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WHAT ACCOUNTS FOR THE CHANGES IN U.S. FISCAL POLICY TRANSMISSION?[1]

Florin O. Bilbiie[2], André Meier[3] and Gernot J. Müller[4]

In 2006 all ECB publications will feature a motif taken from the €5 banknote.

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Abstract

Using vector autoregressions on U.S. time series for 1957-1979 and 1983-2004, we find government spending shocks to have stronger effects on output, consumption, and wages in the earlier sample. We try to account for this observation within a DSGE model featuring price rigidities and limited asset market participation. Specifically, we estimate the structural parameters of the model for both samples by matching impulse responses. Model-based counterfactual experiments suggest that increased asset market participation accounts for some of the changes in fiscal transmission. However, the key quantitative factor appears to be the more active monetary policy of the Volcker-Greenspan period.

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Keywords: Government Spending, Asset Market Participation, Fiscal Policy, Monetary Policy, DSGE, Vector Autoregression, Minimum Distance Estimation

Non-technical Summary

One of the most prominent issues in macroeconomics concerns the effects of an increase in government spending. In recent empirical research on postwar U.S. data, Blanchard and Perotti (2002) provided evidence that consumption and output respond positively to an exogenous fiscal shock. More detailed analysis, however, appears to reveal changes in the transmission of U.S. fiscal policy shocks around the early 1980s. Specifically, both Perotti (2005) and Mihov (2003) report fresh VAR-based evidence showing a substantial reduction in the expansionary effects of spending shocks after 1980.

What accounts for the changes in fiscal policy transmission over time? The fact that the above-mentioned studies point to a break date around 1980 suggests several interesting hypotheses. First, it is widely accepted that the conduct of monetary policy differed substantially before and after the 1980s. This change may, of course, have affected the transmission of shocks in the economy quite generally. A second hypothesis draws on the observation that fiscal policy itself has changed. Perotti (2005), for example, notes that a typical shock to government spending displays much less persistence in the later sample. A third explanation stresses the economics of private consumption behavior by pointing out the possible consequences arising from an increase in asset market participation. Indeed, retail financial markets were subject to significant restrictions until the late 1970s. These restrictions may have effectively prevented a large fraction of households from smoothing consumption in the desired way, giving rise to "Keynesian" consumption behavior. To the extent that this explains the strong crowding-in effects of government spending documented for the 1960s and 1970s, one may conjecture that the change in fiscal transmission around 1980 is critically related to the process of financial liberalization enacted at the same time. Thus, increasing asset market participation competes with changes in monetary and fiscal policies as candidate explanations for the observed decline in the effects of U.S. government spending.

The goal of the present paper is to evaluate the relative importance of these different causes. A better understanding of how and why fiscal transmission changed during the early 1980s seems valuable in its own right but also with respect to the more general changes in business cycle behavior that have come to be called the "Great Moderation". Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) were the first to highlight a marked decrease in the volatility of economic activity since the mid-1980s. Several subsequent papers, including Stock and Watson (2003) and Ahmed, Levin and Wilson (2004), have attempted to explain the sources of this phenomenon, examining some of the same aspects that we focus on, notably changes in macroeconomic policies and the behavior of the private sector.

Our analysis proceeds in three steps. We begin by adding to the empirical evidence on fiscal transmission provided by Perotti (2005) and Mihov (2003). Specifically, we estimate structural VARs on U.S.

time series for 1957:1-1979:2 ('S1') and 1983:1-2004:4 ('S2') and document the aforementioned reduction in the strength and persistence of fiscal policy effects on output, wages and private consumption. S1 and S2 constitute appropriate samples for our study, because they allow us to characterize fiscal policies *before* and *after* any of the potentially important changes to monetary policy, government spending, financial markets, and the business cycle in general.

