Empirical evidence on the stabilizing role of fiscal and monetary policies in the US

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Abstract

I apply SVAR tools and counterfactual simulation techniques to study the (de)stabilizing role of monetary and fiscal policies in the US, using quarterly data from 1955 to 2005. Monetary and fiscal disturbances contributed much less to output volatility in the second part of the sample. This result stems from their smaller impact and, to a lesser extent, from a decline in the respective variance. Systematic taxes net of transfers were the most important stabilizing force in the course of postwar recessions until the eighties. Monetary policy had a comparatively smaller role in offsetting the downturns in activity at those episodes. Net taxes have, however, suffered a marked lost of effectiveness in recent decades.

JEL: E52, E62, E63

Keywords: fiscal policy, monetary policy, stabilization, structural vector autoregression

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1 Introduction

The (de)stabilizing role of fiscal and monetary policies can be assessed by considering the role of exogenous policies as a source of business cycle fluctuations and also the contribution of endogenous policies to dampen them. These aspects depend in turn on how active policies have been and the impact on output they had. The goal of this paper is to present evidence about such questions for the US taking as a reference data for 1955 to 2005. Structural change over the period is accounted for on the basis of split-sample (separating the pre- and post-1980 periods) and rolling-sample estimates. There is a great deal of literature seeking to determine changes in the way monetary policy was conducted and its effect on the economy, including Bovin (2006), Bovin and Giannoni (2006), Primiceri (2005) and Sims and Zha (2006) among others. Such an analysis has been much less explored for the fiscal side.[1] My paper takes up this task and focuses, in addition, on aspects arising from the joint consideration of fiscal and monetary policies. From the empirical viewpoint, it also relates to the literature on the great moderation (see, for instance, Stock and Watson (2002), Ahmed et al. (2004), Canova (2009) and references therein), as far as the role played by policymakers in it is concerned.

The analysis is made in the framework of a simple, textbook-like macroeconomic system with five equations: three of them are structural - a monetary policy rule and equations for government revenue and expenditure, the latter capturing both the reaction function of fiscal authorities and automatic responses to macroeconomic variables. There are two additional equations which can be seen as solved out versions, respectively, for GDP and inflation, of standard IS and aggregate supply curves. The disturbances in these last equations do not have, contrary to the policy disturbances, a structural interpretation (that is, I do not disentangle aggregate supply and private aggregate demand innovations). This set-up is described in Section 3 and has some common points with that in Blanchard and Watson (1984), one of the earliest contributions to the SVAR literature.

[1] Two exceptions are Auerbach (2002) and Taylor (2000), but they differ substantially from the approach followed here, among other things in that they estimate single-equation relationships.

The macroeconomic system is cast and estimated in the form of an identified VAR. Thus I have to tackle joint identification of monetary and fiscal policy innovations and this links with a few studies that dealt with the same question, such as Perotti (2004) and Canzoneri et al. (2002), appearing in the wake of literature considering each policy in isolation. The most prominent simultaneity issue arising in this context - the co-movement between taxes and the monetary policy instrument, the federal funds rate - has, however, not received much attention before. I model this carefully by allowing a contemporaneous nonzero elasticity of taxes to the short-term interest rate. Some of the contemporaneous coefficients in the equations for the fiscal variables are calibrated using non-sample information, following Blanchard and Perotti (2002). This requires that I generalize the OECD method to derive the elasticity of personal income taxes to GDP that they use, to encompass the semi-elasticities to inflation and the short-term interest rate.

A general remark about the approach followed in this paper is that I take it as given that endogenous and exogenous policies have real effects and attempt to assess them. Also as preliminary point, Section 2 addresses the ability of identified VARs to estimate the effects of fiscal policy on GDP, which has been forcefully questioned (Ramey (2008)) on the grounds that SVAR fiscal disturbances are anticipated by agents.

Section 4 addresses the first question above, that is, the contribution of exogenous policies to the volatility of output. The key finding is that policy disturbances both on the fiscal and monetary sides were much less destabilizing in the second part of the sample. Such a result was to an important extent brought about by a smaller impact of those disturbances on output. In fact, there is evidence of a generalized weakening of exogenous policies' effectiveness - particularly marked for taxes and transfers which feature a perverse impact on output in the more recent period. Improved policy in the form of a smaller variance of the shocks is also found to have contributed to the decline in volatility in the case of the federal funds rate and government spending.

Section 5 presents additional empirical results concerning the behavior of monetary and fiscal policies. In particular, their responsiveness to the economy is addressed. Changes in the federal funds rate and taxes net of transfers are dominated by the respective systematic components. By contrast, the exogenous component dominates fluctuations in government expenditure. As far as structural change is concerned, the sensitiveness of taxes net of transfers to economic developments is found to have increased in recent decades. A similar analysis for the funds rate was not conclusive. Another issue addressed is the feedback between the two budget variables. The results in the first subsample, ending in 1980, indicate a tendency for changes in expenditure to lead changes in taxes, and capture a budget-balancing movement in the short-term. In contrast, results for the subsequent period show a long-lasting divergence between the two budget variables. I interpret this as reflecting the conduct of debt stabilization policies from early to mid-eighties on and, toward the end of the sample, «spending the surplus» policies.

Section 6 attempts to quantify the stabilizing role played by endogenous policies. This is done by means of counterfactual simulations. Specifically, I simulate the system under counterfactual assumptions which are, respectively, absence of the *exogenous* component and of the *endogenous* component of policy. By comparing the historical behavior of the variables with the implied behavior, I am able to break down actual changes in policy variables during contractions into the endogenous and exogenous components, and measure the output loss avoided at trough for each of them. I do this for the eight NBER business cycle contractions since 1955, the beginning of the sample. There is evidence that taxes and transfers were the most important force attenuating the severity of recessions up to the eighties. They have markedly lost effectiveness over time, however, in parallel with the same phenomenon for the respective exogenous shocks. The offsetting effect of systematic monetary policy was comparatively smaller in the past and this appears to be accounted for by a slow buildup of the output response against the length of the average recession. Except for more protracted recessions, full impact tends be felt already at the initial stages of the recovery. Government spending has played a minor stabilizing role throughout the whole sample period.

2 On the meaning of fiscal policy shocks and the ability of SVARs to capture them

A correct measurement of the effects of fiscal policy in an SVAR context requires, in the first place, that the shocks are exogenous in relation to the variable, say GDP, on which the impact is being determined. Meaning that the portion of the fiscal variables labelled as the «shock» must not respond to GDP nor, more generally, to variables correlated with it, such as interest rates and prices. As a first point, it is important to ascertain whether there are fiscal policy actions meeting such requirements in practice. Romer and Romer (2009b) investigated the legislated tax changes in the US since World War II and distinguished between four types of motivations behind them: to react to the business cycle, to finance changes in spending, to raise long-run growth and to cope with an inherited deficit (which could be also stated as to cope with growing debt). The Romers classify the last two as exogenous with respect to output fluctuations, and show that they have been clearly more prevalent than their endogenous counterparts throughout the postwar period. Turning to budget outlays, examples of exogenous, or at least party exogenous, interventions are also not difficult to find. These include, for instance, build-ups in defense spending and the creation and extension of certain social programs largely unrelated to the business cycle (like Medicaid). Another fiscal intervention concerns the normally annual decision about across-the-board adjustments to the pay of government employees. Such adjustments are partly endogenous to past inflation to the extent that they make up for it (adding to the other increases in pay related to the advancement of employees), but they are also determined by exogenous policy goals as, for instance, expenditure restraint or achieving wage rates comparable with those in the private sector. The last kind of goals can be very important in practice. This can be seen by analyzing the pay adjustments in the General Schedule which covers most Federal government civilian employees, in the years spanning since mid-fifties.[2] Until the beginning of the seventies, a time when the comparability principle ranked high on the political agenda (see Smith (1982)),

[2] The Federal Civilian Workforce Statistics (US Office of Personnel Management) present a chronology of the General Schedule Pay Legislation since 1945.

the cumulative increase stood over 70 p.p. above the variation in the CPI. By contrast, during the high inflation period from 1973 to 1981 that followed, pay updates fell systematically short of the rise in prices (more than 50 p.p. below, in cumulative terms). Since 1982 the adjustments have been more in line with inflation (negative difference of 19 p.p. in relation to the CPI from 1983 to 2005). Changes in social transfers and purchases of goods and services undertaken in response to business cycle conditions have been infrequent and small over the last decades (Romer and Romer (1994)). Hence, contrary to monetary policy for which the existence of exogenous interventions has been a matter of debate, in the case of fiscal policy many actions fall within this category, even if identification assumptions are generally needed to isolate them.

A second requirement for a correct measurement of the effects of fiscal policy is that the timing of the shocks corresponds to the moment in which they actually impacted economic activity. If fiscal shocks, albeit exogenous, can be anticipated by agents *and* if agents modify their behavior accordingly, identified VARs will still not estimate properly their effects on GDP. This issue is clearly of potential importance in the case of fiscal policy because changes to taxes and spending typically have to go through a legislative process, and thus agents get information about them about them ahead of the implementation. The problem was recognized in earlier SVAR papers on the effects of fiscal policy (Blanchard and Perotti (2002), see also the discussion in Perotti (2007)). At the same time, the event study literature (see Ramey and Shapiro (1998) and subsequent work in the same vein) argued that anticipation effects are likely to invalidate inferences relating to fiscal policy drawn from SVARs. As it is known, this literature has focused on the impact of increases in defense spending in the wake of the major postwar military episodes[3], and dates the shocks when the news about the likely rise in defense spending first came up in the media. Since I employ the SVAR methodology, it is appropriate to put forward some considerations about how serious the issue of anticipation may be.

[3] Although it is adequate to focus on the effects of military episodes, given the added claim to exogeneity, it is often thought that shocks to purchases of goods and services relate only to defense contracts. To put things in perspective, purchases related to defense (as measured by NIPAs) are about 1/3 of the total and, excluding compensation of employees from the aggregate, about 2/5. In terms of the contribution to the overall variance (series in real and per capita terms, sample 1955:1-2005:4) the defense component has a coefficient of variation of 0.13, much smaller than the one of non-defense expenditure which is 0.36.

Note, to start with, that neither the SVAR nor the event study approach present evidence as to the importance of anticipation effects. One way to get it is through micro studies addressing the actual behavior of agents in face of information about pending fiscal shocks. There is a large body of empirical evidence about the way households react to changes in taxes (also some about the reaction to changes in social benefits and, in any case, one might expect that the same type of behavior applies in this case). This has been gathered by the literature documenting the so-called «natural tax experiments» (see Johnston et al. (2006) and the references they cite), and provides support to the hypothesis that tax changes do affect households' behavior at the time revenue is collected. For instance, predictable tax liabilities and refunds have significant contemporaneous impacts on consumption. It is illustrative, in this respect, that although Romer and Romer (2009b) follow a methodology akin to the event study approach, they date «their» benchmark tax shocks according to when the legislated changes impacted revenue. In the same vein, one can assume that households do not smooth consumption in anticipation of small changes in disposable income resulting from shocks to compensation of government employees.

No comparable micro evidence as to the behavior of firms in face of information about pending fiscal changes is (to the best of my knowledge) available. The relevant budget items in this respect are, on the receipt side, taxes on profits and part of social security contributions and, on the outlay side, intermediate consumption and investment. The event study approach has chiefly raised the anticipation issue in relation to military component of these last items. I note that the timing of shocks followed by that approach is not undisputable. Indeed, considerable uncertainty remains at the point the news about the likely military build-up first come up, for instance, as to its actual size, the weapon systems government will purchase, who among competing contractors will be chosen as the supplier, and so on. Thus, it may well be that the relevant timing is when contracts are awarded. It is not unreasonable to think that anticipation matters more for the financial markets, which react to news than for the labor and product markets.[4] Anyway these remain largely open issues.

An issue that admittedly may disturb the measurement of fiscal shocks is raised by the way purchases of durable goods are recorded in NIPAs. NIPAs mostly record such purchases on a cash disbursements basis (see BEA (2005)) while the full amount of the acquisition (known by the supplier from the moment the contract is signed) is likely to be the relevant fact from the private sector's viewpoint. Thus National Accounts will typically record an initial payment which does not reflect the full size of the «true» shock. Still, an important part of purchases of goods and services is not affected by the issue.

3 Methodology

3.1 The equations and identifying restrictions

The results presented in this paper are based on the following system:

$$g_t = a_0^{g,p} p_t + a_0^{g,ff} ff_t + \sum_{i=1}^{4} \mathbf{a}_i^{g} \mathbf{x}_{t-i} + b_0^{g,nt} e_t^{nt} + e_t^{g}, \tag{1}$$

$$nt_t = a_0^{nt,y} y_t + a_0^{nt,p} p_t + a_0^{nt,ff} ff_t + \sum_{i=1}^{4} \mathbf{a}_i^{nt} \mathbf{x}_{t-i} + b_0^{nt,g} e_t^{g} + e_t^{nt}, \tag{2}$$

$$ff_t = a_0^{ff,y} y_t + a_0^{ff,p} p_t + \sum_{i=1}^{4} \mathbf{a}_i^{ff} \mathbf{x}_{t-i} + e_t^{ff}, \tag{3}$$

$$y_t = a_0^{y,g} g_t + a_0^{y,nt} nt_t + \sum_{i=1}^{4} \mathbf{a}_i^{y} \mathbf{x}_{t-i} + w_t^{y}, \tag{4}$$

$$p_t = a_0^{p,g} g_t + a_0^{p,nt} nt_t + \sum_{i=1}^{4} \mathbf{a}_i^{p} \mathbf{x}_{t-i} + w_t^{p}. \tag{5}$$

[4] Although if interest rates moved as a response to fiscal news this would have consequences for real activity (see, for instance, the formalization in Blanchard (1984)).

