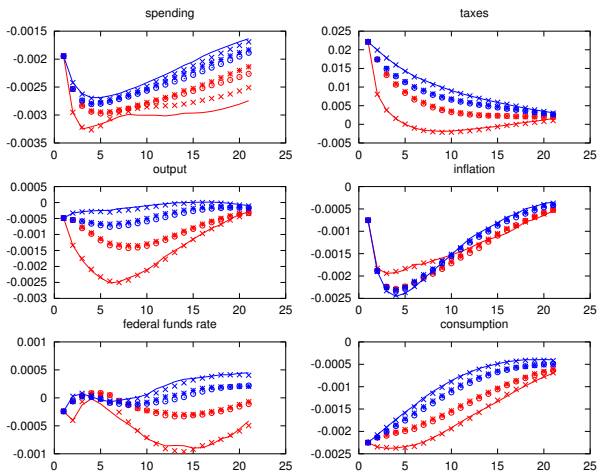
(a) Blanchard - Perotti identification, spending shock

(b) Blanchard - Perotti identification, tax shock



(c) Cholesky identification, spending shock

(d) Cholesky identification, tax shock



(e) Exogenous tax shock

Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, regime specific history; stars: 1% shock, full history; x: 3% shock, regime specific history; circles: 3% shock, full history.

positive output and consumption response to tax increases does not does not make much sense, unless people were afraid of the fiscal position of the U.S. and the higher taxes indicate a expansionary fiscal contraction story, something highly unlikely; probably it is an indication of the high difficulty to extract tax shocks from the residuals of a (T)VAR, even when the techniques used to do it are quite advanced, since the major force behind tax movements is output fluctuations.

In the Cholesky case, tax shocks have a positive effect on inflation initially, a more conventional outcome, since this can be achieved if indirect taxes rise, and a fall in consumption, particularly during recessions; this inflation response is reversed fast. The interest rate falls fast during recessions but does not really move from the staring values in expansions. Like the BP case, they drive spending down and output up during expansions. Even though the Cholesky approach is more atheoretic, the results from it seem to tell a story that is easier to believe, if one has in mind some recent theoretical models analyzing fiscal policy - the tax shocks especially seem more consistent with a simple neoclassical model.

Exogenous tax shocks have similar effects in both regimes, but their magnitudes differ; in both regimes, taxes rise and all the other variables fall, pointing to recessionary effects of taxes, consistent with a Keynesian view of the economy. Particularly the fall in inflation is hard to reconcile with a NK model, as markups and inflation there have opposite signs with output. During recessions however, the fall in output is particularly strong, suggesting that for some reason (e.g. more rule-of-thumb consumers during recessions), it does not seem prudent to consolidate in a recession.

Evidently, there are clear nonlinearities in the responses, especially in those of output and consumption - they both move more in recessions, since having common starting values there does not limit subsequent paths a lot. It is clear that, in recessions, spending causes real variables to increase more and taxes reduce them more. However, the size of the shocks does not seem to matter - or at least shocks of the chosen sizes are not what it takes to have regime switching often, yet I doubt that bigger shocks would ever be politically feasible, unless under extreme circumstances.

This optical impression is verified by the output multipliers from each case; the cumulative spending and tax multipliers[8] are shown in table 3.2. More specifically,

[8]The cumulative multiplier at period p is calculated as the cumulative sum of the response of output

Table 3.2: Cumulative mean multipliers across regimes of the baseline TVAR model

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	0.97	1.22		0.39	0.87		0.11	0.06	-2.58	0.40	0.17	-0.18
T=0	0.76	0.89		0.76	0.89		0.12	0.00	-0.12	0.12	0.00	-0.12
T=4	0.75	0.88		0.50	0.74		0.05	-0.03	-0.80	0.25	0.11	-0.16
T=8	0.91	1.11		0.31	0.76		0.03	0.01	-2.01	0.38	0.19	-0.19
T=16	1.17	1.52		0.28	0.99		0.17	0.15	-4.43	0.54	0.23	-0.19

(a) Mean multipliers using both regime-specific and full history

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	1.26	1.32		0.33	0.85		-0.11	0.03	-4.34	0.42	0.18	-0.09
T=0	0.76	0.89		0.76	0.89		0.12	0.00	-0.12	0.12	0.00	-0.12
T=4	0.86	0.89		0.47	0.73		-0.11	-0.14	-1.30	0.27	0.12	-0.10
T=8	1.21	1.19		0.25	0.74		-0.25	-0.09	-3.44	0.41	0.20	-0.10
T=16	1.59	1.70		0.20	0.96		-0.08	0.18	-7.51	0.57	0.23	-0.08

(b) Mean multipliers using regime-specific history only - 1% shock

BP : Blanchard & Perotti, Ch : Cholesky, ExS : Exogenous Shock.

spending multipliers are much higher during recessions, especially in the BP case, with more pronounced differences if one uses history from the relevant regime - recession multipliers rise and expansion multipliers fall a bit. These multipliers are close to 1 even in the first year of a recession, and could be over 1.5 in prolonged low growth episodes. Overall, these multipliers are in line with previous estimates for the US.

Tax shock multipliers also look different; in the two SVAR cases, they are generally low, yet lower in recession. They are negative in simulations where the recession regime has a recession history, although their magnitude is small. In the case of Romer and Romer tax shocks, the multipliers differ substantially between regimes; they are slightly negative during expansions, but very negative during recessions, although they are low on impact. Such big (in absolute value) multipliers in recessions for R&R shocks are reminiscent of the analogous results of Romer and Romer (2010) in linear models. However, the estimated values here (higher than 4 in recessions at four years) are too big to be accepted without doubt, especially considering the difference in magnitude from those reported from SVARs.

to the cumulative response of the spending or taxes, the latter multiplied by the average share of government spending or taxes in output, as in Perotti (2004).

There is the possibility that the SVAR shocks are not structural, unlike the narrative shocks. However, if one reads the paper that documents the construction of the exogenous tax shocks series (Romer and Romer (2008)), it becomes clear once again that the SVAR shocks could be quite different from the exogenous tax shocks: SVAR shocks refer to shocks to all tax variables together, so they largely consist of a shock to sales and property taxes (with smaller effects on labor supply decisions), while the exogenous tax shocks are in the most part shocks to income and (to a lesser extend to) corporate taxes, and as such can have substantial supply side effects. However, such a view would be open to a different kind of criticism - what is the economic mechanism that would make the responses to tax shocks so different in high and low growth regimes, if they mostly work through their effects in labor supply - why would the later be so much affected during low growth episodes - can the labor supply function be so non-linear?

In general, leaving aside the question of which is the best way to identify fiscal shocks, what the data suggest is that for immediate demand management purposes during a recession, spending may be more effective, even though tax cuts may have stronger long-run effects in recessions; output multipliers are higher for spending increases in the first periods. Additionally, tax increases - consolidations - should be done during expansions; histories of the shocks affect the results strongly - in this respect nonlinearities are important. Additionally, the CB reaction does not seem to be important - either it does not react to fiscal shocks (fiscal dominance) or these shocks do not move inflation strongly enough to force the FED to react. I have to remind though that spending and tax shocks did not have any big effects on inflation; these were mostly negative, and even when they were positive, they were very short lived.

The results presented here suggest that the best policy to drive the economy out of a recession should be a combination of immediate spending increases, lasting a few quarters, to stimulate demand a bit, accompanied by cuts to income and corporate taxes, that give the big boost to the economy after a year. This looks like an optimal policy in ordinary recessions, where the zero lower bound is not operative.

Lastly, a very debated issue, the response of consumption to spending shocks, has a quite clear answer in the previous models: consumption mimics the output response; for whatever reason this may happen (e.g. Keynesian economy, government spending resembling a productivity shock, rule-of-thumb consumers or non-separable utility in

consumption and government spending), if someone expects a positive output reaction then one should also expect a similar consumption response. Overall, despite the differences in magnitudes, the results for each identification method resemble those coming from linear SVARs.

As robustness checks, I have also estimated the responses for all the cases using more lags in the expansion regime, and I have also added as exogenous variables the defense spending and tax shocks of Romer and Romer and Ramey respectively in the BP and Cholesky case. The results do not differ substantially from the baseline case, suggesting that the responses derived using the baseline model are indicative of the identification scheme; only some more nonlinearities and substantially different shapes between regimes are evident in the cases with 2 lags in high growth regimes, but the overall picture does not change. One important difference occurred in the BP tax shock when I used 4 lags in the expansion regime: in this case, the consumption response was negative, probably because the output response was lower, reconciling the results with those of the Cholesky method and conventional wisdom. Adding more lags to the models with Cholesky identification, irrespectively of the addition of exogenous shocks, leads to another major change in the reactions to tax shocks: output now falls and this, apart from the negative consumption response, explains better the fall of inflation after the first period.

3.3.2 The effects of different histories

There is high likelihood that the many shocks that have occurred during the last 50 years have altered the US economy, and these changes may have affected, among other things, the potency of fiscal policy to affect the economy or its transmission mechanism. This may be explored in the following way: produce GIRFs for a specific part of the sample to see whether these change as time passes.

Figure B.1 (in Appendix B.4) presents the GIRFs of the baseline model under different identifying restrictions, where histories from each decade from 1960 up to 2000 have been used. It turns out again that the history used matters: while the responses are similar to those in figure 3.2, a clear pattern emerges in most cases. Specifically, the response of output, taxes and consumption to spending shocks has been stronger during recessions in the 60s and, although not as much, in 90s, confirming the results of Afonso

Table 3.3: Cumulative mean multipliers across regimes of the TVAR model using different decades as histories; 1% shocks.

	60s		70s		80s		90s	
	BP	Ch	BP	Ch	BP	Ch	BP	Ch
Mean	0.97	1.40	0.64	0.99	0.56	0.96	0.85	1.33
T=0	0.76	0.89	0.76	0.89	0.76	0.89	0.76	0.89
T=4	0.78	1.06	0.59	0.78	0.55	0.76	0.73	0.98
T=8	0.95	1.41	0.55	0.86	0.47	0.83	0.80	1.26
T=16	1.13	1.68	0.70	1.19	0.56	1.14	0.95	1.65

(a) Spending, recessions

	60s		70s		80s		90s	
	BP	Ch	BP	Ch	BP	Ch	BP	Ch
Mean	0.43	0.94	0.57	0.97	0.50	0.88	0.37	0.91
T=0	0.76	0.89	0.76	0.89	0.76	0.89	0.76	0.89
T=4	0.56	0.80	0.58	0.77	0.54	0.74	0.52	0.76
T=8	0.41	0.88	0.51	0.85	0.42	0.75	0.33	0.80
T=16	0.31	1.05	0.55	1.14	0.47	1.01	0.23	1.04

(b) Spending, expansions

	60s			70s			80s			90s		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	0.43	0.06	-0.93	0.31	0.11	-0.48	0.33	0.13	-0.40	0.36	0.10	-0.56
T=0	0.12	0.00	-0.12	0.12	0.00	-0.12	0.12	0.00	-0.12	0.12	0.00	-0.12
T=4	0.28	0.07	-0.35	0.19	0.07	-0.29	0.19	0.08	-0.28	0.24	0.08	-0.27
T=8	0.42	0.09	-0.79	0.27	0.12	-0.45	0.29	0.14	-0.41	0.34	0.12	-0.51
T=16	0.58	0.06	-1.49	0.44	0.14	-0.67	0.46	0.19	-0.50	0.48	0.13	-0.84

(c) Taxes, recessions

	60s			70s			80s			90s		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	0.46	0.19	-0.17	0.35	0.15	-0.36	0.31	0.15	-0.31	0.41	0.18	-0.14
T=0	0.12	0.00	-0.12	0.12	0.00	-0.12	0.12	0.00	-0.12	0.12	0.00	-0.12
T=4	0.27	0.12	-0.16	0.21	0.09	-0.26	0.20	0.09	-0.25	0.24	0.11	-0.16
T=8	0.44	0.22	-0.20	0.32	0.17	-0.37	0.28	0.16	-0.34	0.38	0.19	-0.17
T=16	0.64	0.26	-0.16	0.48	0.20	-0.45	0.42	0.21	-0.37	0.57	0.25	-0.11

(d) Taxes, expansions

BP : Blanchard & Perotti, Ch : Cholesky, ExS : Exogenous Shock.

et al (2011)[9]. There are not many differences in the responses during expansions. In any case, the differences found do not seem to have been caused by any differences in the patterns of spending and federal funds rate.

As for tax shocks, no clear differences between decades and common in all identification setups emerge; the only noticeable reaction was that the economy responded better during expansion in the 60s and 90s, only in the BP and Cholesky cases and that the exogenous tax shock implies lower vales for the real variables, as one might expect.

The results from the calculation of multipliers in table 3.3 suggest that spending multipliers also vary by decade and are higher during recessions in 60s and 90s, confirming the visual impression from figure B.1, despite that fact that both regimes have common starting values that necessarily mitigate differences. Tax multipliers do not differ substantially between decades, yet still multipliers from exogenous tax shocks are uniformly lower in recessions, particularly in 60s. An important thing to keep in mind is that we do not observe the high tax multipliers in recessions of the baseline model when exogenous tax shocks are used; this casts doubts on the magnitude of these multipliers, especially since it is the same model that produces them, with just different starting values.

Overall however, these results suggest that there is no clear trend towards lower spending multipliers, casting doubt on the results of Perotti (2004), who documented the fall of spending multipliers after 1980 for the US, among other countries; at least, no significant difference in the reaction of FED is discernible, weakening the case for lower spending multipliers because of more aggressive anti-inflationary policy after Volcker. In addition, the high multipliers of exogenous shocks in recessions do not seem so robust.

3.3.3 The effects of civilian and military spending

Another issue that has not been thoroughly investigated is what happens when the fiscal authority chooses to change different spending variables. Here I look at one major decomposition of spending: defense vs non-defense spending. This distinction may be very important, since defense spending is the definition of useless spending, while one

[9]To avoid criticism based on misunderstandings like that there was only one sallow recession during the 90s, I have to say that the computation uses as starting values all dates in a decade, and the initial regime is a recession or an expansion, meaning that the companion matrix from the relevant regime is used for the first computation; the computation is equivalent to what you would get if each quarter of the relevant decade was the beginning of a recession or an expansion.

can argue that many components of non-defense spending may have various positive effects on growth, both in the short and the long run. In chapter 2 it was demonstrated that civilian spending can have completely different effects on the economy compared to military, and mixing these effects by using total spending in goods and services might be totally misleading.

Only Auerbach and Gorodnichenko (2010) address this question, and find that spending multipliers differ with respect to the spending variable used, and that defense spending has the highest multiplier in recessions (reaching 4). Using the same models, identification restrictions and variables, I simply replace total spending with total defense and non-defense spending. The results are presented in figures B.2 and B.3 for non-defense and defense spending respectively (in Appendix B.4).

These GIRFs to non-defense spending shocks are broadly similar to those of figure 3.2, with stronger output and consumption responses in expansions; spending shocks have similar persistence in both regimes. Only in the Cholesky case the responses of taxes become negative and of inflation positive, resembling qualitatively (but not in shape) those of the BP case; one can assert that differences in the identification schemes for spending do not matter as much as differences in the information sets.

One interesting difference with the baseline model is the reaction to tax shocks in models with non-defense spending in the BP and Cholesky cases. Here, the tax shocks generate a permanent increase in spending, that drives output and consumption to higher levels. In this information set, taxes serve to generate an increase in the non-defense spending of the public sector, something that has a stimulative effect in the economy; in other words, the identified shocks resemble shocks that are associated with a permanent expansion of (potentially useful) government. GIRFs to exogenous tax shocks are just like the BP tax shock of this model, with the only difference being lower starting values of most of the variables.

The most important difference from the baseline model is in the responses to exogenous tax shocks. Here output and consumption responses are very similar across regimes and both turn positive after a few quarters, unlike the baseline case with total spending. Obviously, the multiplier (presented later) will be higher in recessions, but this is due to the tax response, not that of output.

The GIRFs to defense spending - including Ramey's shocks - are quite different. In

all three cases, defense spending increases are less persistent in recessions. Importantly, in all cases output responses are very similar and counter-intuitive: output turns negative after a few periods, faster in recessions. Consumption responses are negative in recessions in all cases and negative in BP and exogenous shocks in expansions too. Taxes do not move a lot in either regime, inflation and interest rate responses are negative. Overall, a low growth, even recessionary, picture, totally different from the one depicted in Auerbach and Gorodnichenko for defense spending, but reminiscent of the results in chapter 2 for defense investment. In addition, it shows the importance of using specifications that enhance the information set and potentially give more robust results - as the models become richer and more similar in the information they contain, the identification method becomes less important. Caldara and Kamps (2008), in linear VARs, also document that similar models produce similar results, regardless of identification differences.

The responses to tax shocks in models with defense spending are close to those with civilian spending, but now because defense spending falls, allowing positive responses of output and consumption in SVAR models and eventually in models with R&R shocks. Yet, in this case non-linearities are more evident.

Table 3.4 has the multipliers of these 2 models under the various identifying restrictions; these verify the lower output responses to defense spending. Spending multipliers in the model with civilian spending are similar with those in the baseline while tax multipliers in SVAR cases uniformly positive; importantly, tax multipliers using the exogenous tax shocks are lower here, tending to be lower than those of spending, as SVAR models predict, casting doubt on the size of tax multipliers using these shocks and their robustness to different information sets.

Spending multipliers in models with defense expenditures are lower than those of the previous case regardless of the identification and, oddly, are higher in expansions; these results are opposite to those reported by Auerbach and Gorodnichenko. Tax multipliers are very big again, reminding the values of the baseline model - however, these values are suspect, since they seem to depend on the inclusion of defense expenditures in the model.

As mentioned before, it seems clear that different spending variables have totally different effects on the economy. This is not peculiar: there are many categories of civilian

Table 3.4: Cumulative mean multipliers across regimes of the TVAR model with non-defense and defense spending; 1% shocks, regime specific history.

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	1.12	1.56		0.34	1.19		0.71	0.51	-0.32	0.54	0.33	0.28
T=0	0.41	0.59		0.41	0.59		0.09	0.00	-0.43	0.09	0.00	-0.43
T=4	0.98	1.03		0.35	0.72		0.18	0.08	-1.41	0.29	0.18	-0.07
T=8	1.26	1.63		0.27	1.08		0.65	0.40	-0.78	0.50	0.31	0.22
T=16	1.26	2.02		0.35	1.62		1.15	0.89	0.45	0.77	0.49	0.62

(a) Non-defense spending

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	-0.06	0.21	-1.02	0.20	0.61	0.53	0.57	0.57	-2.14	0.42	0.14	0.02
T=0	0.99	1.09	3.56	0.99	1.09	3.56	0.09	0.00	-0.20	0.09	0.00	-0.20
T=4	0.36	0.57	0.46	0.60	0.84	1.70	0.14	0.01	-1.93	0.24	0.09	-0.11
T=8	-0.13	0.15	-1.37	0.27	0.69	0.64	0.45	0.40	-5.51	0.39	0.15	-0.03
T=16	-0.44	-0.12	-2.50	-0.22	0.35	-0.74	0.94	1.05	-0.43	0.59	0.19	0.16

(b) Defense spending

BP : Blanchard & Perotti, Ch : Cholesky, ExS : Exogenous Shock.

spending that are considered to be growth enhancing, like expenditure in education or public investment, while defense spending is the definition of useless public spending; however, even useless public spending is not usually considered to cause output to fall - this makes sense only if the resources used for it utilize an inferior production function, or distortionary taxes are raised more aggressively to pay for it; chapter 2 describes a model consistent with the first explanation. Additionally, taxes used to finance different types of spending can have totally different effects: taxes used to expand the useful public sector may not be especially harmful, while budget consolidations using higher taxes and lower useless spending may even be beneficial - these results echo the tale of expansionary fiscal contractions, but for specific types of spending.

3.3.4 Investment and unemployment

Another much neglected issue is what happens to other important macroeconomic variables during recessions and expansions. In this section I look at the responses of two of the most cyclical variables, private investment and unemployment, which replace consumption.

The responses are on figure B.4 for investment and B.5 for unemployment (again in

Table 3.5: Cumulative mean multipliers across regimes of the TVAR models with investment and unemployment rate; 1% shocks, regime specific history.

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	1.99	2.08		1.03	1.10		-0.24	-0.66	-0.57	0.16	0.04	0.29
T=0	0.88	0.89		0.88	0.89		0.13	0.00	0.47	0.13	0.00	0.47
T=4	1.68	1.79		0.90	0.96		-0.17	-0.42	-0.02	0.18	0.11	0.48
T=8	2.16	2.29		1.00	1.08		-0.31	-0.74	-0.52	0.19	0.12	0.41
T=16	2.30	2.37		1.14	1.22		-0.31	-0.89	-1.10	0.13	-0.02	0.11

(a) Investment

	Spending multipliers						Tax multipliers					
	Recession			Expansion			Recession			Expansion		
	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS	BP	Ch	ExS
Mean	2.06	2.03		1.17	1.13		-0.61	-0.76	-0.20	0.29	0.13	0.62
T=0	0.95	0.95		0.95	0.95		0.09	0.00	-0.08	0.09	0.00	-0.08
T=4	1.73	1.68		0.98	0.98		-0.43	-0.52	-0.16	0.21	0.15	0.38
T=8	2.23	2.18		1.13	1.10		-0.78	-0.88	-0.23	0.30	0.20	0.68
T=16	2.38	2.36		1.34	1.26		-0.77	-0.98	-0.23	0.36	0.10	0.85

(b) Unemployment Rate

BP : Blanchard & Perotti, Ch : Cholesky, ExS : Exogenous Shock.

Appendix B.4). Spending responses are very similar in both BP and Cholesky cases, and are characteristically non-linear - real variables and inflation rise more in expansions, interest rate falls more in recessions. Investment rises strongly in recessions while it does not move in expansions. The results from unemployment model are also similar, with unemployment rate falling strongly in recessions. Lastly, higher economic activity is associated with rising inflation, opposite to what one would observe in an NK model. These results have a definite Keynesian flavor.

Tax shocks lead to a decrease in government spending, stronger in recessions with BP identification, the opposite using exogenous tax shocks. Output declines, but much more strongly in recessions. Inflation and the interest rate fall, the latter more strongly in recessions. Investment declines, much faster in recessions. Unemployment falls marginally in the 2 SVAR cases, suggesting diminished effects of taxes on this variable, but quite strongly in the exogenous shock case, a movement that must be associated with the minimal output response (even positive in expansions) in this case. Once again the R&R shocks raise some questions.

Multipliers for these cases are presented in table 3.5. Spending multipliers here

are the highest of all models, both in expansions and in recessions, exceeding 2 in the latter case. These highly cyclical variables give negative tax multipliers in all cases in recessions, with values not exceeding -1 in general; in addition, apart from being lower than the ones of spending, we do not observe big differences in the value of tax multiplier among the various identification cases. Anyway, once again the extreme values obtained using the R&R shocks are not maintained.

3.4 A theory model to explain some of the baseline results

At this point I will try to develop a theory model to account for the basic results. This model must have some asymmetry built in it, so as to respond differently in recession or expansions. At this point it is useful to repeat the basic reactions of the variables: after a spending shock, output, consumption, investment rise and unemployment falls - these reactions become more forceful in recessions; at the same time the nominal variables, inflation and the federal funds rate, do not seem to respond differently in the two regimes. Taxes also seem to have bigger and worse effects during recessions.

The closest work in spirit with this one is the paper by Canzoneri et al (2011), where the authors develop a model based on Curdia and Woodford (2009); their aim is to explain the asymmetric effects of spending shocks during business cycle that were found by Auerbach and Gorodnichenko (2010). Their model is based on the asymmetry generated by financial frictions over the business cycle - these countercyclical frictions make the consumption of borrowers rise more after a spending shock during recessions, and create big multipliers. Another paper that tries to explain the apparent non-linearities of the business cycle is Eggertsson and Krugman (2012), where the forced deleveraging during recessions help to explain the empirical findings.

In this paper I explore a different mechanism, following the lead of Reis (2007), that is related to policy - the response of policy to changing circumstances; Reis observed that the baseline RBC - DSGE can be consistent with a wide range of responses to government spending shocks, if the policy rules are parameterized appropriately - it is quite wrong to draw general conclusions from the results of models where only balanced budget fiscal expansions are undertaken.

The key elements of the model are the following two. First, government is assumed to produce a public good that enters the private sector production function; this idea

has a long tradition in economics, and papers with DSGEs using this idea include Baxter and King (1993) or Linnemann and Schabert (2006); most economist, including some who adhere to the narrative approach to identify spending shocks (e.g. Ramey 2011), are quite comfortable with the notion that government produces goods (e.g. public infrastructure like roads or water facilities) or services (e.g. police or education) that enter directly or indirectly in the private sector's production function. Technically, an assumption of this kind is required to overcome the negative wealth effect; it is not the only possible[10], but it is the easiest and produces a very familiar model, similar to the one in the previous chapter.

In addition, the government conducts a kind of countercyclical policy: in recessions, taxes are not allowed to increase so fast, because government coordinates fiscal policy instruments, reducing the tax rate to accommodate the effects of spending. The presentation shows the levels model and the steady state for all variables, and the model is solved using typical linearization techniques in Dynare.

3.4.1 The model

3.4.1.1 Households

The economy is inhabited by numerous households that belong to the interval [0,1]. The representative household maximizes the intertemporal utility (1) subject to the budget constraint (2).

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(ln(C_t) - \frac{\kappa L_t^{1+\theta}}{1+\theta} \right) \tag{3.1}$$

$$C_t + K_{t+1} - (1-\delta)K_t + B_t = (1-\tau_t^w)W_t L_t + R_t K_t + R_{t-1}^b B_{t-1} \tag{3.2}$$

C_t is consumption, L_t is the labor supplied in a period, K_t is capital owned by the household, W_t the real wage, τ_t^w is the tax rate on wage income, B_t are new (one period) bond purchases, $R_t K_t$ is income from lending capital to firms, $R_{t-1}^b B_{t-1}$ is income from bond holdings. Household can choose C_t, B_t, K_{t+1} and L_t and takes the rest of the

[10] One could resort to Rule of Thumb consumers (Galí, López-Salido and Vallés (2007)), requiring a monetary model, but several trials have shown that it is very difficult to produce a variant of such a model giving multipliers of the required magnitude. Other possible solutions, like firm entry (Devereux, Head and Lapham (1996)), do not differ in essence from the chosen approach.

variables as given.

The solution of this problem gives rise to the usual Euler equations for consumption (3), bonds (4) and labor supply (5).

$$\frac{1}{C_t} = E_t \frac{1}{C_{t+1}}(1 + R_{t+1} - \delta) \tag{3.3}$$

$$\frac{1}{C_t} = E_t \frac{1}{C_{t+1}}(1 + R_t^B) \tag{3.4}$$

$$W_t = \frac{\kappa L_t^{\theta} C_t}{1 - \tau_t^w} \tag{3.5}$$

3.4.1.2 Firms

The private sector in the economy produces a good that can be used either for consumption or investment. There are many firms belonging in the interval [0,1], each producing the same consumption good under perfect competition.

For firms in the consumption sector the problem is to minimize cost, $W_t L_t^p + R_t K_t$, subject to the production function (6), which is a standard Cobb-Douglas one, with a modification: G_t, a good produced by the government, affects the labor productivity, so it has an externality, and its exponent, γ, controls the size of this externality; A is the level of technology, R_t the real return to capital. As it is typical in competitive sectors, each firm employs labor L_t^p and capital K_t up to the point where the factor price equals the marginal product as shown in equations (7) and (8), price equals marginal costs and profits are zero.

$$Y_t = AK_t^{\alpha}(G_t^{\gamma} L_t^p)^{1-\alpha} \tag{3.6}$$

$$R_t = \alpha A K_t^{\alpha-1}(G_t^{\gamma} L_t^p)^{1-\alpha} = \alpha \frac{Y_t}{K_t} = MPK_t \tag{3.7}$$

$$W_t = (1-\alpha) A K_t^{\alpha} G_t^{\gamma(1-\alpha)} L_t^{p-\alpha} = (1-\alpha)\frac{Y_t}{L_t} = MPL_t \tag{3.8}$$

An important thing to notice is that this is the big sector in the economy. This has the consequence that factor prices, the rental rate of capital R_t and the real wage W_t are determined in this sector. Government is a price taker.

3.4.1.3 Government

The government collects taxes and buys labor services L^g to produce the government service to the private sector G_t using production function (9). As mentioned before, the largest part of government consumption is wages, so in the model what the fiscal authority buys is simply labor services, at the market wage rate, in a setup similar to Linnemann (2009). The government budget is given by (10), and (11) gives the tax policy reaction function: taxes are set to ensure solvency via ξ, which measures the strength of tax response to debt, without excessively changing tax rates, and coordinate policy objectives when needed with the parameter $\varepsilon_{\tau g}$.

$$G_t = L_{gt}^{\chi} \tag{3.9}$$

$$W_t L_t^g + R_{t-1}^b B_{t-1} = \tau_t^w W_t L_t + B_t \tag{3.10}$$

$$\begin{aligned} ln\left(\tau_t^w W_t L_t / \tau^w W L\right) &= \rho_\tau ln\left(\tau_{t-1}^w W_{t-1} L_{t-1} / \tau^w W L\right) + \xi ln\left(B_{t-1}/B\right) \\ &\quad + \varepsilon_{\tau g} ln\left(W_t L_t^g / W L^g\right) + e_{\tau t} \end{aligned} \tag{3.11}$$

Lastly, public employment follows a simple AR(1) process (12). Variables with no subscripts denote steady state values, e_{lgt} and $e_{\tau t}$ are iid spending and tax (rate) shocks.

$$L_t^g = (1 - \rho_{lg})\overline{L^g} + \rho_{lg} L_{t-1}^g + e_{lgt} \tag{3.12}$$

3.4.1.4 Market Clearing and Equilibrium

To clear the markets, demand must equal supply in all of them; this leads to the following identities for labor market (13), and the GDP identity (14).

$$L_t = L_t^p + L_t^g \tag{3.13}$$

$$Y_t = C_t + K_{t+1} - (1 - \delta)K_t \tag{3.14}$$

The equilibrium is defined by solving the system that is defined by equations (2) - (13).

3.4.1.5 Steady state

From (3) and (4) one can calculate the steady state (ss henceforth) values of the real interest rates: $R = 1/\beta - 1 + \delta$ for capital, $R = 1/\beta - 1$ for bonds. The knowledge of the ss value of labor, $L = 0.3$, allows to calculate the ss values of $L^g = 0.15L$, $L^p = (1 - 0.15)L$ and $G = (L^g)^{\chi}$. From MPK (equation (4)) one has the output to capital ratio $\frac{Y}{K} = \frac{R}{\alpha}$; then, dividing the production function of Y (6) by K allows one to calculate the steady state value of the capital to labor ratio in private sector: $\frac{K}{L^p} = \left(\frac{R}{\alpha A}\right)^{1/(\alpha-1)} G^{\gamma}$. Using this ratio in (8) makes it possible to calculate the value of wage: $\overline{W} = (1-\alpha)\frac{Y}{L} = (1-\alpha)\frac{Y}{K}\frac{K}{L^p} = \frac{1-\alpha}{\alpha}\frac{K}{L^p}R$. Then $K = \frac{K}{L^p}L^p$, $Y = \frac{Y}{K}K$ and $C = Y - \delta K$ follow directly. The target level of debt to GDP ratio gives B and (10) allows us to find the ss value of $\tau^w = \frac{WL^g + (R^b - 1)B}{WL}$.

3.4.2 The responses to fiscal policy shocks in recessions and expansions

3.4.2.1 Solution procedure

As I mentioned before, the driving idea of this exercise is that potentially very simple (and quite old-fashioned) mechanisms can go a long explain towards explaining the observed behavior of the main macro variables after fiscal policy shocks. In particular, I will deal with just one.

The basic mechanism used to give asymmetric responses to spending primarily is a very simple one that seems quite plausible on a priori grounds: I assume that $\varepsilon_{\tau g}$, the coefficient that measures the strength of the reaction of taxes to government spending, falls during recessions - any government is likely to be quite reluctant to balance the budget during recessions, unless it faces severe market pressure to do so, something that has not happened to the U.S. after the second World War, at least according to my knowledge.

This assumptions mean that the world is perceived to have two states, expansion and recession; during each state the same model describes the economy, with just the 1 different parameter. Then the policy functions are derived for each state using familiar linear techniques, and the model is simulated in each state to produce IRFs in the familiar way. The procedure is implemented in Dynare; cumulative output multipliers are calculated by the formula $mult_t = \frac{\sum_{t=1}^{T}(Y_t^{F,A})}{\sum_{t=1}^{T}(F_t^A)}$, $Y^{F,A}$ is the path of output after the

Table 3.6: Parameters used in calibration and their values; known steady state values of variables

Parameter	Value	Description
β	0.99	Time discount factor
δ	0.025	Depreciation of capital
θ	2	Frisch elasticity of labor supply
κ	$\frac{W(1-\tau^w)}{L^\vartheta C}$	Normalization factor for disutility of labor
α	0.3	Share of capital
γ	0.4	Value of externality of government services
χ	0.5	Productivity of government workers
A	1	Level of technology in consumption sector
ρ_τ	0.9	strength of tax smoothing
B/Y	3	ss debt to GDP ration (75% on annual basis)
ξ	0.2	elasticity of tax rate to debt
$\varepsilon_{\tau g}$	0 / -0.2	elasticity of tax rate to government spending in expansions / recessions
ρ_{lg}	0.9	Autoregressive coefficient of L_g
σ_{lg}	0.01	Variance of e_{lg}
σ_τ	0.01	Variance of $e_{\tau t}$
L	0.3	Steady state level of employment
L^g	$0.15L$	Steady state level of government employment

fiscal shock in the relevant regime (after the business cycle shock, that determines the state of nature) and F is the budget variable shocked, spending (WL^g, by increasing government employment) or taxes (T, by increasing the tax rate).