In the second step, we introduce a dynamic stochastic general equilibrium (DSGE) model featuring price rigidities, monetary and fiscal policies, as well as limited asset market participation. Thus, the model nests all three possible explanations for differences in fiscal transmission across samples. Given that economic interest is centered on the impulse responses associated with a government spending shock, we consider this statistic as the critical nexus between theory and data. Accordingly, we rely on a minimum distance strategy that matches impulse responses from the theoretical model with those obtained from the VARs. This procedure provides us with estimates for the parameters of our model for both samples and thereby allows us to judge the quantitative importance of changes in both household behavior and government policies. Estimating our model for both samples, we allow policy parameters and the extent of asset market participation to vary, while all deep parameters (pertaining to preferences and technology) are assumed to remain unchanged. The parameter estimates we obtain confirm that asset market participation has increased considerably after 1980. Our results on monetary policy align with the consensus view that the Fed has taken a tougher stand on inflation after 1980. In addition, the estimates characterizing fiscal policy are also quite different across samples, implying that government spending shocks have become less persistent and more deficit-financed in S2.

In a third step, we run counterfactual experiments to assess the individual impact of these changes on the transmission of fiscal shocks. Keeping all deep parameters constant, we investigate which of the changes between the two samples may have been pivotal for the change in fiscal transmission. We find that increased asset market participation accounts for some of the changes in the propagation of government spending shocks, notably the reduced persistence of effects in S2. However, the key quantitative factor driving the changes appears to be monetary policy. Lastly, the change in the degree of deficit financing is crucial to account for the strikingly different responses of government debt across the two samples.

1 Introduction

One of the most prominent issues in macroeconomics concerns the effects of an increase in government spending. The topic takes center stage in the policy debate and has received great attention in the theoretical literature at least since Keynes' *General Theory*. Recently, empirical research dealing with this question has flourished, as well. In a seminal study based on vector autoregressions (VAR) for a long postwar sample, Blanchard and Perotti (2002) provided evidence indicating a positive response of consumption and output to a one-time fiscal shock. Specifically, the authors analyzed U.S. time series data from 1960 to 1997 and reported a spending multiplier for consumption between one third and one. Similar findings were obtained by Fatás and Mihov (2001) and Galí, López-Salido and Vallés (2005).

More recent empirical studies, however, suggest that the transmission of fiscal policy shocks actually changed around the early 1980s. Indeed, both Perotti (2005) and Mihov (2003) provide fresh VAR-based evidence showing a substantial reduction in the expansionary effects of spending shocks after 1980.

What accounts for the changes in the transmission of U.S. fiscal policy over time? The fact that the aforementioned studies point to a break around 1980 suggests several interesting hypotheses. First, it is widely accepted that the conduct of monetary policy differed substantially before and after the 1980s. This change may, of course, have affected the transmission of shocks in the economy quite generally. A second hypothesis draws on the observation that fiscal policy itself has changed. Perotti (2005), for example, reports that a typical shock to government spending displays much less persistence in the later sample. A third explanation stresses the economics of private consumption behavior by pointing out the possible consequences arising from an increase in asset market participation. Indeed, retail financial markets were subject to significant restrictions until the late 1970s. Bilbiie and Straub (2004a) argue that these restrictions may have effectively prevented a large fraction of households from smoothing their consumption in the desired way. Lacking access to asset markets, such households would tend to exhibit an extreme version of "Keynesian" consumption behavior, where current consumption perfectly tracks current income, as has been suggested in recent papers by Galí, López-Salido and Vallés (2005) and Bilbiie and Straub (2004b). To the extent that this explains the strong crowding-in effects of government spending documented for the 1960s and 1970s, one may conjecture that the change in fiscal transmission around 1980 is critically related to the process of financial liberalization enacted at the same time.[1] Specifically, deregulation and financial innovation may have widened private access to asset markets, reducing the number of households who fail to smooth their consumption profiles (in response to government spending shocks). As a bottom line, changes in private-sector finance compete with changes in monetary and fiscal policies as candidate explanations for the observed decline in the effects of U.S. government spending.

The goal of the present paper is to evaluate the relative importance of these different causes. A better understanding of how and why fiscal transmission changed during the early 1980s seems valuable in its own right but also with respect to the more general changes in business cycle behavior that have come to be called the "Great Moderation". Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) were the first to highlight a marked decrease in the volatility of economic activity since the mid-1980s. Several subsequent papers, including Stock and Watson (2003) and Ahmed, Levin and Wilson (2004), have attempted to explain the sources of this phenomenon, examining some of the same aspects that we focus on, notably changes in macroeconomic policies and the behavior of the private sector.