Purchases of goods and services (including of capital goods) are denoted by g_t, taxes net of transfers by nt_t, the federal funds rate by ff_t, detrended GDP (i.e. the output gap) by y_t and inflation by p_t. The vector $\mathbf{x}_t$ includes the variables in the system: $\mathbf{x}_t = [g_t, nt_t, ff_t, y_t, p_t]'$. The structural policy innovations (e_t^g, e_t^{nt} and e_t^{ff}) are ortogonal to each other and also to w_t^y and w_t^p, while these two innovations will be in general correlated. As usual in the SVAR methodology, the identification restrictions are imposed on the contemporaneous coefficients (the a_0's), while the lag structure of the model (the $\mathbf{a}$'s) is left unrestricted. I assume that either $b_0^{g,nt}= 0$ or $b_0^{nt,g}= 0$. I did not include deterministic terms in the equations; the discussion of the assumptions about the low-frequency properties of series is given in a subsection below.

The system was estimated with quarterly data, which were seasonally adjusted (except for the funds rate) at source. The lag length was set to 4. The fiscal variables and output are the logarithms of the levels measured in real and *per capita* terms. Inflation is calculated from the GDP deflator and, like the federal funds rate, is measured at annual rates. I give more details about the definition of the fiscal variables and sources in Appendix B. Throughout the paper, nt_t is also sometimes called simply «taxes», and g_t «expenditure» or «spending». The reference sample is 1955:1-2005:4. Since I want to explore the changes in the behavior and effects of policies over time, I generally present results for two subsamples, splitting the main sample into two parts: 1955:1-1979:4 and 1980:1-2005:4. The counterfactual exercises are carried out on the basis of rolling subsamples, spanning as well over 25 years, so that the recessions approximately coincide with the middle of them.

The first two equations above are those for government expenditure and net taxes.[5] If one assumes, following Blanchard and Perotti (2002), that any government reaction to macroeconomic conditions takes more than one quarter to be implemented, the a_0's in (1) and (2) can be interpreted as the *automatic* contemporaneous response of the fiscal variables to macroeconomic conditions. Such a response may be brought about, in particular, by mechanisms built

[5] To consider each side of the budget separately, rather than the deficit, allows us to investigate potential differentiated behavior and impacts. The definition of revenue as taxes net of transfers is in line with their impact operating through the standard aggregate demand channel. Such definition has also the practical advantage of lumping together in the revenue variable the budget categories that respond automatically to the business cycle.

in the tax code, transfer programs and budgeting procedures. Since the fiscal variables are in real terms, deflated by the GDP deflator, this also induces a contemporaneous co-movement of g_t and nt_t with p_t (these points are detailed in the discussion of the calibration of the parameters). The parameters $a_0^{nt,y}$ and $a_0^{nt,p}$ will capture the automatic responses of net taxes to activity and prices within the quarter, and $a_0^{g,p}$ of government spending to prices. It appears relatively undisputable that spending does not react to contemporaneous movements in activity, and therefore current GDP is absent from equation (1). Turning to the semi-elasticity of taxes to the short-term interest rate, can $a_0^{nt,ff}$ be set to zero? I argue it cannot. This point deserves special attention since it lies at the very heart of the joint identification of monetary and fiscal policy, and has hardly been dealt with by the literature. It is therefore addressed separately below. As to the corresponding parameter in the expenditure equation, $a_0^{g,ff}$, one expects it to be indeed equal to zero, since there is no obvious mechanism linking purchases of goods and services and interest rates within the quarter. However, once $a_0^{nt,ff} \neq 0$, the estimation of $a_0^{g,ff}$ comes at no additional cost. Hence I estimate this coefficient rather than impose a zero restriction, in order to have exact identification (see Section 3.5). Note further that I allow either the structural innovation to net taxes to enter the equation for g_t, or the structural innovation to expenditure to enter the equation for nt_t (borrowing from Blanchard and Perotti). It makes sense to do so because when setting fiscal policy, government takes into consideration both sides of the budget. Identification of the respective parameters ($b_0^{g,nt}$ and $b_0^{nt,g}$) requires that one of them is set to zero or, equivalently, that net taxes and spending are ordered one after the other. Given that such an identification restriction is arbitrary, the results have to be checked under both possibilities.

The coefficients in $\mathbf{a}^g$ and $\mathbf{a}^{nt}$ will reflect any systematic response of government to macroeconomic developments - the fiscal policy rule, the lagged automatic reaction to the economy, and the persistence in budget variables brought about by the way fiscal policy is set (since the government budget and tax laws are not designed from scratch each year).[6] Non-systematic

[6] Here it is interesting to draw a parallel with monetary policy rules based on interest rate targeting, in which the Federal Reserve is, in principle, freer to set the interest rate at a given level. Nevertheless, the literature has

policy is captured by the structural fiscal shocks (e_t^g and e_t^{nt}) whose effects one endeavours to trace using the SVAR methodology.

Equations (1) and (2) are supposed to capture fiscal policy rules. Literature on this issue for the US such as Bohn (1998) and, more recently, Favero and Giavazzi (2007) argued that fiscal authorities have acted according to a government debt stabilization motive besides an output stabilization one. I did not take debt on board in the system, nevertheless. The reason is that the fiscal actions to cope with growing debt or protracted deficits approximately qualify as exogenous, for they are unrelated to current economic developments. It is, thus, acceptable that they are part of the shocks that will be used to measure the macroeconomic impact of fiscal policy. Note that such debt stabilization motive can be distinguished from the short-term interaction between the sides of the budget, say, when taxes are raised simultaneously with measures that increase spending. In this case there may be endogeneity, and the current and lagged values of net taxes and expenditure in equations (1) and (2) ensure that the estimated shocks will not be «polluted» by it. Note that the evidence as to whether debt enters significantly the fiscal equations is anyway weak. Estimating the reduced-form of the system with lags of the variables in $\mathbf{x}_t$ and the lagged debt to GDP ratio (lags 1 to 4 in turn), the latter regressor was not significant at standard levels in the spending and net tax equations (though the coefficient signs were the expected ones, that is, negative and positive respectively). My reading of these results is that fiscal variables may have responded to government debt mostly in an nonlinear fashion: for example, corrective action was triggered only upon the cumulative imbalance reaching a certain threshold (as in the period of sharp growth in the government debt to GDP ratio, from 1982 to 1995).

Equation (3) is the monetary policy rule and builds on well known literature showing that (i) the federal funds rate provides a good measure of the monetary policy instrument, and (ii) the rule can be modelled as the federal funds rate responding to output gap and to the deviation

assumed that the Fed smooths the changes in interest rates, implying that the rule includes lags of the policy variable (see, for instance, Clarida et al. (2000)). In the case of fiscal policy there are even more reasons to follow such a specification.

of inflation from a target (see e.g. Bernanke and Blinder (1992), Taylor (1993) and Christiano et al. (1999)). In this context it is common to assume that monetary authorities observe the developments in activity and inflation and react accordingly within the quarter, whereas GDP and inflation are slow-moving variables that respond with a certain delay to changes in the interest rates. I follow this assumption.[7] A systematic response of monetary authorities to contemporaneous fiscal developments is ruled out, that is, the current values of government budget variables do not enter the monetary policy rule. As it is well known, monetary policy VARs usually include a commodity price indicator in order to eliminate the so-called «price puzzle». I do not follow this practice because, on the one hand, the issue matters essentially for the impact on inflation, while the focus here is a narrow one, on activity. Moreover, since estimation is based on short time periods, it is important to keep the system as small as possible.

Consider, finally, equations (4) and (5). I do not identify non-policy innovations, and these equations may be seen as solved-out versions for output and prices of the IS and aggregate supply relationships. Since current fiscal variables enter the former relationship, they will enter both equations as well. Moreover, the disturbances w_t^y and w_t^p will be correlated, and a function of the underlying structural private aggregate spending and aggregate supply innovations.[8]

3.2 The semi-elasticity of net taxes to the short-term rate

I address first a preliminary issue concerning the definition of net taxes which has a direct implication for the way this variable responds to the interest rate. Net taxes are equal to taxes minus transfers and the latter can be computed either *including* or *excluding* interest paid (there are examples of both treatments in the literature). The first definition implicitly assumes that the fiscal structural shocks originate in the full budget, and the second one that they originate in

[7] To check the pratical implications of this assumption, I experimented with ff_t ordered before y_t and p_t as well. Switching the ordering does not matter much for the estimated parameters in the fiscal equations, nor for the effects of fiscal innovations on output over time. It matters for the effects of monetary policy shocks on GDP, in particular, in the initial quarters (this point is analysed in Christiano et al. (1999)). One gets the counter-intuitive result that a tightening in monetary policy causes a *positive* initial reaction on GDP.

[8] Let the contemporaneous part of the IS curve be given by $y_t = fiscal\ variables + \alpha p_t + \varepsilon_t^d$ and aggregate supply by $y_t = \beta p_t + \varepsilon_t^s$. The respective structural innovations are ε_t^d and ε_t^s. Equation (4) obtains solving out this system for y_t and (5) solving it out for p_t.

the primary budget. I argue that the latter is the appropriate definition. SVARs are supposed to identify and trace the effects of discretionary non-systematic fiscal policy. However, the direct determinants of interest outlays are the interest rates and the stock of debt and not (except in very particular cases) discretionary fiscal policy actions. In other words, the structural fiscal innovations do not enter an equation (actually, rather an identity) explaining government interest outlays. From the point of view of empirical work, sticking to the primary budget implies that the econometrician has to deal with only one channel through which the unexpected movements in interest rates may impact movements in net taxes - the tax base - ruling out an additional impact via the interest bill. Thus the precise issue is whether $a_0^{nt,ff}$ can be set to zero, when net taxes are defined *without* considering interest paid, as in this paper.

The correlation between the residuals of the reduced-form equations for net taxes and the funds rate is around 0.19 and 0.42, respectively, in the first and second subsamples. It is thus reasonably high. Naturally that correlation is partly caused by a common response of the two variables to the business cycle, in the first case reflecting the action of the automatic stabilizers, in the second one due to the action of the Federal Reserve (and a similar argument applies to inflation). Nevertheless, the preliminary evidence is clearly against setting $a_0^{nt,ff}$ to zero. Note also that the opposite causality - a contemporaneous response of monetary policy to fiscal variables - seems less plausible and should imply an important correlation between the reduced-form residuals of federal funds and expenditure equations. The latter is however negligible (0.04 and -0.03 in the first and second subsamples).

3.3 Assumptions regarding the low-frequency properties of the data

Although the analysis in this paper is confined to the short-term effects of policies and does not rely on long-run identification restrictions, the sample spans over 50 years and, hence, some discussion of the assumptions about the low-frequency properties of the data is in order. There is no point in entering here the debate about unit root behavior versus stationarity around a deterministic linear trend of GDP for the US. In addition, both hypotheses might not be fully

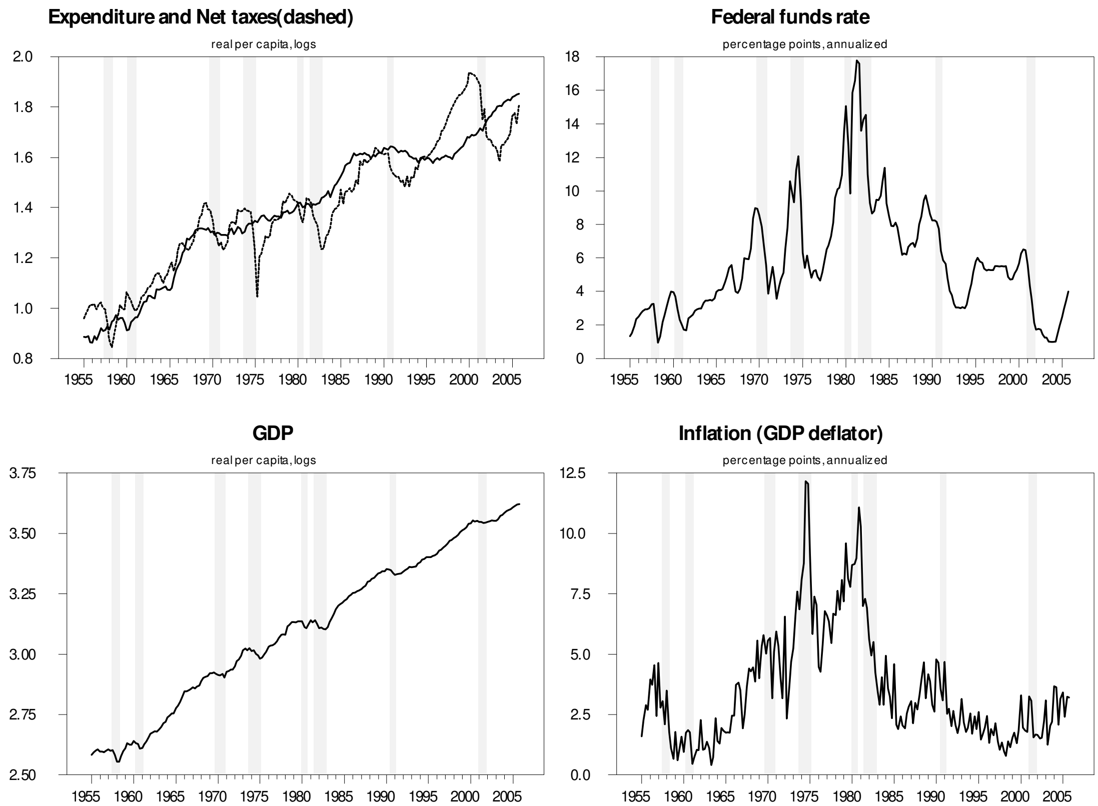

Figure 1: Macroeconomic variables, 1955:1-2005:4, and NBER recession dates

adequate as they do not accommodate the observed decline in the long-run GDP growth over the last decades (as noted by Blanchard (1989)). Note that the evolution of the fiscal variables throughout the sample (Figure 1) is also well characterized by a decreasing long-run growth rate. Therefore, I formalize the trends in GDP and budget variables as deterministic, but allow for a quadratic term in order to capture the change in average growth over time. This specification was used in Blanchard and Perotti (2002) and is also one of the measures of the output gap considered by Clarida et al. (2000) in the estimation of a monetary policy rule for the US. As the system also includes an interest rate and inflation for which it does not make sense to assume a trending behavior, the deterministic trends in GDP and fiscal variables are removed by OLS regression prior to estimation of the system.