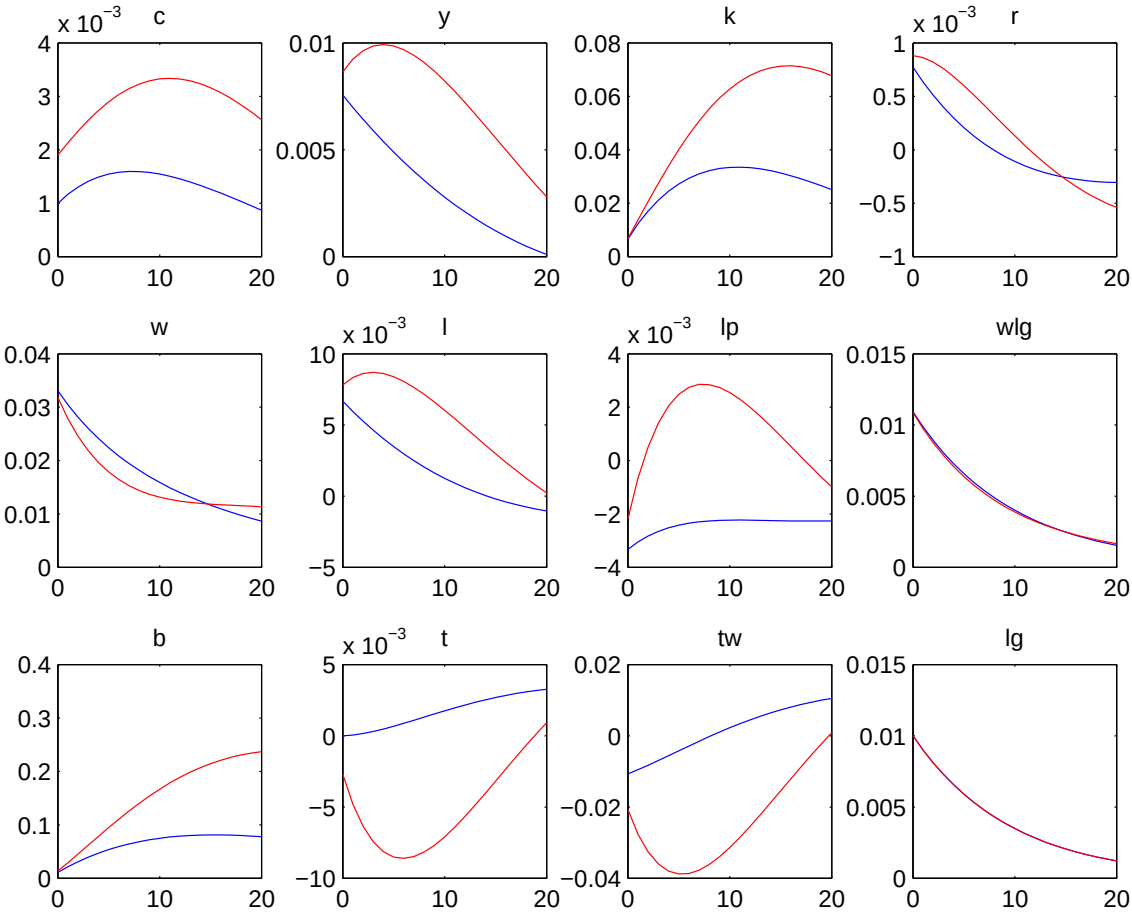
3.4.2.2 Calibration, IRFs and discussion

Table 3.6 presents the values of the parameters and the known steady state variables; time period is a quarter. Many of the values of the parameters are quite standard in the literature. For those that are not, the following remarks are appropriate. The parameters of fiscal policy equations all affect the results. Productivity of government workers is assumed lower than that in the private sector, similarly to chapter 2, and the value of the externality γ is not high. They where chosen so that we get positive consumption responses even in expansions, as some of the econometric results show, and multipliers with the desired characteristics, that is stronger spending multipliers in recessions and stronger spending multipliers than tax ones in both regimes, as in section 3.3.

Figure 3.3 presents the responses of the variables[11] to spending shocks in both

[11]In both figures 3.3 and 3.4, variables are defined as: c=consumption, y=output, k=capital, r=real return on capital, w=real wage, l=labor, lp=private sector labor, lg=government sector labor, wlg=government spending, t=tax collections, tw=income tax rate, b=real debt.

Figure 3.3: Model responses to spending shocks; red: recession, blue: expansion



regimes. The responses are consistent with several qualitative features of the data, if we consider Cholesky and BP identifications appropriate for spending shocks. In particular output, labor, investment and consumption rise in both regimes, more strongly in recessions; the model is able to generate asymmetric responses to spending shocks. This result is driven by the fall in tax rates in recessions, as government is slower to balance the budget; this means that their distortionary effects diminish. People find it optimal to work more in this period, as productivity is higher and taxes lower. Panel A of figure 3.5, which graphs output multipliers in both regimes, confirms these effects.

Figure 3.4 presents the IRFs to tax shock in both regimes, and the second panel of figure 3.5 the cumulative output multipliers to tax increases. As it is evident, the mechanism is not successful at all to generate asymmetry. The reason is that only one parameter really affects the reaction to tax shocks, and that is ξ, the elasticity of tax rate to changes in debt, which increases tax multipliers and reduces spending ones as it increases - however, it is highly unlikely that such a policy is relevant for the US in the

Figure 3.4: Model responses to tax shocks; red: recession, blue: expansion

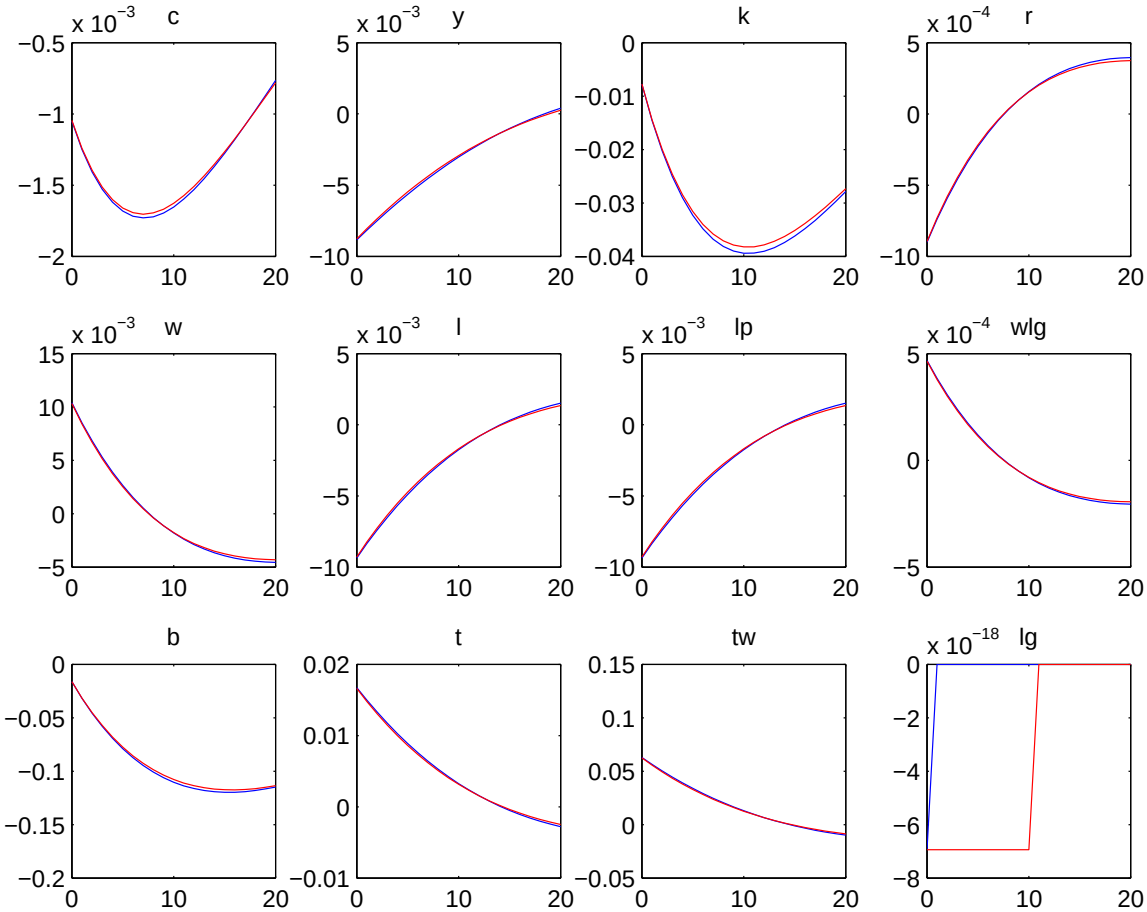
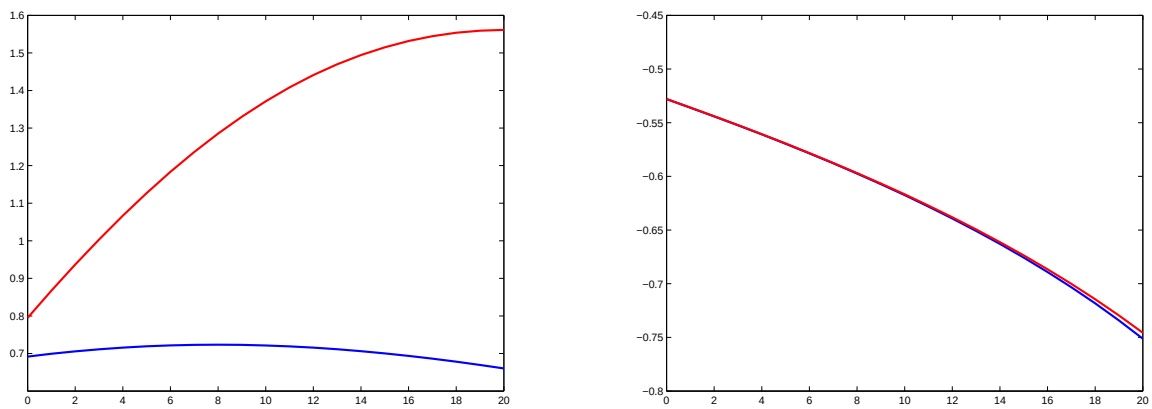


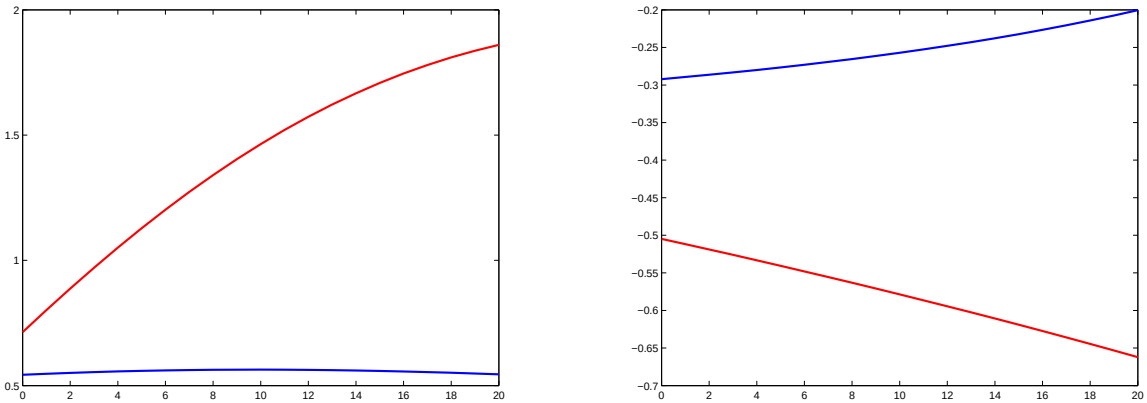
Figure 3.5: Output multipliers; red: recession, blue: expansion



(a) Spending shocks

(b) Tax shocks

Figure 3.6: Output multipliers with 2 taxes; red: recession, blue: expansion



(a) Spending shocks (b) Tax shocks

sample period - only countries under severe debt limits would be obliged to react more in debt during a recession, and obviously this would hardly be the recommended policy prescription in recessions.

However, it is possible to generate asymmetry in reaction to tax shocks in a different way, using a slight modification to the model at hand. Suppose that there are 2 taxes available, a lump-sum and a distortionary one, each covering 50% of government expenses in steady state. What would be the differences if government could increase both to balance the budget, or only the wage income tax? Logic says that in the first case we have less distortions, so macroeconomic variables would fall by less. This is precisely what happens in reality. Think of the following scenario: government does have these two taxes at hand. In normal times, it is free to choose any tax to close the budget - let's assume it uses both, each to yield the same amount of revenue[12]. However, in bad times it can only use the wage income tax to close the budget, for reasons beyond economic analysis, like not wanting to increase consumption taxes that hurt poor more, or because "serious" governments deserving loans have to make their citizens suffer more etc. Then, in recessions one would necessarily obtain a higher tax multiplier. This is confirmed in figure 3.6, where the output multipliers from this exercise are plotted; while spending multipliers are quite similar, tax multipliers are now different, with those in recessions higher, and quantitatively not very different from the best estimates for tax multipliers.

[12]Using only the non-distortionary tax would imply a zero effect on real variables.

3.5 Conclusion

In the present paper I have tried to shed some light on the effects of fiscal shocks, both spending and tax ones, during good and bad times. To this aim, several different models were estimated and simulated under a variety of identifying restrictions for the structural shocks.

While some of the results seem contradictory, fortunately some also hold in most of the cases, and allow one to draw some general conclusions from the previous analysis. The first one is that thresholds exist in the data - it is highly likely that such a model describes the data better. In addition, both coefficients from different regimes and different histories change responses to shocks quite a lot.

The second is that spending shocks may have large positive effects on economic activity in low growth periods, and that these effects are not much dependent on the behavior of the central bank - the latter does not seem to accommodate spending policies. The output multiplier of spending shocks in recessions is likely to be over 1.5, making spending, at least non-defense one, a powerful tool to dampen recessions. Another important result is that different spending variables may have totally different effects: civilian spending is quite stimulative, while military spending might even be bad for economic activity. Finally, the power of spending policies to affect the economy does not seem to be diminished in the last decades, contrary to previous results.

A third is that identifying shocks is a dirty business with many gray areas - one of these is taxes, since it is very difficult to isolate exogenous shocks from their movements; they are just too correlated with output. Another problem is that responses are dependent on the information set, even in the cases of exogenous shocks. Assuming that the ones identified in this work are meaningful tax shocks, then one should not expect taxes to affect the economy in a uniform way; the more likely answer is that the effects of taxes, and in particular the tax multiplier, even if it is bigger in recessions, is not as big as the one of spending. The extreme values reported in this study and in Romer and Romer (2010) seem to depend on particular information sets, and are not robust to reasonable changes in variables. Based on that, a tax multiplier around 1 in recessions seems realistic, while it seems reasonable to say that it is close to zero in expansions.

These estimates also have important policy implications. Higher spending multipliers suggest using spending increases in recessions to stimulate the economy. Higher

multipliers of both policy variables in recessions imply that sensible policy makers would never want to consolidate during recessions.

One should not expect big responses of inflation or interest rates due to fiscal shocks; assuming these move somewhat, these responses are (or become soon) probably negative. Lastly, consumption and investment follow the output pattern, while (unremarkably) unemployment the opposite. Overall, once again the world looks somewhat more Keynesian.

Off course, as with any econometric application, the results presented in this work can be extended and / or verified in numerous ways. The two more obvious ones are a) to use a Bayesian approach to estimation in order to economize on degrees of freedom and b) to use data from other countries to see whether results from the U.S. are common, or a special case. Another thing to do is to look deeper in the effects of taxes - there are many things that elude our understanding. All these routes are left for future research.

Finally, a DSGE model (or better, a DSGE model for each regime) is set up that manages to explain some of the basic results of the econometric analysis, namely the stronger responses of the main macro variables during recessions to either spending and (not so successfully in this case) tax shocks. The mechanism that is able to generate these responses is very simple: the lower speed of adjustment of tax rates to debt in this regime; this mechanism is successful in replicating qualitatively the responses to spending shocks, and with a simple modification, that is add a non-distortionary tax instrument, in the case of tax shocks too. Such a simple way to achieve these effects is quite encouraging for the ability of DSGE models to replicate observed responses, at least in the real sector, but is also warning us for the (in)validity of drawing general conclusions from special cases of theoretical models - these can be designed to be so general that they can be compatible with many of the observed patterns in the data. Evidently, more work is needed in order to understand and build models that are able to replicate these responses. This is left for future research.

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Chapter 4

The Effects of Fiscal Policy using Long-Run Identification

4.1 Introduction

It is hard to overstate the practical importance of knowing what are actually the effects of fiscal policy in the economy. As the recent crisis has shown, there are limitations to the ability of central banks to stabilize the economy, and this is much more evident in the case of EMU, where in some countries the crisis is far from over.

There are several important and interrelated issues concerning the effects of fiscal policy. The first is what are the sizes of the multipliers, i.e. the effect of changes in the policy variable to output; the spending multiplier is considered to be close to one, as the majority of studies in Ramey (2011) find; however, it is notoriously difficult to estimate the tax multiplier, because in the data taxes are very highly correlated with GDP, so are mostly driven by the cyclical movements of output.

The second issue is what is the transmission mechanism of fiscal policy. The typical neoclassical model, and most of current DSGEs, predict that spending has a multiplier lower than one, since the increase in useless government consumption (that will eventually lead to higher taxes) forces consumption to fall. This is unlike the results of the majority of SVAR studies, which predict that consumption rises after increases in spending. The tax multiplier naturally depends heavily on the nature of taxes in the model: a lump-sum tax has very different effects compared to a distortionary income tax.

The third is whether it is possible to consolidate without too much pain. In an famous paper, Alesina and Perotti (1995) advocated that a fiscal consolidation based on spending cuts is preferable to tax increases, since the former has a negative effect on interest rates, that leads to increases in private sector's investment and consumption. Naturally, such a view considers government spending as predominantly useless, and reducing it does not deteriorate the equilibrium of the economy.

The methods used so far, namely SVAR analysis à la Blanchard and Perotti or using Cholesky decomposition of the variance-covariance matrix, or using exogenous shocks, have several drawbacks: in the previous chapter it was shown that exogenous tax shocks do not give particularly robust results, while SVAR methods impose many restrictions, which may be justified on a priori grounds, but typically are not testable; in chapter 2 it was shown that Ramey's exogenous shocks are of limited use, capable to inform us about defense spending, and not to be used to draw general conclusions, while SPF forecast errors are not structural and using them may lead to incorrect conclusions. Sign restrictions are also not immune to problems, and their application in fiscal policy issues is likely to be less successful than in e.g. in business cycle issues, for the reasons discussed earlier in section 1.2.1.4.

In this chapter I will try, like many others before, to give some answers to the first two issues, and as a byproduct of the analysis to the third. To do that, I employ a methodology different to those already used; I follow the recent literature in that I try to estimate the effects using IV methods instead of the reduced form covariance matrix. Following Pagan and Pesaran (2008), instead of trying to find exogenous instruments to estimate responses to fiscal shocks, I use the instruments that become available by employing the main identification restrictions: that some shocks have permanent and some other have transitory effects. This procedure generates quite good instruments, that allow reliable estimates of the structural equations while needing fewer restrictions in the contemporaneous relations. Several countries are used, the choice of which is mainly due to the availability of long enough fiscal data - especially taxes and transfers.

The basic results from the various models confirm the basic findings from the SVAR methodology: in response to a spending shock, economic activity (measured by output) is higher. Importantly, the spending shock has a positive effect on consumption, suggesting the the simple neoclassical model is not consistent with the data. In addition,

inflation and the nominal interest rate fall, something that is consistent with a New Keynesian model where spending shocks lead to a fall in markups. A tax shock has a negative effect on economic activity; both consumption and output fall; additionally, it tends to have a positive effect on prices and the interest rate.

Spending multipliers are positive and quite high in some cases, and not as uniform among countries as those estimated using SVAR methods. Tax multipliers are consistently lower than the ones of spending in absolute value; the tax multipliers for US and UK are much lower than those estimated using exogenous tax shocks. Also, despite differences in estimates in a shorter sample starting in 1981, there does not seem to exist a general trend towards lower spending multipliers, contrary to what Perotti (2004) finds.

An important finding is that the size of spending multipliers depends on the policy coefficients - the countries with more countercyclical spending policies are the ones with the bigger spending multipliers. The same thing happens with taxes - the countries with the highest elasticity of taxes with respect to output also have the highest tax multipliers.

The remaining of the paper is structured in the following way. Section 4.2 presents the methodology. Section 4.3 presents the identification assumptions and the results from various specifications. Section 4.4 extends the results and discusses in depth certain aspects of them. Section 4.5 concludes. Appendix C presents additional description of the data, tests and results not included in this chapter.

4.2 Methodology

4.2.1 Theory

This paper used Structural Vector Autoregression models (SVAR - in particular Structural Vector Error Correction models, SVECM) to estimate the effects of fiscal policy shocks. The typical implementation of SVAR models is to estimate the effects of "structural" shocks by utilizing enough restrictions in the variance-covariance matrix of the reduced form residuals to make estimation of the matrix of contemporaneous effects possible. In this paper I will use a different approach, proposed by Pagan and Pesaran (2008) that bases estimation of contemporaneous effects on the separation of structural shocks into those that have long lasting effects on the economy - permanent shocks,

and to those that only affect the economy for a limited period - transitory shocks. This procedure has the advantage that it potentially allows more parameters of the structural form to be estimated, but its implementation depends on the availability of suitable instruments. Ultimately, the estimation procedure resembles very much that of traditional Keynesian Structural Econometric Models, but otherwise estimates are used to perform typical SVARs analysis.

To begin with, assume that the true model is an SVAR in *n I(1)* variables like the following[1]

$$\mathbf{A_0 z_t} = \mathbf{A_1 z_{t-1}} + \mathbf{A_2 z_{t-2}} + \varepsilon_\mathbf{t}, \tag{4.1}$$

which, like all VARs, can be transformed to the following form

$$\mathbf{A_0 \Delta z_t} = -(\mathbf{A_0} - \mathbf{A_1} - \mathbf{A_2})\mathbf{z_{t-1}} - \mathbf{A_2 \Delta z_{t-1}} + \varepsilon_\mathbf{t} = -\mathbf{A(1) z_{t-1}} - \mathbf{A_2 \Delta z_{t-1}} + \varepsilon_\mathbf{t}, \tag{4.2}$$

and, if there exist $r<n$ cointegrating relations, the reduced form of the model can be written as

$$\begin{aligned} \Delta \mathbf{z_t} &= -\mathbf{A_0^{-1} A(1) z_{t-1}} - \mathbf{A_0^{-1} A_2 \Delta z_{t-1}} + \mathbf{A_0^{-1}} \varepsilon_\mathbf{t} = -\Pi \mathbf{z_{t-1}} + \Psi \mathbf{\Delta z_{t-1}} + \mathrm{e_t} \\ &= -\alpha\beta' z_\mathbf{t-1} + \Psi \mathbf{\Delta z_{t-1}} + \mathbf{e_t} \end{aligned} \tag{4.3}$$

while the structural one as

$$\mathbf{A_0 \Delta z_t} = -\tilde{\alpha}\beta' \mathbf{z_{t-1}} - \mathbf{A_2 \Delta z_{t-1}} + \varepsilon_\mathbf{t},\ \tilde{\alpha} = \mathbf{A_0}\alpha. \tag{4.4}$$

The idea is that knowledge of some elements of $\tilde{\alpha}$ allows to use the relevant cointegration relations, $\beta' \mathbf{z_{t-1}}$ as instruments to estimate some of the contemporaneous effects in $\mathbf{A}^0$ matrix. The authors, making use of the assumption that some shocks are permanent while other are transitory, and partitioning all matrices conformably, manage to derive that *"the structural equations for which there are known permanent shocks must have no*

[1]The presentation follows closely the paper.

error correction terms present in them", so the first *n-r* rows of $\tilde{\alpha}$ are filled with zeros[2]. Our system is thus represented by two sets of equations, the first *n-r* having the unit roots of the system and the other *r* having the *I(0)* structural shocks. One can easily depict these in matrix form (by partitioning the matrices in (1) accordingly) as

$$\begin{bmatrix} \mathbf{A}_{11}^0 & \mathbf{A}_{12}^0 \\ \mathbf{A}_{21}^0 & \mathbf{A}_{22}^0 \end{bmatrix} \begin{bmatrix} \mathbf{z_{1t}} \\ \mathbf{z_{2t}} \end{bmatrix} = \begin{bmatrix} \mathbf{A_{11}^1} & \mathbf{A_{12}^1} \\ \mathbf{A_{21}^1} & \mathbf{A}_{22}^1 \end{bmatrix} \begin{bmatrix} \mathbf{z_{1,t-1}} \\ \mathbf{z_{2,t-1}} \end{bmatrix} + \begin{bmatrix} \mathbf{A}_{11}^2 & \mathbf{A_{12}^2} \\ \mathbf{A}_{21}^2 & \mathbf{A}_{22}^2 \end{bmatrix} \begin{bmatrix} \mathbf{z_{1,t-2}} \\ \mathbf{z_{2,t-2}} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}.$$

This system has *I(1)* variables, as well as shocks; to render the system stationary, one needs to first difference the first set of equations (as no cointegration terms appear in these equations) and impose the cointegration restrictions in the second set. Thus the stationary system can be written as

$$\begin{bmatrix} \mathbf{A}_{11}^0 & \mathbf{A}_{12}^0 \\ \mathbf{A}_{21}^0 & \mathbf{A}_{22}^0 \end{bmatrix} \begin{bmatrix} \Delta\mathbf{z_{1t}} \\ \Delta\mathbf{z_{2t}} \end{bmatrix} = \begin{bmatrix} 0 \\ -\tilde{\alpha}_2\beta' \end{bmatrix} \mathbf{z_{t-1}} + \begin{bmatrix} \mathbf{A_{11}^1} & \mathbf{A}_{12}^1 \\ -\mathbf{A_{21}^2} & -\mathbf{A_{22}^2} \end{bmatrix} \begin{bmatrix} \Delta\mathbf{z_{1,t-1}} \\ \Delta\mathbf{z_{2,t-1}} \end{bmatrix} + \begin{bmatrix} \mathbf{A}_{11}^2 & \mathbf{A_{12}^2} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta\mathbf{z_{1,t-2}} \\ \Delta\mathbf{z_{2,t-2}} \end{bmatrix} + \begin{bmatrix} \Delta\varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}. \tag{4.5}$$

With some simple algebra[3], one can see that the system can be transformed to the MA representation of the stationary time series $\Delta\mathbf{z_t}$ to the transformed shock vector $\mathbf{w_t}$

$$\begin{aligned} \mathbf{A}(\mathbf{L})\Delta\mathbf{z_t} &= \begin{bmatrix} \mathbf{0} \\ -\tilde{\alpha}_2\beta' \end{bmatrix} \mathbf{z_{t-1}} + \begin{bmatrix} \Delta\varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \Rightarrow \\ \Delta\mathbf{z_t} &= \mathbf{A}(\mathbf{L})^{-1} \begin{bmatrix} \mathbf{0} \\ -\tilde{\alpha}_2\beta' \end{bmatrix} \mathbf{z_{t-1}} + \mathbf{A}(\mathbf{L})^{-1} \begin{bmatrix} \Delta\varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \Rightarrow \end{aligned}$$

[2]This assumes that equations with permanent shocks are placed first, and it will be an assumption maintained for the rest of this exposition.

[3]The derivation is very similar to section 3.3 of Pagan & Pesaran (2008).

$$
\begin{aligned}
\Delta \mathbf{z_t} &= \mathbf{C(L)} \begin{bmatrix} \mathbf{0} \\ -\tilde{\alpha}_2\beta' \end{bmatrix} \mathbf{z_{t-1}} + \mathbf{C(L)} \begin{bmatrix} \Delta\varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \\
&= \begin{bmatrix} \mathbf{C_{11}(L)0} - \mathbf{C_{12}(L)}\tilde{\alpha}_2\beta' \\ \mathbf{C_{21}(L)0} - \mathbf{C_{22}(L)}\tilde{\alpha}_2\beta' \end{bmatrix} \mathbf{z_{t-1}} + \begin{bmatrix} \mathbf{C_{11}(L)}\Delta\varepsilon_{1t} + \mathbf{C_{12}(L)}\varepsilon_{2t} \\ \mathbf{C_{21}}(L)\Delta\varepsilon_{1t} + \mathbf{C_{22}(L)}\varepsilon_{2t} \end{bmatrix} \\
&= -\begin{bmatrix} \mathbf{C_{12}(L)} \\ \mathbf{C_{22}(L)} \end{bmatrix} \tilde{\alpha}_2\beta'\mathbf{z_{t-1}} + \begin{bmatrix} \mathbf{C_{11}(L)}\Delta\varepsilon_{1t} + \mathbf{C_{12}(L)}\varepsilon_{2t} \\ \mathbf{C_{21}(L)}\Delta\varepsilon_{1t} + \mathbf{C_{22}(L)}\varepsilon_{2t} \end{bmatrix} \Rightarrow \\
\Delta \mathbf{z_t} &= \begin{bmatrix} \mathbf{C_{11}(L)}\Delta\varepsilon_{1t} + \mathbf{C_{12}(L)}(\varepsilon_{2t} - \tilde{\alpha}_2\beta'\mathbf{z_{t-1}}) \\ \mathbf{C_{21}(L)}\Delta\varepsilon_{1t} + \mathbf{C_{22}(L)}(\varepsilon_{2t} - \tilde{\alpha}_2\beta'\mathbf{z_{t-1}}) \end{bmatrix} \\
&= \mathbf{C(L)} \begin{bmatrix} \Delta\varepsilon_{1t} \\ (\varepsilon_{2t} - \tilde{\alpha}_2\beta'\mathbf{z_{t-1}}) \end{bmatrix} = \mathbf{C(L)w_t}
\end{aligned}
$$

In fact, because $\mathbf{C_{12}(1)}$ has the long run effects of transitory shocks on variables with unit root shocks, it must hold that $\mathbf{C_{12}(1) = 0}$. In addition, $\mathbf{A(L)}^{-1} = \mathbf{C(L)} \Rightarrow \mathbf{A(1)C(1) = I_n}$ and since $\mathbf{A_{11}(1)C_{12}(1) + A_{12}(1)C_{22}(1) = 0}$, the facts that $\mathbf{C_{12}(1) = 0}$ and $\mathbf{C_{22}(1) \neq 0}$ (it has to be nonzero otherwise $\mathbf{C(1)}$ would not be invertible) lead us to find that $\mathbf{A_{12}(1) = 0}$: *in the structural equations with permanent shocks, the coefficients on current values and lags of* ***all*** *variables with transitory shocks must sum to zero.* Both $\mathbf{C(1)}$ and $\mathbf{A(1)}$ are block lower diagonal.

However, these are not the only restrictions that are allowed by separating the shocks in permanent and transitory. It can be the case that a variable with a permanent shock is not affected by all other permanent shocks in the long run, and that the permanent shock it contains does not affect other variables with permanent shocks in the long run. A commonly used assumption of this type is the monetary dichotomy - neither nominal nor real variables affect the other in the long run. This has the effect to render $\mathbf{C_{11}(1)}$ block diagonal, and necessarily give $\mathbf{A_{11}(1)}$ the same block diagonal structure. As a consequence, *when a variable with permanent shocks has zero long run effects on the other variables with permanent shocks, the coefficients of its current and lagged values in these equations must also sum to zero.*

To have a better understanding of the effect of restrictions, this is how the first set of equations in the structural form (5) will transform to when the restrictions are imposed.

$$
\begin{aligned}
\mathbf{A_{11}^0}\Delta\mathbf{z_{1t}} + \mathbf{A_{12}^0}\Delta\mathbf{z_{2t}} &= \mathbf{A_{11}^1}\Delta\mathbf{z_{1,t-1}} + \mathbf{A_{12}^1}\Delta\mathbf{z_{2,t-1}} \\
&\quad + \mathbf{A_{11}^2}\Delta\mathbf{z_{1,t-2}} + \mathbf{A_{12}^2}\Delta\mathbf{z_{2,t-2}} + \Delta\varepsilon_{1t} \Rightarrow \\
\mathbf{A_{11}^0}\Delta\mathbf{z_{1t}} + \mathbf{A_{12}^0}\Delta\mathbf{z_{2t}} - \mathbf{A_{12}^0}\Delta\mathbf{z_{2,t-1}} + \mathbf{A_{12}^0}\Delta\mathbf{z_{2,t-1}} &= ... \Rightarrow \\
\mathbf{A_{11}^0}\Delta\mathbf{z_{1t}} + \mathbf{A_{12}^0}\Delta^{\mathbf{2}}\mathbf{z_{2t}} + \mathbf{A_{12}^0}\Delta\mathbf{z_{2,t-1}} &= ... \Rightarrow \\
\mathbf{A_{11}^0}\Delta\mathbf{z_{1t}} + \mathbf{A_{12}^0}\Delta^{\mathbf{2}}\mathbf{z_{2t}} + (\mathbf{A_{12}^1} + \mathbf{A_{12}^2})\Delta\mathbf{z_{2,t-1}} &= ... \Rightarrow \\
\mathbf{A_{11}^0}\Delta\mathbf{z_{1t}} + \mathbf{A_{12}^0}\Delta^{\mathbf{2}}\mathbf{z_{2t}} &= \mathbf{A_{11}^1}\Delta\mathbf{z_{1,t-1}} - \mathbf{A_{12}^2}\Delta^{\mathbf{2}}\mathbf{z_{2,t-1}} \\
&\quad + \mathbf{A_{11}^2}\Delta\mathbf{z_{1,t-2}} + \Delta\varepsilon_{1t}.
\end{aligned}
$$

This form, since the variables with transitory shocks (and permanent shocks with zero long run effects) appear in second differences, readily allows the use of two kinds of instruments for the estimation of the elements of $\mathbf{A_{11}^0}$ and $\mathbf{A_{11}^2}$: the lagged cointegrating errors $\beta'\mathbf{z_{t-1}}$ and lagged first differences $\Delta\mathbf{z_{2,t-1}}$ of the variables with transitory shocks. As it is evident, the equations with the permanent shocks are at least just identified - in addition, as estimations progress, the estimated structural errors can (and probably should) be used as instruments. In the second set of equations, only the estimated structural errors are available as instruments, so here one would need additional restrictions to identify the model, or valid instruments outside the model. Yet, this procedure allows more coefficients of the $\mathbf{A}^0$ matrix to be estimated.

4.2.2 Weak Instruments

As with all IV exercises, this one too may be plagued by the presence of weak instruments; for the problems caused by their presence, a good introduction is Stock, Wright and Yogo (2002). The previous analysis has shown that it is possible to find many instruments to estimate the $\mathbf{A^0}$ matrix consistently with a minimum set of restrictions. However, there is no guarantee that these instruments will be sufficiently strong for the purpose. In fact, this is an empirical question, that cannot be answered a priori.