Our analysis proceeds in three steps. We begin by adding to the empirical evidence on fiscal transmission provided by Perotti (2005) and Mihov (2003). Specifically, we estimate structural VARs on U.S. time series for 1957:1-1979:2 ('S1') and 1983:1-2004:4 ('S2') and document the aforementioned reduction in the strength and persistence of fiscal policy effects on output, wages and private consumption. S1 and S2 constitute appropriate samples for our study, because they allow us to characterize fiscal policies *before* and *after* any of the potentially important changes to monetary policy, government spending, financial markets, and the business cycle in general. In the second step, we introduce a dynamic stochastic general equilibrium (DSGE) model featuring price rigidities, monetary and fiscal policies, as well as limited asset market participation. Thus, the model nests all three possible explanations for differences in fiscal transmission across samples. Given that economic interest is centered on the impulse responses associated with a government spending shock, we consider this statistic as the critical nexus between theory and data. Accordingly, we rely on a minimum distance strategy that matches impulse responses from the theoretical model with those obtained from the VARs. This procedure provides us with estimates for the parameters of our model for both samples and thereby allows us to judge the quantitative importance of changes in both household behavior and government policies. Similar estimation methods have been employed by several other authors, although mostly in the context of monetary policy. The most prominent examples are Rotemberg and Woodford (1997) and Christiano, Eichenbaum and Evans (2005); the first application to the context of fiscal policy is provided in a paper by Bouakez and Rebei (2003).[2] Addressing a recent criticism by Chari, Kehoe, McGrattan (2005) and others, we ensure in our analysis that the dynamics of the theoretical model are fully nested in the VAR, so that the typical problem of omitted state variables does not arise. Estimating our model for both samples, we allow policy parameters and the extent of asset market participation to vary, while all deep parameters (pertaining to preferences and technology) are assumed to remain unchanged. This enables us, in the third step, to run counterfactual experiments by which we evaluate the three candidate explanations for the changes in fiscal policy transmission.

The rest of this paper is structured as follows. In section 2, we introduce our model, i.e. the stylized economy for which we obtain theoretical impulse responses. Section 3 looks at the empirical counterpart, presenting our data, our structural VAR and the associated empirical impulse responses. Our estimation strategy is detailed in section 4, which is followed by a discussion of the results in section 5. In section 6, we present several counterfactual experiments that shed light on the importance of different explanations for our findings. Finally, section 7 summarizes the paper and provides a conclusion.

2 The Model

The model, which draws on both Galí, López-Salido and Vallés (2005) and Bilbiie and Straub (2004b), is a standard cashless DSGE model with sticky prices that, in addition, features limited asset market participation.[3] Apart from a continuum of households, there is a continuum of monopolistically competitive producers which set prices on a staggered basis. Moreover, the model specifies two policy-makers. A monetary authority sets its policy instrument, the nominal interest rate. A fiscal policy authority purchases the consumption good, raises lump-sum and income taxes and issues nominal debt.

2.1 Households

There is a continuum of households $[0, 1]$ consuming the final good. We assume that a fraction $1 - \lambda$ of households smooth consumption by participating in asset markets - these households are '*asset holders*'. Specifically, they trade a riskless one-period bond and hold shares in firms. The rest of the households on the $[0, \lambda]$ interval do not participate in asset markets - we dub them '*non-asset holders*'. This distinction between households is assumed to arise not from preferences but from their actual capacity (or lack thereof) to participate in asset markets, as in Bilbiie (2005).[4] The most important causes for limited asset market participation appear to be concrete institutional constraints like the ones described in Mishkin (1991). While we do not take a stand as to what are the deep reasons underlying such institutional constraints, we view them as a plausible aspect of reality and try to assess their empirical relevance in explaining the effects of government spending shocks.