If the time-series properties of GDP are controversial, those of the short-term interest rate and inflation are hardly less. Stationarity of both series follows from a great deal of theoretical models that rationalize the use of monetary policy rules. Visual inspection of the respective charts in Figure 1, however, indicates a long-run path difficult to square with stationarity around a single long-run mean - a driftless random walk appearing more appropriate. However, alternative stationary characterizations would be equally plausible, such as around a long-run mean with an upward shift in the period from mid-seventies to mid-eighties. This assumption could be rationalized as a temporary increase in expected inflation implicit in the monetary policy rule, brought about by the inflationary process in the seventies. Nevertheless, as it would have some degree of arbitrariness - in particular, as to the moment of the upward shift in the mean - a conventional specification was chosen, including only a constant.

3.4 Calibration of elasticities of the government budget items

Before one looks into the identification and estimation of the system, it is appropriate to consider the possibility of calibrating some of the parameters in the net tax and expenditure equations on the basis of institutional information, following Blanchard and Perotti (2002). They relied on the framework developed by the OECD (Giorno et al. (1995), updated in van den Noord (2000) and Girouard and André (2005)) to compute the elasticity of personal income taxes to GDP. In Appendix A, I extend this by deriving analytical expressions for the elasticity of personal income taxes to prices and the semi-elasticity to the short-term interest rate. As discussed there, however, this latter parameter cannot be calibrated on the basis of the data made available by the OECD and remaining assumptions. I give in the appendix, in addition, the details underlying the calculation of the elasticities of the remaining taxes and transfers to activity and prices. Summing up, one is able to obtain $a_0^{nt,y}$, $a_0^{nt,p}$ and $a_0^{g,p}$ from non-sample information, but not $a_0^{nt,ff}$ which has to be estimated along with the other elements of the matrix of the contemporaneous coefficients.

Note that Perotti (2004) studied the effects of fiscal policy in a system with the interest rate and prices, but imposing a zero semi-elasticity of net taxes to the sort-term interest rate (and also using assumptions different from the ones here in order to derive the responses to prices). This simplifies the identification task but, as seen, is not adequate in the US context (Perotti's study deals with the US in the framework of a group of OECD countries).[9]

3.5 Identification and estimation

It is useful to write down the matrices with the contemporaneous structural coefficients, denoted by $\mathbf{A}_0$ and $\mathbf{B}_0$:

$$\mathbf{A}_0 = \begin{bmatrix} 1 & 0 & -a_0^{g,ff} & 0 & -(a_0^{g,p}) \\ 0 & 1 & -a_0^{nt,ff} & -(a_0^{nt,y}) & -(a_0^{nt,p}) \\ 0 & 0 & 1 & -a_0^{ff,y} & -a_0^{ff,p} \\ -a_0^{y,g} & -a_0^{y,nt} & 0 & 1 & 0 \\ -a_0^{p,g} & -a_0^{p,nt} & 0 & 0 & 1 \end{bmatrix} \mathbf{B}_0 = \begin{bmatrix} 1 & b_0^{g,nt} & 0 & 0 & 0 \\ b_0^{nt,g} & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \qquad (6)$$

in which the calibrated parameters are in parentheses and, I recall, it is assumed that either $b_0^{nt,g} = 0$ or $b_0^{g,nt} = 0$.

I estimated first the reduced-form system. There are 15 independent moments in the reduced-form covariance matrix and, excluding the information needed to obtain the 5 variances of the disturbances plus the covariance between w_t^y and w_t^p, one is left with 9 usable moments. Given the restrictions I impose on the contemporaneous coefficients and as I am able to compute $a_0^{nt,y}$, $a_0^{nt,p}$ and $a_0^{g,p}$ on the basis of non-sample information, there are 9 parameters to estimate. Therefore, the order condition is satisfied for exact identification. Contrary to Blanchard and Perotti (2002), the system cannot be estimated by instrumental variables (this would be, for instance, possible if the federal funds rate was predetermined with respect to all the other

[9] Canzoneri et al. (2002) also consider a system with the federal funds rate and prices, but concentrated on modelling the impact of the short-term rate on government interest outlays. The definition of variables adopted here rules out this sort of co-movement, as already explained.

variables). I estimated the decomposition by maximum likelihood, but note that the case at hand differs slightly from standard structural decompositions in that the covariance matrix of the system 1 to 5 is not diagonal (as the covariance between w_t^y and w_t^p is nonzero).[10] Also note that the information about the calibrated parameters is incorporated into $\mathbf{A}_0$ and $\mathbf{B}_0$ as average values over the subsamples.

4 The destabilizing role of exogenous policies

Variance decompositions are the natural starting point for assessing the effect of exogenous policy disturbances on the volatility of output. Table 1 shows the breakdown of the variance of the n-quarter ahead forecast error for output into the proportion accounted for by each of the three identified policy disturbances, and the macroeconomic disturbances as a whole.[11] I present the point estimates and one-standard error bands in brackets computed on the basis of Monte Carlo simulations[12], separately for the subsamples 1955:1-1979:4 and 1980:1-2005:4. As memo items are shown the point estimate for the long-run error variance, and the respective decomposition in absolute terms. This quantity is of interest because it theoretically matches the unconditional variance (whose estimate is also shown), helping explain the change between periods. The figures for the two statistics differ in practice since, for example, they are small-sample estimates and the first one assumes an autoregressive representation that does not exactly hold. Nevertheless, the unconditional variance of output is well approximated, and the procedure is informative

[10] This feature complicates the maximization process: as a strategy I took as initial values for the parameters in $\mathbf{A}_0$ and $\mathbf{B}_0$ the estimates obtained when a diagonal covariance matrix is imposed (i.e. corresponding to an overidentified system). Then, I reestimated allowing a non-diagonal covariance matrix and searching over a grid of initial values for the variances. The final results were very close both to the ones in the overidentification case and also to the ones where exact identification is obtained in a standard way, by imposing an arbitrary ordering between prices and output (i.e. if eiher prices entered equation (4) or output entered equation (5)).

[11] The latter is equal to the contribution associated with the variances and covariance of the disturbances in output and price equations. As it turns out, the role of the covariance term is very small in the case of GDP. It represents around ± 1 to ± 2 percent of the total long-run forecast error variance in both subsamples.

[12] The simulations were computed as follows. The OLS estimates of the reduced-form coefficients and covariance matrix were used to draw for the vector of coefficients (assuming normality). The covariance matrix and its structural factorization, obtained as described in Section 3.5, remain unchanged throughout. I found that a sizeable proportion of the replications (for instance, almost one half in the first sample) implied non-stationary systems, for which the long-run forecast error is not finite. I disregarded them. The one-standard error bands are computed as the percentiles 0.16 and 0.84 of the simulated distribution on the basis of 1000 draws.

about how it was accounted for by the source disturbances in each of the subsamples considered.

Table 1: Variance decomposition for output

	Sample 1955-1979				Sample 1980-2005			
Proportion	Policy sh.			Macroec.	Policy sh.			Macroec.
due to	e^g	e^{nt}	e^{ff}	sh.	e^g	e^{nt}	e^{ff}	sh.
1Q ahead	12.5	10.0	0.3	77.2	4.1	0.5	0.2	95.2
4Q ahead	12.4	16.0	2.2	69.4	2.5	1.6	2.5	93.4
	(7.5,18.8)	(9.2,21.9)	(0.6,6.7)	(59.7,75.7)	(1.0,5.6)	(0.5,4.8)	(1.0,6.2)	(85.4,95.1)
12Q ahead	21.1	19.5	8.7	50.6	5.7	2.9	1.9	89.6
	(10.0,30.8)	(7.5,27.6)	(2.8,26.5)	(35.5,60.8)	(1.8,14.0)	(1.4,12.4)	(1.4,7.1)	(71.0,90.9)
Long-run	23.9	19.9	7.2	49.0	5.7	4.2	3.8	86.3
	(9.7,32.7)	(6.1,26.2)	(4.8,28.5)	(33.2,60.6)	(5.4,25.2)	(3.2,17.7)	(2.5,10.3)	(54.9,81.6)
Memo:								
uncd. var.		*13.3*				*4.7*		
long-run FEV		*13.0*				*3.4*		
decomp.	*3.1*	*2.6*	*0.9*	*6.4*	*0.2*	*0.1*	*0.1*	*3.0*
shock var.	*1.7*	*5.1*	*0.3*		*0.9*	*4.9*	*0.5*	

Notes: Rows 1st to 4th: percentage of the forecast error variance for GDP accounted for by structural policy disturbances (government spending, net taxes and funds rate) and macroeconomic disturbances, point estimates with one-standard error bands in parenthesis. Rows 5th: unconditional variance of output. Row 6th and 7th: long-run forecast error variance and absolute decomposition by disturbance (point estimates only). Row 8th: standard error of policy shocks.

According to the point estimates, in the first half of the sample policy shocks jointly accounted for slightly more than half of long-run movements in output gap, not far from the corresponding figure of 44 per cent presented in Blanchard and Watson (1984) (using a sample from 47:1 to 82:4). In the period 1980-2005, in contrast, only around 15 percent of long-run GDP variance is attributable to them. Such point estimates in the second half of the sample are however close to the lower limit of the confidence for the policy disturbances and beyond the upper limit for the macroeconomic ones. Hence, this appears to overstate somewhat the loss of importance of the policy disturbances over time. If one takes instead the average of the simulated distributions (not shown), the share of long-run variance becomes about 1/3 and 2/3 for policy and non-policy disturbances, respectively, in the post-1980 period, against 1/2 for each group in the pre-1980 years. These figures still support a reduction in the relative role of exogenous policies as a source of output volatility in recent decades.

As said, the point estimate of the long-term forecast error variance mimics well the unconditional variance of output, including its well known decline in recent decades (note that the 2008-09 recession is beyond my sample period). That indicator goes down from 13.3 in the period 1955:1-1979:4 to 4.7 in 1980:1-2005:4, the phenomenon known as the great moderation.[13] Looking at the decomposition of the long-run variance in *absolute terms*, there is a generalized fall of the contribution across all disturbances in the post-1980 years. Such movement was sharper in the case of policy shocks leading to their mentioned loss of importance vis-a-vis their macroeconomic counterparts. On balance, evidence in Table 1 thus indicates that more than half of the decline in output volatility can ultimately be ascribed to the effect of exogenous policies.

In order to explore this result further, note that the contribution to a variable's variance of primary shocks depends both on the own variance and the impact on that variable (i.e. shock propagation). Over the two subsamples, the variance of policy shocks (last line in Table 1) remained broadly stable for net taxes, went down by about 50 percent for spending and up by a similar percentage for the federal funds rate. It is worth noting that the results I get for this last variable hinge on the inclusion of the early eighties in the second subsample, corresponding to the Volcker desinflation period, characterized by high volatility of the instrument and estimated shocks. In fact, when the second subsample is restricted to 1982:4-2005:5, the variance of monetary policy the disturbances I get is around 0.1, implying a fall of 60 percent in comparison with the pre-1980 period. In general these figures indicate that improved exogenous monetary and fiscal (as far as spending is concerned) policies played some role in the decline of output variance.[14] Nevertheless, the results also suggest a dampening of the effect of policy shocks on GDP not only in the case of net taxes but, given the magnitude of the decrease in the absolute

[13]Recall that the paper uses detrended log real and *per capita* output. Other studies though using alternative volatility measures - for instance, defined on the basis of growth rates - and slightly different sample periods present reductions in the range from 40 to 50 percent in terms of standard deviation (see Ahmed et al. (2004)) which are similar to the one I get.

[14]In what concerns government expenditure shocks, one may conjecture that the smaller deviation of pay updates from average inflation in the more recent period (see Section 2) contributed importantly for that reduced volatility.