Specifically, for the potential problems of using long-run identifying restrictions, the interested reader may consult Faust and Leeper (1997), and especially Pagan and Robertson (1998) and Fry and Pagan (2005), who demonstrate how identification restrictions, and in particular long-run ones, lead to finding suitable instruments to estimate $\mathbf{A}^0$; this procedure may lead to valid yet weak instruments, that could weaken sub-

sequent analysis. Erceg et al (2005) found that even though long-run restrictions can recover the true sign and pattern of the responses to technology shocks, they are subject to significant small-sample bias and give rather imprecise estimates; these problems can be caused by the weak instruments generated by such restrictions. An estimator that is robust to weak instruments can be a partial solution to this problem.

In brief, in the presence of weak instruments the relevant literature has shown that it is better to avoid the IV estimator in such a case - Stock and Yogo (2002) are among the authors documenting the disadvantages of its use. The most common alternatives to the IV estimator are LIML and Fuller-k estimators, but the relevant (quite big) literature is still experimenting with other estimators, commonly based on the jackknife principle. There are no still no widely accepted methods to estimate in such an environment.

In this work, I depart from standard treatments of IV estimation in two ways: the first departure is that I use single equation methods to assess the strength of the instruments instead of using matrix rank statistics, as typically done in modern uses of IV estimation; the reason is that the loss in power from using the full system methods is quite high, even when the instruments are of acceptable quality; consequently, Shea's (1997) partial R^2 statistic will be reported. For more details and discussion see Zervas (2014).

In addition, unlike most attempts in the SVAR literature, I do not use the IV estimator, but instead a newly proposed one - see Hausman et al (2012), the Heteroskedastic Fuller (HFUL). This estimator, which is a modification of Fuller based on the jackknife principle, has much more desirable properties - namely is as good as Fuller in homoskedasticity, but much better in heteroskedasticity, as documented by the aforementioned authors. It is consistent in heteroskedasticity, unlike IV, LIML and Fuller estimators. In homoskedasticity, compared to the IV estimator, it has much better point estimates in terms of bias and confidence intervals generated by its standard errors have much better coverage; compared to LIML, it is much more concentrated around the true value, giving more robust estimates, and the confidence intervals generated by its standard errors almost match those of LIML in correct coverage, despite being shorter, making it preferable in practice, overcoming the main advantage of LIML, median unbiasedness. HFUL can be written as (see Bekker and Crudu 2013 equation 9):

$$\begin{aligned} \beta &= [\mathbf{X}'(\mathbf{P}-\mathbf{D})\mathbf{X} - \mathrm{k}\mathbf{X}'\mathbf{X}]^{-\mathbf{1}}[\mathbf{X}'(\mathbf{P}-\mathbf{D})\mathbf{X} - \mathrm{k}\mathbf{X}'\mathbf{y}] \\ \mathrm{k} &= \frac{(T+1)\alpha - 1}{T+\alpha-1},\ \alpha = mineig(\{[\mathbf{y}\,\mathbf{X}]'[\mathbf{y}\,\mathbf{X}]\}^{-\mathbf{1}}\{[\mathbf{y}\,\mathbf{X}]'(\mathbf{P}-\mathbf{D})[\mathbf{y}\,\mathbf{X}]\}), \end{aligned} \tag{4.6}$$

where $\mathbf{y}$ is the endogenous variable, $\mathbf{X}$ the regressors, $\mathbf{P} = \mathbf{Z}(\mathbf{Z}'\mathbf{Z})^{-\mathbf{1}}\mathbf{Z}'$ is the projection matrix of the instruments $\mathbf{Z}$, $\mathbf{D}$ is a diagonal matrix with the elements of the main diagonal of $\mathbf{P}$, and T is the sample length.

4.2.3 Impulse Responses

Typical SVAR analysis aims to generate the impulse responses of the system to the structural shock(s) of interest. I will not deviate from this tradition. Since the interest lies on the effects of fiscal policy, I estimate the $\mathbf{A}^0$ matrix with the procedure described in the previous subsection and then feed (the relevant columns of) its inverse to the companion matrix generated by the reduced form VECM, in order to get the impulses to innovations in government spending and taxes. Confidence intervals for these impulse responses are generated in a Bayesian way (Koop and Korobilis 2010 is a useful introduction to the literature), assuming an uninformative natural conjugate Normal-Wishart prior given by the HFUL estimates of each structural equation separately and the OLS estimates of the reduced form VECM (assuming known - not estimated - cointegrating relations for reasons explained later). The posterior has the form

$$\Sigma = \mathrm{iW}(\mathrm{V},\ \nu),\ \mathrm{B}|\Sigma = N(B,\ \Sigma) \tag{4.7}$$

where iW(V, ν) is the inverse Wishart distribution centered at V with ν degrees of freedom, B and V are the estimated coefficient vector (or vectorized system in the case of VECM) and variance covariance matrix of parameters respectively; ν is equal to the number of columns of V plus 3, so as to be uninformative[4]. Confidence intervals are generated by Monte Carlo integration: in each iteration, a draw from the iW distribution gives a variance covariance matrix for each equation (or the VECM), which is then used to get a draw for the coefficient vector, assemble the $\mathbf{A}^0$ matrix as well as the companion

[4]There are no clear guidelines for the selection of ν, except that it has to be low so as not to drive the results, with no explicit numbers, and at least equal to the columns of V, in order for the distribution to have support. 3 was chosen as it is low, yet not as low as to make IRFs meaningless.

matrix and calculate the IRFs for this iteration.

4.3 Results

4.3.1 Data, model setup and identification restrictions

The dataset includes 6 countries, US, UK, EMU, France, Canada and Australia. The choice of countries was dictated by the availability of fiscal, and especially tax data, publicly in the internet covering a time period sufficient to estimate a VAR - the shortest sample available, in the case of France, begins in 1980. Frequency is quarterly. More details on the data are available in Appendix C.1.

The sample is not uniform in all countries, but differs primarily according to data availability. In all countries it stops at the end of 2006 (end of 2005 in EMU case, as the database has not been updated further) - this date was chosen in order to avoid possible nonlinearities from the crisis. The beginning of the sample is 1960:1 in US and UK; 1963:1 in Canada; 1970:1 in Australia (no interest rate is available before late 60's); 1981:1 in France and EMU - in the latter case the database starts at 1970, but it is more reasonable to treat the initial EMU countries as a unified economy only after ERM had essentially fixed the exchange rates and harmonized monetary policy across them.

For each country, a VECM with 7 variables[5] was estimated; the variables are real government spending in good and services (consumption and investment) - g, real GDP - y, inflation (from GDP deflator) - pi, real private consumption - c, real private investment - ip, real net taxes - t, and a short term interest rate - i. All models have two lags in VAR form. In all VECMs 4 cointegrating restrictions are imposed: g - t (stationarity of fiscal deficit), ip - y and c - y (balanced growth path - great ratios are stationary) and i - pi (stationarity of the real interest rate). In all cases, the necessary deterministic variables to make the cointegrating relations (as close as possible to being) stationary are used - fortunately breaks appear to have an economic significance - these break variables are restricted in the cointegrating relations. For more details on lag selection and cointegrating properties of the data, the interested reader should read Appendix C.2.

[5] One thing to mention here is that there is a tradeoff between the VAR dimension and the appropriate lag length - bigger VARs typically allow one to use less lags, as truncated VARs have an infinite VAR representation, so many lags are needed to approximate the infinite polynomial sufficiently well.

With 4 cointegrating relations, the identifying assumption in section 4.2.1 means that in the structural form, there are 3 equations having the permanent shocks - the unit roots of the system, and 4 equations with transitory shocks[6]. The assumption is that the variables with the permanent shocks are g, y and pi, so we have a permanent fiscal (spending shock), a permanent real ("supply") shock and a permanent nominal shock (like the central bank's inflation target). The other variables carry the transitory shocks - t has the transitory fiscal (tax) shock - the fiscal authority first decides about the level of spending, and then adjusts taxes to maintain solvency.

There is another identifying assumption concerning the permanent shocks: the permanent nominal shock does not affect g and y in the long run, and pi is not affected by real shocks in the long run. Then, as shown in section 4.2.1, in the equation for pi all other endogenous variables (including g and y) appear in second differences, allowing to use lagged differences as instruments, while in the equations for g and y, pi appears in second differences, so its lagged difference is once again a valid instrument. Thus, the structural equations with permanent shocks are always overidentified, as the available instruments to estimate the 6 unknown coefficients of the first 3 rows of the $\mathbf{A}^0$ matrix are, at the very least, the lagged cointegrating errors (4) and the lagged first differences (4, 6 in the equation for pi), and progressively the estimated structural errors become available. In addition, since lagged differences are likely to be quite good instruments for the second differences[7], it seems reasonable to start the estimation of structural equations from the equation for pi, followed by the one for g and then the one for y.

Turning now to the equations with transitory shocks, we see that there are less instruments than necessary to estimate all the elements of the last 4 rows of the $\mathbf{A}^0$ matrix - the only available instruments to begin with are the 3 estimated permanent shocks, and as estimation progresses the estimated transitory shocks will become available. Thus, some more restrictions are necessary. The most obvious ones are possible in the equations for i and t: a central bank following a Taylor rule (in general, a c.b. with a mandate to stabilize the economy and fight inflation) would only react on output and inflation - if it also tends to accommodate the fiscal authority, then it would react to spending increases - but no reaction to c, ip or t are expected, therefore the relevant coefficients

[6] I also assume that the structural errors are uncorrelated within the period and impose that assumption by including these errors as instruments even if they are not needed.

[7] This is verified in the data, as it will become evident in Appendix C.3.

are set to 0. If the tax equation follows the interest rate equation, 4 instruments (the estimated structural errors) are available; the minimum for a tax equation (tax reaction function) would consist of the reaction of taxes to output and inflation, but also adding spending (it is conceivable that the fiscal authority changes taxes in response to spending changes) and interest rate (either reaction to market pressure to close deficits or countercyclical fiscal policy - when c.b. tightens to fight inflation, government tries to mitigate the pain) seems justified. Finally, one more restriction is needed, and it is placed in the equation for consumption, where I assume that consumption is not affected by investment contemporaneously - consumption decisions precede those for investment. In total, this procedure requires 6 restrictions in the $\mathbf{A}^0$ matrix, instead of 21 that would be necessary if covariance restrictions were used. The pattern of the estimated matrix is the following (with * are the estimated elements):

$$\begin{bmatrix} 1 & * & * & * & * & * & * \\ * & 1 & * & * & * & * & * \\ * & * & 1 & * & * & * & * \\ * & * & * & 1 & 0 & * & * \\ * & * & * & * & 1 & * & * \\ * & * & * & 0 & 0 & 1 & * \\ * & * & * & 0 & 0 & 0 & 1 \end{bmatrix} \tag{4.8}$$

However, this sequence of estimating the structural equations is not kept if it does not result in good instruments, and the structural equations are reordered so as to find overall better instruments. The method should be viewed as quite successful in generating both valid and strong instruments, suitable to estimate the contemporaneous relations. The Sargan and Andreson - Rubin tests, as well as the partial R^2 statistics presented in tables C.8 and C.9 in Appendix C.3, for all countries and identification patterns, confirm this. As it is evident, in only a few coefficients instruments are rather (but not very) weak, and it is for this cases that I opted to use the HFUL estimator.

In addition, it is usually (and reasonably) argued that spending does not react to other variables contemporaneously due to the time it takes to parliaments to enact legislation, as well as due to implementation lags - this is the argument used to justify the Cholesky decomposition with spending ordered first as an appropriate way to identify

spending shocks. For this reason, an alternative identification pattern is used, which is like (8), except that in the first line only the third element, the response of spending to inflation, is estimated; this is a pattern analogous to the one used in Blanchard and Perotti (2002) and Perotti (2004) - except that the response to inflation is estimated, not imposed.

In addition, in the equation for taxes, the aforementioned authors fix the elasticities based on information outside the model, e.g. on the tax structure. In the current implementation, the procedure generates instruments that allow estimating these elasticities.

4.3.2 Results

This section presents the results of both specifications. To begin with, figure 4.1 presents the impulse responses to spending shocks from the baseline specification for all countries with 90% posterior intervals. Spending increases cause output to rise significantly in all countries, with the exception of UK where the increase is marginally insignificant. Importantly, consumption rises significantly in all cases. In most countries, private investment rises significantly, with the exception of UK and (the first periods of) EMU; in fact, it is this particular response that seems to determine the strength of the output response - since consumption always rises, it is the response of private investment that will determine the total output response. Taxes rise, as the cointegration restriction forces them to match the spending increase eventually - however, initially we get a deficit. In what concerns nominal variables, spending increases force inflation to fall significantly in all countries; this effect is consistent with with a baseline NK model where all shocks with positive effects on output work through the fall in markups, and consequently inflation. Lastly, the effects on interest rates are not uniform - they fall in France, EMU and US, a response consistent with the fall in inflation, do not move significantly in UK and rise significantly in Australia and Canada.

Next, figure 4.2 shows the responses to tax increases in the baseline specification. In all cases, taxes rise, yet there is an important distinction in these responses: in Australia, France, EMU and the US, taxes eventually return to zero; in Canada and the UK, they set in a positive value. This is a fundamental difference, as the workings of cointegration restrictions force the system to settle on a different equilibrium; in the first case, spending does not move significantly, so output is rather free to move and

falls driving consumption and investment down. In the other case, spending settles in a higher equilibrium, and forces output to increase, as a predominantly spending increase would do - the consumption response is negative in Canada or essentially zero in the UK, leaving private investment to do the adjustment; one might not want to consider these cases as having proper tax shocks; alternatively, one might want to consider these cases as a combination of a tax shock and a permanent fiscal expansion. In what concerns the nominal variables, inflation and interest rates rise in France and EMU, consistently with a baseline NK model where recessions are linked with increases in markups and inflation. In the other countries inflation (after an initial positive response in UK, Australia and Canada) and interest rates fall, consistently with a Keynesian view of the economy.

Turning now to the alternative identification, one has to bear in mind that spending is identified similarly to typical SVAR implementations, and responses to spending shocks are expected to behave similarly to those generated from conventional Cholesky decompositions with spending first - unless the estimated inflation coefficient has some significant effect. Tax shocks are identified as in the previous case, so no big differences are expected between them. These expectations are verified in the data, if one compares the IRFs in figures 4.3 with those in figure C.1 in appendix C.4 and those in figure 4.4 with those in 4.2. Therefore, I will only discuss spending results here: once again, a spending increase causes output and consumption to increase significantly in all cases; taxes rise to close the deficit. Private investment responses are positive in the end of the forecasting period, but in most cases negative initially. Inflation and interest rates fall in all cases. These responses are quite uniform and their similarity in all countries of the sample, their similarity with a modified NK model and their simplicity, both in implementation as well as in justification, are probably the reasons for the widespread use of Cholesky identification to spending shocks.

In table 4.1 the cumulative output multipliers[8] of all aforementioned cases are presented; The multipliers of Cholesky shocks are in table C.10 in Appendix C.4, and their similarity with those of alternative identification for spending shocks is striking. Output multipliers of spending are much higher in the baseline identification in Australia, Canada and US, are essentially the same in the two identifications in France and UK,

[8]The cumulative sum of the IRFs of output divided by the same sum of the fiscal variable, divided by the average share of the fiscal variable in GDP.

Figure 4.1: Responses to spending increases with 90% posterior intervals - baseline identification

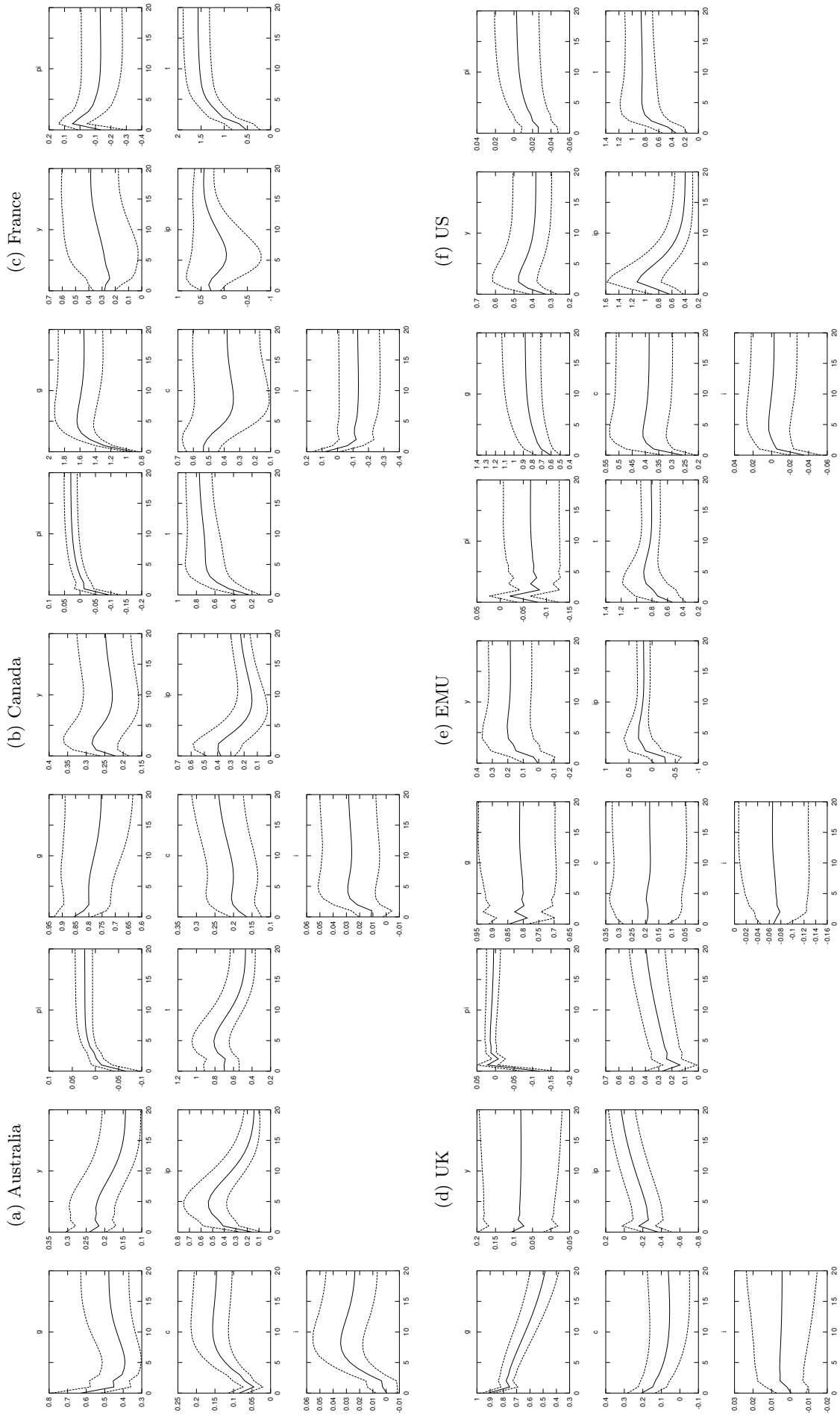


Figure 4.2: Responses to tax increases with 90% posterior intervals - baseline identification

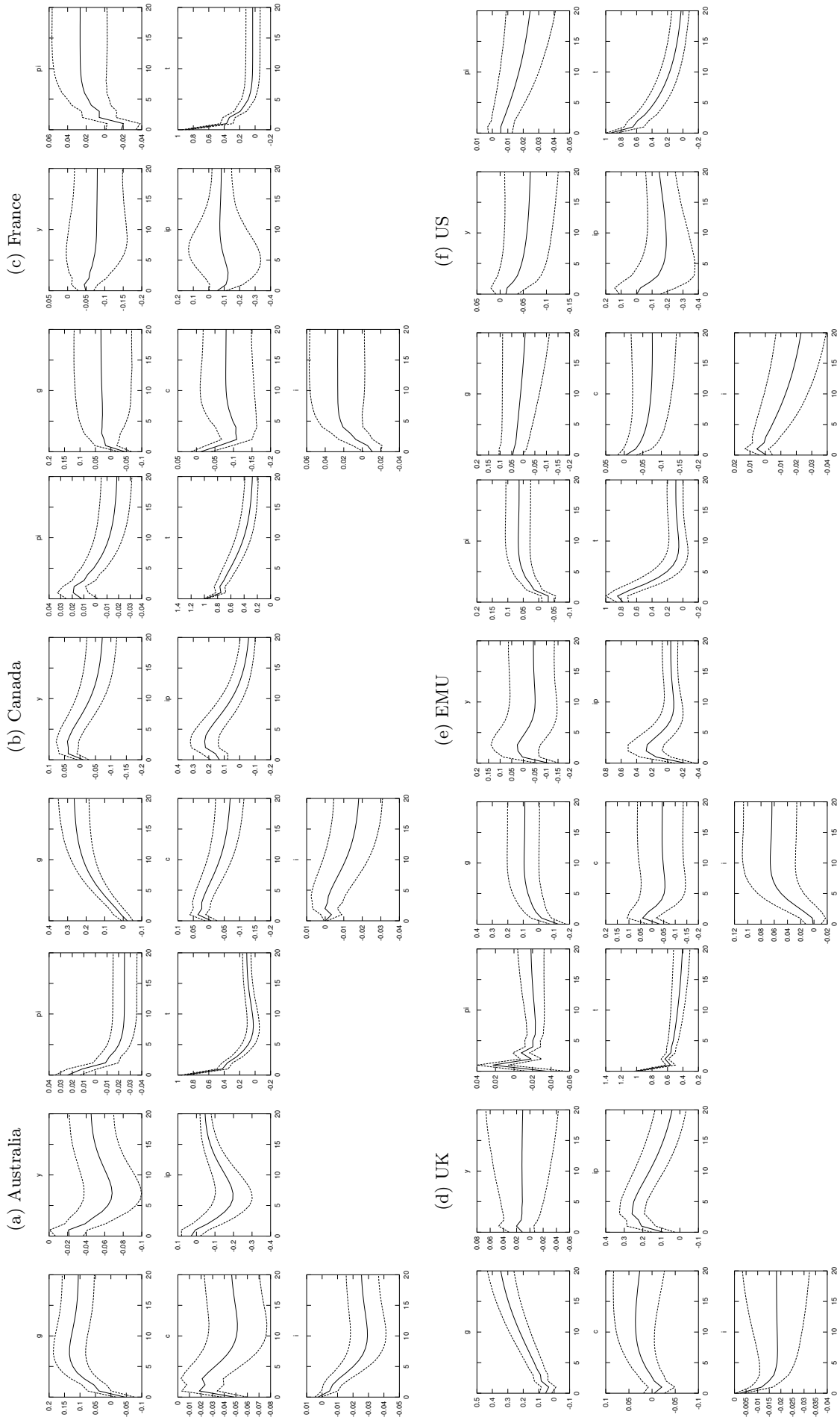
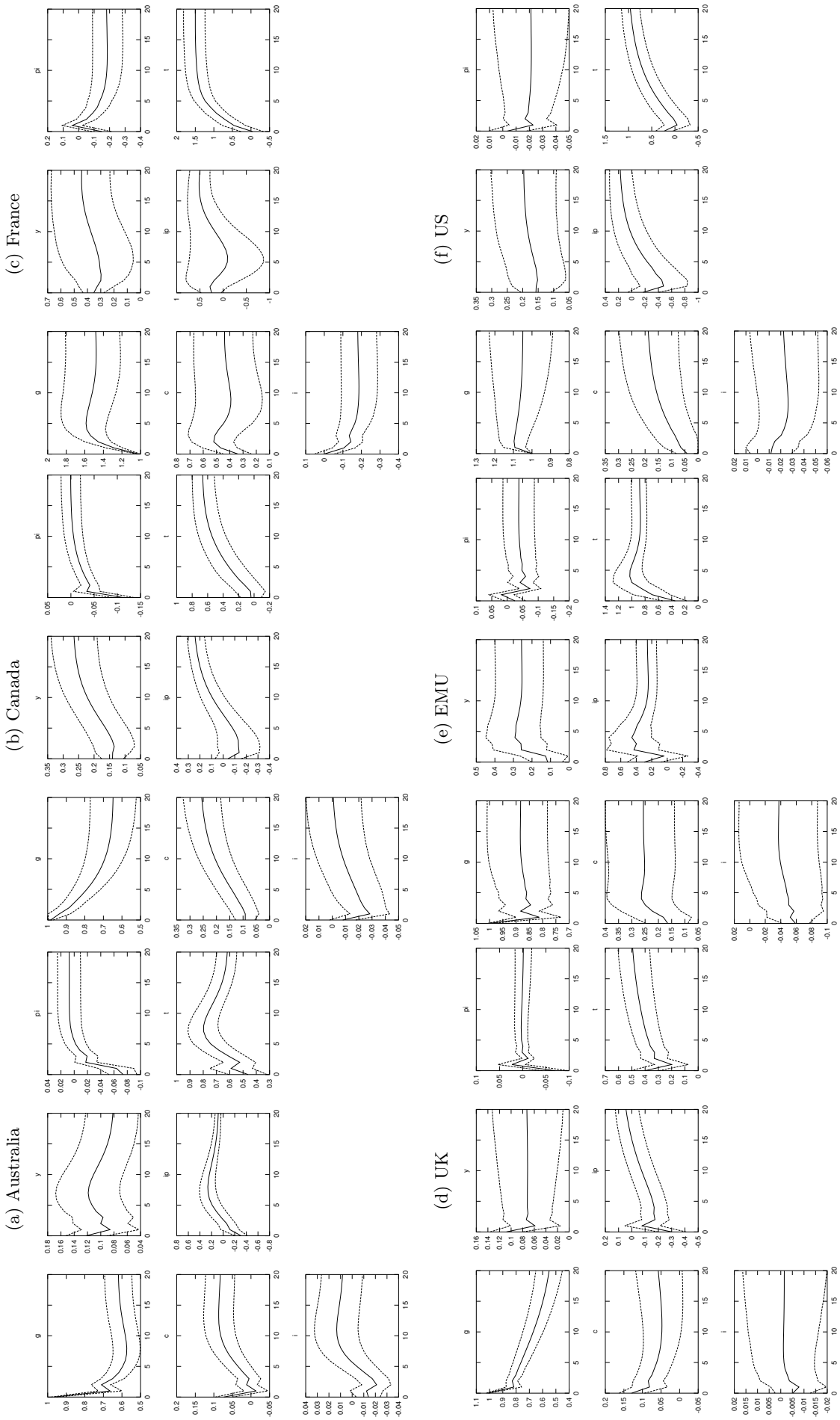


Figure 4.3: Responses to spending increases with 90% posterior intervals - alternative identification



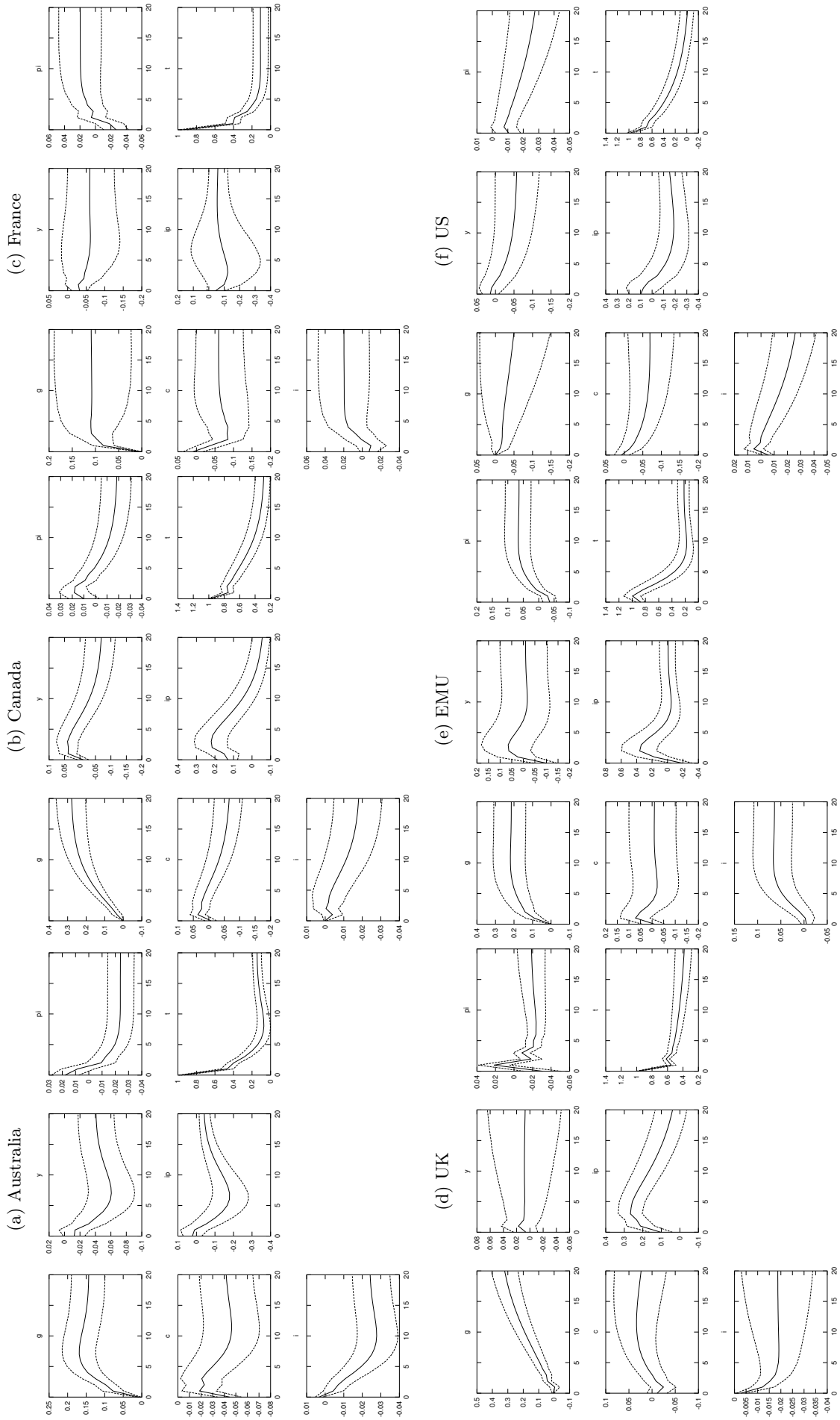


Figure 4.4: Responses to tax increases with 90% posterior intervals - alternative identification

Table 4.1: Output multipliers

	Australia			**Canada**			**France**			**UK**			**EMU**			**US**		
baseline	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	1.64	**1.86**	2.07	0.92	**1.10**	1.29	0.81	**1.08**	1.36	0.10	**0.52**	0.97	-0.42	**0.03**	0.47	2.33	**2.70**	3.11
t=4	1.94	**2.34**	2.76	1.07	**1.39**	1.72	0.28	**0.67**	1.08	-0.01	**0.49**	1.02	-0.16	**0.59**	1.31	2.51	**2.97**	3.47
t=8	1.95	**2.41**	2.96	1.02	**1.35**	1.69	0.18	**0.65**	1.12	-0.03	**0.51**	1.08	0.06	**0.81**	1.52	2.35	**2.77**	3.21
t=16	1.66	**2.09**	2.62	1.01	**1.33**	1.65	0.24	**0.71**	1.19	-0.08	**0.55**	1.21	0.17	**0.90**	1.56	2.13	**2.50**	2.88
alternative	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	0.45	**0.61**	0.76	0.46	**0.61**	0.76	0.95	**1.20**	1.48	0.35	**0.47**	0.60	0.16	**0.51**	0.88	0.54	**0.78**	1.02
t=4	0.42	**0.69**	0.96	0.41	**0.68**	0.94	0.40	**0.80**	1.25	0.21	**0.40**	0.60	0.47	**1.05**	1.67	0.37	**0.72**	1.06
t=8	0.48	**0.80**	1.13	0.52	**0.82**	1.10	0.28	**0.76**	1.29	0.19	**0.42**	0.64	0.63	**1.21**	1.84	0.39	**0.75**	1.10
t=16	0.49	**0.80**	1.14	0.78	**1.11**	1.42	0.35	**0.85**	1.38	0.17	**0.45**	0.73	0.68	**1.24**	1.85	0.44	**0.81**	1.17

(a) Spending

	Australia			**Canada**			**France**			**UK**			**EMU**			**US**		
baseline	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.22	**-0.12**	-0.04	-0.14	**-0.05**	0.04	-0.22	**-0.15**	-0.08	-0.03	**0.04**	0.11	-0.97	**-0.65**	-0.32	-0.22	**-0.07**	0.05
t=4	-0.82	**-0.47**	-0.20	-0.01	**0.17**	0.33	-0.77	**-0.39**	-0.09	-0.06	**0.07**	0.20	-0.76	**-0.07**	0.50	-0.69	**-0.23**	0.08
t=8	-1.97	**-1.05**	-0.46	-0.12	**0.12**	0.34	-1.68	**-0.72**	-0.06	-0.10	**0.07**	0.24	-1.57	**-0.21**	0.75	-1.13	**-0.42**	0.04
t=16	-3.51	**-1.72**	-0.70	-0.51	**-0.12**	0.20	-3.83	**-1.34**	0.00	-0.16	**0.08**	0.30	-3.26	**-0.61**	1.03	-2.26	**-0.83**	-0.01
alternative	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.15	**-0.07**	0.01	-0.14	**-0.05**	0.04	-0.16	**-0.09**	-0.03	-0.04	**0.02**	0.08	-0.81	**-0.52**	-0.22	-0.05	**0.08**	0.19
t=4	-0.62	**-0.34**	-0.10	0.00	**0.17**	0.33	-0.56	**-0.25**	0.01	-0.08	**0.05**	0.18	-0.42	**0.12**	0.59	-0.32	**-0.01**	0.24
t=8	-1.39	**-0.76**	-0.29	-0.10	**0.13**	0.33	-1.10	**-0.44**	0.06	-0.12	**0.05**	0.22	-0.75	**0.13**	0.83	-0.66	**-0.16**	0.21
t=16	-2.19	**-1.18**	-0.47	-0.47	**-0.10**	0.22	-1.92	**-0.70**	0.09	-0.20	**0.06**	0.29	-1.30	**0.02**	1.07	-1.65	**-0.53**	0.18

(b) Tax

and are lower in the baseline identification in EMU. In the alternative identification they are close to one in all countries but UK.