2.1.1 Asset holders

Each asset holder on the $[\lambda, 1]$ interval chooses consumption $C_{A,t}$, leisure $L_{A,t}$ and nominal bond holdings $B_{A,t+1}$ by solving the following intertemporal problem:

$$\max E_t \sum_{s=0}^{\infty} \beta^s \frac{\left(C_{A,t+s} L_{A,t+s}^{\varphi}\right)^{1-\sigma}}{1-\sigma} \tag{1}$$

subject to the budget constraint

$$R_t^{-1} B_{A,t+1} + P_t C_{A,t} + P_t T_t = B_{A,t} + (1-\tau)\left(W_t N_{A,t} + P_t D_{A,t}\right), \tag{2}$$

where $\beta \in (0,1)$ denotes the discount factor. R_t is the gross nominal return on bonds purchased in period t, P_t denotes the price level, W_t the nominal wage, and $D_{A,t}$ represents real dividend payments to households who own shares in the monopolistically competitive firms. $N_{A,t}$ are hours worked by the asset holder; they are given by $N_{A,t} = 1 - L_{A,t}$, where time endowment has been normalized to one. We further assume that the income tax rate τ is constant, and that real lump-sum taxes T_t are adjusted according to a rule specified below. Note that the utility function in (1) is non-separable in consumption and leisure and belongs to the King-Plosser-Rebelo class, being consistent with balanced growth. Maximizing utility (1) subject to (2) implies the first order conditions

$$R_t^{-1} = \beta E_t \left[\Lambda_{t,t+1}\right], \tag{3}$$

$$\text{where } \Lambda_{t,t+s} = \left(\frac{C_{A,t}}{C_{A,t+s}}\right)^{\sigma} \left(\frac{L_{A,t+s}}{L_{A,t}}\right)^{\varphi(1-\sigma)} \frac{P_t}{P_{t+s}}, \tag{4}$$

$$\text{and } \frac{C_{A,t}}{L_{A,t}} = \frac{1-\tau}{\varphi} \frac{W_t}{P_t}. \tag{5}$$

2.1.2 Non-asset holders

Non-asset holders choose consumption $C_{N,t}$ and hours $N_{N,t}$ in each period t by solving the intratemporal problem

$$\max \frac{\left(C_{N,t} L_{N,t}^{\varphi}\right)^{1-\sigma}}{1-\sigma} \tag{6}$$

subject to the condition that consumption expenditure equals net income,

$$P_t C_{N,t} = (1-\tau) W_t N_{N,t} - P_t T_t. \tag{7}$$

The first order condition associated with (6) is given by

$$\frac{C_{N,t}}{L_{N,t}} = \frac{1-\tau}{\varphi}\frac{W_t}{P_t}. \tag{8}$$

Note that we have assumed preference homogeneity: φ and σ are the same for both types of households. This is consistent with the view that the only source of heterogeneity among households is their access to asset markets, which can be limited due to exogenous institutional constraints. We also assume that hours worked in steady state are the same for both types of households, $N_A = N_N = N$. This assumption, while simplifying the analytics considerably, is largely innocuous for our results; since the focus of our paper is on the dynamic responses to shocks, steady-state differences between the two types of agents are of secondary importance. Moreover, evidence concerning the relationship between average hours worked and wealth is, to the best of our knowledge, lacking. Because of preference homogeneity, marginal rates of substitution are equalized and hence consumption shares in steady state are equal across groups, $C_A = C_N = C$; this requires that steady-state asset income be zero.[5] See Appendix A for details.

2.2 Firms

Final output is produced by a representative competitive firm. This firm purchases differentiated intermediate goods $i \in [0,1]$ from monopolistically competitive producers and combines them into the final good. The aggregation technology is of the CES form, with ε denoting the constant elasticity of substitution:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{9}$$

where $Y_t(i)$ denotes the quantity used of differentiated good i at time t. The final-goods firm maximizes profits $P_t Y_t - \int_0^1 P_t(i) Y_t(i) di$, where P_t is the overall price index for the final good and $P_t(i)$ denotes the price of intermediate good i. This implies downward-sloping demand for each intermediate input:

$$Y_t(i) = \left(P_t(i)/P_t\right)^{-\varepsilon} Y_t, \tag{10}$$

while the price index is given by $P_t = \left(\int_0^1 P_t(i)^{1-\varepsilon} di\right)^{1/(1-\varepsilon)}$.