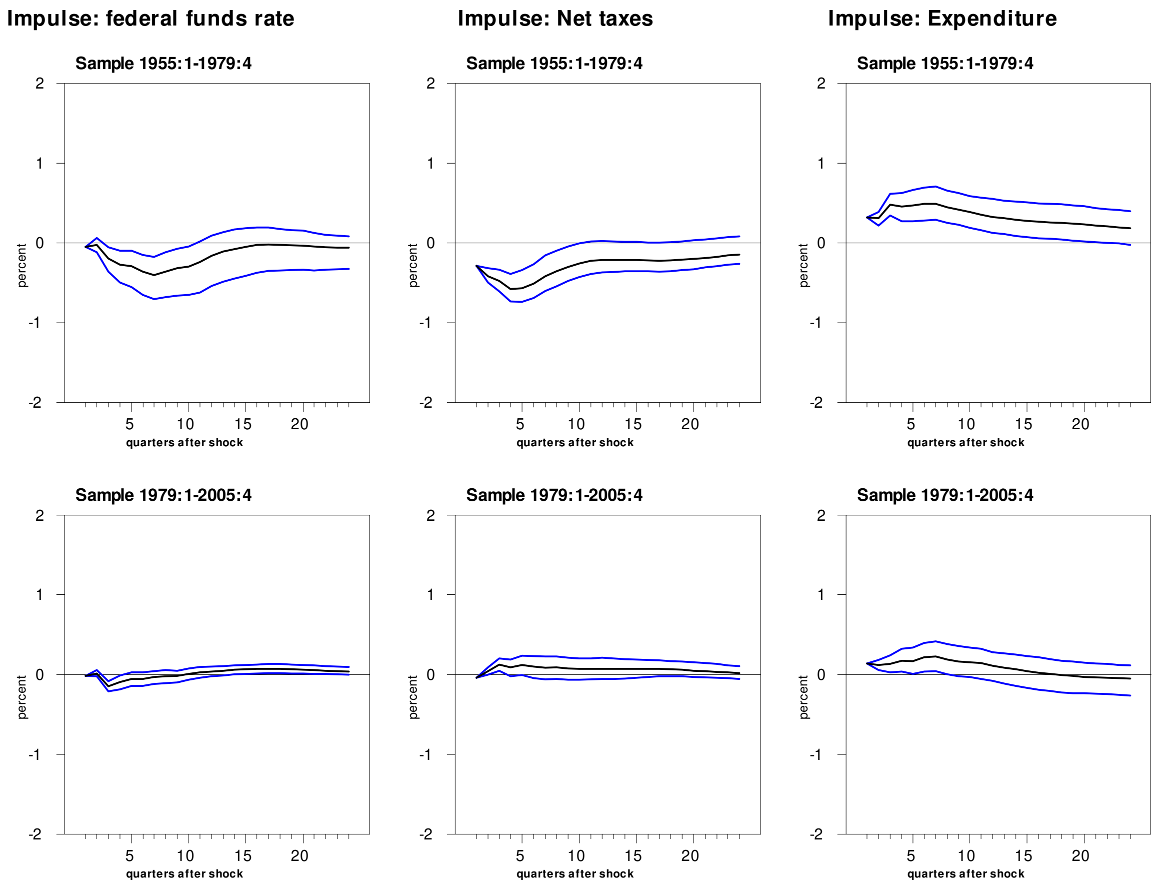

Figure 2: Impact of policy shocks on ouput

contributions documented in Table 1, also in the case of the federal funds rate and spending.

Figure 2 depicts the effects of policy shocks of the *same* size in both subsamples (equal to the standard error in the first one) on output: point estimates and one-standard error confidence bands computed using the same methodology as for the variance decompositions. The charts show a marked subsample sensitivity with respect to the impact of exogenous fiscal policy on real activity. In the pre-1980 period the evidence is consistent with the Keynesian prior.[15] That

[15]It can also be reconciled with neoclassical models, since a distinction between macro theories could only be made by considering the effects on output components. This is not the objective of the study. Note, however, that the definition of fiscal variables on the revenue side is more suited for investigating the effects of fiscal policy in a Keynesian framework.

impact becomes much smaller in the recent decades for expenditure, while for net taxes there is even a perverse effect on output.

The impact multiplier of spending shocks on output in the first subsample is significant and stands at 1.3. It builds up subsequently to a peak multiplier around 2.0 reached around the third quarter. In the post-1980 years, in contrast, the corresponding peak impact figure is 1.0 only and the response stands overall on the brink of non-significance. Structural net tax innovations trigger a fall of output before 1980, the multiplier being equal to -0.7 on impact and -1.4 at trough (attained three quarters out). Note that the magnitude of the response depicted in Figure 2 is nevertheless similar to that for spending shocks, because the size of net tax shocks in currency is about twice larger. When the estimation period starts in 1980, the point estimate changes to a positive very small effect on output (maximum impact equal to 0.4), albeit barely significant.

Such break in the effectiveness of exogenous fiscal policy is in line with the evidence presented in Perotti (2004) (also as regards the reversion of the sign of the impact of net taxes in recent decades) who considered two subsamples approximately coinciding with mine: 1960:1-1979:4 and 1980:1-2001:4. A well known earlier study, Blanchard and Perotti (2002), obtained relative large Keynesian effects on the two sides of the budget using data from 1960:1 to 1997:4. The specification they follow has important differences in comparison to the one followed here. For instance, it does not control for the monetary policy variable (nor for prices) and this may amplify the depressing effects of net tax shocks.[16] Nonetheless, the measured effectiveness of fiscal policy seems to depend more on the sample period than on the inclusion of the monetary policy instrument in the system. In particular, Blanchard and Perotti's sample does not comprise the years between end-1990s and mid-2000s, and their inclusion contributes to the measured decrease in fiscal policy effectiveness. For example, when I take the full sample but ending in 1997 instead of 2005, the spending multiplier goes down from 1.9 to 1.3. More on the time profile of policy effectiveness is given in Section 6.

[16] If the funds rate is omitted from net tax equation and that variable enters with a positive sign in this equation, net tax shocks will respond positively to the funds rate.

There is also a weakening of the impact of exogenous monetary policy in recent decades. In the pre-1980 sample, the dynamics of GDP take more time to build up following monetary policy shocks, by comparison with their fiscal counterparts. I compute an indicator of relative policy effectiveness (analogous to the fiscal multiplier). The maximum impact on output is attained about seven quarters out and stands at about 0.7 percent per p.p. of change in the funds rate. In the second subsample, the profile of the response changes in that the peak impact is reached quicker. The relative effectiveness goes down to less than half of the figure for the years prior to 1980. Such findings are consistent with those presented elsewhere (for instance, Bovin and Giannoni (2006))

Different explanations have been put forward for the lost of influence of exogenous policies on output which, for the purposes of this paper, is useful to divide into two groups. The first one includes explanations coming from the behavior of the private sector, say, financial innovation may have allowed households and firms to protect themselves better against fluctuations in interest rates and budget aggregates. The second group includes explanations related to the conduct of *endogenous* policies. For instance, it has been argued that the weakening of the effect of fiscal policy shocks stems from the more powerful stabilizing role of monetary policy in recent decades. Such explanation has been put forward also to justify the smaller impact of monetary policy shocks. Similarly, if automatic stabilizers had become more effective in the post-1980 period, this would mitigate the effect of exogenous policies. In the subsequent sections, some evidence bearing on this second type of explanations is presented and does not favour it. The reaction of the federal funds rate following budget shocks (Section 5.3) is not consistent with a stronger dampening impact in the second subsample. At the same time, the counterfactual simulations carried out in the last part of the paper point to a smaller stabilizing effect of fiscal policy (the results for monetary policy being not informative).

In comparison to previous work dealing with the great moderation, the findings here presented are novel in one respect - the role of exogenous fiscal policy in the moderation of GDP fluctuations. This possibility has been generally overlooked as studies centered on monetary side as far as policy explanations for the phenomenon were concerned.[17] Actually part of what these studies assigned to good luck may be accounted for by fiscal shocks (whose effect is captured by the general demand shock in case of omission).

5 Some aspects about the behavior of monetary and fiscal policies

5.1 Responsiveness to the economy

This section deals with aspects concerning the behavior of monetary and fiscal policy that can be inferred still using standard VAR tools. The first one is the responsiveness of endogenous policies to economic developments. One way to assess this is by looking at the joint contribution of macroeconomic disturbances to the variance of the error in forecasting the policy variables. This is shown in Table 2. In order to compare the figures, before and after 1980, I present as previously the long-run forecast error and absolute contributions, as well as the unconditional variance. Given that, as said, the behavior of the funds rate was markedly different at the beginning of the eighties in comparison to subsequently, I also present the estimates excluding the period 1982:4-2005:4 in square brackets.

Subsample sensitivity questions apart, there is a clear difference between the role of non-policy disturbances for the fluctuations in net taxes and spending. They explain about 1/2 of the long-run variation in the first case, but only around 1/4 in the second (this latter figure is much smaller in the point estimate which is however close to the lower limit of the confidence band). A great deal of movements in net taxes are thus endogenous reflecting the reaction of both automatic and discretionary policies to output. While our methodology does not allow to distinguish between them, analyses typically indicate a much more important role of automatic

[17] An exception in this regard is Stock and Watson (2002) who in one of their exercises considered the role of fiscal shocks but concluded that they had played a negligible role. The approach they follow differs from the one here in that they take directly the structural shocks, say, monetary, fiscal, and so on from different studies. These shocks are not ortogonal by construction and cannot be used to decompose the variance of output as I do here.

responses, and the difference vis-a-vis the behavior of spending is consistent with this conclusion. In fact, own innovations to government expenditure are the most important source for the respective variance decomposition. Most movements in it pursued policy goals that cannot be traced back - and hence are exogenous - to macroeconomic conditions. Among these goals feature, as alluded to in Section 2, national security, expenditure restraint and wage comparability with the private sector. Finally, the important endogenous content of the monetary policy instrument reflects the conduct of stabilization actions by the Federal Reserve.

Table 2: Variance of policy variables accounted for by macroeconomic shocks

	Sample 1955-1979			Sample 1980-2005		
Proportion	Exp.	Net taxes	Fed. funds	Exp.	Net taxes	Fed. funds
1Q ahead	3.3	47.9	3.7	3.8	27.5	15.0 [11.8]
4Q ahead	5.9	70.3	39.8	4.7	53.7	73.6 [49.4]
	(3.6,12.5)	(62.0,74.6)	(30.3,47.9)	(3.2,10.4)	(44.5,60.4)	(66.9,76.2)
12Q ahead	16.8	52.1	56.2	8.2	60.3	84.1 [53.8]
	(10.7,30.7)	(39.5,60.3)	(38.2,64.9)	(5.1,22.4)	(43.0,67.8)	(67.5,84.7)
Long-run	27.7	54.9	61.6	12.2	47.8	78.3 [39.0]
	(18.6,47.0)	(37.9,61.6)	(35.6,64.8)	(10.4,37.9)	(30.2,58.7)	(43.4,76.8)
Memo:						
uncd. var.	*23.4*	*60.9*	*7.2*	*27.7*	*97.1*	*14.0 [6.2]*
long-run FEV	*27.5*	*79.8*	*12.8*	*34.1*	*88.1*	*7.9 [4.7]*
macroec. sh.	*7.6*	*43.8*	*7.9*	*3.9*	*42.1*	*6.1 [1.8]*
var. w_t^y		*1.2*			*0.3 [0.2]*	
var. w_t^p		*0.9*			*0.5 [0.4]*	

Notes: Rows 1st to 4th: percentage of the forecast error variance for policy variables accounted for by macroeconomic disturbances, point estimates with one-standard error bands in parenthesis. Rows 5th: unconditional variance of expenditure, net taxes and the federal funds rate. Row 6th and 7th: long-run forecast error variance and absolute contribution (point estimates only). Rows 8th and 9th: variance of each macroeconomic disturbance. In square brackets are figures computed restricting the second subsample to the period 1982:4-2005:4.

The proportion of the long-run variance of net taxes accounted for by the non-policy shocks remained broadly stable between the pre- and post-1980 periods. This also holds for the contribution measured in absolute terms. Note that there was a large rise of the unconditional variance which the statistic computed on the basis of the long-run forecast error does not fully replicate. In any case, the variance of the macroeconomic disturbances went down considerably between the two periods, as shown in the Table, particularly that of GDP which accounts for the bulk of the long run net tax fluctuations.[18] Hence, an increase in responsiveness has most likely occurred. The question arises whether this is accounted for by automatic or discretionary responses. Auerbach (2002) studied the sensitivity of economic stabilizers to the business cycle concluded that it has fluctuated over time but without a defined trend, being roughly stable on average from one subsample to the other. The results I get are thus likely to be accounted for by discretionary responses, and match the evidence in Taylor (2000). This may be seen as surprising since legislated tax changes responding to cyclical developments were approximately confined to the period covered by the first subsample (see, for instance, Romer and Romer (2009b)). Bush II tax cuts build possibly the only exception of a measure whose motivation was partly anti-recessionary in the post-1980 period until the end of my sample. Several factors may nevertheless contribute to an apparent increase in the anti-cyclical nature of discretionary policy. Firstly, poor timing of countercyclical policy may blur the estimation of its pattern in the first subsample. For instance, the 1975 tax rebate and other measures enacted by the Nixon administration were felt mostly in the second quarter of the year, that is, one quarter after the trough of the recession. Secondly, in some occasions after 1979 policy was countercyclical by coincidence: Reagan tax cuts, albeit not aiming at stimulating demand, were implemented in the course of the 1981-82 recession. Thirdly, the growth of revenue in the nineties was quicker than justified by the boom, since the incomes of people in higher tax brackets rose particularly fast. This may be captured in the estimation as a countercyclical response.