The output multipliers of tax shocks are higher in the baseline identification in Australia, France, EMU and the US, and they are the same in Canada and UK. Importantly, the absolute values of tax multipliers are always lower than those of spending multipliers, especially in the first two years, in all countries. One thing to remember is that, as shown in Appendix C.3, if one accepts the validity of the identifying restrictions then one has to admit that tax equations are very well identified, since the quality of IVs for this equation is very good, and the estimates have to be close to true parameter values. Another is that it is possible to generate responses compatible with usual a priori views on tax shocks (negative output and consumption responses), unlike typical SVAR models, in which this is quite hard to achieve.

An interesting thing to note, deserving further scrutiny, is that in the SVAR models with short-run restrictions in Appendix C.4, in two countries one is able to generate conventional responses to shocks in taxes and significantly negative (and quite big) output tax multipliers: in Australia and the US. Although this is just a conjecture, perhaps it has to do with a characteristic that is unique to these two countries: they constitute the most closed economies in the sample. It may be possible that this kind of structural shocks, that occur in variables highly correlated with real activity, like taxes or interest rates, are only identifiable using SVAR methods in closed economies, where external shocks do not complicate things any further.

Finally, as it is evident from the results presented in Appendix C.5, adding foreign activity variables, namely Lutz Kilian's Global Activity Measure (GAM), does not significantly affect results. In particular, it is clear from table C.11 that GAM enters the models of Australia, Canada, UK and US in the full sample (here sample starts at 1969:1 since GAM is not available before 1968), but does not enter the models in the post 81 period in all countries but UK - possible reasons for this effect might be that the system of flexible exchange rates made foreign shocks less influential, despite the increase in trade volume; in addition, for countries other than U.S., the introduction of flexible exchange rates allowed the use of monetary policy to stabilize the economy, as the central bank did not have to maintain a peg. Multipliers reported in table C.12 for the baseline identification case in the cases were GAM was significant indicate that the

Table 4.2: Spending equations estimates

	Baseline						Alternative
Country	y	pi	c	ip	t	i	pi
Australia	-1.2245	0.16216	0.0057431	-0.090879	**-0.076016**	-0.96463	**0.44939****
Canada	-0.25456	0.087817	-0.099398	**-0.14293**	-0.0079698	-0.58892	0.1444
France	**0.35299**	-0.10364	**-0.2678****	-0.082346	**-0.044098**	-0.18186	-0.11382
UK	0.23702	-0.069004	**-0.55235****	0.045219	0.04114	-0.88331	**-0.27122***
EMU	0.20944	0.064692	**-0.30542**	**0.13343**	-0.10404	-0.090416	-0.079025
US	0.44249	0.20997	**-1.5081***	**-0.18325***	0.050065	**1.2137***	-0.041856

Significance (one sided): at 10% level bold, at 5% level bold and star, at 1% level bold and double star

main results remain intact, and possibly are even stronger[9].

4.3.3 Why do multipliers across identifications differ?

The answer is off course that the estimates differ. But which estimates drive the results? Obviously, the prime suspect is the spending equation. In table 4.2 the estimated coefficients for contemporaneous variables from spending equations of all countries are presented. A few things are worth mentioning. First, the inflation coefficients in the alternative identification, the one resembling the Blanchard and Perotti approach, are insignificant in most cases and their values are much lower in absolute value than the baseline value considered by Perotti (-0.5); additionally, in the full equations no coefficient of inflation is ever significant, casting doubt on the true significance of inflation coefficients in the two cases (Australia and UK) where they were significant.

The most important thing however is the estimates of the full equations. In most cases, there are significant estimates, some of which are highly so; especially the coefficients of private consumption are significant in 4 out of 6 countries. These estimates suggest the implementation of some kind of countercyclical policy in real time, unlike the usual arguments suggesting that the fiscal authority is not reacting contemporaneously to changing economic environment. The estimates also suggest that the size of multipliers is roughly analogous to the strength of that countercyclical policy. US that has the strongest countercyclical policy also has the strongest output multiplier.

In addition, the estimates suggest that the usual identification of spending shocks by government spending ordered first in the Cholesky ordering is likely to be misspecified

[9] As it is shown in table C.13 in that Appendix, the reasons for higher spending multipliers, to be discussed in the next section, are the same.

in several occasions. In fact, eliminating some insignificant regressors (inflation in all cases, output in UK, US and EMU[10], consumption in Australia and Canada) reveals that the results obtained in these restricted models (available on request) do not change substantially from those in the baseline specification. The most notable differences are that the spending multipliers of Australia, EMU and UK rise - in EMU the multiplier becomes very similar to the one obtained by the alternative identification - and that both US multipliers fall slightly.

4.4 Further issues

4.4.1 Stability of responses - do the exchange rate regime or policy changes affect the outcomes?

In Perotti (2004) it was documented that there was a fall in government spending multipliers, that was attributed by the author and by Bilbiie et al (2008) mostly to the change in monetary policy, that became more anti-inflationary after 1980, and consequently less accommodative to fiscal expansions; in addition, a contributing factor was also the fall in the percentage of credit constrained consumers. Canzoneri et al (2012) argue for a related, yet different explanation: the change in exchange rate regime that led to a change in monetary policy target, from exchange rate stabilization to interest rate stabilization, and secondarily increased openness.

Do these findings survive the change in identification restrictions? Table 4.3 presents the spending and tax multipliers from estimating the models of Australia, Canada, UK and US in a shorter sample, 1981 - 2006[11]; one may compare the relevant entries with those of Cholesky identification presented in table C.10 in Appendix C.4. Once again, the results from the alternative identification are similar to those from the Cholesky.

However, the baseline identification does not reveal any general trend towards reduced effectiveness of spending increases. Only in Australia can one clearly observe such an effect. In US, the multiplier falls only on the first few periods, while in Canada and the UK it actually rises. Tax multipliers do not change substantially, yet they increase a bit (in absolute value) in UK and US. It seems that the fall in the effectiveness of

[10]Eliminating output in the spending equation of France allows spending multiplier to reach 2 on impact and 1.55 in the long run.

[11]France and EMU are omitted since the short sample was used from the beginning.

Table 4.3: Multipliers: estimation sample 1981 - 2006

	Australia			**Canada**			**UK**			**US**		
baseline	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.06	**0.09**	0.25	1.72	**2.30**	2.90	0.21	**0.36**	0.52	1.10	**1.62**	2.40
t=4	0.15	**0.42**	0.70	1.77	**2.65**	3.64	0.59	**0.88**	1.18	1.77	**2.49**	3.49
t=8	0.24	**0.53**	0.81	1.28	**2.12**	2.99	0.69	**1.05**	1.40	2.02	**2.71**	3.63
t=16	0.34	**0.60**	0.88	1.11	**1.93**	2.76	0.82	**1.21**	1.59	2.09	**2.71**	3.49
alternative	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	0.08	**0.24**	0.38	-0.13	**0.08**	0.28	-0.03	**0.08**	0.19	-0.15	**0.21**	0.51
t=4	0.19	**0.46**	0.73	-1.04	**-0.58**	-0.15	0.11	**0.33**	0.55	-0.73	**-0.07**	0.45
t=8	0.30	**0.59**	0.88	-1.25	**-0.63**	-0.09	0.15	**0.43**	0.70	-0.83	**0.00**	0.63
t=16	0.39	**0.68**	0.97	-0.85	**-0.05**	0.66	0.21	**0.56**	0.89	-1.09	**0.05**	0.82

(a) Spending

	Australia			**Canada**			**UK**			**US**		
baseline	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.03	**0.04**	0.11	-0.02	**0.07**	0.16	-0.05	**0.00**	0.06	-0.55	**-0.36**	-0.14
t=4	-0.21	**0.06**	0.28	0.06	**0.27**	0.44	-0.29	**-0.10**	0.07	-1.08	**-0.48**	0.04
t=8	-0.87	**-0.25**	0.18	0.00	**0.26**	0.48	-0.44	**-0.16**	0.08	-1.61	**-0.53**	0.20
t=16	-3.33	**-1.20**	-0.10	-0.43	**-0.02**	0.33	-0.66	**-0.23**	0.10	-2.96	**-0.65**	0.57
alternative	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.04	**0.04**	0.11	-0.03	**0.05**	0.13	-0.07	**-0.01**	0.05	-0.12	**0.00**	0.13
t=4	-0.20	**0.07**	0.28	0.09	**0.27**	0.42	-0.33	**-0.14**	0.02	-0.15	**0.16**	0.43
t=8	-0.80	**-0.22**	0.18	0.01	**0.25**	0.46	-0.50	**-0.21**	0.02	-0.28	**0.20**	0.58
t=16	-2.68	**-1.03**	-0.12	-0.47	**-0.07**	0.28	-0.77	**-0.30**	0.04	-0.67	**0.27**	0.86

(b) Tax

spending policy is an artifact of the changes in the variance-covariance matrix after 1980, which naturally affect any identification method based on the residuals; both the Cholesky decomposition of the residual variance-covariance matrix and the method of Blanchard and Perotti are using residuals.

These findings echo the finding of Sims and Zha (2006) that the best model for US is the one with break only in the variance-covariance matrix, not in the coefficients of the VAR. In addition, they confirm the results in Caldara and Kamps (2008), who do not find any appreciable fall in spending multipliers in the US, once the turbulent years of 1979 - 1982, when the FED under Volcker increased interests rates very aggressively to battle inflation, were omitted from the sample.

Overall, these results considered jointly with those in section 4.3 suggest that changes in monetary policy or differences in openness[12] do not seem to affect the results in any unambiguous way.

4.4.2 The size of the US tax multiplier

In the last years a consensus seems to have been reached over the size of the spending multiplier (defining spending as purchases of goods and services - public consumption and investment), which is is considered around, perhaps slightly higher than 1. However, there is an ongoing debate on the value of the tax multiplier; this is sparkled by the difficulty to find proper instruments to estimate the parameters of the tax equation[13] and the inability to resort to some easy way out, like placing taxes e.g. second or third in the Cholesky ordering. As argued by Caldara and Kamps (2012) the elasticities of policy variables (government spending and taxes) to output are of great importance for the estimation of the relevant output multiplier, and the different identification restrictions are in effect priors for these parameters. A Cholesky ordering imposes an output elasticity of government spending equal to 0, while the different ways to estimate output elasticities of net taxes lead to estimates ranging from 0 to infinity (in the pure sign restrictions case). They conclude however that the spending multiplier should be

[12]Schematically, the countries in the sample can be divided in the following groups with respect to how open they are: a) more closed economies, US and Australia, b) relatively open, UK and France and c) open, Canada and EMU. Openness is defined as the sum of imports and exports to GDP ratio.

[13]A reminder: typical SVAR analysis is usually done not for the $\mathbf{A}^0$ matrix of contemporaneous relations but for the $\mathbf{B}$ matrix that relates reduced form residuals with the underlying "structural" shocks. Most authors mentioned in this section work with the latter matrix. For more details, an excellent introduction to the SVAR methodology is chapter 9 of Lütkepohl (2005).

Table 4.4: Tax equations - estimates of baseline identification

	Baseline			
Country	g	y	pi	i
Australia	**0.41823***	**1.5057****	**-1.0807***	-1.1132
Canada	-0.0065107	**0.94668****	-0.1481	0.98888
France	0.068446	**1.6555****	0.3204	0.45749
UK	**0.24049***	**0.93411****	**0.36805**	**2.7481****
EMU	**0.70528****	**1.266****	-0.13391	1.1179
US	**-0.47542***	**2.221****	**2.4491****	**1.2539**

Significance (one sided): at 10% level bold, at 5% level bold and star, at 1% level bold and double star.

higher than the one of taxes for reasonable values of the elasticities.

Perhaps the most convincing way to estimate the output elasticity of taxes is to find a proper exogenous tax shock and either use it directly to estimate the output response, or indirectly as an instrument for structural tax shocks. Romer and Romer (2010) are the first who have presented an exogenous tax shock for the US and followed the first route to directly estimate output responses. Mertens and Ravn (2013a,b) take an extended version of these shocks[14] and follow the second, estimating output elasticities of taxes around 3. In all these papers output multipliers of taxes are very high, typically higher than 2 and even higher than 3 in some specifications. Cloyne (2013) finds very similar results for the UK. Perotti (2012) extends the Romer and Romer dataset for the US and finds output elasticities of taxes around 1.8 and output tax multipliers around 1.5 after 3 years.

These results are at odds with those obtained by the implementation of Blanchard - Perotti approach, which gives much lower multipliers (typically lower than spending). The main difference is the output elasticity of taxes which, for the countries of the sample, is calculated as follows: US=1.85, UK=0.76, Canada=1.86, Australia=0.81 (Perotti 2004); EMU=1.54 (Burriel et al 2009); France=0.8 (Biau and Girard 2004).

From section 4.3.2 one may recall that in the present study the estimated effects of taxes resemble those of the Blanchard - Perotti SVAR approach, and that the estimated tax equations are well identified[15]. What are the estimated output elasticities of taxes? The estimates of the coefficients for the contemporaneous variables of the tax equation are presented in table 4.4 for the baseline case of all countries. As it is evident, the

[14]They distinguish between anticipated and unanticipated tax changes based on the time it took for implementation after legislation. They use unanticipated shocks in their estimates.

[15]The interested reader may check Appendix C.3.

Table 4.5: Output multipliers of baseline specification for the US with Mertens-Ravn unanticipated shocks included

	spending			**taxes**		
	0.1	**base**	0.9	0.1	**base**	0.9
t=0	1.70	**1.98**	2.27	-0.28	**-0.12**	0.00
t=4	1.82	**2.18**	2.57	-0.85	**-0.38**	-0.07
t=8	1.74	**2.09**	2.45	-1.41	**-0.63**	-0.16
t=16	1.63	**1.95**	2.27	-2.99	**-1.20**	-0.28

estimated output elasticities of taxes are very significant, but not high enough to generate the very high output multipliers of taxes found in studies using exogenous tax shocks - their values are not that different from those calculated using the Blanchard - Perotti approach. One may observe that these elasticities of taxes with respect to output are broadly analogous to the size of the tax multiplier - countries with higher elasticities have higher tax multipliers[16].

To compare results from this work with those generated by the use of exogenous tax shocks, I re-estimated the baseline specification for the US adding the Mertens - Ravn unanticipated shocks as instruments. The multipliers are presented in table 4.5. A quick comparison between them and those in table 4.1 allow one to easily see that they do not change the baseline results in any fundamental way; spending multipliers are slightly lower, tax multipliers are higher but spending multipliers are still big, definitely much bigger than those of taxes. IRFs (not presented) do not differ from those of the baseline.

In addition, following Mertens and Ravn, I estimate their tax equation as would be written in the current specification: $\mathrm{u_t^t} = \vartheta_\mathrm{g}\varepsilon_\mathrm{t}^\mathrm{g} + \vartheta_\mathrm{y}\mathrm{u_t^y} + \vartheta_\mathrm{pi}\mathrm{u_t^{pi}} + \vartheta_\mathrm{c}\mathrm{u_t^c} + \vartheta_\mathrm{ip}\mathrm{u_t^{ip}} + \vartheta_\mathrm{t}\varepsilon_\mathrm{t}^\mathrm{t}$ $+\vartheta_\mathrm{i}u_t^i$, where u denote residuals from the relevant equations and ε the estimated structural errors; the coefficient of interest is ϑ_y and the equation is estimated by IV, using two different sets of instruments: all structural errors and the Mertens and Ravn unanticipated tax shocks, or all structural errors except the one from output equation and the aforementioned shocks; the elasticity of taxes to output is estimated to be 2.15 (S.E. 0.041) in the first case or 2.19 (S.E. 0.117) in the second. These elasticities are almost equal to the one estimated in the baseline case; it could be the case that their results depend on the different specifications they used, in which they do not include so many macroeconomic variables and could be more vulnerable to non-invertibility problems.

[16]The results of table C.14 in section C.5 of the Appendix maintain this conclusion even when the foreign activity variable (GAM) is included in the models.

4.4.3 Discussion - what are the implications of the results?

As mentioned in the introduction, a fundamental issue with fiscal policy is whether it is possible to consolidate without too much pain. A rather large literature has taken this issue. One strand of it asserts that it is possible to consolidate without (much) pain, if the chosen policy is to cut expenses and not raise taxes - in fact such a policy is associated with expansions (expansionary fiscal contractions); representative papers of this view are Alesina and Perotti (1995) and Alesina and Ardagna (2010). The mechanism behind this effect is that cutting state helps to reduce the interest rate and also has a negative effect on wages, that helps to spur a supply driven expansion.

However, this view is seriously contested. Perotti (2011) suggests that in major episodes of expansionary fiscal contractions no such effects were present, but rather whatever growth happened was simply the export led growth that followed the large depreciations after the fiscal consolidations. In addition, using a new dataset on fiscal consolidations, Guajardo et al (2011) argue that fiscal consolidations are associated with large contractions and that any positive effects on economic activity found by the opposite view is simply the artifact of using wrong measures of fiscal policy stance (typically cyclically adjusted deficits) that generate positive bias.

The results obtained in this paper suggest that the expansionary austerity theory is highly unlikely to actually hold. Spending multipliers are consistently bigger than tax ones, even when the are not big. Thus, in all cases cutting spending will do more harm than raising taxes, even when that harm will be small.

Another thing worth discussing is what determines these multipliers. An mentioned in the introduction, currently economists typically think that the extend of monetary accommodation and the number of rule-of-thumb consumers determines the outcome. However, no particular monetary accommodation is seen in the responses and it seems hard to argue that US have the largest percentage of such consumers, even though they lack many elements of the welfare state of Europe. Another mechanism is required to generate the observed responses, especially the positive ones of consumption and investment. In the sample, the size of the multiplier is related to the sizes of the elasticity of spending with respect to economic activity and the elasticity of taxes with respect to output - the bigger these elasticities are (in absolute value), the stronger the relevant

multiplier[17].

Another thing worth mentioning is that in most countries countercylclical policy is conducted using spending - arguably, since the bulk of spending is not related to the cycle, such policies will have small magnitude. On the other hand, the positive coefficient of spending in the tax equation is probably because taxes are not used to manage demand, but to satisfy fiscal solvency - only in US one observes a negative coefficient in spending.

4.5 Conclusion

In this chapter I have tried to estimate the effects of fiscal policy in economic activity with particular emphasis to spending and tax multipliers. For this, I have used the tools of typical SVAR methodology but with novel identifying restrictions, based on the separation of structural shocks to permanent and transitory; these allow to find proper instruments to estimate the contemporaneous relations. It turned out in most cases that the instruments are quite good for the purpose.

The results confirm the findings of SVAR methodology, that spending causes an increase in economic activity, and importantly an increase in consumption; taxes cause economic activity to fall. Importantly, like in SVAR studies, spending multipliers are higher; this is an important result, as it casts doubt on the results of some important recent papers, that have found very high output multipliers of taxes using exogenous tax shocks. This kind of results obtained in this paper support a predominantly Keynesian view of the economy.

In addition, fiscal multipliers depend heavily on certain parameters of the matrix of contemporaneous relations, those that are mostly related to how strongly spending or taxes respond to economic activity - multipliers depend on policy. The stronger the countercyclical reaction of spending, the stronger the output multiplier of spending. The bigger the output elasticity of taxes, the bigger (other things equal) the tax multiplier.

Also, they do not support a commonly held view, that fiscal policy is less effective the latter decades that it was before. The findings of previous studies are probably due

[17] One may argue that also the degree of openness is relevant, as Australia and US, which are the most closed economies, had the biggest multipliers. However Canada has the third strongest multiplier, despite the fact that it is the most open economy in the sample. In addition, increased openness after 1980 does not seem to reduce these multipliers.

to breaks in the correlations of residuals, not the underlying model. In addition, the common view, founded in the Mundell - Flemming model, that fiscal policy is more potent in fixed exchange rates finds no support in the results.

Furthermore, such results strongly refute the empirical relevance of theories like the expansionary fiscal consolidation - fiscal adjustments, necessary as they may be, are never easy or painless, and this is probably the reason policy makers postpone them as much as they can. In any case, the advice to cut government consumption in consolidations seems to be a bad one. This is particularly relevant in current consolidations in Eurozone countries - it seems that the adjustment programs could be more successful if they were better designed.

Lastly, this work can be extended in various ways, like adding countries, changing variables etc. However, the most important extension seems to be the implementation of this identification method to datasets consisting of annual data. If anything, tax data are frequently available in annual frequency, for quite some time, but only rarely can one find data covering more than 20 years on quarterly frequency; long run restrictions can be implemented in principle with annual data, allowing to vastly increase the country coverage and obtaining more general results. It remains to be seen if it is possible to successfully implement it in lower frequency - if it is possible to generate good instruments to estimate the contemporaneous relations in such an environment.

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Chapter 5

A Prototype Model of Fiscal Policy

5.1 Introduction

In the previous chapter the econometric analysis has shown that differences in fiscal multipliers can be traced to differences in the reactions of policy variables to changing environment. In chapter 3 this idea was also used to make a basic DSGE model match qualitatively certain features of the responses to the regime switching models simulated there. It was shown that if policy makers do not rush to suppress deficits, it is possible to generate the typical responses found in most SVAR studies (including the present work) for spending, in each regime, and the use of two taxes, one distortionary and one not, to balance the budget allows to generate asymmetries to tax shocks. This was achieved without any need to resort to financial frictions or the zero lower bound, which was however unlikely to bind in the used sample.

The use of policy rules is a topic scarcely studied in the context of fiscal policy. Most papers assume some simple relations, usually in the form of Autoregressive processes for policy instruments, mainly to close the model - e.g. one may look at Burnside et al (2004) or Edelberg et al (1999). Especially if taxes are lump-sum, most economists think that Ricardian equivalence should make them irrelevant to the workings of the model. Alternatively, (distortionary or not) taxes are usually modeled as the instrument to satisfy budget constraint - they react to debt to ensure long run solvency.

The main topic in this chapter is to see where this idea can lead: can policy rules

explain country differences shown in chapter 4? In addition, can such rules reproduce the estimated responses, e.g. that spending has higher multipliers than taxes? As it will become evident later, such rules can actually generate qualitatively some of the sought for responses, especially the higher spending multipliers and their bigger magnitude to that of tax multipliers.

The remaining of this chapter is structured in the following way. Section 5.2 summarizes the model and presents the multipliers for a variety of policy rules. Section 5.3 concludes.

5.2 The model and the multipliers of different policies

5.2.1 The model

Fiscal rules and their effects is a topic the literature has scarcely addressed so far: Ludvigson (1996) was the first to describe the macroeconomic effects of cuts of distortionary income taxes - this deficit financed policy led to an expansion, with positive output and consumption reactions. Most of literature treats policy rules to study optimal policy and monetary and fiscal policy interactions, mainly to see whether the Ramsey equilibrium can be approximated with fiscal and monetary policy rules either in the context of balanced budgets (e.g. Schmitt-Grohé and Uríbe 1997) or allowing the accumulation of debt (Schmitt-Grohé and Uríbe 2004, 2006 and 2007); it is found that balanced budgets can be destabilizing and in any case suboptimal to changing debt levels. However, the focus was entirely on monetary policy, and fiscal policy was in general passive.

Reis (2007), to the best of my knowledge at least, was the first to point out that fiscal policy rules matter a lot in DSGE, and chosen appropriately allow one to replicate any desired pattern in the reactions of endogenous variables even in an RBC with distortionary taxes and balanced budgets, at least if several distortionary taxes are available and the fiscal authority may choose the policy instrument. In addition, he asserted that especially in modern monetary models, fiscal policy matters, since demand matters, as e.g. price or wage rigidities affect the adjustment paths and ultimately the change in real variables.

The model used in the simulations is entirely identical to the one in section 3.4.1, so the interested reader should read there for a full description. A model that generates

Table 5.1: Parameters used in calibration and their values; known steady state values of variables

Parameter	Value	Description
β	0.99	Time discount factor
δ	0.025	Depreciation of capital
θ	2	Frisch elasticity of labor supply
κ	$\frac{W(1-\tau^w)}{L^\vartheta C}$	Normalization factor for disutility of labor
α	0.3	Share of capital
γ	0.4	Value of externality of government services
χ	0.7	Productivity of government workers
B/Y	3	ss debt to GDP ratio (75% on annual basis)
ρ_τ	0.9	strength of tax smoothing
ξ	–	Speed of reaction of taxes to debt
ε_{gy}	–	Elasticity of government spending to output
ε_{ty}	–	Elasticity of taxes to output
ε_{tg}	–	Elasticity of taxes to government spending
ρ_{lg}	0.9	Autoregressive coefficient of L_g
σ_{lg}	0.01	Variance of e_{lg}
σ_τ	0.01	Variance of $e_{\tau t}$
L	0.3	Steady state level of employment
L^g	$0.15L$	Steady state level of government employment

positive output and consumption responses to taxes is essential, since they are present in the data. The easiest and more transparent way to do it is to assume that spending has some form of productivity externality for the private sector. The differences with this model are only two, and they concern the conduct of fiscal policy: equations (3.11) and (3.12) have been replaced with the following two:

$$\begin{aligned} ln\left(\tau_t^w W_t L_t / \tau^w WL\right) &= \rho_\tau ln\left(\tau_{t-1}^w W_{t-1} L_{t-1} / \tau^w WL\right) + \xi ln\left(B_{t-1}/B\right) \\ &\quad + \varepsilon_{\tau g} ln\left(W_t L_t^g / WL^g\right) + \varepsilon_{\tau y} ln\left(Y_t/Y\right) + e_{\tau t} \end{aligned} \tag{5.1}$$

$$L_t^g = (1-\rho_{lg})L^g + \rho_{lg} L_{t-1}^g + \varepsilon_{gy} ln\left(Y_t/Y\right) + e_{lgt} \tag{5.2}$$

These policy rules are inspired by the estimates of chapter 4, especially tables 4.2 and 4.4, where it is evident that the policy rules involve more variables than those typically assumed in DSGEs, namely an autoregressive process for spending and a set of tax rules to stabilize debt. The above equations constitute more general rules, allowing more complex interactions of policy variables and consequently they allow more complex

reactions of the endogenous variables. The model calibration is presented in table 5.1[1]. The 4 parameters appearing in policy rules are ξ, the speed of adjustment of taxes to debt, ε_{gy} and ε_{ty}, the elasticities of policy variables to changing economic environment, and ε_{tg} which indicates whether tax policy is coordinated with spending policy (negative coefficient) or simply reacts to increased spending mechanically to reduce the deficit (positive). The coefficient on past tax rate, ρ_τ, is fixed at 0.9.

The simulation experiment is very simple: the model is solved in Dynare for all combinations of values of the 4 parameters, and cumulative multipliers are calculated as in chapter 3. The parameters can take the following values: $\varepsilon_{gy} \in \{-1, -0.8, -0.6, -0.4, -0.2, 0\}$ - it cannot take positive values as this leads to indeterminacy; $\varepsilon_{ty} \in \{0, 0.5, 1, 1.5, 2, 2.5\}$, yet one has to admit that this not quite the elasticity of taxes to output in the data; $\varepsilon_{tg} \in \{-0.4, -0.2, 0, 0.2\}$[2]; lastly $\xi \in \{0.1, 0.3, 0.5, 0.7, 0.9\}$. Two sets of simulations are run, one using only a distortionary wage tax, and the other using both the wage tax and a lump sum tax, each covering 50% of revenue. In the second case, the fiscal block is described in the following equations:

$$
\begin{aligned}
ln\left(T_t/T\right) &= \rho_\tau ln\left(T_{t-1}/T\right) + \xi ln\left(B_{t-1}/B\right) + \varepsilon_{\tau g} ln\left(W_t L_t^g / W L^g\right) \\
&\quad + \varepsilon_{\tau y} ln\left(Y_t/Y\right) + e_{\tau t} && (5.3) \\
L_t^g &= (1-\rho_{lg}) L^g + \rho_{lg} L_{t-1}^g + \varepsilon_{gy} ln\left(Y_t/Y\right) + e_{lgt} && (5.4) \\
T_t &= t_t + \tau_t^w W_t L_t && (5.5) \\
t_t &= \tau_t^w W_t L_t && (5.6)
\end{aligned}
$$

Here the tax rule is in total revenue, T_t, that is split equally to a lump-sum tax, t_t, and the revenue from the distortionary wage tax, $\tau_t^w W_t L_t$; both adjust when when T_t changes, so that they contribute equally to the budget, like in chapter 3.

5.2.2 Multipliers of different policies

Figures 5.1 and 5.2 plot the mean multipliers of spending for each tax structure. The results are saying a consistent story: in all graphs, the lower ε_{tg} and ε_{ty}, the higher the

[1]The only difference is the increase of χ, the productivity of goverment workers to 0.7 from 0.5, but it was essential to maintain determinacy of the model when fiscal policy was very responsive to output.

[2]The simulation with distortionary taxes had to stop at 0.2 in this case for determinacy reasons.

spending multiplier. In addition, increasing ξ uniformly decreases the multiplier, more so in the case where only distortionary taxes are available. In the latter case, multipliers can be from over 2 to 0.5, depending on chosen policy mix. In the case of 2 taxes, multipliers do not differ that much: they range from 1.7 to 0.8.

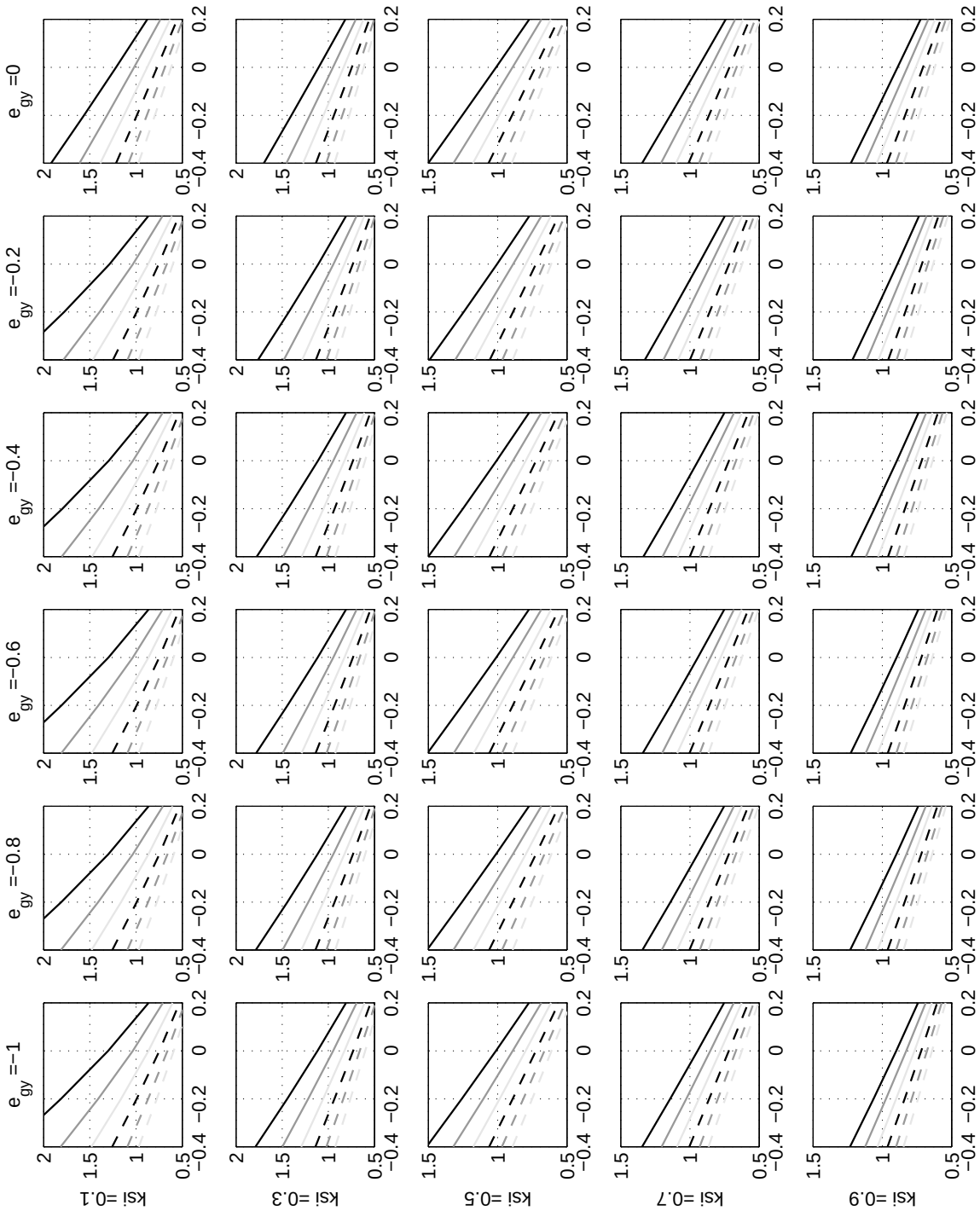
Turning to taxes multipliers, figures 5.3 and 5.4 present the mean multipliers for each tax structure. The results here are striking: the tax multiplier is very low, if government conducts any kind of stabilization policy that reduces the speed of adjustment of taxes to debt, but most importantly, when it uses countercyclical spending to stabilize the economy. When two tax instruments, one distortionary and one not, are available, the tax multiplier is from negligible to low, no matter what spending policies are, and is always smaller than spending multiplier, with the exception of some cases when spending is not used at all for stabilization of output.

In the case of one tax instrument, things are more involved. At first, when the speed of adjustment to debt is not very high, any kind of countercyclical spending policy results in a very low tax multiplier here too. With high speeds of adjustment, we get some peculiar patterns, mainly because taxes fall to negative ground and their reduction allows output to rise.

The last column of figure 5.3, which shows tax multipliers when no countercyclical spending policy is conducted, deserves a special attention. Here is the only case where we get sizable multipliers, with their value increasing in the elasticity of taxes to output, but mostly affected by the speed of adjustment to debt. With high speed of adjustment of taxes to debt ($\xi > 0.7$), things become complicated, since fast reduction of debt allows tax rates to fall and output to rise, causing again changes in sign of multiplier, a situation that complicates drawing conclusions.

In general, we can see that differences in policy can explain some aspects of the results in chapter 4. In particular, the model is quite successful in generating higher spending multipliers when fiscal policy is countercyclical. Like the estimates of table 4.2, spending multipliers are higher, the higher the strength of countercyclical reaction. In addition, spending multipliers are almost always higher than the ones of taxes, unless we get some peculiar responses because of very strong debt adjustment. In any case, even with only very mild countercyclical policy, spending multipliers are higher, and are always higher if non-distortionary taxes are available as a policy tool.

Figure 5.1: Mean Spending multipliers, distortionary taxes.