The monopolistically competitive producers of intermediate goods face a technology which is linear in labor and subject to a fixed cost F:

$$Y_t(i) = N_t(i) - F, \text{ if } N_t(i) > F, \text{ otherwise } Y_t(i) = 0. \tag{11}$$

The share of the fixed cost F in steady-state output governs the degree of increasing returns to scale. Real profits of a generic firm are thus given by $O_t(i) \equiv [P_t(i)/P_t] Y_t(i) - [W_t/P_t] N_t(i)$. Following Calvo (1983) and Yun (1996), intermediate-good firms are assumed to adjust their prices infrequently. We define α as the probability of keeping the price constant in a given period. This exogenous probability is independent of past price adjustments. Accordingly, with probability $(1-\alpha)$, the firm is able to reoptimize and change its price. Given this possibility, a generic firm i will set $P(i)$ in order to solve

$$\max E_t \sum_{s=0}^{\infty} \alpha^s \Lambda_{t,t+s} \left[P_t(i) Y_{t,t+s}(i) - W_{t+s} Y_{t,t+s}(i) \right]$$

subject to the demand function (10). Recall from (4) that $\Lambda_{t,t+s}$ denotes the stochastic discount factor characterizing asset holders, who own the firms. The first order condition for this problem is given by

$$E_t \sum_{s=0}^{\infty} \alpha^s \Lambda_{t,t+s} \left(P_t(i) - \frac{\varepsilon}{\varepsilon - 1} W_{t+s} \right) = 0. \tag{12}$$

In equilibrium each producer who sets a new price $P_t(i)$ in period t will choose the same price and the same level of output.

2.3 Monetary policy

Monetary policy is characterized by an interest rate feedback rule whereby the nominal interest rate R_t is a function $\Phi(.)$ of expected inflation:

$$R_t = \Phi\left(E_t \Pi_{t+1}\right), \tag{13}$$

where $\Pi_{t+1} \equiv P_{t+1}/P_t$ denotes gross inflation between t and $t+1$. The constant elasticity of the feedback function, ϕ_π, governs the response of interest rates to expected inflation.

2.4 Fiscal policy

The fiscal authority purchases consumption goods, G_t, raises distortionary and lump-sum taxes and issues debt, B_{t+1}, consisting of one-period nominal discount bonds. The government budget constraint reads as

$$R_t^{-1} B_{t+1} = B_t + P_t \left[G_t - \tau Y_t - T_t \right]. \tag{14}$$

Letting $g_t = (G_t - G)/G$, where letters without time subscript denote steady-state values, we assume that government spending follows an exogenous AR(2) process,

$$g_t = \rho_1 g_{t-1} + \rho_2 g_{t-2} + \varepsilon_t, \tag{15}$$

which allows for a hump shaped response of spending to ε_t, an i.i.d. government spending shock with time-invariant variance σ_ε^2.

The financing of government expenditure is determined by a deficit rule. Let $D_t = G_t - T_t - \tau Y_t$ denote the primary deficit, i.e. total non-interest spending less revenues. We also define the *structural* deficit, $D_{s,t}$, as the primary deficit adjusted for automatic responses of tax revenues resulting from deviations of output from its steady-state value: $D_{s,t} = D_t + \tau(Y_t - Y) = G_t - T_t - \tau Y$. To ensure consistency with the empirical counterpart of the model (and for ease of comparison with other empirical studies), we divide the deficit and debt variables by output Y_t.[6] Letting $\hat{d}_{s,t}$ denote a first order Taylor approximation of $D_{s,t}/Y_t$ around the steady state, we assume that the structural deficit is adjusted according to the following rule:

$$\hat{d}_{s,t} = \eta \hat{d}_{s,t-1} + \phi_g G_Y g_t + \phi_b \hat{b}_t, \tag{16}$$

where $\hat{b}_t \equiv B_t/(P_{t-1}Y_{t-1})$ is real debt divided by last period's output, so that it remains a state variable. Rules of this type have been studied extensively, see e.g. Bohn (1998) and Galí and Perotti (2003). The parameter η captures the possibility that budget decisions are autocorrelated, while the parameter ϕ_g measures the degree of deficit finance of temporary increases in government spending. For ease of interpretation, we rescale the coefficient on spending with the steady-state share of government spending in output, G_Y. Thus all variables are in output units. Finally, the parameter ϕ_b governs the response of the deficit to the beginning-of-period ratio of debt to GDP, hence capturing a 'debt stabilization' motive: a negative value of ϕ_b indicates that deficits are adjusted in order to stabilize outstanding debt.