I now turn to the responsiveness of the federal funds rate to economic conditions. This issue has been intensively debated and a number of studies (see, for instance, Bovin (2006) and Primiceri (2005) and references therein) have found that the reaction of monetary authorities to the economy gained strength in recent decades, although this conclusion is not fully consensual. Unfortunately the unconditional variance of the funds rate is poorly approximated in both subsamples by the procedure I have been using. In the second subsample, this is perhaps due to

[18] This quantity depends also on the change in the covariance between the two macroeconomic disturbances, as they are not ortogonal. Like for GDP, however, for net taxes the contribution of the covariance term is rather small.

the much higher volatility of the series in the early eighties (total variance decreases from 14.0 to 6.2 when the period 1980:1-1983:3 is excluded from the sample), which is not captured in the estimation with constant coefficients throughout the subsample as a whole. The approximation improves when the post-1983:3 sample is taken. Comparing these latter figures with the ones for the period prior to 1980, the contribution of macroeconomic disturbances went down both in relative and absolute terms. However, given the overestimation of the unconditional variance by the long-run forecast error in the first subsample, the fall in macroeconomic shocks' volatility and the uncertainty about precise magnitudes, it is difficult to draw conclusions in this case.

5.2 The feedback between net taxes and spending

A question of interest in this context is the mutual response between the two sides of the budget. Figures in Table 3 indicate that expenditure shocks account for a sizeable proportion of the long-run movement in net taxes, about 1/5 in the first subsample and 1/4 in the second - though the confidence bands are wide. In contrast, innovations to net taxes explain a small amount of the forecast error variance for spending in both subsamples whatever the horizon taken (this is particularly pronounced if the point estimates are taken, but also the average of the simulated distribution also indicates a share of only 10 percent).

Table 3: Variance of fiscal variables accounted for by fiscal shocks

	Sample 1955-1979				Sample 1980-2005			
Proportion	Expenditure		Net taxes		Expenditure		Net taxes	
due to	e^g	e^{nt}	e^g	e^{nt}	e^g	e^{nt}	e^g	e^{nt}
1Q ahead	96.6	0.0	10.1	41.2	94.8	0.0	0.3	66.0
4Q ahead	90.8	0.8	10.0	11.1	90.3	0.2	1.3	42.7
	(80.6,91.7)	(0.3,3.5)	(6.0,15.4)	(9.3,14.3)	(81.7,92.3)	(0.2,2.5)	(0.5,4.3)	(33.9,49.7)
12Q ahead	77.8	2.5	23.4	8.5	87.9	0.4	5.9	32.4
	(54.2,77.8)	(0.9,9.7)	(12.9,31.4)	(5.9,14.0)	(69.5,88.0)	(0.5,6.7)	(1.6,17.6)	(19.7,44.0)
Long-run	60.2	5.2	21.1	9.5	84.4	2.4	25.6	23.3
	(26.0,61.4)	(2.7,17.2)	(10.4,29.9)	(5.5,17.1)	(46.5,79.2)	(1.8,17.4)	(9.4,41.7)	(12.9,35.0)

Notes: Percentage of the forecast error variance for expenditure and net taxes accounted for by structural fiscal disturbances, point estimates with one-standard error bands in parenthesis.

In order to complement this evidence, it is useful to look at the impact of shocks to each fiscal variable on the opposite side of the budget (Figure 3). Net tax shocks have essentially no impact irrespective of the sample period. On the contrary, spending shocks trigger a significant effect in the two subsamples, but the respective sign changes from positive in the pre-1980 data to negative in the subsequent period. The magnitudes of these effects are similar and thus nearly cancel out in the full-sample responses (not shown), and the same occurs for the variance decomposition of spending. The maximum impact stands at about 1.3 percent in the first subsample and -1.0 percent in the second one. The figure for the period before 1980 matches the initial shock, which has a size of 1.3 percent as well, given that the levels of the two fiscal variables are close. The results thus capture a short-term budget-balancing movement in the pre-1980 period, but not subsequently.

These results are robust to a reversal of the ordering, i.e. to placing expenditure after taxes. When this is the case, impulse-responses hardly move in comparison to Figure 3. Similarly, net tax innovations continue to be unimportant for spending fluctuations and spending innovations to account for a sizeable part of net tax unconditional variance (almost 25 percent in each of the subsamples). What conclusions can be drawn from this? Firstly, given that the results hold under both possible orderings, there is evidence of causality going from spending to taxes and not the other way around. Secondly, the mechanism underlying the respective relationship changed from one subsample to the other. Political economy offers multiple explanations for casual links between the sides of the budget, going in both directions. The results in the first subsample indicate a tendency for changes in expenditure to lead changes in taxes. They are consistent with the main findings of older studies such as von Furstenberg et al. (1986), whose sample period roughly corresponds to my first subsample, and may reflect the way important spending programs (e.g. the interstate highway system) were financed during the fifties and sixties.

The results for the post-1980 years, causality apart, imply a negative correlation between the budget variables. This was a period of larger and long-lasting budget imbalances of both

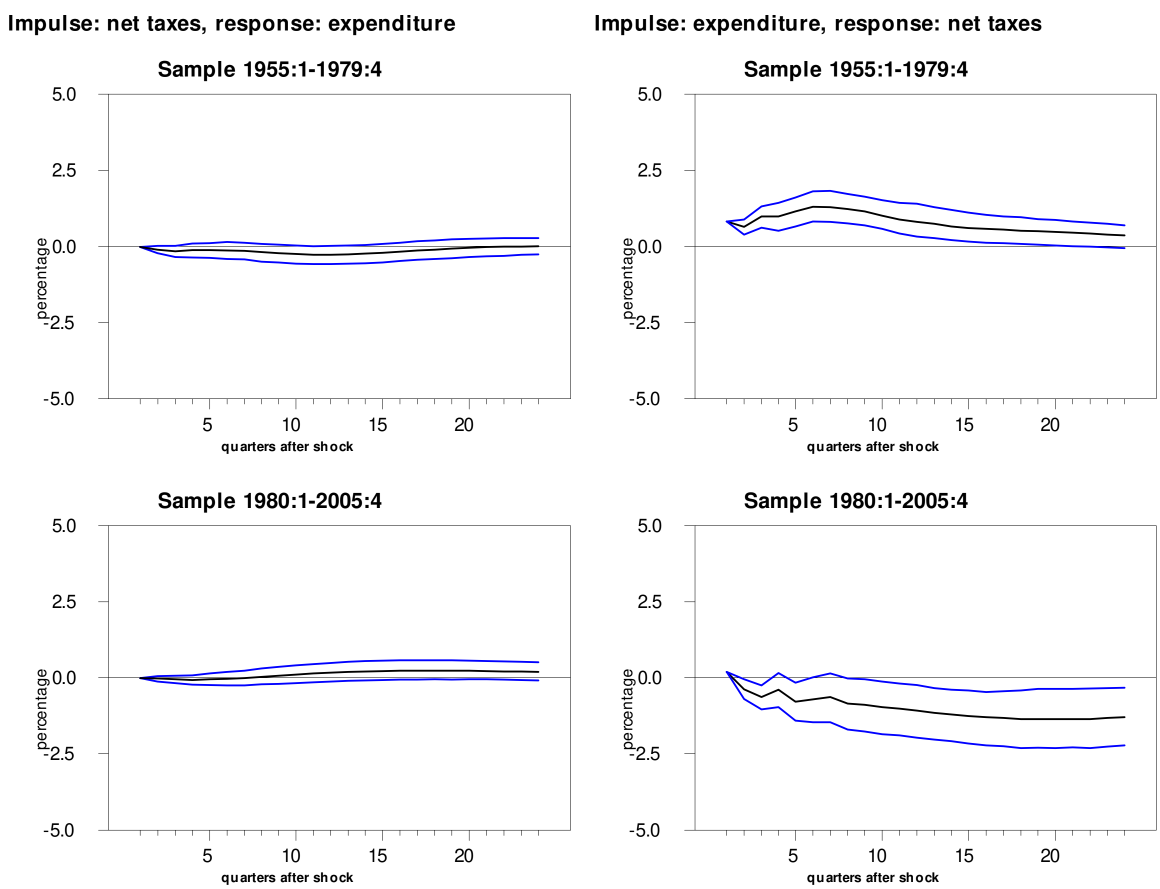

Figure 3: Responses of fiscal variables to fiscal shocks

signs, as depicted in Figure 1, characterized by debt stabilization policies (during the Clinton years and before) and «spending the surplus» policies (during the Bush II years). Both entail changes in the two sides of the budget going in the opposite direction in the short-run.[19] More difficult to explain is the direction of the causality, running from spending to taxes; this may be just chance causality given that we are looking at small samples.

A potential intertemporal link between the two sides of the budget that received attention recently is the «starve the beast hypothesis» which predicts that tax cuts lead to spending reductions. The results here are against this hypothesis for the US (consistently with Romer and Romer (2009a)).

5.3 Interaction between fiscal and monetary policies

To start with I consider the reaction of the budget variables to monetary policy shocks. Net taxes go up following a tightening in monetary policy[20] (Figure 4), a result presumably brought about by the reaction within the quarter of the tax base of the personal income tax to movements in short-term rates. Christiano et al. (1996), working with flow of funds data, reported an initial contraction of government borrowing following a tightening in monetary policy. The same phenomenon is disclosed here. In the period before 1980, the response weakens quickly and becomes negative after about 1 year as recession takes hold, in line with the depressing effect of the monetary shock on output. In the second subsample, there is simply a rapid decay toward zero. The response of expenditure in the wake of a funds rate shock, albeit small and on the brink of non-significance, has a negative sign that is difficult to interpret.

I now turn to the pattern displayed by the funds rate following government budget shocks (Figure 5). The evidence for the first subsample appears consistent with the operation of the

[19] Given that transfers are netted out against taxes in the definition of variables followed, my results cannot capture a possible feedback beween revenue and mandatory outlays. Such a feedback could particularly originate in the «pay-as-you-go» budget rules in place during the nineties, which required that changes in one of those be matched by changes in the other.

[20] The contemporaneous semi-elasticity of net taxes to the federal funds rate is estimated at 0.6 and 1.0 p.p., respectively, in the pre- and post-1980 periods. This implies that a 1 p.p. increase in the funds rate leads to a rise in net taxes from 0.5 to 1 percent, on impact.

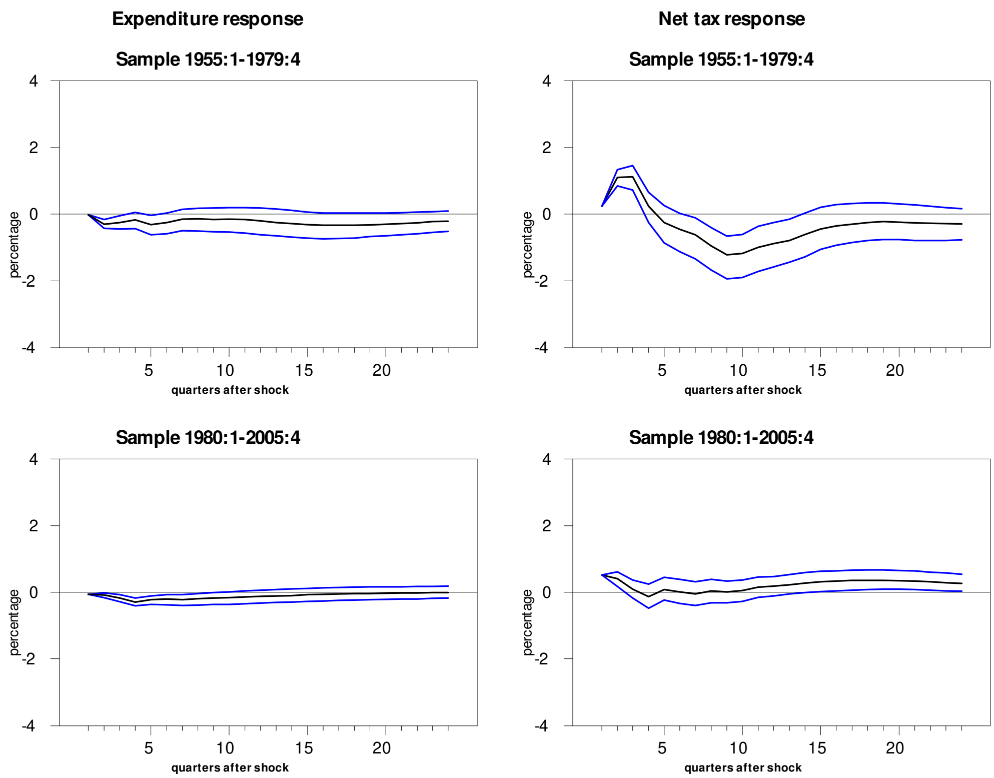

Figure 4: Responses of fiscal variables to a monetary policy shock

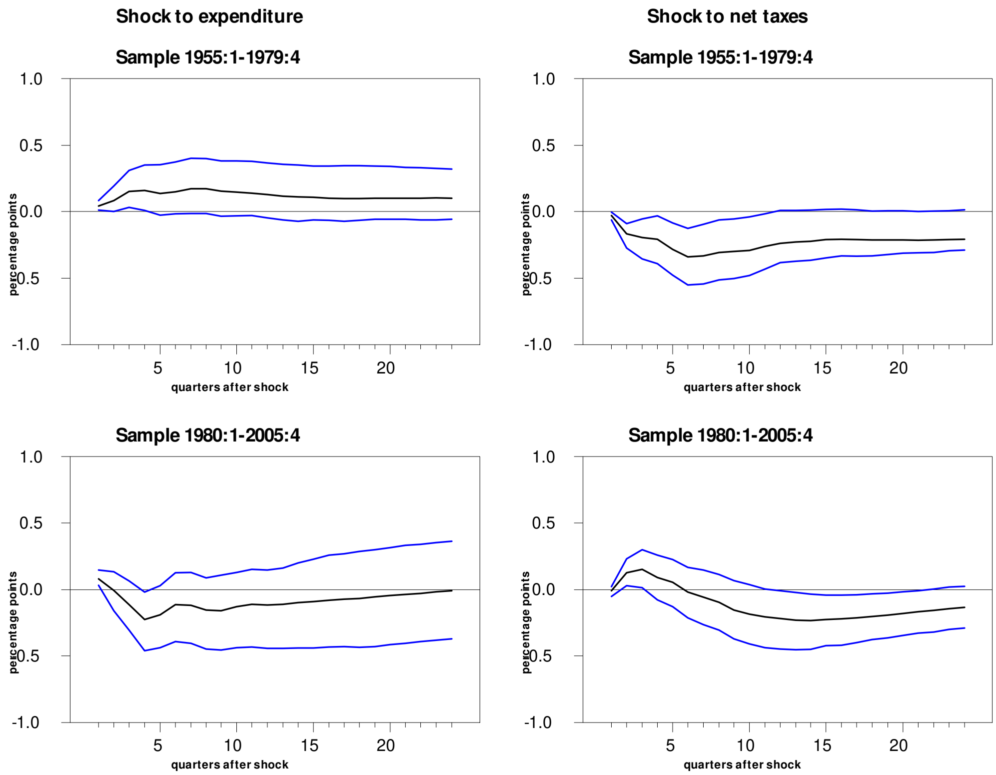

Figure 5: Response of the federal funds rate to fiscal shocks

policy rule, given that net tax and spending innovations work, respectively, as negative and positive aggregate demand shocks (also as far as the responses of inflation - not shown - are concerned). In the post-1980 years the negative trajectory of the short-term rate following spending shocks is - ruling out an accommodating behavior - difficult to explain, as those shocks are still expansionary (and the effect on inflation still positive) albeit much less effective than in the first subsample. As far as net taxes are concerned, the initial rise in the funds rate may be triggered by the perverse effect on output, while subsequently the response to declining inflation takes hold. In any case, the evidence is clearly not consistent with the weakening of fiscal shocks' effectiveness being explained by the behavior of monetary policy, for the kind of response I get would magnify their effects rather than mute them.