X-axis: ε_{tg} values; lines represent the multipliers for different ε_{ty} values: black solid: 0, medium gray solid: 0.5, light gray solid: 1, black dashed: 1.5, medium gray dashed: 2, light gray dashed: 2.5.

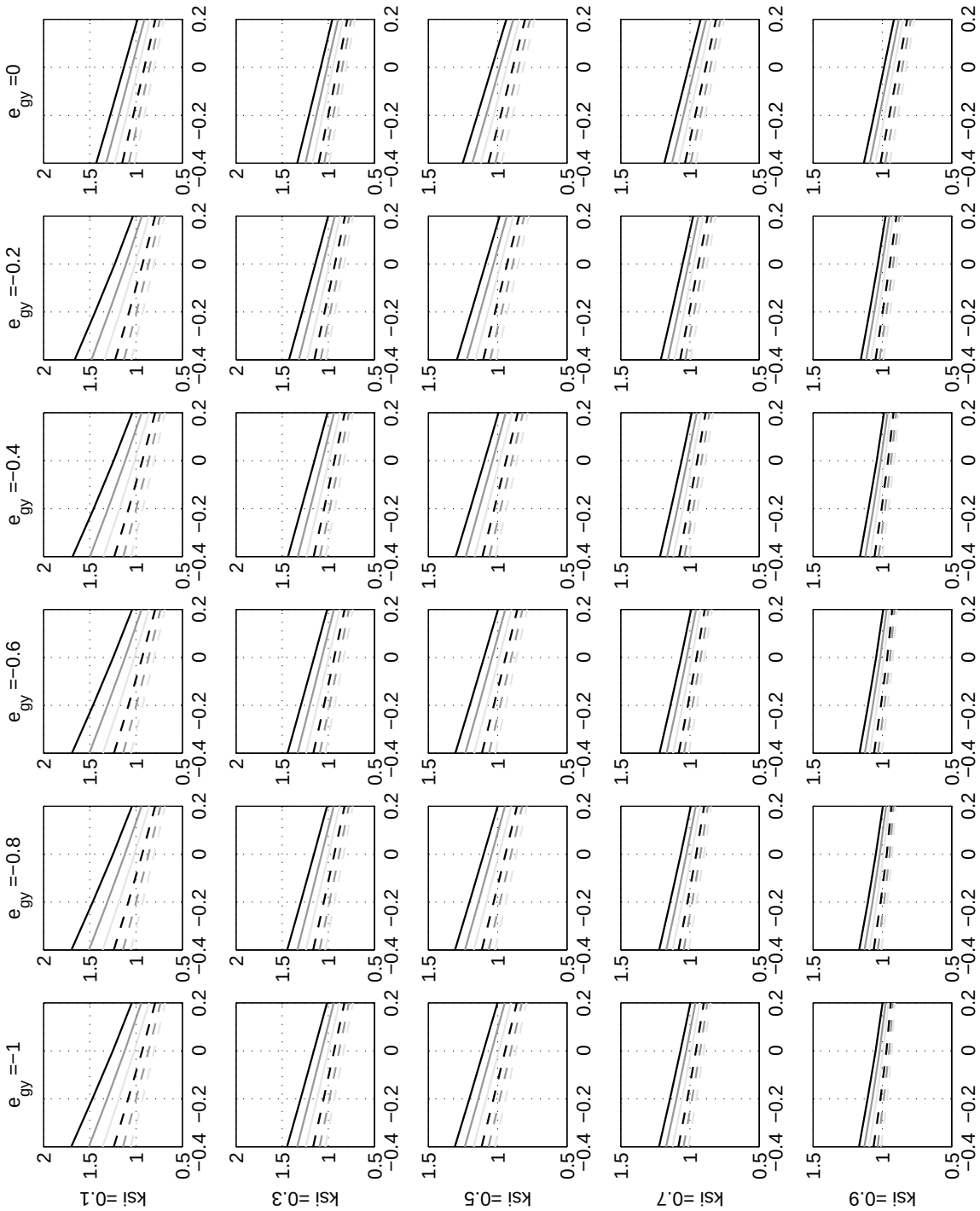
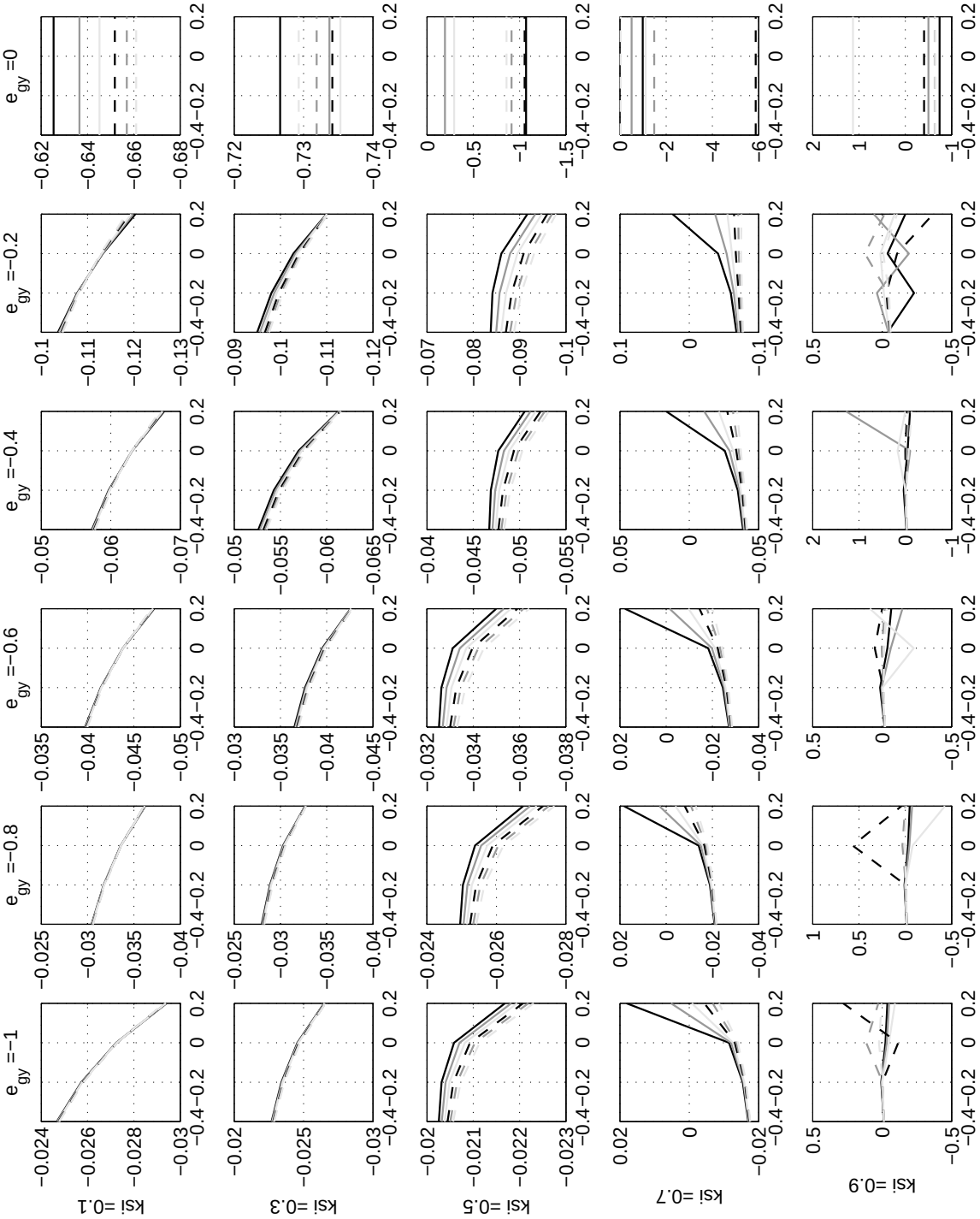


Figure 5.2: Mean spending multipliers, distortionary and lump-sum taxes.

X-axis: ε_{tg} values; lines represent the multipliers for different ε_{ty} values: black solid: 0, medium gray solid: 0.5, light gray solid: 1, black dashed: 1.5, medium gray dashed: 2, light gray dashed: 2.5.

Figure 5.3: Mean tax multipliers, distortionary taxes.



X-axis: ε_{tg} values; lines represent the multipliers for different ε_{ty} values: black solid: 0, medium gray solid: 0.5, light gray solid: 1, black dashed: 1.5, medium gray dashed: 2, light gray dashed: 2.5.

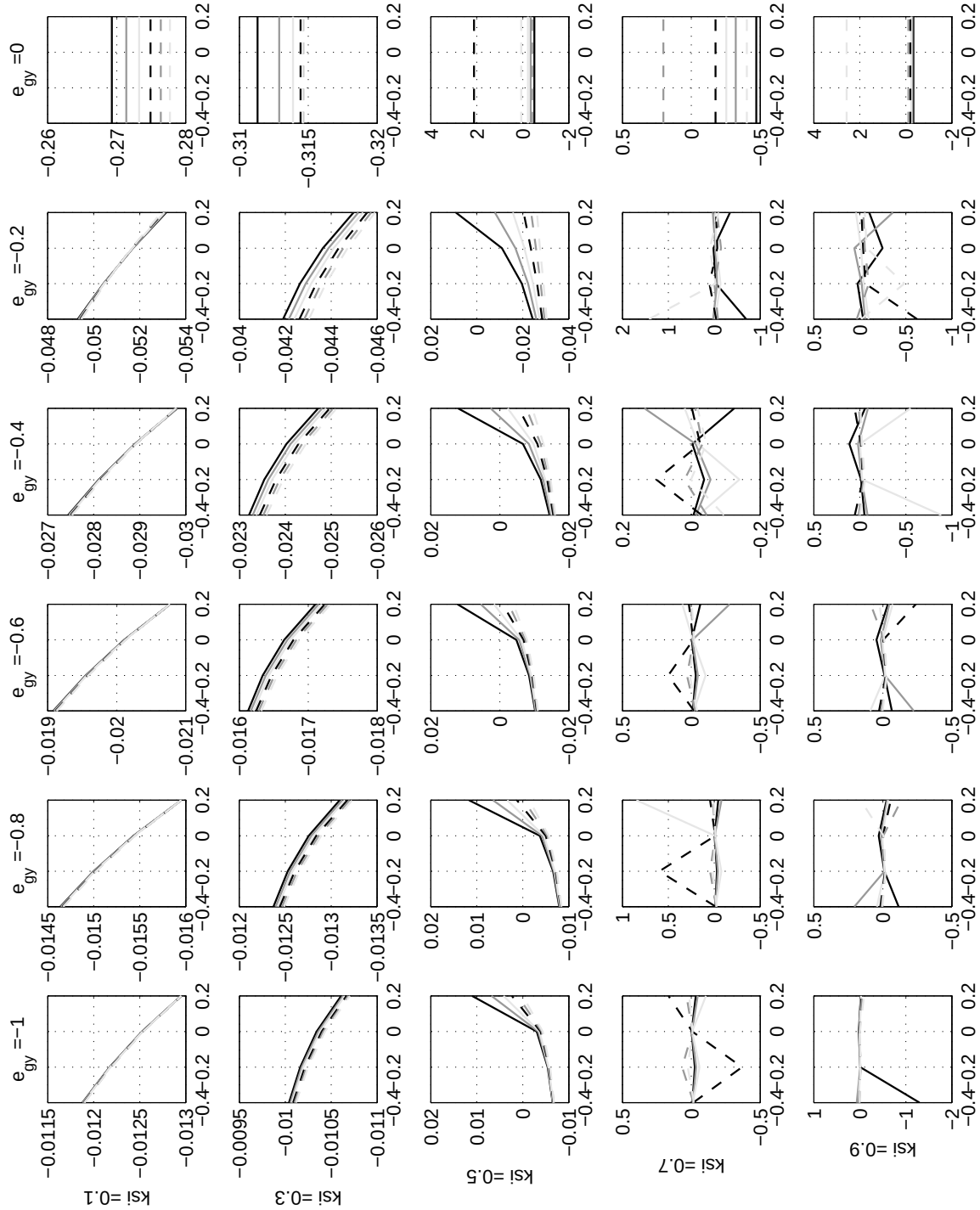


Figure 5.4: Mean tax multipliers, distortionary and lump-sum taxes.

X-axis: ε_{tg} values; lines represent the multipliers for different ε_{ty} values: black solid: 0, medium gray solid: 0.5, light gray solid: 1, black dashed: 1.5, medium gray dashed: 2, light gray dashed: 2.5.

However, the model is not that successful in generating the tax multipliers observed in table 4.1. Only in Canada and the UK one could assert that the estimates conform with the predictions of the model, because in these two countries the tax multipliers are close to zero. In the other four cases, the only way to get higher tax multipliers would be to accept the lack of countercylcical policy, something the data might tolerate only in the EMU case. Thus, one can only conclude that the modeling of the taxes and their effects in the model is inadequate[3]. And, it seems that this is prevalent in DSGE models. The issue with these models is probably that they do not have the required heterogeneity to generate realistic responses to taxes - rule of thumb consumers is no solution to this problem. Taxes probably operate through marginal tax rates, not average ones, which is what one models in a DSGE; but marginal tax rates can not work in a model where all are the same.[4] Nevertheless, the results in this chapter justify a reconsideration of how fiscal policy is described in DSGE models, and most importantly in models that are used in policy making.

This exercise has however some practical lessons to teach. The main is that one should not expect to consolidate costlessly (or close to), as argued by some. If public spending has some productive value, then one can expect higher spending multipliers than taxes ones. This argument does not include social security and transfers in general, but the political issues generated when a government tries to cut this part of spending can be insurmountable. If taxes are not excessive (in the model they are not), it seems preferable to increase them, especially non-distortionary ones if they are available.

Let us compare the results in the previous graphs with the policies implemented in certain EMU countries. Tax policy has moved towards the lower right corner, probably increasing multipliers of distortionary taxes, increasing the potential harm tax increases cause. Spending policy has probably moved in positive ground for ε_{gy}, at least in some of them; in the model, this leads to indeterminacy - then, the depression in Greece comes as no surprise, and can be attributed to, bad at the very least, policy design.

[3]Or that in reality fiscal policy is not operating in a consistent manner, applying one rule in some cases and another in other.

[4]An alternative explanation could be that taxes work mostly through their effect on the steady state, but is not possible to explore such an effect in models that are linearized around a constant steady state. In any case, the magnitude of the estimated effects of taxes in this thesis does not justify taking this route for them and not in the case of spending, that consistently gives stronger effects.

5.3 Conclusion

In this chapter a simulation exercise was conducted in order to see how different policies, in the form of different spending and tax rules affect the macroeconomic outcomes in a baseline DSGE model. Spending rules that allow to conduct countercyclical policy manage to give the desired outcomes, especially in cases of debt financing in the presence of distortionary taxes. However, tax rules are not very successful in the task of mimicking the pattern of estimated multipliers to tax shocks. They can give empirically relevant tax multipliers for most countries only in the absence of countercyclical spending, contrary to the results in chapter 4, where important countercyclical reactions of spending were estimated in most countries. In any case more work in needed to explain these effects and incorporate them in policy analysis.

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Chapter 6

Concluding Remarks

As was stated in the introduction, the principal question in this thesis is the size of fiscal multipliers. In particular, the main motivation was a) to look at the differences of multipliers according to different spending categories, b) to delve into differences of multipliers over the business cycle, c) to examine whether the findings survive the change in identifying restrictions and d) to investigate which fiscal instrument, spending or taxes, has bigger multiplier (in absolute value) and therefore should be used when needed. Secondary (but by no means in importance) issues explored were the ones of fiscal foresight and the stability of multipliers over time. In addition, a major issue is how fiscal policy works - which model is more consistent with the data?

Two important issues were not investigated in this thesis. The first is the effects of components of taxes, but the exogenous shocks do not provide many observations for the different categories of taxes, and the identification method of chapter 4 that utilizes long-run restrictions does not easily extend to the components of spending and taxes. The second is the effects of transfers, but this variable is more correlated with the business cycle, reducing the likelihood to extract proper structural shocks, and social security does not change the total income of households substantially, as the bulk of taxes collected to finance it is returned to households. Nevertheless, several important results were obtained.

In chapter 2 I was mostly engaged in answering question a, as well as the issue of fiscal foresight. The latter did not prove to be a major concern, at least in U.S. data, as there were no evidence that one could improve the model by adding more information, as would be expected if agents were actually behaving as if they were utilizing more

of it. The important finding was that there are big differences in the effects of various spending categories. Civilian spending has a beneficial effect on economic activity; this spending category resembles to a kind of productivity shock in a real model, giving some supportive evidence to papers advocating this explanation for the positive effects of government spending on economic activity; civilian consumption seems to affect private consumption and investment particularly strongly, while civilian investment has the highest output multiplier. On the contrary, military spending appears to have rather neutral, and in some cases harmful, effects; especially government investment seems to have a particularly negative effect on economic activity, like a negative productivity shock. This later effect is not predicted by any standard theory. To explain this finding, I set up a DSGE, whose key property is the disaggregation of the budget variables, each of which can have quite distinct effects, as in reality. In particular, government consumption - hires are assumed to work in a manner similar to a productivity shock. Military equipment purchases work in the opposite way, because they are produced by an inferior production function - shifting resources towards this unproductive sector lowers the overall production of the economy. The mechanism is successful in replicating qualitatively the observed responses.

Chapter 3 was mainly about answering question b, the one about the size of (both spending and tax) multipliers over the business cycle. Civilian spending shocks appear to have large positive effects on economic activity in low growth periods, effects that do not seem to depend heavily on the behavior of the central bank - the latter does not seem to accommodate spending policies. The output multiplier of spending shocks in recessions is likely to be over 1.5, making civilian spending a powerful tool to dampen recessions, while military spending might even lead to recessionary outcomes, confirming the findings of chapter 2. In what concerns taxes, the results are less clear cut, but the most sensible thing to say, mostly based on the results from exogenous shocks, is that taxes have adverse macroeconomic effects only when they are raised / imposed during recessions - they do not seem to affect output during expansions. A theoretical explanation is proposed for the main effects on real variables which is based on policy asymmetries over the cycle: in a DSGE model, a lower speed of adjustment of taxes to debt in recessions is quite successful in replicating qualitatively the responses to spending shocks; the inclusion of two taxes, one distortionary and one not, and the use of the first

only in recessions (possible reasons are mentioned in the chapter) allows one to generate the desired asymmetries in the responses to tax shocks too.

In chapter 4 I undertook issue c, in an international data set using a different way to identify fiscal shocks, in particular using the restrictions implied by splitting the shocks in permanent and transitory, and the instruments generated by the aforementioned division. Once again, spending causes an increase in economic activity, and notably an increase in consumption; taxes cause economic activity to fall. Importantly, fiscal multipliers depend heavily on certain parameters of the matrix of contemporaneous relations, those that are mostly related to how strongly spending or taxes respond to economic activity - multipliers depend on policy. The stronger the countercyclical reaction of spending, the stronger the output multiplier of spending. The bigger the output elasticity of taxes, the bigger (other things equal) the tax multiplier. This finding is in accordance with the mechanism used in chapter 3 to generate asymmetric responses to fiscal shocks over the business cycle.

A simulation exercise in chapter 5 allows one to see how different policies, in the form of different spending and tax rules, affect the macroeconomic outcomes in a baseline DSGE model similar to the real model of chapter 3. Spending rules that allow to conduct countercyclical policy manage to give the desired outcomes, especially in cases of debt financing in the presence of distortionary taxes. However, tax rules are not very successful in the same task. In most cases, they can give empirically relevant tax multipliers only in the absence of countercyclical spending, contrary to the results in chapter 4, where important countercyclical reactions of spending were estimated; more work in needed to explain these effects. Nevertheless, the simulation demonstrates the importance of policy reactions/rules, a topic usually neglected by economists when they try to design models or make sense of the available data.

Turning now to question d, it has been answered in chapters 3 and 4, where multipliers of both spending and taxes were estimated. The outcome is very clear: spending multiplier is higher (in absolute value), and by a comfortable margin. This naturally has profound policy implications: it is better to use spending to stimulate the economy, and consolidating during recessions is a bad policy, particularly when implemented by cutting spending. In addition, it makes certain theories, like the expansionary austerity, void of any empirical relevance.

In what concerns the issue of stability of responses over time, in chapters 3 and 4 it has been shown that the power of spending policies to affect the economy does not seem to be diminished in the last decades, contrary to previous results.

The combined results of the empirical analysis in this thesis support and extend the results obtained so far by the many studies using SVAR analysis, and have some aspects compatible with typical Keynesian theory, like the increase of consumption after spending shocks or the higher magnitude of spending multiplier; generally, one should expect positive responses of real variables after spending shocks, and smaller negative ones after tax shocks. Other results however, like the zero to negative response of inflation to spending increases, are more compatible with modern NK models where spending works as a productivity shock. In any case, as we progressively obtain more results, the case for fiscal policy operating in a (semi-)Keynesian manner becomes more and more robust.

Finally, on the issue of which model describes fiscal policy more accurately, since in all chapters consumption was found to increase after spending shocks and government spending multiplier was bigger, the evidence suggest that Keynesian models are better to use in analyzing fiscal policy, compared to the baseline RBC/NK model. However, this should not be seen as a dismission of DSGE modeling in general as inappropriate to accurately describe fiscal issues: there are some theories that are capable to produce the desired effects, and in the present work some other variations are proposed that are reasonably successful to replicate the results from the empirical analysis. Certainly, more work needs to be done, especially in the directions of i) properly modeling the effects of fiscal policy on labor market and ii) describing taxes better.

Appendix A

Appendix to Chapter 2

In this appendix some more results from the baseline models of Chapter 2 will be presented. The following results use another identification method, in particular sign restrictions. Estimation and general implementation of the procedure has been done similarly to Uhlig (2005), but searching for impulse matrices has been done according to Rubio-Ramirez et al (2005, 2010, algorithm 2) and the penalty function was implemented according to Enders et al (2011).

At first I estimate the VAR using OLS - the prior implied is the uninformative natural conjugate Normal-Wishart prior, leading to a similar posterior centered at the OLS estimates, just like in Uhlig (especially Appendix B); the assumption is that the reduced form and the structural residuals are linked by the equation $\mathbf{U_t} = \mathbf{BE_t}$ (see also section 1.2.1 for the general discussion of Structural VAR), where $E(\mathbf{U_t}\mathbf{U_t}') = \Sigma$ and $E(\mathbf{E_t}\mathbf{E_t}') = \mathbf{I}$. Drawing from the posterior, for each replication we can form the companion matrix, a candidate Σ and $\mathbf{P}$, the lower Cholesky factor of Σ; then one can calculate $\mathbf{B}$ as if $\mathbf{B} = \mathbf{PQ}$, where $\mathbf{Q}$ (the crucial matrix, since its columns carry the weights needed to identify the structural errors) is generated by decomposing random standard normal matrices using the QR decomposition. Then IRFs are generated, and if the sum of the squared deviations from the sign restrictions for all shocks, variables and horizons do not violate the sign restrictions by more than 0.001, the impulses are kept.

As mentioned in section 1.2.1.4, sign restrictions are more likely to identify true responses when several shocks are identified and the shocks under investigation explain a significant portion of the variance of the residuals; this second requirement leads one to

be sceptical on the suitability of this kind of restrictions for fiscal policy issues. Nevertheless, in this implementation 6 structural shocks are assumed, namely a government spending shock (e^g), a tax shock (e^t), a supply shock (e^s), a demand shock (e^d), an inflation - cost-push shock (e^π) and a monetary policy shock (e^m). The variables are the same as in chapter 2, in particular a spending variable (g), net taxes (t), output (y), inflation (π), federal funds rate (i) and consumption (c) - real variables are logs of per-capita values. The spending variables are total spending, govenrment consumption and investment, and their civilian and military counterparts.

The restrictions, inspired by the DSGE literature, are the following: the spending shock drives spending up - output also rises when total spending or civilian spending variables are increased; the results of chapter 2 indicate that military spending variables have lower multipliers, even negative in military investment case, so for comparison purposes the reaction of output to military spending variables is left unrestricted. The supply (technology) shock drives output, taxes and consumption up but inflation down; demand shocks increase all variables except spending; monetary policy shocks drive interest rate up, do not affect spending and drive all other variables down; tax shocks increase taxes and decrease consumption; inflation shocks raise inflation and interest rates and reduce consumption. In another variant, spending shocks also decrease taxes and tax shocks also decrease the spending variable. These restrcitions are enforced either for 1 or 4 periods or for 4 periods for the fiscal variables but for 1 period for the rest. Table A.1 shows these restrictions:

Table A.1: Sign restrictions

	e^g	e^s	e^d	e^m	e^t	e^π
g	+				(-)	
t	(-)	+	+	-	+	
y	+ ( )	+	+	-		
π		-	+	-		+
i			+	+		+
c		+	+	-	-	-

In table A.2 the output multipliers to spending and in table A.3 those to tax shocks are presented. Multipliers are from 10,000 replications, and blanks correspond to cases where identification failed to produce valid outcomes or produced to few to be able to calculate quantiles of responses. As it is clear from the first table, results are broadly similar to those reported in section 2.3 of main text, and multipliers tend to be higher (in

some cases very much so), casting doubt on the validity of these results. In addition, tax multipliers tend to vary quite a lot, with no apparent explanation, since the tax variable and identification restrictions are the same in all models. These results are indicative of possible difficulties related to sign restrictions, already discussed in section 1.2.1.4. In addition, figures A.1 to A.3 present the IRFs to spending shocks when only spending or taxes (and output or consumption where applicable, but not the other fiscal variable) are restricted; as it is evident from the graphs, the confidence intervals are very wide, leading to insignificant results in most cases, and are scarcely informative for variables not restricted a priori.

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Table A.2: Output multipliers to spending shocks - sign restrictions

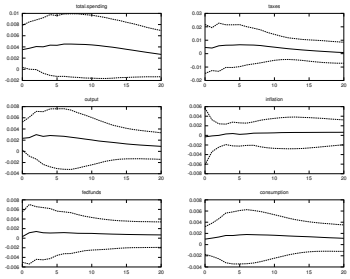
		Spending only				Spending and Taxes			
		mean	period 0	period 4	period 8	mean	period 0	period 4	period 8
total spending	4 periods fiscal, 1 all	2.51	2.67	2.71	2.61	1.63	2.43	1.69	1.45
	1 period all	2.98	3.29	3.35	3.13	2.34	2.95	2.60	2.36
	4 periods all	3.13	3.33	3.52	3.34	10.64	15.28	11.61	9.98
civilian spending	4 periods fiscal, 1 all	4.50	4.49	5.12	5.15	3.16	3.86	2.86	3.17
	1 period all	4.67	5.19	5.61	5.27	4.18	4.54	4.34	4.62
	4 periods all	4.97	5.45	6.01	5.78	32.53	41.46	33.48	33.27
defense spending	4 periods fiscal, 1 all	0.41	0.97	0.51	0.27	-1.31	-1.69	-1.96	-1.48
	1 period all	0.42	0.99	0.54	0.31	-0.43	-0.96	-0.93	-0.51
	4 periods all	0.42	0.42	0.27	0.40				
total consumption	4 periods fiscal, 1 all	3.20	3.56	3.51	3.43	1.97	2.97	2.04	1.88
	1 period all	3.63	4.28	4.17	3.88	2.72	3.50	3.08	2.83
	4 periods all	3.63	4.49	4.13	3.89	2.98	4.72	3.34	2.94
civilian consumption	4 periods fiscal, 1 all	5.67	5.29	6.42	6.67	4.82	4.38	4.68	5.42
	1 period all	5.98	6.25	7.17	6.94	5.94	5.29	6.33	7.06
	4 periods all	6.56	6.81	7.85	7.71	6.85	7.20	7.46	7.84
defense consumption	4 periods fiscal, 1 all	1.09	1.24	0.85	0.92	-1.30	-1.98	-2.55	-1.54
	1 period all	0.88	0.87	0.77	0.80	-0.15	-1.25	-0.97	-0.19
	4 periods all	0.41	0.97	0.36	0.21	-1.36	-1.68	-1.82	-1.94
total investment	4 periods fiscal, 1 all	3.59	3.96	4.59	3.79	3.37	4.66	4.20	3.34
	1 period all	5.39	5.41	6.67	5.88	6.56	5.93	6.69	6.67
	4 periods all	5.41	4.60	6.47	6.18				
civilian investment	4 periods fiscal, 1 all	9.59	6.51	8.98	9.70	4.80	5.78	4.33	3.81
	1 period all	12.67	8.63	12.91	13.42	11.81	8.73	10.35	11.89
	4 periods all	13.72	8.71	13.40	14.54				
defense investment	4 periods fiscal, 1 all	-3.60	0.69	-2.79	-4.15	-7.76	-3.66	-9.64	-9.43
	1 period all	-3.69	0.16	-2.69	-4.31	-4.39	-2.56	-5.69	-5.15
	4 periods all								

Table A.3: Output multipliers to tax shocks - sign restrictions

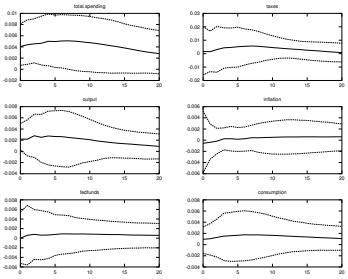
		Tax only				Spending and Taxes			
		mean	period 0	period 4	period 8	mean	period 0	period 4	period 8
total spending	4 periods fiscal, 1 all	-1.38	0.23	-0.50	-1.40	-1.30	0.69	0.02	-0.96
	1 period all	-0.70	0.36	-0.19	-0.89	-0.75	0.83	0.22	-0.72
	4 periods all	-2.62	0.32	-0.69	-2.37	-1.88	0.77	0.05	-1.27
civilian spending	4 periods fiscal, 1 all	-2.36	0.20	-0.60	-1.88	-1.82	0.01	-0.69	-1.50
	1 period all	-9.77	-0.33	-2.54	-9.60	-2.39	0.51	-0.28	-1.65
	4 periods all	-6.09	0.08	-1.13	-3.81	-2.26	0.50	-0.34	-1.72
defense spending	4 periods fiscal, 1 all	-3.64	-0.13	-1.57	-4.80	-1.81	0.60	-0.19	-1.65
	1 period all	-488.89	-0.35	-2.69	-18.95	-11.78	-0.58	-2.54	-6.68
	4 periods all	-3.95	-0.15	-1.71	-5.35				
total consumption	4 periods fiscal, 1 all	-0.89	0.31	-0.33	-1.07	-1.27	0.62	-0.01	-1.12
	1 period all	-0.49	0.33	-0.22	-0.83	-0.54	0.79	0.26	-0.70
	4 periods all	-1.95	0.25	-0.72	-2.25	-2.31	0.75	-0.17	-1.90
civilian consumption	4 periods fiscal, 1 all	-2.29	0.18	-0.69	-2.10	-2.88	0.10	-0.76	-2.18
	1 period all	-3.36	-0.17	-1.81	-4.35	-1.80	0.53	-0.26	-1.63
	4 periods all	-3.35	0.23	-0.66	-2.66	-2.36	0.24	-0.58	-1.75
defense consumption	4 periods fiscal, 1 all	-2.65	-0.13	-1.60	-4.14	-1.03	0.70	0.02	-1.32
	1 period all	-17.08	-0.35	-2.50	-10.36	-34.68	-0.54	-2.48	-7.83
	4 periods all	-2.87	-0.11	-1.50	-4.17	-1.42	0.65	-0.12	-1.68
total investment	4 periods fiscal, 1 all	-1.87	0.21	-0.51	-1.62	0.20	1.03	0.52	0.15
	1 period all	-1.69	0.28	-0.46	-1.33	-1.37	0.71	-0.04	-0.81
	4 periods all	-5.71	0.26	-1.08	-3.81				
civilian investment	4 periods fiscal, 1 all	-2.35	0.19	-0.55	-1.80	-0.71	0.01	-0.34	-0.67
	1 period all	11.82	-0.45	-3.10	-21.31	-0.33	0.67	0.03	-0.35
	4 periods all	26.27	-0.39	-2.77	-15.03				
defense investment	4 periods fiscal, 1 all	9.17	-0.40	-2.96	-21.19	-2.22	0.56	-0.33	-1.38
	1 period all	24.87	-0.36	-2.57	-13.58	-1.87	-0.28	-1.04	-1.81
	4 periods all								

Figure A.1: IRFs to total spending, total civilian and total military spending (90% C.I.)

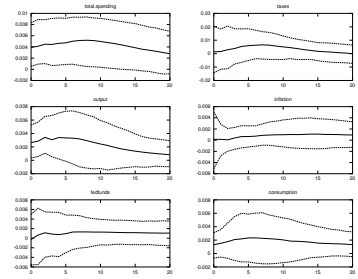
(a) Total spending, 1 period sign restrictions on all



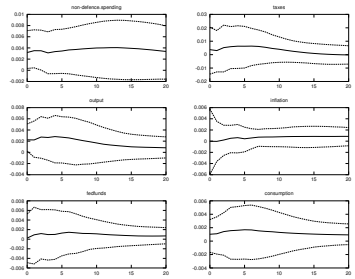
(b) Total spending, 4 period sign restrictions on spending, 1 on rest



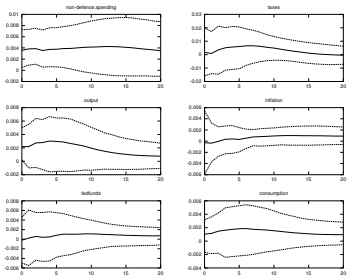
(c) Total spending, 4 period sign restrictions on all



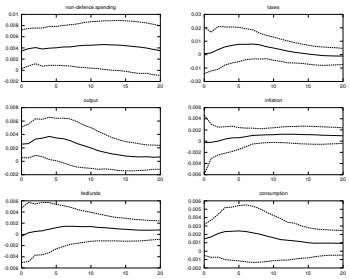
(d) Total civilian spending, 1 period sign restrictions on all



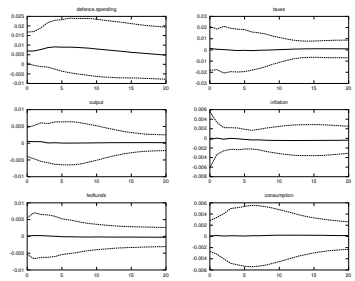
(e) Total civilian spending, 4 period sign restrictions on spending, 1 on rest



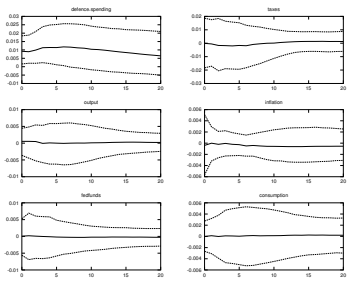
(f) Total civilian spending, 4 period sign restrictions on all



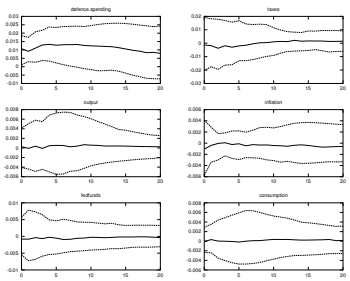
(g) Total military spending, 1 period sign restrictions on all



(h) Total military spending, 4 period sign restrictions on spending, 1 on rest



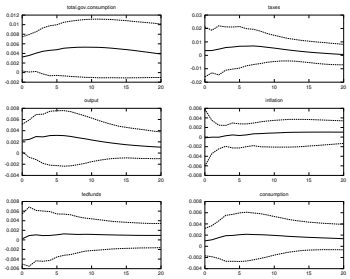
(i) Total military spending, 4 period sign restrictions on all



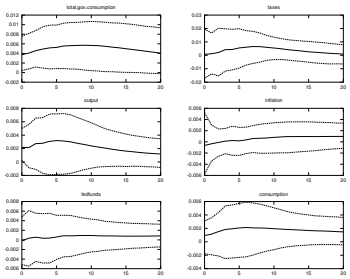
Variables are in the following order: spending variable, taxes, output, inflation, federal funds rate, private consumption.