2.5 Equilibrium, market clearing and aggregation

A rational expectations equilibrium is a sequence of processes for all prices and quantities introduced above such that the optimality conditions hold for all agents and all markets clear at any given time t. Specifically, market clearing requires that labor demand equal total labor supply, $N_t = \lambda N_{N,t} + (1-\lambda) N_{A,t}$, all profit income be distributed as dividends to shareholders (asset holders) and all government debt be held by asset holders, $B_{t+1} = (1-\lambda) B_{A,t+1}$. By Walras' law, then, the goods market also clears: $C_t + G_t = Y_t$, where aggregate consumption is $C_t \equiv \lambda C_{N,t} + (1-\lambda) C_{A,t}$. We solve numerically a locally approximate (log-linear) version of the model around its non-stochastic steady state, see Appendix B for details.

2.6 Government spending shocks and consumption

This subsection describes the intuition behind fiscal transmission in our model. For a formal presentation of all the effects outlined in this section, see the loglinearized version of the Euler equations in Appendix B. To begin with, consider the case in which utility is separable ($\sigma \rightarrow 1$).[7] Note that an increase in government spending will generally depress the consumption of asset holders because of a negative wealth effect resulting from the induced increase in the tax burden (in present value terms). In the case of an active monetary policy, i.e. for $\phi_\pi > 1$, there is an additional substitution effect operating in the same direction; this is triggered by a rise in the real interest rate as the increase in government spending leads to a rise in inflation. These channels of transmission are at the heart of the analysis in standard business cycle models, e.g. Baxter and King (1993) and Linnemann and Schabert (2003). They generally induce a crowding out of private consumption in response to higher government spending.

In contrast, in the present model it is possible for total private consumption to increase, the basic mechanism relying upon a strong enough increase in the real wage. In fact, a higher real wage induces an increase in the consumption of non-asset holders, which may eventually more than offset the fall in the consumption of asset holders. Note in this context that the reliance upon a strong *conditional* response of the real wage to government spending shocks does not contradict the notorious *unconditional* acyclicality of real wages (see the discussion in Christiano and Eichenbaum (1992))[8].

The response of the real wage naturally depends on the interplay of labor supply and demand. To begin with, a government spending shock increases the demand for goods. With sticky prices à la Calvo, this has an effect on labor demand: firms who cannot change their price will adjust quantities, hence shifting labor demand at a given wage (the rest of the firms will increase their prices, creating inflation). This effect is larger, the larger the degree of price stickiness (and is absent with flexible prices). Meanwhile, labor supply shifts for two different reasons. First, there is a direct income effect on the labor supply of non-asset holders who are willing to work more as the tax burden increases. This shift can be avoided on impact if spending is deficit-financed, because the path of taxation matters for non-asset holders. Second, asset holders also increase labor supply for a given wage: this is due both to the wealth effect - asset holders internalize the government budget constraint - and to intertemporal substitution. The latter effect occurs if an increase in inflation triggers an increase in the real interest rate, thus providing incentives for asset holders to postpone consumption. Consequently, the overall shift in labor supply is smaller, the smaller: i) the persistence of the government spending shock: lower persistence reduces the present discounted value of taxes and the wealth effect on asset holders; ii) the degree of monetary policy activism: a less aggressive monetary policy implies a lower real interest rate and thereby weakens asset holders' incentives to postpone consumption; and iii) the degree of deficit financing: deficit financing reduces the wealth effect on non-asset holders.