6 The stabilizing role of endogenous policies during contractions: a counterfactual exercise

In this section, the identified VAR estimated previously is used to shed some light on the effects of endogenous monetary and fiscal policies during postwar business cycle contractions. In order to do so, I carry out a counterfactual exercise in the spirit of Sims and Zha (1998) and Bernanke et al. (1997). The basic idea behind it is to compare the historical behavior of the variables of interest with the implied behavior when the system is simulated under counterfactual assumptions, which here concern modifications in the policy responses and paths of exogenous policy shocks. I undertake this exercise for each of the eight business cycle contractions - as given by the NBER dates - from 1955 to 2005. Analyses like the one carried out below have been pursued by previous literature using different methodologies - a particularly well-known example being Romer and Romer (1994), who nevertheless did not differentiate between endogenous and exogenous policies.

The detailed methodology of this counterfactual exercise is as follows. For each contraction and each policy variable, I simulate the system (1) to (5) under two scenarios: (i) absence of the *exogenous* component of policy and (ii) absence of the *endogenous* component of policy. The simulation period starts at the first quarter after the peak and ends at the quarter of the trough. More precisely, taking g_t as an example, exercise (i) is carried out with the parameters in all equations at their estimated values and the shocks set to their estimated paths during the simulation period, except for $\hat{e}_t^g$ which is set to zero. Exercise (ii) shuts down any systematic reaction of g_t so that during the simulation period the variable in driven only by exogenous shocks (i.e. the variable follows a random walk). This is done by setting all parameters in (1) to zero, except for the first lag of expenditure which is set to one. Otherwise the shocks to all variables, including $\hat{e}_t^g$, are set to their estimated paths and the parameters in the remaining equations are at their estimated values. As a first step I split the actual change in the policy variable into the exogenous and endogenous components. These obtain as the difference between the actual level and the simulated level of the policy variable at trough in each of the exercises. Similarly, the effect on GDP is measured as the difference between the actual level of output gap and the level implied by the simulations.

Given the evidence of structural change presented above, the exercise is carried out on the basis of 25-year rolling subsamples whose mid-points coincide roughly with the start of each recession. For the recessions taking place close to the beginning and the end of the sample, I take respectively the extreme subsamples 1955:1-1979:4 and 1980:1-2005:4 (the ones used in the preceding sections).

It is well known that the implementation of such policy analyses in a VAR context is not without caveats given the issues raised by the Lucas critique: one can argue that if endogenous policy had been different from the historical path, agents could have reacted differently. In defense of this approach, one can put forward the argument of Sims and Zha that it may provide acceptable results if the deviation of policy from its historical path is not too protracted. The episodes considered lasted on average less than 4 quarters. Beyond that issue of a more theoretical nature, another caveat to be made concerns the reliance on the identification assumptions.

6.1 Breaking down the change in policy variables into the endogenous and exogenous components

Table 4 breaks down the actual peak-to-trough change in expenditure, net taxes and the federal funds rate into the systematic and exogenous components. This is measured in percentage points also in the case of the fiscal variables, as these are taken in terms of percent deviation from trend. Note that the actual change in each policy variable is not exactly matched by the sum of the two components, because the structural shock indirectly interacts with the endogenous structure of the system after it has impacted the respective policy variable. The simulation exercise by definition does not capture such an interaction, but the approximation generally works well. There are however exceptions, for instance, the endogenous component of net taxes is overestimated in the 1960-61 recession and, to a lesser extent, in the 1973-75 and 1981-82 ones.

Table 4: Decomposition of changes in the policy variables during contractions

Business cycle contractions	Expenditure (p.p., cumulative) actual change	cf. decomp. exog.	endog.	Net taxes (p.p., cumulative) actual change	cf. decomp. exog.	endog.	Fed. funds rate (p.p., cumulative) actual change	cf. decomp. exog.	endog.
57:03-58:02	1.2	0.2	1.0	-16.0	-2.2	-12.0	-2.3	0.4	-2.9
60:02-61:01	2.9	1.3	1.5	-6.9	2.1	-16.1	-1.7	0.3	-2.0
69:04-70:04	-2.5	-1.8	-0.7	-15.8	0.8	-14.3	-3.4	-1.5	-1.7
73:04-75:01	1.8	3.1	-2.2	-18.4	2.3	-28.3	-3.7	-2.9	-1.4
80:01-80:03	-2.5	-2.6	0.5	-8.7	1.1	-9.4	-5.2	-1.2	-3.9
81:03-82:04	1.8	-0.9	3.7	-20.5	0.4	-27.4	-8.3	-1.0	-7.2
90:03-91:01	0.6	1.0	-0.6	-8.6	-1.6	-6.3	-1.7	0.0	-1.8
01:01-01:04	1.9	0.7	1.2	-12.6	-0.1	-9.5	-3.5	-1.4	-1.0

Notes: The dates indicate the peak and trough quarters. Actual change in the variable is measured as the variation peak-to-trough. The components are equal to the difference, at the trough, between the actual figure for the policy variable and the simulated figure shutting down the exogenous or the endogenous response, respectively. The simulation period starts in the first quarter after the peak. The sample periods are: 1955:1-1979:4 - 1st and 2nd recessions, 1957:3-1982:2 -3rd, 1961:3-1986:2 - 4th, 1967:3-1992:2 - 5th, 1968:3-1993:2 - 6th, 1977:3-2002:2 - 7th and 1980:1-2005:4 - 8th.

Figures in Table 4 indicate a consistent pattern of anti-recessionary endogenous movements in the federal funds rate and net taxes, in line with the evidence presented above about the responsiveness of these variables to the economy. Nothing comparable happens for government expenditure whose endogenous variation is not even uniformly countercyclical (i.e. positive). In this case the exogenous component dominates, documenting the importance of own innovations for spending fluctuations.

The exogenous component of net taxes is relatively unimportant against the overall change. It will capture, for instance, the impact of factors unrelated to the economy causing changes in social transfers (e.g. aging populations): recessions coinciding with periods of particularly high growth will tend to have smaller such components.[21] Another factor that might be present in the results - prior to 1980 - is «bracket creeping». Personal income tax brackets used to remain unchanged for some time, which happened in the years overlapping with all recessions during that

[21] Visual inspection of the chart with the growth rate of (real and per capita) transfers not related to unemployment indicates that this may have been the case of the recessions at the beginning of the 1990s and 2000s.

period (see Tax Foundation (2007)). This amounted to a tax increase even without legislation passed, and may explain the sign and particularly large size of the exogenous component in the 1973-75 recession, given its length and high level of inflation (although this phenomenon may have been also partly captured as an endogenous response to inflation).

The figures do not indicate a noticeable difference in the relative importance of the endogenous and exogenous components for the funds rate before and after 1980. In some recessions, notably the 1973-75 one, an important part of the reduction in the funds rate was captured by the exogenous component, that is, the actual loosening was larger than implied by the estimated rule. This fits in with the reading of the Fed's behavior during this episode in Romer and Romer (1994), in that, the Fed recognized at an early stage the downturn in activity but hesitated to take action (in what can be seen as acting according to the rule) due to concerns about inflation. However, in view of the unfavorable output developments, decided subsequently to cut the funds rate more sharply.

Movements in government expenditure during contractions have been much smaller than for the other variables: they averaged 1.5 standard deviations[22] against almost 5 in the case of the funds rate, and almost 6 in the case of net taxes. The most important spending item is compensation of employes which reacts negatively to current inflation (as calibrated above), given that all variables are in real terms and, one would expect, on average positively to lagged inflation. This mechanism should reduce the endogenous component in periods of rising inflation and the opposite in times of declining inflation, as it can be indeed observed for the recessions of 1973-75 and 1981-82 which coincided with such periods. Note also that great deviations from inflation of pay updates of government employees, as it used to happen until the beginning of the 80s, will be reflected on the exogenous component.

[22] Considering only the positive (i.e. countercyclical) changes.

6.2 Impact of endogenous policies on GDP

Table 5 shows the impact on GDP of the outlined pattern of endogenous changes in policy variables during contractions. The stabilizing role is computed as the output loss avoided at trough, i.e. the difference between the actual level and the simulated level without the operation of endogenous policies. By comparing this figure and the actual contraction of output (also shown), it is possible to have a measure of the relative dampening effect at that point. The counterfactual multiplier/relative effectiveness figure intends to capture the effectiveness of endogenous policies, and is obtained as the relationship between the stabilizing impact and the change in the policy variable. In parenthesis appear the indicators for the maximum impact of *exogenous* policy, as computed in Section 4, taking the same rolling samples. These are shown in order to give a rough indication about effectiveness of endogenous *vs* exogenous policies (note, however, that in the first case effectiveness is assessed at trough of the recession while, in the second case, it is measured at the point where it is highest).

Table 5: Impact of fiscal and monetary policies on output

Business cycle contractions	actual output change (p.p.)	Impact of endogenous change in:					
		Expenditure		Net taxes		Fed. funds rate	
		cf. stabil. role (p.p.)	cf. multiplier	cf. stabil. role (p.p.)	cf. multiplier	cf. stabil. role (p.p.)	cf. relative effectiv.
57:03-58:02	-6.6	0.3	1.9 (2.1)	6.1	-2.5 (-1.4)	0.3	-0.1 (-0.7)
60:02-61:01	-3.6	0.5	1.7 (2.1)	6.5	-2.0 (-1.4)	0.2	-0.1 (-0.7)
69:04-70:04	-3.6	-0.2	- (1.5)	7.2	-2.3 (-1.3)	0.8	-0.4 (-0.9)
73:04-75:01	-7.2	-0.3	- (1.1)	7.7	-1.4 (-1.1)	0.1	-0.1 (-0.7)
80:01-80:03	-3.8	0.1	1.7 (1.4)	0.7	-0.4 (-0.5)	0.2	-0.0 (-0.4)
81:03-82:04	-6.4	1.2	1.8 (1.6)	3.5	-0.7 (-0.5)	2.0	-0.3 (-0.4)
90:03-91:01	-2.9	-0.1	- (1.8)	-0.4	0.3 (0.7)	0.0	-0.0 (-0.3)
01:01-01:04	-1.8	0.1	0.7 (1.0)	-0.4	0.2 (0.3)	0.1	-0.1 (-0.3)

Notes: The dates indicate the peak and trough quarters. Actual change in output is measured as the variation peak-to-trough. The stabilizing role is equal to the difference at trough between the actual GDP level and the simulated level, shutting down the endogenous response. The multiplier/relative effectiveness indicator is the ratio between the output loss avoided and the change in policy variable; in parenthesis is shown the maximum effect of exogenous policy shocks on GDP relative to the impulse. The simulation period starts in the first quarter after the peak. The rolling sample periods are: 1955:1-1979:4 - 1st and 2nd recessions, 1957:3-1982:2 -3rd, 1961:3-1986:2 - 4th, 1967:3-1992:2 - 5th, 1968:3-1993:2 - 6th, 1977:3-2002:2 - 7th and 1980:1-2005:4 - 8th.

Taxes net of transfers played a key stabilizing role in the recessions during the sixties and seventies. This resulted from the important countercyclical movements in the variable coupled with its great effectiveness to stimulate activity. In effect, the multiplier of endogenous net taxes is estimated in the range 2.0 to 2.5 (and above that of exogenous policy) in the course of that period. The effectiveness of endogenous net taxes has weakened over time and in the last two recessions they had even small destabilizing role. Given that this variable is chiefly associated with automatic movements, it follows that not only discretionary but also automatic policy seems to have lost capacity to stimulate activity. An important caveat about these conclusions is that the last two recessions considered were particularly short and mild, and this may bias the results toward finding smaller effects of policy. In any case, there is way to check their plausibility in broad terms. The bulk of long-run GDP variance explained by macroeconomic disturbances is associated with the one in output equation (almost all in the first subsample and 90 percent in the second one). As seen in table Table 2 (last two lines), there was a reduction of about 80 percent of this disturbance's variance. If the stabilizing role of fiscal policy was indeed smaller in the second subsample, then one would expect that reduction not to be fully «passed-on» to GDP volatility, that is a smaller decrease in the absolute contribution of macroeconomic disturbances to output volatility. The figures in Table 1 indicate a fall of 50 percent, perhaps a bit more, in this quantity. While these figures are surrounded by great uncertainty, they are not inconsistent with the conclusions outlined.