Figure A.2: IRFs to total government consumption, total civilian and total military government consumption (90% C.I.)

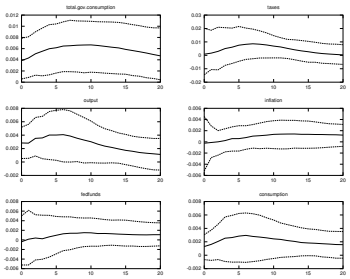
(a) Total government consumption, 1 period sign restrictions on all



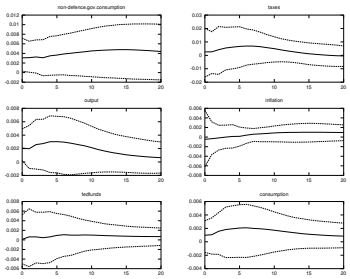
(b) Total government consumption, 4 period sign restrictions on spending, 1 on rest



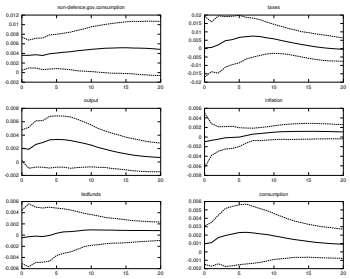
(c) Total government consumption, 4 period sign restrictions on all



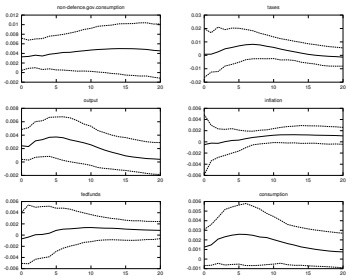
(d) Total civilian government consumption, 1 period sign restrictions on all



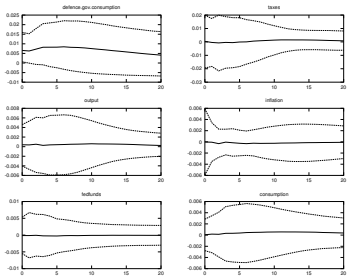
(e) Total civilian government consumption, 4 period sign restrictions on spending, 1 on rest



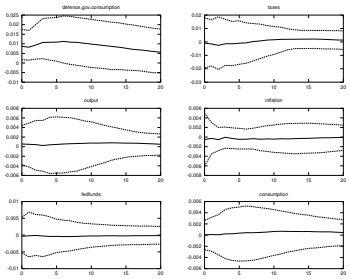
(f) Total civilian government consumption, 4 period sign restrictions on all



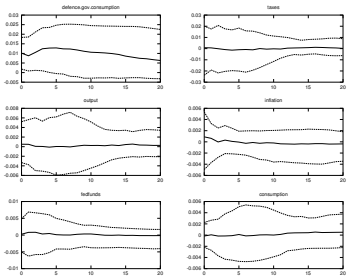
(g) Total military government consumption, 1 period sign restrictions on all



(h) Total military government consumption, 4 period sign restrictions on spending, 1 on rest



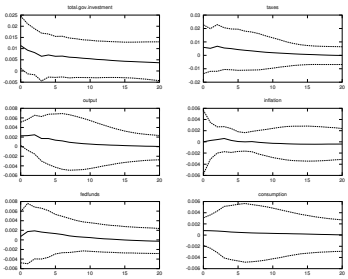
(i) Total military government consumption, 4 period sign restrictions on all



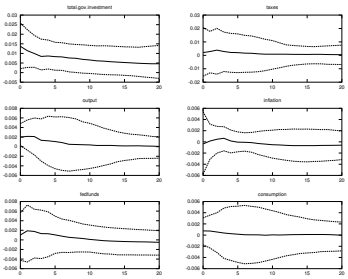
Variables are in the following order: spending variable, taxes, output, inflation, federal funds rate, private consumption.

Figure A.3: IRFs to total government investment, total civilian and total military government investment (90% C.I.)

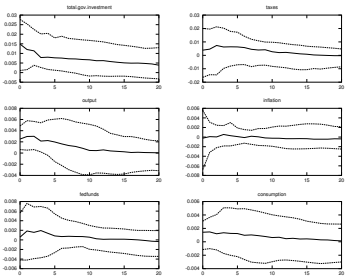
(a) Total government investment, 1 period sign restrictions on all



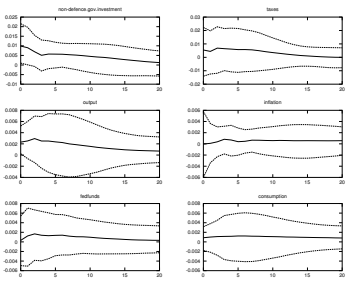
(b) Total government investment, 4 period sign restrictions on spending, 1 on rest



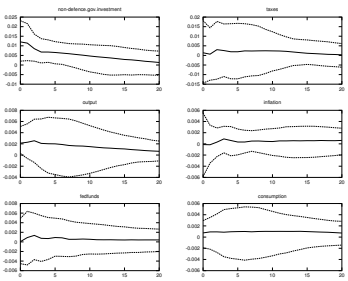
(c) Total government investment, 4 period sign restrictions on all



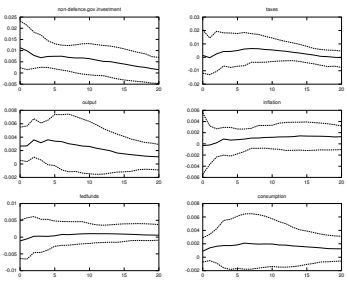
(d) Total civilian government investment, 1 period sign restrictions on all



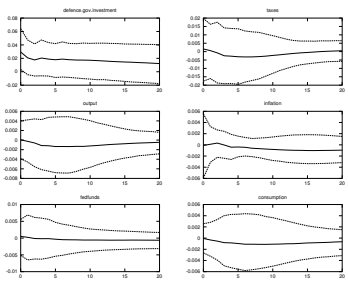
(e) Total civilian government investment, 4 period sign restrictions on spending, 1 on rest



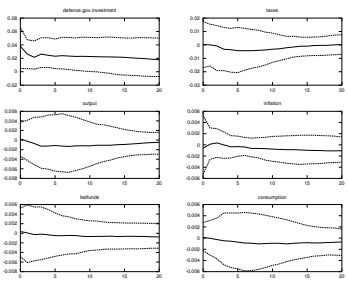
(f) Total civilian government investment, 4 period sign restrictions on all



(g) Total military government investment, 1 period sign restrictions on all



(h) Total military government investment, 4 period sign restrictions on spending, 1 on rest



Variables are in the following order: spending variable, taxes, output, inflation, federal funds rate, private consumption.

Appendix B

Appendix to Chapter 3

B.1 Data

The data used are for the U.S.; the data frequency is quarterly; the sample covers 1960q1 to 2006q4. The choice of the sample is made in the light of the Discussion in Blanchard and Perotti (2002)[1] who argue that the 50's are not expected to be from the same stochastic process as the rest of the series because of the Korean war and the large increase in taxes to finance that war, and especially Perotti (2007) who discusses about the effects of including the Korean War on the results under different identification assumptions; the sample ends in 2006, since a similar argument should apply to the recent crisis.

Most data series come from the National Income and Product Accounts (NIPA) tables, published by the Bureau of Economic Analysis[2]. The following series from the NIPA tables are used: At first the main macro variables, namely real total output, real total private consumption and real total private investment. The main government spending variable[3] is total government spending on goods and services, in particular total government consumption and investment (includes federal defense and and non-defense spending and state and local spending, but excludes transfers). Additionally, I use two more spending variables, total civilian (non-defense, without transfers) and total defense spending (both include government consumption and investment) on good and services. The tax variable is total net taxes, calculated as the sum of personal taxes,

[1] Throughout the Appendices, referenced papers are included in the Bibliography section of the relevant chapter.

[2] Available at http://www.bea.gov/national/nipaweb/index.asp.

[3] The government spending and tax variables are similar to those used by Perotti (2004).

Table B.1: Augmented Dickey Fuller unit root tests

Y		C		I		GCI		GCINDEF		GCIDEF	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
3	3	5	3	2	1	4	1	1	1	5	4
-3.343	**-3.343**	-2.3374	-2.85703	**-3.933***	**-3.393**	-3.001	-2.225	-2.929	-2.929	-2.873	-2.46
0.059	**0.059**	0.413	0.177	**0.011**	**0.052**	0.132	0.475	0.153	0.153	0.171	0.348

TNET		USPRIV_WR		UNRATE		FEDFUNDS		INFL	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
2	1	1	1	1	1	7	3	4	1
-3.675*	-2.915	-2.441	-2.441	**-2.996***	**-2.996***	-2.202	-2.602	-2.188	-2.524
0.024	0.157	0.358	0.358	**0.035**	**0.035**	0.488	0.279	0.496	0.316

Bold: significance at 10%; bold and *: significance at 5%; bold and **: significance at 1%.

taxes on production and imports, corporate taxes and social security contributions minus transfers, for total government (federal and state and local). Inflation is the annualized quarterly GDP inflation rate.

Additional sources are St Louis FED's FRED® database[4] for the nominal interest rate and the unemployment rate. The nominal interest rate is the federal funds rate.

All the above variables (except unemployment, inflation and the interest rate) are in logs of the real per capita relevant variables, where the deflator used is the relevant deflator for each variable, except the fiscal variables, which are deflated by the GDP deflator. Population has been calculated by dividing nominal GDP by nominal per capita GDP. All series are seasonally adjusted at annual rates by the source.

B.2 Unit root and unit root vs thresholds tests

One of the main motivations of this research was the observation that many time series that are customarily considered to be unit roots may not be so, but may be better described by a threshold autoregressive model, quite often a stationary one or a partial unit root (unit root in one regime but not in the other). If this is the case, the linear VAR might not be as appropriate to model the multiple time series DGP as usually thought. In this section I will discuss the time series properties of the variables used in the subsequent analysis.

First, table B.1 presents the ADF unit root tests on the series used; as it is evident, most of the series can be described as unit roots under the assumption of linearity. The results are calculated for the 1960:1 - 2006:4 sample, and the unit root test is for constant

[4]Available at http://research.stlouisfed.org/fred2/.

and trend for all variables but the last three, in which case it is only for constant[5]. In the third row is the lag length picked by AIC and BIC criterion respectively, in the fourth the ADF t-test and in the fifth the asymptotic p-value.

However, these results are not rock solid. Leaving out the very important (and quite elusive) question concerning the best modeling approach and the robustness of these tests in different circumstances, tables B.2 - B.3 suggest that many of the variables under consideration may plausibly be described as threshold stationary or as partial unit roots; to the best of my knowledge, this study is the first to present some evidence on the time series properties of most of these variables from a threshold perspective, and as far as I know the first to incorporate time series testing for thresholds in the modeling framework. The same sample and the same lags in each regime have been used as in the linear case (something that might work in favor of the linear model if one regime has few observations).

One of the basic reasons that it is difficult to work with nonlinear models is that there are ... just too many of them. How can we know that we found the best model? One way to proceed seems to be the following: start from the simplest two regime ones, which is what I do in this work. Following this route, the linear unit root model will be tested against: a) the threshold autoregressive (TAR) model assuming threshold effects in either all regressors or lagged differences only using the test proposed by Caner and Hansen (2001)[6], with stationary threshold; b) STAR (Smooth Transition TAR) in lagged levels using Kapetanios, Shin and Snell (2003); c) the TAR model again using lagged levels as thresholds and block-bootstrapping the residuals using Seo's (2008) test. In the second and third test the variables are detrended first to have zero means. I have to add that a STAR model should have power even when the DGP is TAR and vice versa, since the former should be able to reject the linear unit root more easily in cases where the transition function looks more like an abrupt change model. In the following, a 0.15

[5]Definitions: Y = GDP, C = consumption, I = private investment, GCI = total government spending on goods and services, GCINDEF = non-defense spending on goods and services, GCIDEF = defense spending on goods and services, TNET = net taxes, USPRIV_WR = wage rate, UNRATE = unemployment rate, FEDFUNDS = federal funds rate, INFL = inflation; for more information look at the previous section.

[6]A word of caution is needed here: in the Caner and Hansen's paper they have many different ways of testing for unit roots; I use the following three of them, namely a) the unidentified bootstrap testing, where testing is done with bootstrap data are generated by a linear unit root null estimated from the data, b) the unidentified asymptotic testing and c) the identified asymptotic testing, where in these two cases testing is done using the critical values presented in the paper; the strongest rejection from all cases is presented.

Table B.2: Caner - Hansen threshold unit root test

(a) Caner and Hansen test for threshold stationarity vs unit root - lagged level is allowed to have different coefficients in each regime; t-tests; bold: significance at 10% in at least one case; bold and *: significance at 5% in at least one case; bold and **: significance at 1% in at least one case. Case 1: 4 period moving average of first difference of variable; case 2: 4 period moving average of first difference of Y.

threshold		Y		C		I		GCI		GCINDEF		GCIDEF	
variable		AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
case 1	R1	**-3.356***	**-3.356***	-2.799	**-2.99**	**-3.259***	**-4.122****	-0.767	**-3.534***	-1.778	-1.778	-2.135	-2.94
	R2	-2.584	-2.584	-1.989	-2.656	**-3.317**	-1.623	**-3.031**	0.864	-1.587	-1.587	-2.55	-1.267
case 2	R1			-2.113	-1.057	**-3.408***	**-3.694***	**-3.378***	-2.81	-1.869	-1.869	**-3.235**	-2.336
	R2			-1.669	**-3.056**	**-3.178**	-2.832	-2.25	-1.575	-2.838	-2.838	0.502	-1.41

threshold		TNET		USPRIV_WR		UNRATE		FEDFUNDS		INFL	
variable		AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
case 1	R1	**-6.901****	**-6.784****	-1.708	-1.708	-1.708	-1.708	0.13	-0.537	-0.415	-1.638
	R2	-2.078	-2.04	-2.523	-2.523	**-4.491****	**-4.491****	**-4.053****	**-4.031****	-1.182	-0.798
case 2	R1	**-4.869****	**-5.116****	-1.98	-1.98	**-3.825****	**-3.825****	-0.429	-0.68	-2.066	-2.619
	R2	-2.635	-2.582	-1.32	-1.32	**-3.158**	**-3.158**	-1.845	-1.807	0.351	0.074

(b) Caner and Hansen test for threshold stationarity vs unit root - lagged level is restricted to have the same coefficient in both regimes; t-tests; bold: significance at 10%; bold and *: significance at 5%; bold and **: significance at 1%. Case 1: 4 period moving average of first difference of variable; case 2: 4 period moving average of first difference of Y.

threshold	Y		C		I		GCI		GCINDEF		GCIDEF	
variable	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
case 1	**-4.109***	**-4.109***	**-3.013**	**-3.312**	**-4.634****	**-4.435****	-3.636	**-3.227**	**-3.706***	**-3.706***	**-3.622**	**-3.627**
case 2			**-3.502***		**-4.612****		**-4.139****		**-3.540**		**-3.562**	

threshold	TNET		USPRIV_WR		UNRATE		FEDFUNDS		INFL	
variable	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
case 1	**-5.145****	**-5.026****	-2.94	-2.94	**-4.301****	**-4.301****	**-3.561****	**-4.152***	**-2.735***	**-3.675****
case 2	**-5.289****		-2.809	-2.809	**-4.726****	**-4.726****	**-2.718***		**-3.075***	

Table B.3: Further linearity tests

(a) Kapetanios, Shin and Snell test for threshold stationarity vs unit root

Y		C		I		GCI		GCINDEF		GCIDEF	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
-3.289	**-3.289**	-2.623	**-3.347**	**-3.182**	-2.792	-2.97	-3.039	-2.839	-2.839	-2.676	-2.372

TNET		USPRIV_WR		UNRATE		FEDFUNDS		INFL	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
-6.184**	**-4.934****	-2.265	-2.265	**-3.291***	**-3.291***	**-2.986***	**-3.804****	-1.829	-2.383

t-tests; bold: significance at 10%; bold and *: significance at 5%; bold and **: significance at 1%.

(b) Seo test for threshold stationarity vs unit root

Y		C		I		GCI		GCINDEF		GCIDEF	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
1.406**	**1.406****	**0.4694****	**0.668****	**1.143****	**0.883****	**0.795***	**0.315***	**1.415****	**1.415****	**1.837****	**1.349****
0.002	**0.002**	**0.003**	**0.003**	**0.003**	**0.003**	**0.014**	**0.034**	**0.001**	**0.001**	**0.003**	**0.001**

TNET		USPRIV_WR		UNRATE		FEDFUNDS		INFL	
AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
9.776**	**6.435****	**1.901****	**1.901****	**0.765****	**0.765****	**1.247****	**1.732****	**0.748****	**0.653****
0.000	**0.000**	**0.002**	**0.002**	**0.002**	**0.002**	**0.006**	**0.009**	**0.005**	**0.004**

Wald test; bold: significance at 10% in at least one case; bold and *: significance at 5% in at least one case; bold and **: significance at 1% in at least one case. Residual block length used: 5 - 30. The lowest p-value is shown.

quantile of observations is left out of the grid search at each end of the sample, in order to have a minimum number of observations in each regime.

As it is evident from tables B.2 - B.3, many of the usual assumptions about time series behavior of these variables may not be tolerated by the data; especially output, consumption, investment, taxes and unemployment may be stationary (with regime switching) or partial unit roots. These results allow one to defend the choice to use a nonlinear model in order to look at the effects of fiscal policy on the main macro variables.

B.3 Testing for threshold effects

Here the results from the thresholds tests for the system will be presented. I test the threshold model against the linear one, but I also try to compare it with a structural break model (SBVAR), and let the data pick the best model. I use the levels of the variables, since there are quite some evidence for nonlinearities of the threshold form, and differencing might interfere with possibly important nonlinear reactions.

The baseline model I test is TVAR on levels, with total spending, taxes, output, inflation, the federal funds rate and consumption comprising the vector of endogenous variables and a constant, a time trend and a squared time trend being the exogenous variables; the variables have this order, except when the Cholesky identification is used, where taxes follow output - this ordering is consistent with the fact that the major force behind tax movements are output fluctuations.

The threshold variable is a 4-period (backwards) moving average of output growth rate. The reason for choosing this variable is that it is a natural business cycle indicator (not the only natural candidate though) and that output is included in all model specifications, so the threshold variable is endogenous to the system, making it possible to have endogenously generated regime switching[7]. One lag is allowed in each regime, as it is indicated by the BIC criterion for the linear model; the threshold lag (d) is varied between 1 and 4. The results are shown in table B.4. Threshold estimates are those from the information criteria, which is equivalent to the quasi ML estimate of the minimum log determinant of the variance - covariance matrix. The p-values for the Wald statistics have been calculated using 1000 replications.

[7]One should also consider that papers using other threshold variables like interest rates or financial conditions are probably splitting the sample in a way similar to the papers that use a business cycle indicator - after all, low interest rates and tight money are correlated with low output growth rates.

Table B.4: Linearity tests for the baseline model

Model	Tsay	Ef. Bounds Wald	AIC	HQ	BIC	supWald	aveWald	expWald	Threshold
Linear			-55.528	-55.151	-54.598				
SBVAR		2.0118	-56.523	-55.770	-54.664				1980:3
TVAR, d=1	72.58	2.3885	-56.559	-55.806	-54.700	69.08	22.63	31.39	0.0019398
	(0.0466)					(0.018)	(0.047)	(0.027)	
TVAR, d=2	70.09	2.4392	-56.203	-55.450	-54.344	75.49	27.42	34.15	0.0031590
	(0.0695)					(0.010)	(0.018)	(0.010)	
TVAR, d=3	67.03	2.0440	-56.136	-55.383	-54.277	42.37	19.95	18.49	0.0015010
	(0.1096)					(0.122)	(0.107)	(0.106)	
TVAR, d=4	44.34	2.1112	-55.883	-55.129	-54.024	52.46	18.52	21.65	0.0044003
	(0.8229)					(0.054	(0.167)	(0.066)	

P-values, where applicable, are in parenthesis. H0 is a linear VAR with 1 lag for all tests.

Table B.5: Linearity tests for the baseline specification with more lags

Model	Tsay	Ef. Bounds Wald	AIC	HQ	BIC	supWald	aveWald	expWald	Threshold
					2 lags				
Linear			-55.799	-55.171	-54.250				
SBVAR		2.3485	-56.516	-55.261	-53.418				1975:2
TVAR, d=1	99.686	2.9013	-56.873	-55.618	-53.775	91.71	38.19	42.75	0.0019398
2l/2h	(0.227)					(0.013)	(0.041)	(0.009)	
TVAR, d=1		1.8960	-56.744	-55.740	-54.265	72.83	38.39	33.01	0.0019398
1l/2h						(0.012)	(0.004)	(0.009)	
					3 lags				
Linear			-55.913	-55.034	-53.744				
SBVAR		2.7373	-56.769	-55.011	-52.431				1975:2
TVAR, d=1	121.68	3.2908	-57.125	-55.367	-52.787	136.6	64.46	64.68	0.0019398
3l/3h	(0.5923)					(0.019)	(0.013)	(0.019)	
TVAR, d=1		1.8854	-56.910	-55.655	-53.811	90.45	47.92	41.87	0.0019398
1l/3h						(0.012)	(0.010)	(0.012)	
					4 lags				
Linear			-55.933	-54.803	-53.144				
SBVAR		3.1991	-56.776	-54.516	-51.198				1975:2
TVAR, d=1	156.42	3.4797	-57.186	-54.926	-51.608	156.87	74.41	74.46	0.0012934
4l/4h	(0.6089)					(0.043)	(0.033)	(0.042)	
TVAR, d=1		1.7924	-56.889	-55.382	-53.170	99.74	52.46	46.26	0.0019398
1l/4h						(0.008)	(0.032)	(0.008)	

2 - 4 lags in each regime or 1 lag in low growth and 2 - 4 lags in high growth regime; p-values, where applicable, are in parenthesis. H0 is a linear VAR with the same number of lags for all tests.

Table B.6: Linearity tests for the alternative specifications

Model	Tsay	Ef. Bounds Wald	AIC	HQ	BIC	supWald	aveWald	expWald	Threshold
	non-defense spending								
Linear			-55.794	-55.417	-54.864				
SBVAR		2.1191	-56.797	-56.044	-54.938				1980:3
TVAR, d=1	79.446	2.5246	-56.741	-55.987	-54.882	82.14	29.83	38.84	0.0019398
	(0.0137)					(0.011)	(0.012)	(0.012)	
	defense spending								
Linear			-53.903	-53.526	-52.973				
SBVAR		1.9697	-54.775	-54.021	-52.915				1980:3
TVAR, d=1	72.134	2.1169	-54.924	-54.171	-53.065	45.74	18.06	20.27	0.0015018
	(0.0506)					(0.090)	(0.116)	(0.075)	
	investment								
Linear			-52.668	-52.292	-51.739				
SBVAR		2.0775	-53.406	-52.652	-51.546				1995:2
TVAR, d=1	59.573	2.1568	-52.939	-52.186	-51.080	61.96	23.11	27.24	0.0019398
	(0.280)					(0.032)	(0.047)	(0.029)	
	unemployment rate								
Linear			-48.018	-47.641	-47.088				
SBVAR		1.989	-48.540	-47.786	-46.680				1983:2
TVAR, d=1	81.679	2.766	-48.584	-47.831	-46.725	82.63	31.72	37.60	0.0019398
	(0.009)					(0.001)	(0.006)	(0.001)	

1 lag in both regimes; p-values, where applicable, are in parenthesis. H0 is a linear VAR with 1 lag for all tests.

As it is evident, the TVAR model is supported by all tests, and the preferred threshold lag is one. It clearly separates the sample in a high growth and a low growth regime. The low growth regime occurs 21% of time (41 observations out of 188). In table B.5 the same results are presented for the best threshold models with 2 - 4 lags in each regime (typically the first lag of the threshold variable) or 1 lag in low and 2 - 4 lags in high regime, and again the outcome is similar. In addition, the models with 1 lag in low and more lags in high regime have the virtue that they give cleaner residuals. The threshold value does not change much in most cases.

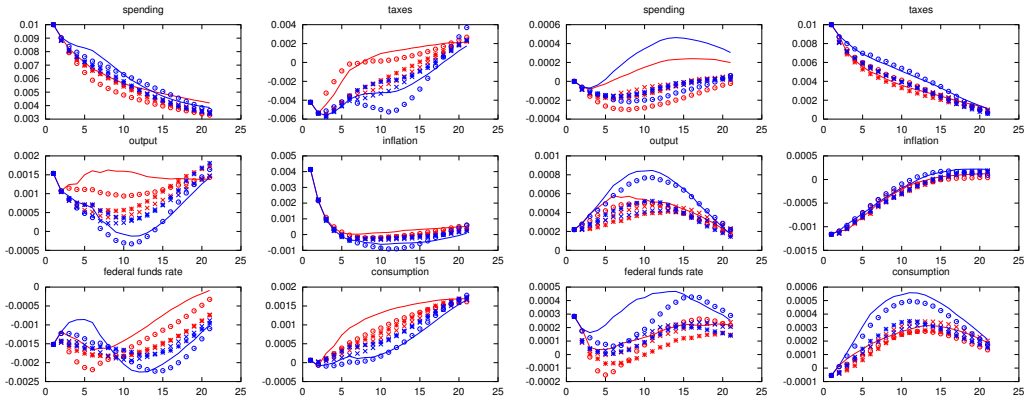
The TVAR model is supported by the data in most of the alternative specifications I have tested, in particular using non-defense spending or defense spending as the spending variable or replacing consumption with investment or unemployment rate (in the last place). Table B.6 presents the tests for models with 1 lag in both regimes. The specification with investment is the least supportive for the TVAR model, but since the Wald tests support it and investment is one of the variables that moves a lot during the

business cycle, I include this model too.

B.4 Figures not presented in the main text

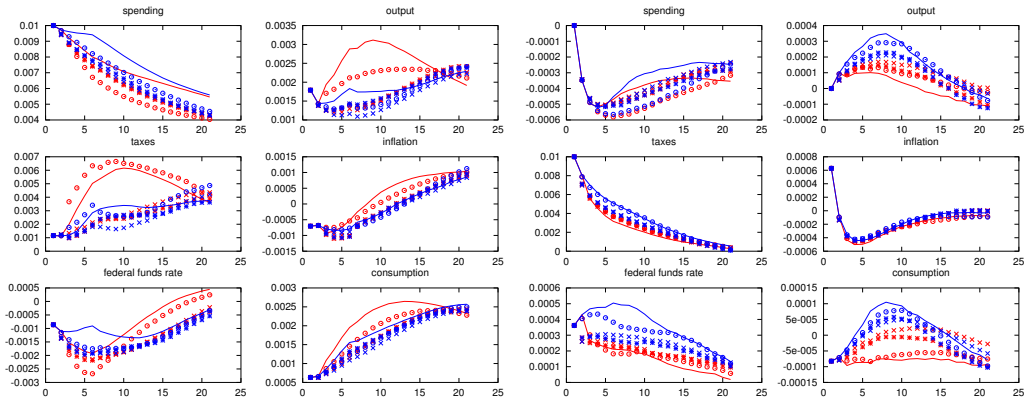
In this appendix the figures B.1 to B.5, showing the GIRFs of the additional models not included in the main test are presented.

Figure B.1: Baseline model varying starting histories by decade, various identifications.



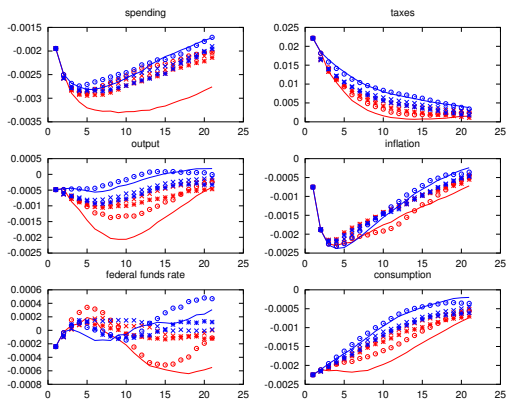
(a) BP spending shock

(b) BP tax shock



(c) Cholesky spending shock

(d) Cholesky tax shock

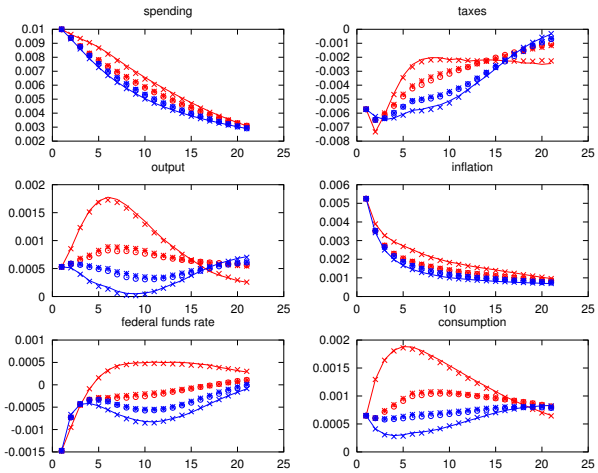


(e) Exogenous tax shock

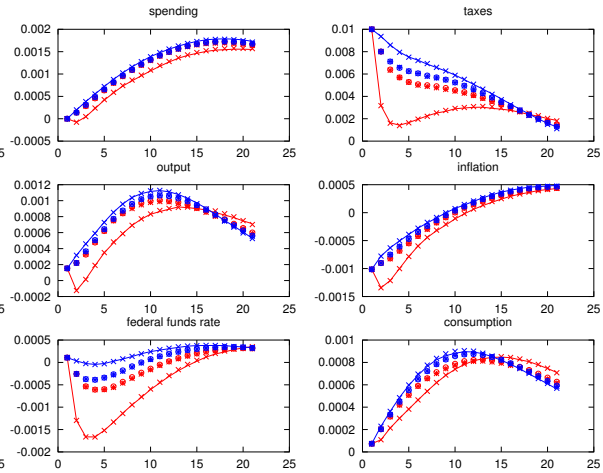
Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, 60s; stars: 1% shock, 70s; x: 1% shock, 80s; circles: 1% shock, 90s.

Figure B.2: Non-defense spending, various identifications.

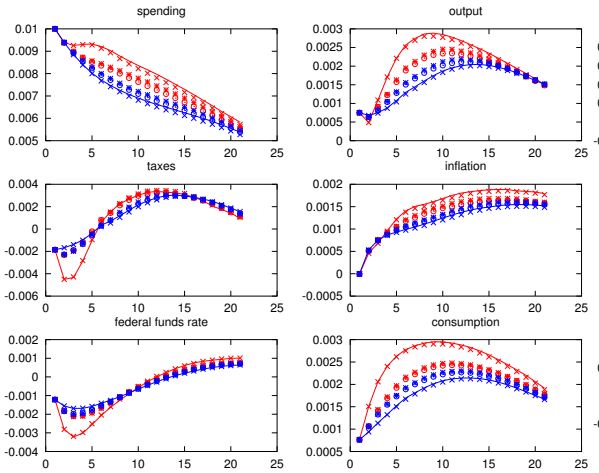
(a) BP spending shock



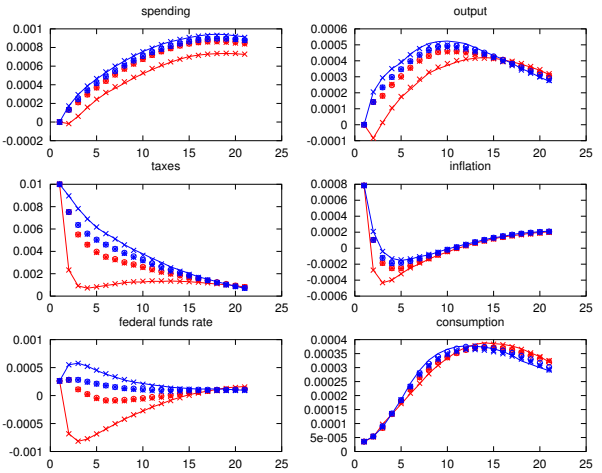
(b) BP tax shock



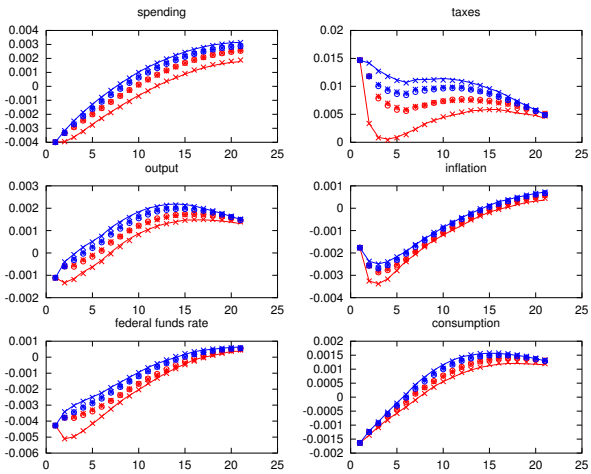
(c) Cholesky spending shock



(d) Cholesky tax shock

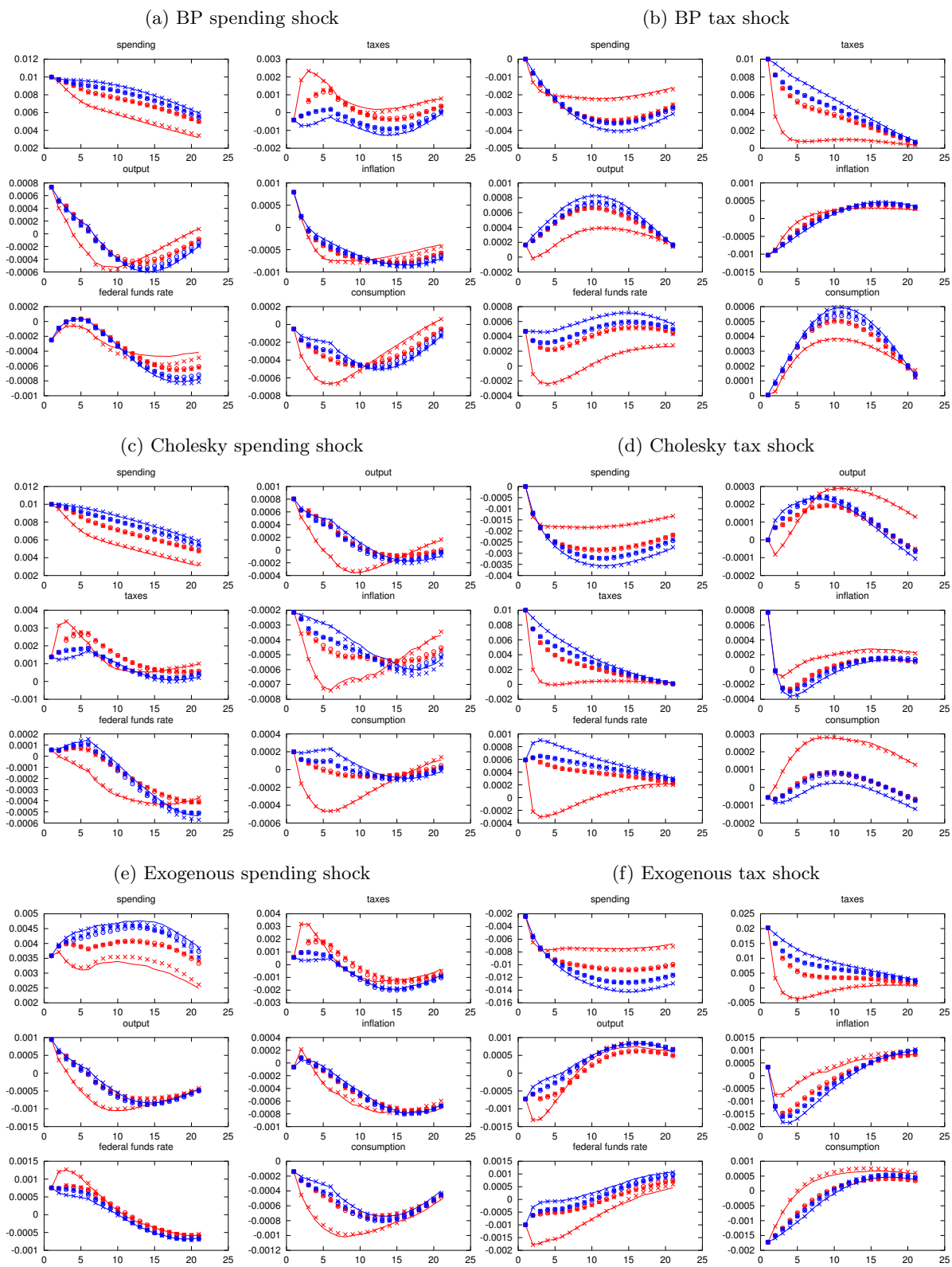


(e) Exogenous tax shock



Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, regime specific history; stars: 1% shock, full history; x: 3% shock, regime specific history; circles: 3% shock, full history.

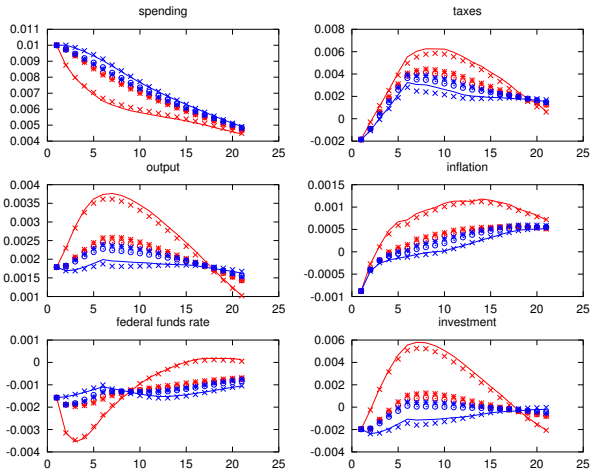
Figure B.3: Defense spending, various identifications.



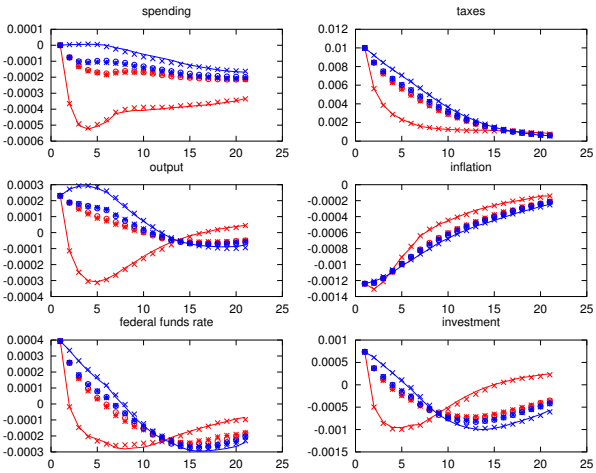
Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, regime specific history; stars: 1% shock, full history; x: 3% shock, regime specific history; circles: 3% shock, full history.

Figure B.4: Private investment, various identifications.

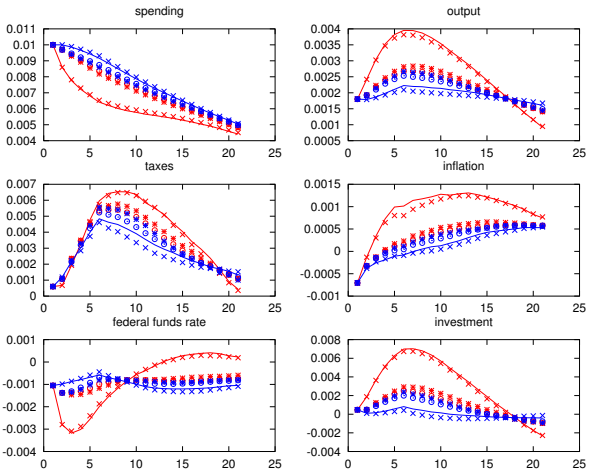
(a) BP spending shock



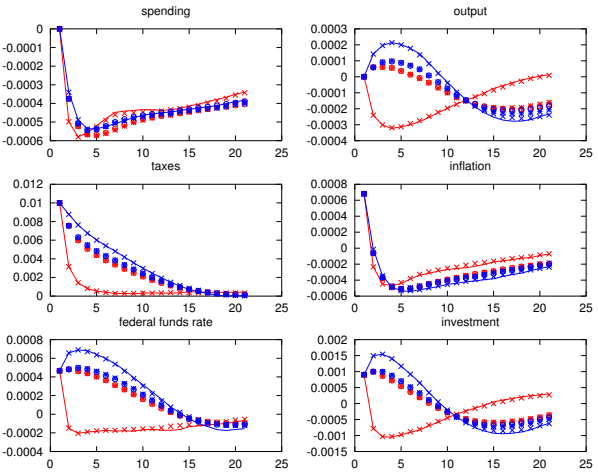
(b) BP tax shock



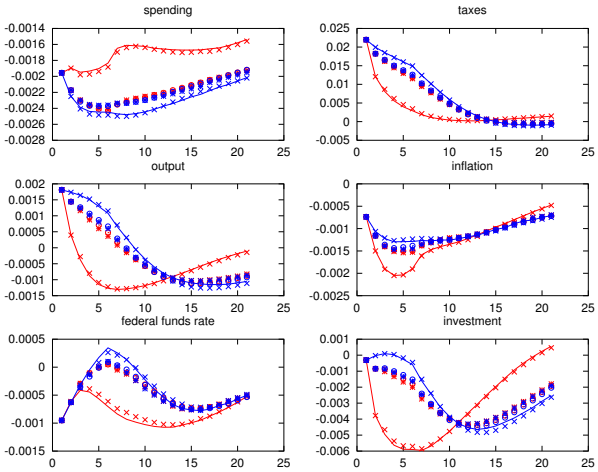
(c) Cholesky spending shock



(d) Cholesky tax shock



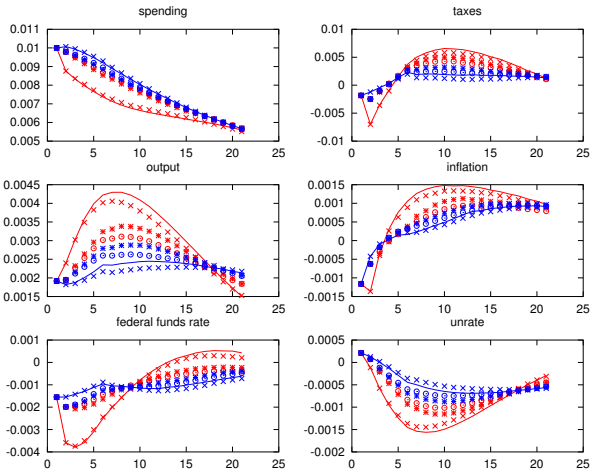
(e) Exogenous tax shock



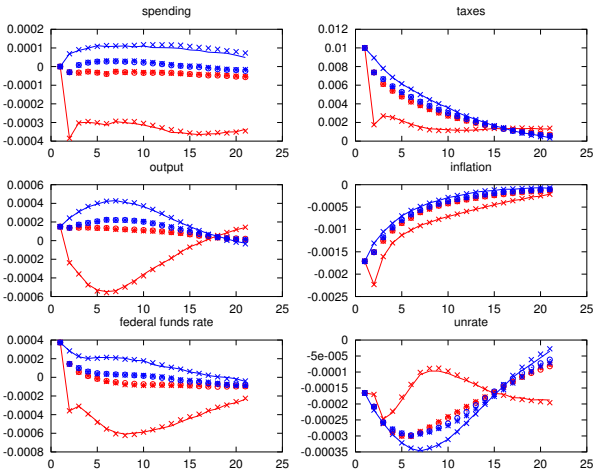
Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, regime specific history; stars: 1% shock, full history; x: 3% shock, regime specific history; circles: 3% shock, full history.

Figure B.5: Unemployment rate, various identifications.

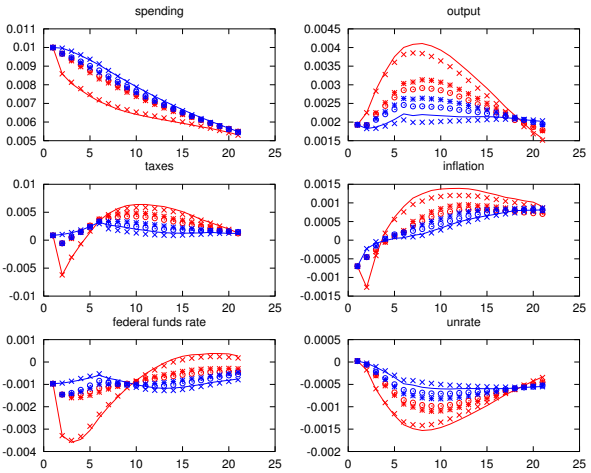
(a) BP spending shock



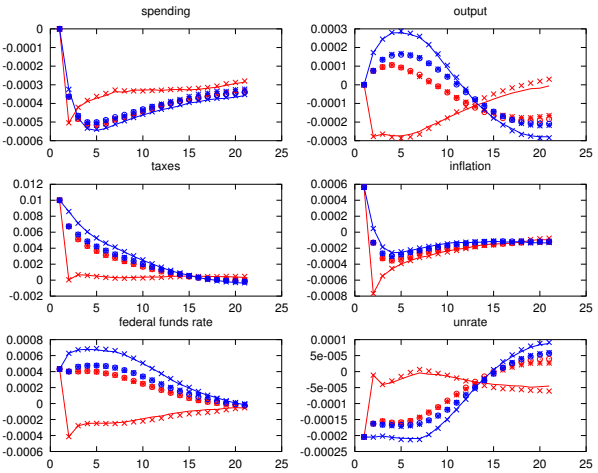
(b) BP tax shock



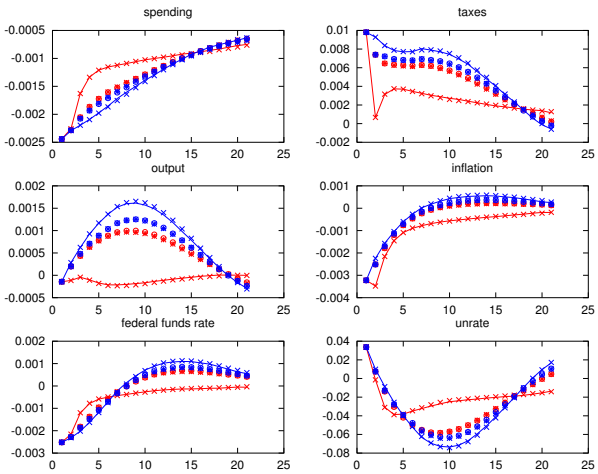
(c) Cholesky spending shock



(d) Cholesky tax shock



(e) Exogenous tax shock



Red: starting in recession regime; blue: starting in expansion regime. Lines: 1% shock, regime specific history; stars: 1% shock, full history; x: 3% shock, regime specific history; circles: 3% shock, full history.

B.5 Results with regime switching in variance - covariance matrix

In Chapter 3, and in particular throughout section 3.3, the assumption regarding empirical models has been that that the variance-covariance matrix of residuals has been common across regimes, not least because this assumption facilitated comparison with models using exogenous shocks; in the latter case, the lack of observations of structural shocks in recessions suggests that breaking the sample in high and low growth periods would not give good estimates or their effects in the latter period. However, one potential criticism is that it is indeed possible to have such effects, and (old and) recent theories suggest that the effect of fiscal policy should be higher in recessions. This exercise is undertaken in this section.

In table B.7 the likelihood from different models with and without structural break in variance are included[8]. Basic deterministics include a constrant, a time trend and a squared time trend, as in the models of the chapter, and the extended deterministics add (for reasons that will be discussed shortly) three more time trends for the following periods: 1979:1-1981:2, 1981:3-1983:2, 1983:3-2006:4.

Results with the basic set of deterministic terms: It is clear that the data prefer models with regime switching in variance, either threshold or structural break - however, in models with linear conditional mean, there is some slighter support for a structural brake in variance, and the model with the overall higher likelihood is the structural break in variance model with 2 lags in the VAR. The threshold in variance is precisely the same as the one in the conditional mean in all cases, while the break in variance is estimated at Q2 of 1985. In the first part of table B.8 the spending multipliers of the linear models and each regime of the structural break and threshold models (assuming there is no change in regime of the coefficients, variance or both) from a Cholesky decomposition of the variance covariance matrices are presented; two things stand out: first, allowing a threshold in variance lowers (!) the multipliers in the low growth regime, and second,

[8]Information criteria are not presented because the way information criteria are calculated penalizes extra coefficients in the systematic part of the model, but not extra variance - covariance matrices, so it is not absolutely clear how one should decide which model to choose. In addition, sup-LR tests are also not presented, since it is not clear how the model with threshold in variance - covariance matrix should be simulated in order to calculate the test. However, in the case of linear in conditional mean VARs, sup-LR tests reject the null of a common variance - covariance matrix against the both alternatives (either threshold or structural break in variance - covariance matrix).

Table B.7: Likelihood of various models

	Basic deterministics		Extended deterministics	
Model	Break	LogLik	Break	LogLik
V(1)		5273.6		5306
V(2)		5335.1		5364.5
V(1) thr.	0.00194	5353.1	0.00194	5381.6
V(2) thr.	0.00194	5407.2	0.00194	5431.8
V(1) s.b.	1985Q2	5360.3	1985Q2	5389.8
V(2) s.b.	1985Q2	5431.2	1984Q4	5455.4
TV(1,1)	0.00194	5363.1	0.00194	5440.5
TV(1,1) thr.	0.00194	5424.6	0.00194	5497.5

there are small differences in the multipliers of structural break (in variance) models, that however point to slightly higher spending multipliers in the second part of the sample (the one covering the Great Moderation).

These results are rather surprising, counterintuitive and suspect, given the results in chapter 3 and other papers referenced therein. However, Caldara and Kamps (2008) have observed that it matters a lot in the results for linear VARs how one treats the turbulent years of the Volker disinflation - they observe that taking them out shows that there is no significant difference in the responses to spending shocks before and after that period; this suggests that this period, which by the way was a recessionary one, might drive the results, especially those of the low growth regime. To check this conjecture, the second set of deterministics is added. As it is clear from the relevant results of table B.7, these variables clearly enter the models (and in the linear VARs are significant only in the equations for inflation and interest rates); the threshold models are now the ones that give the most adequate description of the data. In addition, the second part of table B.8 indicates that although the multipliers of linear models do not change so much, those of the TVAR with (and without) break in variance give the expected results: higher multipliers in recessions, by a comfortable margin, indicating that the results of section 3.3 of the main text are robust, once brakes in variance - covariance matrices are properly modelled.

Table B.8: Multipliers with break in variance

	Basic deterministics															
	Low regime (recession or first part of sample) Multipliers								High regime (expansion or second part of sample) Multipliers							
	V(1)	V(2)	V(1) t.	V(2) t.	V(1) sb.	V(2) sb.	TV(1,1)	TV(1,1) t.	V(1)	V(2)	V(1) t.	V(2) t.	V(1) s.b.	V(2) s.b.	TV(1,1)	TV(1,1) t.
MEAN	0.86	0.90	0.34	0.16	0.81	0.80	1.46	-0.01	0.86	0.90	0.94	1.02	0.98	1.16	0.64	0.71
T=0	0.89	0.86	0.30	-0.40	0.94	0.77	0.90	-0.36	0.89	0.86	0.99	1.08	0.77	1.10	0.90	1.04
T=4	0.77	0.79	0.11	-0.53	0.76	0.67	0.82	-0.75	0.77	0.79	0.87	1.00	0.79	1.09	0.66	0.77
T=8	0.76	0.82	0.14	-0.13	0.71	0.71	1.21	-0.40	0.76	0.82	0.86	0.96	0.89	1.09	0.57	0.65
T=12	0.83	0.91	0.31	0.35	0.76	0.80	1.67	0.15	0.83	0.91	0.91	0.99	1.03	1.16	0.57	0.62
T=16	0.95	1.01	0.55	0.78	0.87	0.91	2.04	0.64	0.95	1.01	1.01	1.04	1.16	1.25	0.61	0.64

	Extended deterministics															
	Low regime (recession or first part of sample) Multipliers								High regime (expansion or second part of sample) Multipliers							
	V(1)	V(2)	V(1) t.	V(2) t.	V(1) s.b.	V(2) s.b.	TV(1,1)	TV(1,1) t.	V(1)	V(2)	V(1) t.	V(2) t.	V(1) s.b.	V(2) s.b.	TV(1,1)	TV(1,1) t.
MEAN	0.80	0.98	0.41	0.49	0.75	0.87	1.32	1.95	0.80	0.98	0.85	1.05	0.94	1.24	0.64	0.62
T=0	0.93	0.89	0.81	-0.08	0.98	0.82	1.04	1.39	0.93	0.89	0.95	1.05	0.81	1.06	1.04	1.01
T=4	0.82	0.93	0.50	0.01	0.80	0.81	1.20	2.00	0.82	0.93	0.86	1.06	0.89	1.23	0.74	0.72
T=8	0.78	1.00	0.34	0.44	0.72	0.87	1.35	2.06	0.78	1.00	0.83	1.08	0.94	1.31	0.60	0.58
T=12	0.77	1.03	0.30	0.74	0.70	0.91	1.41	2.02	0.77	1.03	0.83	1.06	0.98	1.30	0.54	0.52
T=16	0.78	1.02	0.32	0.90	0.70	0.92	1.44	2.00	0.78	1.02	0.83	1.04	0.98	1.26	0.52	0.50

t. : threshold in variance; s.b. structural break in variance. Basic deterministics: time and time squared. Extended deterministics: previous and breaks in trend in 1979:1-1981:2, 1981:3-1983:2, 1983:3-2006:4. V(p) stands for VAR(p), TV(p,q) stands for TVAR(p,q).

Appendix C

Appendix to Chapter 4

C.1 Variable Sources and Definitions

As a reminder, all models include 7 variables: total real government spending in goods and services (consumption + investment), real GDP, inflation (from GDP deflator), real private consumption, real private investment, net taxes and the nominal interest rate. Data frequency is quarterly. Needless to say that countries in the study are those for which quarterly non-interpolated fiscal data are freely available and the relevant time series start at least in the 80's. Except from interest rate and inflation, which are in quarterly rates, all other data are in log levels.

In EMU, data are those used in the estimation of ECB's Area Wide Model - available at http://www.eabcn.org/data/awm/index.htm. The interested reader should consult Fagan et al (2001) for details. The data are treated in a manner completely analogous to the one described below for the other countries to derive the needed variables.

For the other countries, data come from OECD - Quarterly National counts or Main Economic Indicators (depending on availability of the particular variable and the sample given) and fiscal data from country sources, typically the quarterly sector accounts of each country. When data are not seasonally adjusted by the source, seasonal adjustment is performed using X12 procedure in Gretl.

In particular, real GDP, real private and government consumption, real total investment, GDP deflator (and investment deflator when needed) and the nominal interest rate are taken from the aforementioned OECD sources. The interest rate is a short-run one; either the overnight rate (typically the Central Bank target rate) or the 3 month

market rate; the one with the longest sample is used.

OECD reports only government consumption in the sources used. In order to get the variables used, one needs government investment, total revenues (or at least total taxes, including social security contributions) and social benefits (or transfers to the private sector in general). So country sources are used to find these series. Tax data are deflated using GDP deflator, government investment data are deflated using investment deflator - then this variable is subtracted from total real investment to give total private investment, and added to government consumption to give total spending in good and services.

For Australia, I use tables 5206.3 - Expenditure on Gross Domestic Product (GDP), Current prices; 5206.15 - General Government Income Account, Current prices; 5206.18 - Taxes, Current prices.

For Canada, I use tables 380-0002 - Gross domestic product (GDP), expenditure-based, quarterly; and 380-0007 - Sector accounts, all levels of government, quarterly.

For France, I use the quarterly government sector accounts - uses and resources. There were tables with 2005 base that had much longer time series, but the data there were not similar to the current tables, so the most recent were used.

For UK, I use the following variables (downloaded from Navidata™ program of ONS): ANBOQ (transfers), ANBTQ (total taxes), ANLYQ (transfers), NNBFQ (government investment). The reason is that these series are much longer than other with similar data.

For US, I use table 3.1 - Government Current Receipts and Expenditures, of National Income and Product Accounts (NIPA).

Government spending comprises of real total government consumption and investment. Net taxes, T = Total revenues (personal taxes + taxes on production and imports + corporate taxes + social security contributions + other revenues) - social benefits. However, if total taxes only are available, they are used.

C.2 Model selection and cointegration analysis

In this appendix I present: a) information selection criteria and autocorrelation tests used to choose lag length of the VAR, b) info criteria and trace statistics to choose the cointegration rank of the VECMs and c) unit root tests for the cointegrating relations, for all countries. I follow Pesaran and Smith (1998) for the choice of VECM. Lütkepohl (2005) is an excellent choice for the details of model selection in general.

As it is evident in table C.2, the info criteria support VECM models of case 4 in most cases, usually with one lag (of levels VAR) in the case of HQ and BIC, but typically two lags are needed to remove autocorrelation from the residuals. However, the data are quite uninformative with respect to the cointegration rank, as shown in tables C.3 to C.7; trace tests support 3 cointegrating relations in most cases, while the info criteria also diverge - AIC supports 5 relations in most countries, HQ 4 and BIC 3 relations; the likelihood is quite flat with respect to differences in cointegration rank.

The cointegrating relations in the specifications are four, as mentioned in the text, and include one to ensure long-run fiscal solvency (g - t), the great ratios (c - y and ip - y) and stationarity of the real interest rate (i - pi). In US, these relations appear to be stationary, according to the unit root tests presented below. Only the real interest rate can be considered stationary in all cases. Nevertheless, allowing for the following breaks renders the other cointegrating relations stationary (or very close to) in most cases:

Table C.1: Breaks

Australia	1981:1 - macroeconomic reforms	1993:2 - beginning of inflation targeting	
Canada	1981:1 - macroeconomic reforms / moderation	1994:1 - NAFTA	
France	1986:1 - common market	1993:1 - Maastricht	1999:1 - Euro
UK	1981:1 - macroeconomic reforms / moderation	1993:1 - Maastricht / Floating exchange rate	
EMU	1986:1 - common market	1993:1 - Maastricht	1999:1 - Euro
US		1994:1 - NAFTA	

Breaks consist by both a break in level and the trend in the specific date. Table C.5 has the results of the unit root tests of the cointegrating relations. In most cases, the break in 90's helps to achieve stationarity in the shorter sample (1981 - 2006), and was added to the full sample for consistency of the specifications. The many breaks in EMU and France seem justified given the economic history of the EMU counties - in any case, they are needed to make the cointegrating relations stationary. Finally, the trends and the breaks are restricted in the cointegrating relations in the estimated models.

Table C.2: VAR selection

	Australia			Canada			France			UK			EMU			US		
	AIC	HQ	BIC	AIC	HQ	BIC	AIC	HQ	BIC	AIC	HQ	BIC	AIC	HQ	BIC	AIC	HQ	BIC
1 lag	-41.71	-41.17	-40.39	-45.21	-44.75	-44.06	-55.92	-55.25	-54.28	-41.87	-41.43	-40.77	-57.67	-57.00	-56.03	-53.41	-52.96	-52.3
2 lags	-41.77	-40.82	-39.44	-45.43	-44.59	-43.38	-56.27	-55.08	-53.35	-41.98	-41.19	-40.02	-57.73	-56.55	-54.82	-55.64	-54.84	-53.6
3 lags	-41.70	-40.34	-38.35	-45.31	-44.12	-42.37	-56.25	-54.55	-52.06	-41.89	-40.75	-39.08	-57.64	-55.94	-53.45	-55.83	-54.69	-53.0
4 lags	-41.71	-39.94	-37.34	-45.14	-43.58	-41.30	-55.95	-53.74	-50.48	-41.86	-40.37	-38.19	-57.75	-55.53	-52.28	-55.77	-54.28	-52.1

(a) Information Criteria for VAR

	Australia		Canada		France		UK		EMU		US	
	LM 1 lag	LM 4 lags	LM 1 lag	LM 4 lags	LM 1 lag	LM 4 lags	LM 1 lag	LM 4 lags	LM 1 lag	LM 4 lags	LM 1 lag	LM 4 lags
1 lag	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 lags	1.00	0.01	1.00	0.69	1	0.74	1	0.44	1	0.17	1.00	0.00
3 lags	1.00	0.93	1.00	1.00	1	1.00	1	1.00	1	0.83	1	0.94
4 lags	1.00	1.00	1.00	1.00	1	1.00	1	1	1	1.00	1	1

(b) LM autocorrelation tests for VAR: p-values

Table C.3: Trace tests for Cointegration 1: p-values

Australia																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.20	0.09	0.03	0.00	0.19	0.05	0.01
2	0.00	0.01	0.00	0.00	0.01	0.34	0.10	0.03	0.06	0.56	0.35	0.16	0.09	0.43	0.47	0.26
3	0.00	0.08	0.18	0.05	0.16	0.57	0.55	0.33	0.39	0.87	0.80	0.59	0.24	0.58	0.50	0.28
4	0.06	0.49	0.54	0.24	0.23	0.72	0.82	0.59	0.48	0.81	0.89	0.72	0.21	0.55	0.73	0.48
5	0.16	0.79	0.63	0.21	0.34	0.70	0.76	0.37	0.43	0.81	0.87	0.49	0.16	0.59	0.71	0.34
6	0.42	0.71	0.65	0.03	0.48	0.76	0.61	0.03	0.56	0.91	0.66	0.03	0.29	0.54	0.40	0.03

Canada																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.10	0.07
2	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.06	0.08	0.06	0.17	0.19	0.14
3	0.05	0.07	0.13	0.08	0.17	0.27	0.23	0.19	0.32	0.33	0.38	0.28	0.27	0.39	0.38	0.24
4	0.19	0.36	0.34	0.23	0.43	0.54	0.30	0.28	0.62	0.73	0.57	0.42	0.60	0.76	0.57	0.37
5	0.39	0.24	0.38	0.11	0.47	0.30	0.52	0.21	0.46	0.48	0.67	0.43	0.47	0.57	0.68	0.39
6	0.48	0.18	0.33	0.01	0.47	0.13	0.32	0.02	0.31	0.18	0.45	0.04	0.38	0.28	0.51	0.04

France																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.00	0.10	0.10	0.11	0.00	0.06	0.11	0.16
3	0.00	0.01	0.03	0.03	0.03	0.14	0.11	0.14	0.04	0.31	0.20	0.23	0.04	0.18	0.22	0.29
4	0.07	0.62	0.66	0.36	0.17	0.74	0.49	0.33	0.24	0.56	0.25	0.32	0.16	0.37	0.42	0.65
5	0.20	0.65	0.92	0.59	0.66	0.74	0.70	0.56	0.76	0.80	0.58	0.54	0.34	0.55	0.62	0.39
6	0.29	0.26	0.78	0.08	0.47	0.30	0.67	0.04	0.59	0.38	0.70	0.04	0.24	0.25	0.50	0.05

Table C.4: Trace tests for Cointegration 2: p-values

UK																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.00
1	0.00	0.02	0.00	0.00	0.00	0.04	0.00	0.00	0.05	0.16	0.06	0.02	0.02	0.09	0.04	0.01
2	0.02	0.24	0.03	0.00	0.04	0.10	0.09	0.02	0.16	0.19	0.22	0.10	0.11	0.17	0.15	0.05
3	0.45	0.53	0.22	0.06	0.22	0.41	0.24	0.08	0.31	0.41	0.30	0.11	0.34	0.39	0.25	0.10
4	0.67	0.63	0.41	0.14	0.62	0.69	0.39	0.13	0.65	0.80	0.41	0.15	0.56	0.64	0.52	0.25
5	0.71	0.74	0.55	0.17	0.86	0.92	0.56	0.17	0.82	0.87	0.67	0.22	0.64	0.79	0.48	0.13
6	0.47	0.44	0.73	0.05	0.61	0.51	0.83	0.08	0.57	0.48	0.79	0.08	0.45	0.42	0.66	0.06

EMU																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.03	0.00	0.03	0.15	0.08	0.00	0.00	0.03	0.02
2	0.00	0.00	0.00	0.00	0.00	0.07	0.17	0.09	0.01	0.08	0.35	0.24	0.01	0.03	0.18	0.16
3	0.00	0.03	0.07	0.02	0.04	0.17	0.33	0.15	0.02	0.11	0.42	0.32	0.17	0.19	0.51	0.53
4	0.03	0.55	0.56	0.31	0.14	0.59	0.62	0.37	0.06	0.35	0.66	0.53	0.19	0.12	0.37	0.45
5	0.53	0.78	0.56	0.23	0.60	0.79	0.55	0.28	0.31	0.38	0.70	0.62	0.28	0.12	0.37	0.53
6	0.64	0.13	0.88	0.28	0.61	0.16	0.86	0.32	0.40	0.06	0.57	0.62	0.37	0.04	0.38	0.61

US																
	1 lag				2 lags				3 lags				4 lags			
Rank	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5	case 2	case 3	case 4	case 5
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1	0.00	0.07	0.10	0.05	0.01	0.11	0.17	0.08	0.04	0.33	0.14	0.06	0.04	0.31	0.10	0.04
2	0.12	0.23	0.32	0.20	0.18	0.71	0.69	0.53	0.22	0.87	0.79	0.64	0.28	0.60	0.49	0.35
3	0.57	0.65	0.58	0.37	0.81	0.89	0.81	0.65	0.80	0.94	0.92	0.85	0.61	0.89	0.86	0.79
4	0.80	0.91	0.70	0.42	0.81	0.93	0.79	0.58	0.69	0.88	0.93	0.75	0.62	0.80	0.90	0.73
5	0.77	0.97	0.81	0.37	0.79	0.95	0.85	0.46	0.63	0.84	0.87	0.43	0.58	0.60	0.85	0.42
6	0.72	0.74	0.93	0.19	0.66	0.55	0.91	0.19	0.66	0.16	0.92	0.15	0.56	0.13	0.74	0.05

Table C.5: Unit root tests of cointegrating relations.

		c-y	ip-y	g-t	i-pi
constant	ADF	0.08	0.76	0.08	0.09
	ADF-GLS	0.10	0.74	0.02	0.05
	PP	0.06	0.86	0.02	0.00
trend	ADF	0.26	0.08	0.14	0.26
	ADF-GLS	-2.35	-2.00	-2.49	-2.58
	PP	0.20	0.22	0.03	0.00
	ADF break	0.10	0.04	0.18	0.00

(a) Australia

		c-y	ip-y	g-t	i-pi
constant	ADF	0.20	0.51	0.42	0.04
	ADF-GLS	0.28	0.83	0.10	0.00
	PP	0.14	0.56	0.37	0.00
trend	ADF	0.54	0.16	0.62	0.13
	ADF-GLS	-2.13	-2.36	-1.93	-2.98
	PP	0.29	0.22	0.56	0.00
	ADF break	0.03	0.01	0.03	0.00

(b) Canada

		c-y	ip-y	g-t	i-pi
constant	ADF	0.46	0.18	0.59	0.13
	ADF-GLS	0.15	0.28	0.23	0.10
	PP	0.46	0.61	0.42	0.01
trend	ADF	0.45	0.15	0.75	0.02
	ADF-GLS	-1.77	-0.89	-1.21	-1.97
	PP	0.40	0.50	0.58	0.00
	ADF break	0.00	0.58 (0.03)	0.25 (0.03)	0.00

(modified specifications with more lags reject unit root in the break case)

(c) France

		c-y	ip-y	g-t	i-pi
constant	ADF	0.92	0.70	0.40	0.00
	ADF-GLS	0.59	0.86	0.12	0.09
	PP	0.91	0.67	0.26	0.00
trend	ADF	0.35	0.16	0.42	0.01
	ADF-GLS	-1.24	-2.58	-2.11	-2.49
	PP	0.31	0.04	0.21	0.00
	ADF break	0.05	0.14	0.56	0.00

(d) UK

		c-y	ip-y	g-t	i-pi
constant	ADF	0.09	0.51	0.41	0.71
	ADF-GLS	0.22	0.27	0.11	0.20
	PP	0.06	0.57	0.59	0.26
trend	ADF	0.07	0.19	0.24	0.45
	ADF-GLS	-3.00	-1.21	-1.81	-1.68
	PP	0.04	0.22	0.43	0.04
	ADF break	0.01	0.31 (0.04)	0.05	0.00

(a modified specification with more lags rejects unit root in the break case)

(e) EMU

		c-y	ip-y	g-t	i-pi
constant	ADF	0.90	0.37	0.01	0.09
	ADF-GLS	0.81	0.44	0.00	0.01
	PP	0.87	0.39	0.02	0.00
trend	ADF	0.15	0.03	0.03	0.28
	ADF-GLS	-2.47	-3.59	-3.79	-2.63
	PP	0.04	0.05	0.08	0.00
	ADF break	0.03	0.00	0.00	0.19

(f) US

P-values or test value for ADF-GLS with trend (critical values -2.64 (10%) and -2.93 (5%)) for unit root tests of cointegrating relations (full samples). ADF is the augmented Dickey-Fuller unit root test; PP is the Phillips Perron unit root test; ADF break is an ADF test with constant and trend including the break variables as regressors. In all specifications 2 lagged differences are included.