The figures imply a very large dampening impact of net taxes on economic fluctuations in the sixties and seventies, around 50 percent or more. However, these values have to be seen with caution because when the negative endogenous component is overestimated - as in the 1960-61 and 1973-75 recessions - the same will happen with the mentioned impact (note that the multiplier, as a relative indicator, is not affected by this problem). At the same time, it is natural that I get figures larger than in previous studies, such as Auerbach and Feenberg (2000) and Cohen and Follete (2000)[23], because the scope of the policy measure I use is much

[23] Auerbach and Feenberg (2000) report simulations based on the NBER TAXSIM model. Cohen and Follete (2000) also present the results of simulations, using a large-scale macroeconometric model for the US (FRB/US).

broader than theirs. On the one hand, it includes transfers and state and local government taxes (these are about 40 per cent of total taxes during the sample period, mostly indirect taxes). On the other hand, it also reflects the contribution of discretionary policy. Those studies came to benchmark dampening impacts of about 8 per cent (for aggregate demand shocks).

Systematic monetary policy seems to have had a more modest stabilizing role than fiscal policy in the past, even taking into account a certain degree of overestimation of the latter's role. On average the dampening effect is estimated at around 10 percent. This appears to be due to its comparatively delayed full impact which takes more time to build up than the length of the average contraction (note that the effectiveness indicator for endogenous policy is consistently much smaller than the one for exogenous policy). In the 1981-82 recession, which was longer than average, the stabilizing role of monetary policy was more evident (this did not happen for the 1973-75 episode, but note that the endogenous variation was particularly small in the course of it). This suggests that - except for more protracted recessions - monetary policy has contributed particularly to strengthen recoveries. It is worth noting that the identification assumption that monetary policy has no impact on output within the quarter may contribute to this result. In this case, it is difficult to take out from the exercise any pattern of effectiveness of endogenous policy over time.

Figures in Table 5 indicate that government spending has played a minor role as a stabilizing tool since mid-fifties, with the exception of the 1981-82 recession. The large multiplier of endogenous policy suggests, however, that it *could* have if it had been more used for that purpose. Results also indicate that the reduction in effectiveness was less marked and more concentrated toward the end of the sample than in the case of net taxes.

7 Conclusions

In this paper an SVAR system was estimated, identifying monetary and fiscal policy disturbances. Standard SVAR tools and counterfactual simulations were used to gauge the stabilizing impact of systematic and non-systematic policies, using data from 1955 to 2005. The following main conclusions were reached:

- Policy disturbances were much less destabilizing in the post-1980 years both on the fiscal and monetary sides. This result is mainly explained by a smaller impact of those disturbances on output and, to a lesser extent, by a smaller variance of policy shocks (in the cases of the federal funds rate and government spending). The impact of exogenous policies on output has weakened in the recent decades, this trend being particularly evident for net taxes.

- Net taxes have a large endogenous content featuring a high degree of responsiveness to output, and there has been an increase in such responsiveness over time (possibly reflecting discretionary policy). In contrast, government expenditure is mostly driven by own shocks. The federal funds rate responds strongly to the economy as well, in line with the operation of the monetary policy rule. An analysis of the variation in the strength of that response over time was inconclusive.

- The main stabilizing force during the activity contractions since the beginning of the sample until the eighties were taxes net of transfers, as measured by the reduction in output foregone at the trough of recessions. However, a marked lost of effectiveness appears to have occurred in the recent period. Government spending played a small stabilizing role over the whole sample.

- Monetary policy has contributed comparatively less to offset the downturns in activity during postwar contractions, due to the comparatively slower build-up of the impact on output. This suggests a particularly important contribution to enhance growth at the initial stage of the recoveries.

8 Appendices

A Detailed computation of the contemporaneous fiscal elasticities

A.1 Personal income taxes

The derivation of theoretical expressions for the elasticity to GDP, prices and the interest rate of personal income taxes (which also applies with small changes to the elasticity of social contributions to activity and prices) is a bit more involved than for the remaining types of taxes. I assume that the personal income tax base reacts to prices, as nominal wages adjust to it to some degree, and also to the short-term interest rate, as the latter affects asset income earned by households. Each individual in the population (assumed to be equal to the labor force) earns labour income and/or asset income. Let the real personal income tax revenue be given by $T = [t((W(L,P) + A(FF))(W(L,P) + A(FF))L(Y)]/P$ where $t(.)$ is the average tax rate, W the nominal wage, A individual income on assets, P prices, L employment, Y GDP and FF the federal funds rate.[1] The nominal tax base per worker is $B = W + A$. I assume that the income on assets reacts contemporaneously only to the federal funds rate because, as regards personal interest income, the underlying stock is mostly determined by past economic conditions, while dividends are also linked to past profits.

The elasticity of real personal income tax revenue to output is given by

$$a_{PIT,Y} = \frac{\partial \ln T}{\partial \ln Y} = \frac{\partial \ln t}{\partial \ln W}\frac{\partial \ln W}{\partial \ln L}\frac{d \ln L}{d \ln Y} + \frac{\partial \ln B}{\partial \ln W}\frac{\partial \ln W}{\partial \ln L}\frac{d \ln L}{d \ln Y} + \frac{d \ln L}{d \ln Y} \tag{A1}$$
$$= a_{W,L}a_{L,Y}(a_{t,W} + s_W) + a_{L,Y},$$

[1] I assumed in the computation of the elasticities of purchases of goods and services that the wage bill in the government sector does not respond to macroeconomic developments (see below). One would have to consider a separate elasticity for government's wage bill, as a component of the tax base, to be fully consistent. I have not done so, in order to simplify matters.

where $a_{W,L}$ the elasticity of wages to employment, $a_{L,Y}$ the elasticity of employment to output, $a_{t,W}$ is the elasticity of the (average) tax rate to the wage and $s_W = \frac{W}{W+A}$ is the share of labour income in total income. Note that the expression for $a_{PIT,Y}$ appearing in OECD's work (in Giorno et al. (1995)) corresponds to the one above but with s_W is equal to 1, as they consider labor income only.

The elasticity of the real tax revenue to prices is given by

$$a_{PIT,P} = \frac{\partial \ln T}{\partial \ln P} = \frac{\partial \ln t}{\partial \ln W}\frac{\partial \ln W}{\partial \ln P} + \frac{\partial \ln B}{\partial \ln W}\frac{\partial \ln W}{\partial \ln P} - 1/4 = a_{W,P}(a_{t,W} + s_W) - 1/4, \tag{A2}$$

in which $a_{W,P}$ is the elasticity of wages to prices and the changes in prices are measured at annual rates.

The semi-elasticity of real tax revenue to the short-term interest rate is given by

$$a_{PIT,FF} = \frac{\partial \ln T}{\partial FF} = \frac{\partial \ln t}{\partial \ln A}\frac{d \ln A}{dFF} + \frac{\partial \ln B}{\partial \ln A}\frac{d \ln A}{dFF} = a_{A,FF}(a_{t,A} + s_A), \tag{A3}$$

where $a_{A,FF}$ is the semi-elasticity of asset income to the interest rate and $s_A = \frac{A}{W+A}$ is the share of asset income in total income.

The expressions above are based on the partial derivatives of the real income tax revenue with respect to each one of the variables of interest which assume, by definition, that the *other* variables in the expressions remain constant. This assumption does not raise problems because such partial effect is exactly what the contemporaneous coefficients in the structural equations are supposed to measure.[2] I now examine the assumptions underlying the computation of the elasticities of the average tax rate to the wage and asset income per worker, $a_{t,W}$ and $a_{t,A}$ (the remaining parameters are estimated by means of econometric regressions - see below). It is clear that these elasticities will not be constant throughout the wage and asset income distribution.

[2] That is, the derivative of real direct taxes with respect to Y assumes that FF and P are unchanged when Y varies. Of course, when GDP changes, the federal funds rate and prices may change as well, but this is captured by other contemporaneous coefficients than $a_0^{nt,y}$.

Nevertheless, one needs a summary measure in order to compute the figures using the expressions given above. The OECD approach copes with this, for the labor income case, by computing the average and the marginal tax rates of a representative family with certain characteristics, at different points of the wage distribution. Afterwards a weighted average of each of the two tax rates is computed on the basis of the weight of wage income at each point in total. The ratio of the two weighted averages yields the summary elasticity measure. This procedure is carried out for several years so to incorporate modifications in the tax code.

In order to describe precisely how to extend this procedure to the case of labor and asset income, and to illustrate the difficulties to compute $a_{t,A}$, I now denote *with ij* the magnitudes above evaluated at the arbitrary cohort (W^i, A^j) of the wage and individual asset income distribution, and *without ij* the corresponding aggregate magnitudes. Assuming that the elasticity to the base at a given cohort (W^i, A^j) is the same irrespective of whether there is a marginal variation in the wage or individual asset income[3], and denoting that elasticity by $a^{ij}_{t,B}$, then one can write $a^{ij}_{t,W}{=}s^{ij}_{W}a^{ij}_{t,B}$ and $a^{ij}_{t,A}{=}s^{ij}_{A}a^{ij}_{t,B}$. The corresponding aggregate elasticities are given by

$$a_{t,W}{=}\sum_i \sum_j \phi^{ij} s^{ij}_{W} a^{ij}_{t,B} \qquad \text{and} \qquad a_{t,A}{=}\sum_i \sum_j \phi^{ij} s^{ij}_{A} a^{ij}_{t,B}, \tag{A4}$$

where the ϕ^{ij}'s are the weights computed as the share of wage and asset income associated with the cohort (W^i, A^j) in total income from both sources ($\phi^{ij} = L^{ij}B^{ij}/\sum_i \sum_j L^{ij}B^{ij}$ with B^{ij} equal to $W^i + A^j$ and L^{ij} equal to the number of individuals associated with the cohort (W^i, A^j)). The computation of precise figures for $a_{t,W}$ and $a_{t,A}$ would thus require information about the distribution of (W, A) and the corresponding values for $a^{ij}_{t,B}$, for several years, which is not available.

Nevertheless, the OECD figure should provide a good basis to compute $a_{t,W}$. Note that, if $a^{ij}_{t,B}$ was constant for a given wage level W^i (i.e. it did not depend upon j because all individuals would concentrate in a given cohort A), then $a_{t,W}{=}s_W \sum_i \psi^i_W a^i_{t,B}$ would hold, with the weights

[3] This may not happen for every (W^i, A^j). For instance, if there are tax deductions applying only to labor income, say the first \$X dollars of employment income are exempt from tax, then for wage levels below \$X the marginal change in tax revenue is zero when the wage changes but positive when asset income changes.

ψ^i_W given by the share of wage income associated with the cohort W^i in total, according to the marginal distribution of W. This relationship should provide a reasonable approximation in practice, as there is a higher concentration of individuals (at lower cohorts) for individual asset income than for wages. Further, as labor income represents the bulk of personal income, the elasticities calculated considering only labor income as the tax base (as in OECD) should not be too far from $a^i_{t,B}$. By contrast, such elasticities and information about the the marginal distribution of W would not be suitable for the calibration of $a_{t,A}$.

The OECD figures correspond to $\sum_i \psi^i_W a^i_{t,B} + 1$ (as they refer to the elasticity of the tax revenue not of the tax rate) and vary considerably over time, ranging from 1.3 to 3.9 over the last three decades. The computation of aggregate figures for the shares of labor and asset income - s_W and s_A - does not raise problems since they are just the shares of wage and asset income for the economy as a whole[4] (see Appendix B for the series used). The figure for s_W ranges from 0.75 to 0.85 over the period 1955:1-2005:4.

The remaining parameters in (A1) and (A2) are computed through econometric regressions, following the method in Blanchard and Perotti (2002). Specifically, $\hat{a}_{W,L} = 0.33[\hat{t} = 4.0]$ and $\hat{a}_{W,P} = 0.09[\hat{t} = 1.6]$ are the lag 0 coefficients of a regression of log change in wages on the first lead and lags 0 to 4 of log change in employment and change in annualized inflation (sample 1955:1-2005:4).[5] Note that I take as the price variable inflation measured at annual rates. Likewise $\hat{a}_{L,Y}$ =0.68$[\hat{t} = 12.1]$ is the lag 0 coefficient of a regression of log change in employment on the first lead and lags 0 to 4 of log change in GDP. The average figures for $\hat{a}_{PIT,Y}$ and $\hat{a}_{PIT,P}$ are equal, respectively, to 1.1 and -0.09.

A.2 Social security contributions

The responses of social contributions are based on the corresponding expression for the real revenue $T = [t((W(L,P))W(L,P)L(Y)]/P$, where $t(.)$ is the average tax rate and the other

[4] As $s_W = \sum_i \sum_j \phi^{ij} s^{ij}_W$ and $s_A = \sum_i \sum_j \phi^{ij} s^{ij}_A$.