Table C.6: Minimum info criteria for selecting model and cointegration restrictions - AIC and HQ

		Minimum AIC								Minimum HQ							
		rank 0	rank 1	rank 2	rank 3	rank 4	rank 5	rank6	rank7	rank 0	rank 1	rank 2	rank 3	rank 4	rank 5	rank6	rank7
Australia	value	-61.19	-61.51	-61.67	-61.72	**-61.78**	-61.76	-61.72	-61.66	-60.37	-60.91	-61.19	-61.40	**-61.43**	-61.38	-61.29	-61.17
	lag	4	5	5	2	**2**	2	2	2	1	1	1	1	**1**	1	1	1
	case	4	4	4	4	**4**	4	4	4	3	4	4	4	**4**	4	4	4
Canada	value	-64.83	-65.11	-65.29	-65.44	-65.48	**-65.50**	-65.47	-65.43	-64.40	-64.65	-64.89	-65.00	**-65.01**	-64.97	-64.90	-64.81
	lag	1	2	2	2	2	**2**	2	2	1	2	1	1	**1**	1	1	1
	case	5	4	4	4	4	**4**	4	4	3	4	4	4	**4**	4	4	4
France	value	-73.96	-74.54	-74.92	-75.10	-75.25	**-75.28**	-75.23	-75.14	-73.36	-73.80	-74.18	-74.39	**-74.56**	-74.53	-74.38	-74.21
	lag	1	3	3	2	2	**2**	2	2	1	2	2	1	**1**	1	1	1
	case	5	4	4	4	4	**4**	4	4	3	4	4	4	**4**	4	4	4
UK	value	-61.51	-61.74	-61.91	-62.00	-62.05	**-62.06**	-62.05	-62.00	-61.06	-61.50	-61.61	-61.68	**-61.69**	-61.65	-61.59	-61.49
	lag	3	3	2	2	2	**2**	2	2	1	1	1	1	**1**	1	1	1
	case	4	4	4	4	4	**4**	4	4	3	4	4	4	**4**	4	4	4
EMU	value	-76.83	-77.39	-77.62	-77.82	-77.87	**-77.90**	-77.85	-77.75	-76.24	-76.78	-77.10	-77.30	-77.43	**-77.47**	-77.35	-77.16
	lag	1	2	4	4	2	**2**	2	4	1	1	1	1	1	**1**	1	1
	case	3	4	4	4	4	**3**	4	4	3	4	4	4	2	**2**	2	2
US	value	-68.21	-68.48	-68.66	-68.72	**-68.73**	-68.71	-68.69	-68.62	-67.57	-67.80	-67.91	**-67.92**	-67.88	-67.83	-67.76	-67.65
	lag	2	3	3	3	**3**	3	3	3	1	2	2	**2**	2	2	1	1
	case	4	4	4	4	**4**	4	4	4	3	4	4	**4**	4	4	4	4

Bold indicates the minimum.

Table C.7: Minimum info criteria for selecting model and cointegration restrictions - BIC

		Minimum BIC							
		rank 0	rank 1	rank 2	rank 3	rank 4	rank 5	rank6	rank7
Australia	value	-59.70	-60.74	-60.94	**-61.06**	-61.01	-60.88	-60.71	-60.50
	lag	1	1	1	**1**	1	1	1	1
	case	3	4	4	**4**	4	4	4	4
Canada	value	-63.80	-64.45	-64.67	**-64.70**	-64.64	-64.52	-64.37	-64.21
	lag	1	1	1	**1**	1	1	1	1
	case	3	4	4	**4**	4	4	4	4
France	value	-72.52	-73.45	-73.78	-73.99	**-74.05**	-73.91	-73.70	-73.44
	lag	1	1	1	1	**1**	1	1	1
	case	3	4	4	2	**2**	2	2	2
UK	value	-60.49	-61.36	-61.40	**-61.43**	-61.34	-61.22	-61.09	-60.91
	lag	1	1	1	**1**	1	1	1	1
	case	3	4	2	**2**	2	4	4	4
EMU	value	-75.37	-76.56	-76.78	-76.91	**-77.00**	-76.93	-76.69	-76.40
	lag	1	1	1	1	**1**	1	1	1
	case	3	4	4	2	**2**	2	2	2
US	value	-67.00	-67.64	**-67.64**	-67.63	-67.53	-67.40	-67.26	-67.07
	lag	1	1	**1**	1	1	1	1	1
	case	3	4	**4**	2	2	4	4	4

Bold indicates the minimum.

C.3 Further results not included in main text

In this appendix AR tests for the specification and the overidentifying restrictions, as well as partial R^2 statistics for the strength of identification of each endogenous regressor for all equations are presented. As it is evident in tables C.8 and C.9, almost all structural estimations are well estimated and in almost all cases instruments are at least adequate. Importantly, there are almost always good instruments for spending and taxes in the estimated equations. In the structural equations, invalid instruments (correlated with structural errors) have been removed, so as to make the Sargan TR^2 statistic insignificant[1]. The Anderson - Rubin (AR)[2] statistic tests both specification

[1]Sargan test is performed by regressing the residuals from the HFUL estimation on the instruments, just like the IV case; the TR^2 statistic from this equation is distributed as χ^2_{q-r}, where q is the number of instruments, r the number of endogenous variables and q - r the number of overidentifying restrictions.

[2]A common way to present the IV regression model is to write it as a simultaneous equations model:

$$y = Y\beta + X\gamma + u \quad \text{(I)}$$

$$Y = X\Gamma + Z\Pi + V \quad \text{(II)}$$

where (I) is the structural equation, (II) is the reduced form equation, y is a T×1 vector with the endogenous variable, Y is a T×G matrix of endogenous regressors, X is a T×M matrix of exogenous regressors, Z is a T×K matrix of excluded instruments, u is a T×1 vector with the structural residuals and V is a T×G matrix of reduced form residuals; β and γ are G×1 and M×1 vectors of structural coefficients, while Γ and Π are M×G and K×G matrices with the coefficients of reduced form equations;

Table C.8: Identification and IV specification tests 1

		Sargan		AR tests		partial R^2 - baseline							partial R^2 - alternative						
	equation	p-value base	p-value alt.	p-value base	p-value alt.	g	y	pi	c	ip	t	i	g	y	pi	c	ip	t	i
Australia	g	0.45	0.84	0.75	0.62	nan	0.10	0.79	0.40	0.33	0.59	0.56	nan	nan	0.79	nan	nan	nan	nan
	y	0.18	0.23	0.77	0.97	0.66	nan	0.90	0.39	0.25	0.55	0.50	0.88	nan	0.60	0.38	0.20	0.52	0.47
	pi	0.18	0.30	0.64	0.69	0.37	0.45	nan	0.46	0.39	0.59	0.50	0.73	0.45	nan	0.46	0.39	0.60	0.52
	c	0.78	0.72	1.00	1.00	0.95	0.89	0.89	nan	nan	1.00	0.99	0.95	0.84	0.89	nan	nan	1.00	0.99
	ip	0.48	0.35	0.88	0.70	0.98	0.93	0.98	1.00	nan	1.00	1.00	1.00	0.92	0.99	1.00	nan	1.00	1.00
	t	0.30	0.36	0.70	0.76	0.96	0.90	0.98	nan	nan	nan	0.99	0.99	0.86	0.98	nan	nan	nan	0.99
	i	0.63	0.23	0.99	0.62	0.89	0.86	0.84	nan	nan	nan	nan	0.95	0.80	0.84	nan	nan	nan	nan
Canada	g	0.49	0.93	1.00	0.72	nan	0.24	0.87	0.44	0.27	0.46	0.45	nan	nan	0.74	nan	nan	nan	nan
	y	0.07	0.21	0.66	0.92	0.44	nan	0.17	0.34	0.21	0.47	0.45	0.80	nan	0.15	0.31	0.18	0.47	0.44
	pi	0.09	0.13	0.30	0.35	0.34	0.43	nan	0.44	0.37	0.49	0.50	0.87	0.43	nan	0.45	0.37	0.50	0.50
	c	0.49	0.49	0.81	0.82	0.99	0.81	0.93	nan	nan	1.00	1.00	0.96	0.80	0.93	nan	nan	1.00	1.00
	ip	0.70	0.65	0.98	0.97	1.00	0.95	0.94	0.99	nan	1.00	1.00	0.97	0.95	0.94	0.99	nan	1.00	1.00
	t	0.66	0.67	0.91	0.92	0.97	0.80	0.93	nan	nan	nan	1.00	0.95	0.79	0.92	nan	nan	nan	1.00
	i	0.79	0.85	0.96	0.98	0.95	0.72	0.88	nan	nan	nan	nan	0.95	0.72	0.89	nan	nan	nan	nan
France	g	0.97	0.48	1.00	0.22	nan	0.24	0.80	0.53	0.20	0.47	0.74	nan	nan	0.76	nan	nan	nan	nan
	y	0.22	0.24	0.39	0.43	0.82	nan	0.85	0.40	0.16	0.45	0.74	0.96	nan	0.86	0.36	0.16	0.45	0.73
	pi	0.49	0.59	0.79	0.85	0.15	0.35	nan	0.37	0.20	0.44	0.52	0.78	0.38	nan	0.50	0.20	0.48	0.54
	c	0.80	0.32	1.00	0.75	0.89	0.78	0.86	nan	nan	0.99	0.97	0.86	0.79	0.88	nan	nan	0.99	0.98
	ip	0.27	0.61	0.82	0.96	0.99	0.95	0.98	0.99	nan	0.99	1.00	1.00	0.90	0.96	0.98	nan	0.99	1.00
	t	0.74	0.89	0.94	0.99	0.89	0.81	0.87	nan	nan	nan	0.97	0.98	0.80	0.87	nan	nan	nan	0.97
	i	0.80	0.80	0.97	0.97	0.81	0.76	0.70	nan	nan	nan	nan	0.94	0.75	0.71	nan	nan	nan	nan

Table C.9: Identification and IV specification tests 2

		Sargan		AR tests		partial R^2 - baseline							partial R^2 - alternative						
	equation	p-value base	p-value alt.	p-value base	p-value alt.	g	y	pi	c	ip	t	i	g	y	pi	c	ip	t	i
UK	g	0.44	0.51	0.95	0.20	nan	0.68	0.83	0.43	0.42	0.45	0.37	nan	nan	0.77	nan	nan	nan	nan
	y	0.93	0.96	1.00	1.00	0.07	nan	0.77	0.23	0.44	0.45	0.40	0.94	nan	0.81	0.32	0.45	0.46	0.41
	pi	0.62	0.68	0.98	0.96	0.36	0.40	nan	0.42	0.46	0.45	0.36	0.84	0.40	nan	0.43	0.46	0.45	0.36
	c	0.82	0.93	0.99	1.00	0.96	0.97	0.91	nan	nan	1.00	1.00	0.99	0.97	0.91	nan	nan	1.00	1.00
	ip	0.39	0.41	0.89	0.90	0.99	1.00	0.99	1.00	nan	1.00	1.00	0.99	1.00	0.99	1.00	nan	1.00	1.00
	t	0.10	0.16	0.56	0.63	0.91	0.94	0.89	nan	nan	nan	1.00	0.98	0.94	0.89	nan	nan	nan	1.00
	i	0.49	0.07	0.78	0.31	0.92	0.95	0.92	nan	nan	nan	nan	0.98	0.94	0.86	nan	nan	nan	nan
EMU	g	0.32	0.56	0.62	0.39	nan	0.39	0.70	0.53	0.45	0.44	0.47	nan	nan	0.77	nan	nan	nan	nan
	y	0.47	0.46	0.97	0.97	0.51	nan	0.68	0.33	0.16	0.42	0.10	0.45	nan	0.68	0.34	0.16	0.40	0.10
	pi	0.51	0.59	0.92	0.87	0.39	0.45	nan	0.51	0.42	0.39	0.39	0.81	0.45	nan	0.53	0.42	0.41	0.40
	c	0.84	0.90	0.97	1.00	0.94	0.97	1.00	nan	nan	1.00	0.99	0.99	0.98	0.99	nan	nan	1.00	0.99
	ip	0.52	0.51	0.94	0.93	0.96	0.99	0.99	1.00	nan	1.00	0.99	0.99	0.99	1.00	1.00	nan	1.00	0.99
	t	0.61	0.33	0.63	0.49	0.91	0.96	0.99	nan	nan	nan	1.00	0.99	0.89	0.97	nan	nan	nan	0.98
	i	0.99	0.99	1.00	1.00	0.89	0.64	0.58	nan	nan	nan	nan	0.97	0.60	0.56	nan	nan	nan	nan
US	g	0.82	0.56	1.00	0.43	nan	0.31	0.66	0.14	0.25	0.40	0.21	nan	nan	0.65	nan	nan	nan	nan
	y	0.03	0.25	0.00	0.50	0.13	nan	0.67	0.14	0.20	0.38	0.26	0.93	nan	0.63	0.06	0.12	0.36	0.15
	pi	0.36	0.50	0.89	0.93	0.31	0.31	nan	0.26	0.30	0.36	0.38	0.59	0.31	nan	0.26	0.30	0.36	0.38
	c	0.18	0.42	0.85	0.97	0.52	0.42	0.75	nan	nan	0.87	0.55	0.92	0.59	0.89	nan	nan	1.00	0.79
	ip	0.66	0.48	0.95	0.89	0.82	1.00	0.90	0.78	nan	0.96	0.86	0.99	0.99	0.95	0.95	nan	1.00	0.95
	t	0.11	0.04	0.33	0.15	0.59	0.42	0.85	nan	nan	nan	0.68	0.95	0.63	0.89	nan	nan	nan	0.84
	i	0.65	0.65	0.92	0.92	0.61	0.33	0.72	nan	nan	nan	nan	0.94	0.49	0.80	nan	nan	nan	nan

and the overidentifying restrictions and it is almost always not significant.

Only in the baseline specification for US and UK we observe rather weak instruments for g in the output equation; in the case for US the estimated coefficients are insignificant and close to zero (as in the alternative specification, where g is very well identified) and setting the estimates at zero does not substantially alter the results in either case; in the case for UK, the estimates are very close in both cases, despite the dramatically different quality of instruments across specifications. These two cases illustrate the point made in Zervas (2014) that instruments with partial R^2 of approximately 0.1 are likely to give usable estimates of the relevant structural coefficient.

C.4 Results of SVARs with short run restrictions

SVAR results (IRFs and multipliers) of the models using a Cholesky decomposition - variables are ordered as in the main text. In these models, I change the parameter of the inverse Wishart distribution and use v = 20 (instead of 3 in the main text), because now the variance-covariance matrix of the VAR is used directly to calculate the impact responses, and not only in the draw for the reduced form coefficients.

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the full matrix of residuals $U = [u\ V] \sim \text{iid}(0, \Sigma)$, and Σ is not block diagonal; this last assumption makes u and V correlated, thus creates endogeneity and necessitates the use of an IV procedure for consistent estimation of β. The Anderson-Rubin statistic (Anderson and Rubin 1949) is a test that $\beta = \beta_0$, and is given by:

$$AR(\beta_0) = \frac{(\tilde{y} - \tilde{Y}\beta_0)' P(\tilde{Z})(\tilde{y} - \tilde{Y}\beta_0)/K}{(\tilde{y} - \tilde{Y}\beta_0)' M(\tilde{Z})(\tilde{y} - \tilde{Y}\beta_0)/(T - K - M)}$$

where $\tilde{y}$, $\tilde{Y}$ and $\tilde{Z}$ are the residuals from projecting y, Y and Z respectively on X; *P(A)* is the projection matrix $A(A'A)^{-1}A'$ and *M(A)* is the matrix generating the residuals from the linear projection $I - P(A)$. This statistic has a χ^2_K/K distribution or an *F(K,T-K-M)* under normality.

Table C.10: Output multipliers - Cholesky identification

	Australia			Canada			France			UK			EMU			US		
full sample	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.12	**0.53**	1.19	0.17	**0.77**	1.35	0.12	**0.91**	1.70	-0.17	**0.46**	1.09	-0.39	**0.69**	1.72	-0.10	**0.87**	1.86
t=4	-0.21	**0.65**	1.64	0.08	**0.94**	1.74	-0.53	**0.40**	1.35	-0.35	**0.39**	1.15	-0.17	**1.36**	2.74	-0.24	**0.84**	1.86
t=8	-0.14	**0.76**	1.81	0.18	**1.05**	1.84	-0.61	**0.36**	1.32	-0.38	**0.41**	1.22	0.04	**1.51**	2.78	-0.15	**0.86**	1.78
t=16	-0.04	**0.77**	1.69	0.41	**1.26**	2.07	-0.43	**0.49**	1.36	-0.44	**0.44**	1.35	0.15	**1.51**	2.66	-0.01	**0.91**	1.72
post 81 sample	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.27	**0.27**	0.81	-0.44	**0.21**	0.87				-0.23	**0.16**	0.54				-0.64	**0.27**	1.18
t=4	-0.27	**0.56**	1.40	-1.56	**-0.35**	0.72				-0.16	**0.46**	1.11				-1.35	**0.10**	1.39
t=8	-0.11	**0.69**	1.50	-1.90	**-0.40**	0.80				-0.16	**0.59**	1.32				-1.59	**0.23**	1.59
t=16	0.05	**0.75**	1.45	-1.56	**0.13**	1.50				-0.12	**0.74**	1.51				-1.99	**0.34**	1.72

(a) Spending

	Australia			Canada			France			UK			EMU			US		
full sample	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0
t=4	-0.40	**-0.32**	-0.24	0.20	**0.23**	0.26	-0.01	**0.06**	0.13	-0.01	**0.03**	0.06	0.68	**0.75**	0.83	-0.24	**-0.17**	-0.11
t=8	-1.01	**-0.78**	-0.60	0.20	**0.26**	0.31	-0.12	**0.03**	0.18	-0.03	**0.02**	0.07	0.83	**0.98**	1.12	-0.59	**-0.43**	-0.26
t=16	-1.40	**-1.04**	-0.76	0.05	**0.15**	0.25	-0.34	**-0.07**	0.19	-0.07	**0.02**	0.10	0.95	**1.18**	1.41	-1.41	**-1.02**	-0.64
post 81 sample	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	0	**0**	0	0	**0**	0				0	**0**	0				0	**0**	0
t=4	-0.21	**-0.06**	0.09	0.20	**0.24**	0.28				-0.22	**-0.14**	-0.07				0.09	**0.14**	0.18
t=8	-0.76	**-0.38**	-0.08	0.23	**0.30**	0.36				-0.40	**-0.26**	-0.13				0.02	**0.10**	0.18
t=16	-2.32	**-1.10**	-0.43	-0.09	**0.03**	0.14				-0.61	**-0.39**	-0.21				-0.16	**0.05**	0.23

(b) Tax

Figure C.1: Responses to spending increases with 90% posterior intervals - Cholesky identification

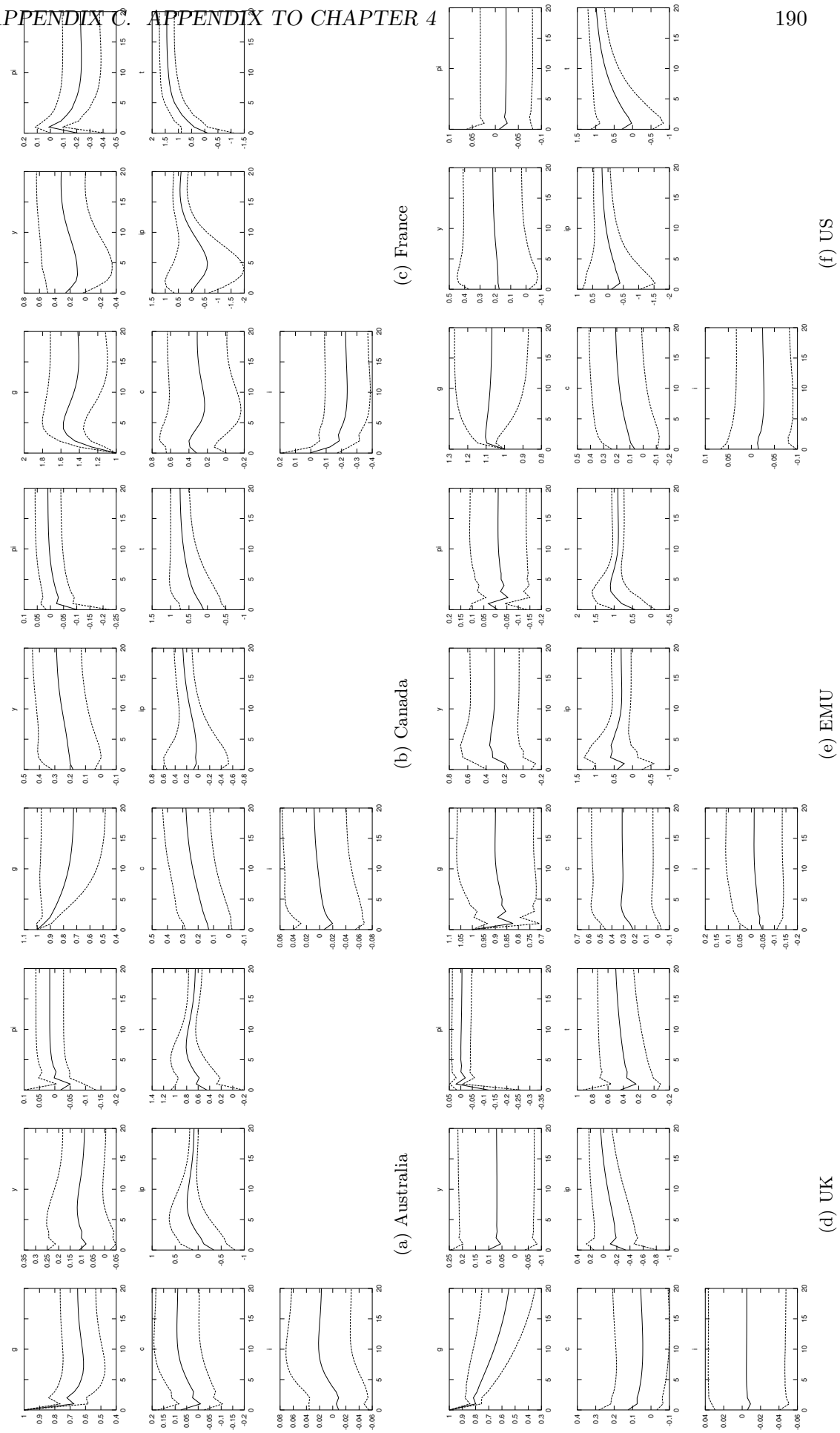
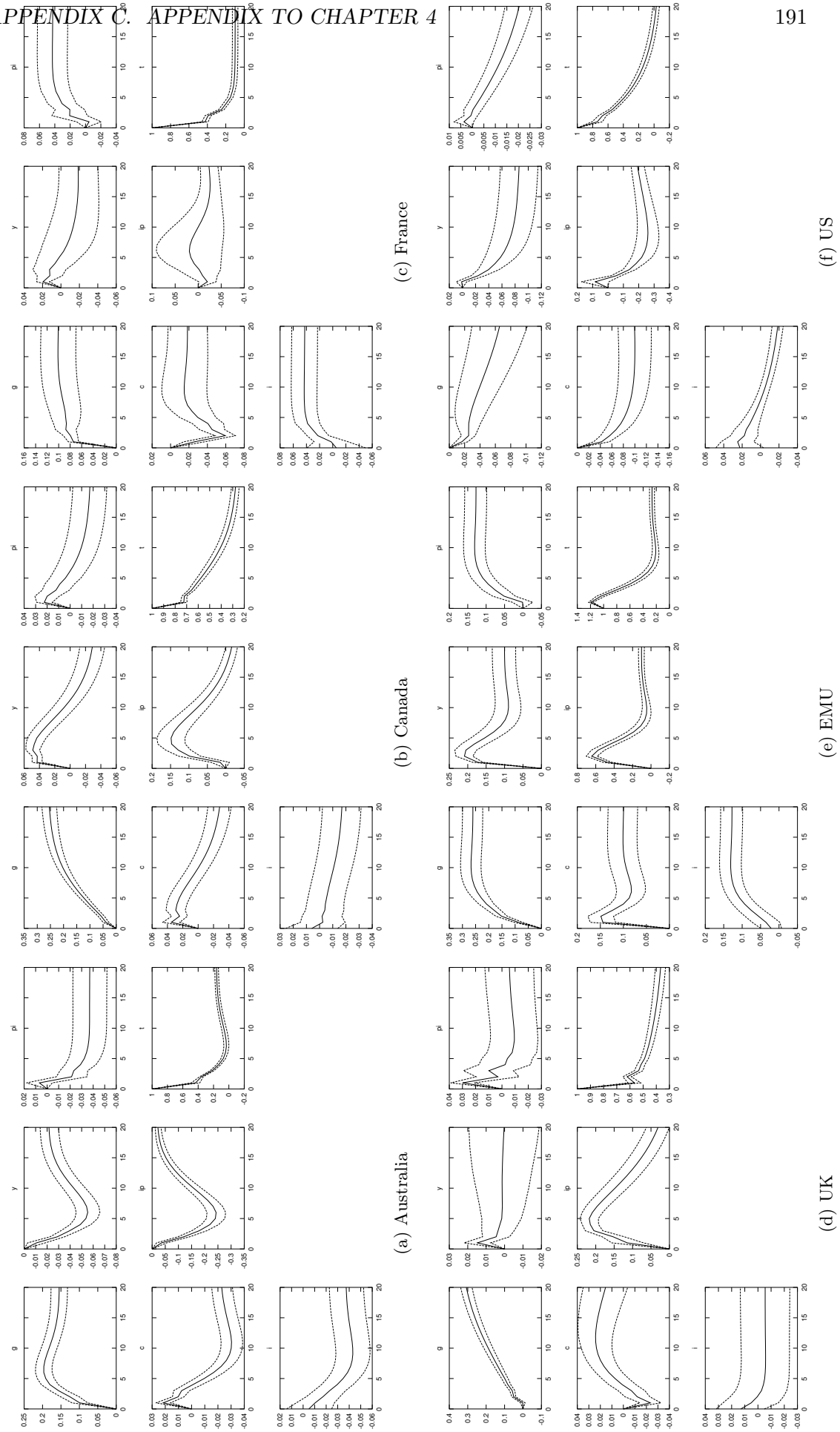


Figure C.2: Responses to tax increases with 90% posterior intervals - Cholesky identification



C.5 Adding foreign variables

In this section of the Appendix the results from models including Kilian's (AER 2009) global activity measure (GAM) are presented; in particular, in the baseline specification for all countries the current value and two lags of this variable are included, in order to account for foreign shocks in the model; sample has to start after 1969:1, as GAM is not available previously. In table C.11 LR test and info criteria for the inclusion of these exogenous variables in the country models are included.

As it is obvious from this table, information criteria do not favour the addition of GAM in the model (with the exception of AIC in case of UK and US in the full sample); LR tests also reject the presence of GAM in the models in the short sample (with the exception of UK). It seems that in the post 81 period, for some reason, the influence of foreign variables has fallen. One can rationalize such an effect by e.g. noting that flexible exchange rates stabilize economies from foreign shocks or that Governments and Central Banks were free to focus on domestic economy in the latter period - in any case the turbulent 70's are excluded from the shorter sample.

In table C.12 spending and tax multipliers for cases[3] were LR tests reject the omission of (current and two lags of) GAM are presented - baseline identification is assumed in all cases. As it is obvious from the table, all major results (higher spending than tax multipliers, not particularly high tax multipliers) remain unaffected - in fact, spending multipliers are higher now in all countries (altough the big increase in the case of US might indicate some endogeneity issues, since US accounts for a big part of global output, especially in the first part of the sample).

Estimates of the contemporaneous coefficients of equations for g and t are presented in tables C.13 and C.14 respectively. As shown in table C.13, as in section 4.3.3 of main text, spending multipliers are roughly analogous to the strength of countercyclical fiscal policy, and are bigger now since the estimated coefficients are bigger in absolute value. In addition, similarly to the results of section 4.4.2, tax multipliers tend to be bigger as output elasticities rise.

[3] AUS, CA, UK and US for 1969 - 2006 period and UK only for 1981 - 2006 period.

Table C.11: Tests and info criteria for inclusion of GAM in models

		LR			AIC		BIC		HQ	
		1969-2006	1981-2006		1969-2006	1981-2006	1969-2006	1981-2006	1969-2006	1981-2006
AUS	test	31.77	26.02	with GAM	-41.25	-43.47	-38.70	-40.27	-40.22	-42.18
	p-value	0.06	0.21	GAM excluded	-41.32	-43.63	-39.20	-40.96	-40.46	-42.55
CA	test	55.80	23.97	with GAM	-45.25	-46.87	-42.75	-43.67	-44.23	-45.57
	p-value	0.00	0.29	GAM excluded	-45.16	-47.04	-43.07	-44.37	-44.31	-45.96
EMU	test		21.00	with GAM		-57.30		-54.02		-55.97
	p-value		0.46	GAM excluded		-57.51		-54.78		-56.40
FR	test		27.12	with GAM		-54.42		-51.22		-53.12
	p-value		0.17	GAM excluded		-54.56		-51.89		-53.48
UK	test	51.89	41.85	with GAM	-42.03	-45.67	-39.52	-42.46	-41.01	-44.37
	p-value	0.00	0.00	GAM excluded	-41.96	-45.67	-39.87	-43.00	-41.11	-44.59
US	test	55.77	29.46	with GAM	-48.46	-51.29	-45.96	-48.08	-47.45	-49.99
	p-value	0.00	0.10	GAM excluded	-48.37	-51.41	-46.28	-48.74	-47.52	-50.33

Table C.12: Output multipliers - Baseline identification with GAM

Spending Multipliers															
	Australia 1969-2006			**Canada 1969-2006**			**UK 1969-2006**			**UK 1981-2006**			**US 1969-2006**		
	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	2.29	**2.56**	2.85	1.38	**1.62**	1.87	0.66	**0.81**	0.96	0.58	**0.75**	0.94	4.67	**5.53**	6.73
t=4	2.80	**3.30**	3.86	1.56	**1.98**	2.42	0.70	**0.92**	1.14	1.10	**1.42**	1.79	4.20	**5.10**	6.27
t=8	2.74	**3.30**	3.99	1.42	**1.82**	2.26	0.76	**1.01**	1.27	1.21	**1.55**	1.94	3.25	**3.93**	4.81
t=16	2.28	**2.83**	3.53	1.33	**1.73**	2.14	0.92	**1.24**	1.58	1.27	**1.58**	1.92	2.45	**2.99**	3.66

Tax Multipliers															
	Australia 1969-2006			**Canada 1969-2006**			**UK 1969-2006**			**UK 1981-2006**			**US 1969-2006**		
	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9	0.1	**base**	0.9
t=0	-0.26	**-0.16**	-0.07	-0.04	**0.05**	0.13	-0.09	**-0.02**	0.06	-0.13	**-0.06**	0.00	-0.11	**0.02**	0.16
t=4	-0.89	**-0.52**	-0.24	0.09	**0.25**	0.41	-0.24	**-0.09**	0.05	-0.41	**-0.22**	-0.06	-0.27	**0.01**	0.26
t=8	-2.05	**-1.12**	-0.51	0.00	**0.22**	0.42	-0.34	**-0.14**	0.04	-0.60	**-0.31**	-0.09	-0.57	**-0.12**	0.23
t=16	-3.82	**-1.87**	-0.77	-0.34	**0.00**	0.29	-0.49	**-0.23**	0.02	-0.87	**-0.44**	-0.14	-1.62	**-0.56**	0.14

Table C.13: Spending equations estimates - GAM included

Country	y	pi	c	ip	t	i
Australia	-1.794	0.064	-0.035	-0.125	**-0.092**	-0.772
Canada	**-0.952***	0.134	0.091	**-0.191**	0.048	-0.248
UK 1969-2006	-0.313	-0.128	**-0.467***	0.027	0.041	-0.409
UK 1981-2006	-1.579	0.165	**-1.780***	-0.044	-0.073	2.160
US	**1.082**	**0.648**	**-2.768****	**-0.342****	0.002	**1.455***

Significance (one sided): at 10% level bold, at 5% level bold and star, at 1% level bold and double star

Table C.14: Tax equations estimates - GAM included

Country	g	y	pi	i
Australia	**0.359***	**1.617****	**-1.147****	-1.272
Canada	0.061	**0.742***	-0.120	0.667
UK 1969-2006	**0.252***	**1.134****	0.067	**3.264****
UK 1981-2006	0.142	**3.023****	**-0.987***	0.334
US	**0.383**	**1.828****	**2.892****	**1.915****

Significance (one sided): at 10% level bold, at 5% level bold and star, at 1% level bold and double star