[5] One could raise the issue of simultaneity in relation to the regressions used to compute some of the parameters in (A1) and analogous expressions. I checked the results of corresponding regressions excluding the leads and using lags of the right-hand side variables as instruments and they differed by little.

variables are as above. The elasticities of real social contributions revenue to output and prices are, respectively,

$$a_{SC,Y}= \frac{\partial \ln t}{\partial \ln W}\frac{\partial \ln W}{\partial \ln L}\frac{d \ln L}{d \ln Y} + \frac{\partial \ln W}{\partial \ln L}\frac{d \ln L}{d \ln Y} + \frac{d \ln L}{d \ln Y} = a_{W,L}a_{L,Y}(a_{t,W}+1) + a_{L,Y}, \tag{A5}$$

$$a_{SC,P} = \frac{\partial \ln t}{\partial \ln W}\frac{\partial \ln W}{\partial \ln P} + \frac{\partial \ln W}{\partial \ln P} - 1/4 = a_{W,P}(1 + a_{t,W}) - 1/4. \tag{A6}$$

The average figures for $\hat{a}_{SC,Y}$ and $\hat{a}_{SC,P}$ are equal, respectively, to 0.88 and -0.17.

A.3 Corporate income taxes

The tax base of the corporate income tax, corporate profits, is supposed to react to GDP and prices. I assume that the tax is proportional (note further that the corporate income tax is recorded on an accrual basis by NIPAs, which should approximately undo the lag between the earning of profits and the payment of the tax). Therefore, real corporate income tax revenue is given by $T = tPR(Y,P)/P$, where t is the tax rate and PR are corporate profits. The elasticities of corporate income taxes to GDP and prices are, respectively,

$$a_{CIT,Y} = \frac{\partial \ln PR}{\partial \ln Y} = a_{PR,Y}, \tag{A7}$$

$$a_{CIT,P} = \frac{\partial \ln PR}{\partial \ln P} - 1 = a_{PR,P} - 1/4, \tag{A8}$$

where $a_{PR,Y}$ and $a_{PR,P}$ are the elasticities of profits to GDP and prices. These parameters were computed as the coefficients for lag 0 of a regression of the first differences of log profits on the first lead and lags 0 to 4 of the change in log GDP and the change in annualized inflation. This yielded $\hat{a}_{PR,Y} = 4.6[\hat{t} = 10.4]$ and $\hat{a}_{PR,P} = 1.8[\hat{t} = 4.7]$. Accordingly, $\hat{a}_{CIT,Y} = 4.6$ and $\hat{a}_{CIT,P} = 1.6$.

A.4 Indirect taxes

The tax base of indirect taxes is assumed to be nominal GDP and the tax to be proportional. The revenue of indirect taxes in real terms is given by $T = tY$, where t is the tax rate, implying a 1.0 elasticity to activity and a 0.0 elasticity to prices.

A.5 Transfers to households

Transfers to households are expected to only to activity mainly through unemployment insurance payments. Such payments have represented on average only about 3 percent of social benefits over the last decade, though at the beginning of the sample they represented a bit more than that, averaging 5 to10 percent. Let real transfers to households be equal to $T = (\bar{T}+UB(Y))/P$, where $\bar{T}$ is the component of transfers that does not react to activity and $UB(Y)$ is the amount of unemployment benefits. The elasticity of transfers to households to GDP is approximately (ignoring the term related to the response of labor force to the business cycle) given by

$$a_{TH,Y} = s_{UB}\frac{d\ln UB}{d\ln Y} = s_{UB}\frac{du}{d\ln Y}\frac{1}{u} = s_{UB}a_{u,Y}\frac{1}{u}, \tag{A9}$$

where s_{UB} is the share of unemployment benefits in total transfers, $a_{u,Y}$ is the unit variation of the unemployment rate in response to a 1 percent increase in GDP and u is the unemployment rate. I set $a_{u,Y}$ equal to -0.24 from Blanchard (1989). The average figure for $\hat{a}_{TH,Y}$ is -0.26.

As to the contemporaneous response to prices, many categories of social benefits such as old-age and unemployment benefits are not indexed within the quarter, and thus a -1.0 elasticity for real outlays seems adequate. By contrast payments related to health programs are likely to be sensitive to change in prices. I assume for them a zero elasticity in real terms. These payments were rather small in the fifties and sixties, but they have become one of the most important components of social benefits, weighting currently over 40 percent. The elasticity of transfers to households to prices is based on an expression analogous to the one above, but picking out the part of transfers that reacts to prices, i.e. health benefits. That is,

$$a_{TH,P} = \frac{d \ln T}{d \ln P} = (s_{HB} - 1)/4, \quad \text{(A10)}$$

where s_{HB} is the share of health benefits in total. The average figure for $\hat{a}_{TH,P}$ is -0.19.

A.6 Purchases of goods and services

Purchases of goods and services are composed of compensation of government employees and intermediate consumption and investment (one does not have to consider here the consumption of fixed capital since it is excluded from the measure of purchases used - see Appendix B). The share of compensation of employees in total was slightly below 50 per cent in the initial years of the sample, but it has represented a bit more than half of the total since mid-sixties. In general one expects intermediate consumption and investment spending to be determined by the nominal amount budgeted, implying a -1.0 elasticity of real purchases to contemporaneous inflation. Also the wage updating process in the government sector is such that price developments typically affect wages with some lag. There may be indexation but with a certain delay, for instance, pay adjustments for the blue-collar occupations in the Federal government (Federal Wage System) are indexed to lagged changes in private sector wages, according to the areas where the services are located (see Office for Personnel Management (2002)). The semi-elasticity of real purchases of goods and services to annualized changes in prices is assumed to be constant:

$$\hat{a}_{G,P} = -1/4. \quad \text{(A11)}$$

B Variable definition and data sources

Fiscal data are from NIPAs Table 3.1. *Government Current Receipts and Expenditures*; data on the components of government consumption, including the breakdown defense/non-defense, are from NIPAs Table 3.10.5 *Government Consumption Expenditures and General Government Gross Output*; data on social benefits including unemployment and health-related benefits are from NIPAs Table 3.12. *Government social benefits* (annual data, the share for the year as a whole was assumed for the quarter).

Taxes = Personal current taxes + Taxes on production and imports + Taxes on corporate income + Contributions for government social insurance + Capital transfer receipts (the latter item is composed mostly by gift and inheritance taxes).

Transfers = Subsidies + Government social benefits to persons + capital transfers paid - Current transfer receipts (from business and persons).

Net taxes = Taxes - Transfers.

Purchases of goods and services = Government consumption - Consumption of fixed capital[1] + Government investment.

Gross domestic product is from NIPAs Table 1.1.5. *Gross Domestic Product.*

Gross domestic product deflator is from NIPAs Table 1.1.4. *Price Indexes for Gross Domestic Product.*

Federal funds rate (quarterly averages of daily data) is from the *FRED database* (Federal Reserve Bank of St. Louis).

Population is from NIPAs Table 2.1. *Personal income and its Disposition.*

Federal debt held by the public (Section 3.1) is from the *FRED database* (Federal Reserve Bank of St. Louis).

Labor income and personal asset income (Section 3.2 and Appendix A) are equal, respectively, to wages and salaries and to the sum of interest income, dividend income and rental income, all from NIPAs Table 2.1. *Personal income and its Disposition.* Proprietors' income was not considered, since there is no obvious way to allocate it between labor and asset income.

Employment in the manufacturing and Average hourly earnings in the manufacturing (Appendix A) are from the *FRED database* (Federal Reserve Bank of St. Louis).

Corporate profits (Appendix A) is from NIPAs Table 1.10. *Gross domestic income, by type of income* (the inventory valuation and capital consumption adjustments were undone).

[1] Consumption of fixed capital is excluded on two grounds. Firstly, there are no shocks to this variable which is fully determined by the existing capital stock and depreciation rules. Secondly, from the viewpoint of the impact on aggregate demand, it is the cost of capital goods *at time of acquisition* (already recorded in government investment) that matters and not *at time of consumption.*

References

Ahmed, S., A. Levin, and A. Wilson (2004). Recent US macroeconomic stability: good policies, good practices or good luck? *Review of Economics and Statistics 86*(3), 824–832.

Auerbach, A. (2002). Is there a role for discretionary fiscal policy? Working Paper 9306, National Bureau of Economic Research.

Auerbach, A. and D. Feenberg (2000). The significance of federal taxes as automatic stabilizers. *Journal of Economic Perspectives 14*(3), 37–56.

BEA (2005). Government transactions. Methodology papers: U.S. national income and product accounts, Bureau of Economic Analysis.

Bernanke, B. and A. Blinder (1992). The federal funds rate and the channels of monetary transmission. *The American Economic Review 82*(4), 901–921.

Bernanke, B., M. Gertler, and M. Watson (1997). Systematic monetary policy and the effect of oil price shocks. Economic Research Reports 25, C.V. Starr Center for Applied Economics.

Blanchard, O. (1984). Current and anticipated deficits, interest rates and economic activity. Working Paper 1265, National Bureau of Economic Research.

Blanchard, O. (1989). A traditional interpretation of macroeconomic fluctuations. *American Economic Review 79*(5), 1046–1064.

Blanchard, O. and R. Perotti (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *Quarterly Journal of Economics 117*(4), 1329–1368.

Blanchard, O. and M. Watson (1984). Are business cycles all alike? Working Paper 1392, National Bureau of Economic Research.

Bohn, H. (1998). The behaviour of U.S. public debt and deficits. *The Quarterly Journal of Economics 113*(3), 949–963.

Bovin, J. (2006). Has monetary policy changed? Evidence from drifting coefficients and real time data. *Journal of Money Credit and Banking 38*(5), 1149–1173.

Bovin, J. and M. Giannoni (2006). Has monetary policy become more effective? *Review of Economics and Statistics 88*(3), 445–462.

Canova, F. (2009). What explains the great moderation in the US?A structural analysis. *Journal of the European Economic Association 7*(4), 697–721.

Canzoneri, M., R. Cumby, and B. Diba (2002). Should the European Central Bank and the Federal Reserve be concerned about fiscal policy? *Federal Reserve Bank of Kansas City Symposium on "Rethinking Stabilization Policy"*, 333–389.

Christiano, L., M. Eichenbaum, and C. Evans (1996). The effects of monetary policy shocks: Evidence from the flow of funds. *The Review of Economics and Statistics 78*(1), 16–34.

Christiano, L., M. Eichenbaum, and C. Evans (1999). Monetary policy shocks: What have we learned and to what end? In J. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1A, pp. 91–157. Amsterdam: Elsevier Sccience BV.

Clarida, R., J. Galí, and M. Gertler (2000). Monetary policy rules and macroeconomic stability: Evidence and some theory. *The Quarterly Journal of Economics 115*(1), 147–180.

Cohen, D. and G. Follete (2000). The automatic fiscal stabilizers: Quietly doing their thing. *Federal Reserve Bank of New York Economic Policy Review 6*, 35–68.

Favero, C. and F. Giavazzi (2007). Debt and the effects of fiscal policy. Working Paper 12822, National Bureau of Economic Research.

Giorno, C., P. Richardson, D. Roseveare, and P. van den Noord (1995). Estimating potential output, output gaps and structural budget balances. Economics Department Working Papers 152, OECD.

Girouard, N. and C. André (2005). Measuring cyclically adjusted budget balances for OECD countries. Economics Department Working Papers 21, OECD.

Johnston, D., J. Parker, and N. Souleles (2006). Household expenditure and the Income Tax rebates of 2001. *American Economic Review 96*(5), 1589–1610.

Office for Personnel Management (2002). Costs of administering the Federal Wage System. Report to Congress, available at www.opm.gov.

Perotti, R. (2004). Estimating the effects of fiscal policy in OECD countries. Proceedings, Federal Reserve Bank of San Francisco.

Perotti, R. (2007). In search of the transmission mechanism of fiscal policy. Working Paper 13143, National Bureau of Economic Research.

Primiceri, G. (2005). Time varying structural vector autoregressions and monetary policy. *Review of Economic Studies 72*(3), 821–852.

Ramey, V. (2008). Identifying government spending shocks: It's all in the timing. Working paper.

Ramey, V. and M. Shapiro (1998). Costly capital reallocation and the effects of government spending. *Carnegie Rochester Series in Public Policy 48*, 145–194.

Romer, C. and D. Romer (1994). What ends recessions? Working Paper 4765, National Bureau of Economic Research.

Romer, C. and D. Romer (2009a). Do tax cuts starve the beast? The effect of tax changes on government spending. *Brookings Papers on Economic Activity*. forthcoming.

Romer, C. and D. Romer (2009b). The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks. *American Economic Review*. forthcoming.

Sims, C. and T. Zha (1998). Does monetary policy generate recessions? Working Paper 12, Federal Reserve Bank of Atlanta.

Sims, C. and T. Zha (2006). Where there regime switches in us monetary policy. *American Economic Review 96*(1), 54–81.

Smith, S. (1982). Pay, pensions, and unemployment in government. *American Economic Review 72*(2), 273–277.

Stock, J. and M. Watson (2002). Has the business cycle changed and why? Working Paper 9127, National Bureau of Economic Research.

Tax Foundation (2007). Federal individual income tax rates history. Tables, available at www.taxfoundation.org.

Taylor, J. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Series in Public Policy*.

Taylor, J. (2000). Reassessing discretionary fiscal policy. *The Journal of Economic Perspectives 14*(3), 21–36.

van den Noord, P. (2000). The size and role of automatic fiscal stabilizers in the 1990s and beyond. Economics Department Working Papers 230, OECD.

von Furstenberg, G., R. Green, and J. Jeong (1986). Tax and spend, or spend and tax? *Review of Economics and Statistics 68*(2), 179–188.