When the shift in labor demand dominates the shift in labor supply (which also requires that the latter be sufficiently inelastic), a high enough increase in the real wage may obtain and cause aggregate consumption to increase. Note, however, that a strong increase in the real wage does not necessarily lead to a rise in aggregate consumption. In fact, there is the offsetting effect of a high increase in marginal costs and a resulting fall in profits, which additionally depresses the consumption of asset holders. Furthermore, while deficit financing works towards ensuring a positive consumption response in most cases, this is not a general result. Due to limited asset market participation, deficits have a negative effect on asset holders' consumption above and beyond the standard wealth effect associated with the present discounted value of government spending. Specifically, an increase in debt siphons further resources away from the potential consumption of asset holders, since they will end up holding all debt issued by the government. For asset holders, this amount - in per capita terms - exceeds the debt level of the government by a factor of $\lambda/(1-\lambda)$, because non-asset holders do not hold any debt.

When utility is non-separable ($\sigma \neq 1$), there is an additional channel changing the co-movement between consumption and hours of asset holders. Specifically, if $\sigma > 1$, hours and consumption will co-move positively: for a given increase in the real wage, asset holders substitute out of leisure into consumption. Thus, the negative wealth effect that induces an increase in hours worked can also induce an increase in consumption. Moreover, $\sigma > 1$ reduces the elasticity of asset holders' consumption to real interest rate movements, since it implies a lower elasticity of intertemporal substitution. As a result, asset holders have weaker incentives to postpone consumption for a given increase in real interest rates.

All things considered, the discussion makes clear that even a relatively parsimonious specification may generate quite complex interactions between the different features of the model. In our view, this further increases the promise of estimating the model's parameters by means of a minimum distance procedure that ensures the greatest possible match between the model's theoretical predictions and important empirical regularities in the data.

3 Empirical Characterization of Transmission

3.1 VAR specification

Having introduced our theoretical model, we now turn to the empirical characterization of fiscal transmission, i.e. the effects of a temporary increase in government spending as inferred from the data. Specifically, we use a VAR framework to obtain estimates of the empirical impulse response functions associated with a government spending shock.

As our goal is to estimate the structural parameters of our model by minimizing the distance between theoretical and empirical impulse responses, we have to ensure that the VAR actually captures the empirical equivalent of the dynamics implied by our theory. In other words, the log-linear model ought to be nested in our VAR. This has two implications. First, the identifying restrictions we use in our VAR have to be consistent with the model. In the VAR literature on fiscal transmission, shocks to government spending have been identified on the assumption that government spending is not contemporaneously affected by the other variables included in the VAR.[9] We rely on the same identifying assumption, thereby conforming with the theoretical model, where government spending is assumed to follow an exogenous AR(2) process. Moreover, like in the model, we allow all variables in the VAR (including debt, which is defined as end-of-period debt) to respond contemporaneously to government spending shocks. In practice, we estimate a recursive VAR where government spending is ordered first and interpret the residual from the first equation of the VAR as a structural innovation to government spending. Following Perotti (2005), such an interpretation can be justified by observing that discretionary fiscal policy plausibly does not respond within a quarter to a change in the economy as reflected by an output innovation. Likewise, automatic stabilization is unlikely to occur within one quarter, given that our definition of government spending comprises government consumption and government investment but does not include transfer payments.

Second, the solution of the log-linearized model implies a state-space system in which all variables are functions of the current state only. The set of state variables in our model comprises current government debt and its lagged value along with the lagged value of output[10] as well as the current value and first two lags of government spending. It is therefore desirable to include this full set of variables in the VAR. In doing so we explicitly address the issue raised in a recent critique of the Structural VAR approach by Chari, Kehoe and McGrattan (2005). These authors show by way of a Monte Carlo exercise that the omission of a state variable from a VAR may cause a severe bias in estimated impulse response functions. The fact that we include the relevant states in our VAR resolves this potential problem and ensures that the model dynamics are actually nested in the empirical specification.

Government debt and government spending are, therefore, the two fiscal variables in our VAR. As the real wage response plays an important role in the transmission of spending shocks, we also include this variable. Eventually, our VAR model comprises five variables: government spending, output, wages, private consumption, and government debt. Spending, output and consumption are expressed in logs of real per capita terms, real wages are in logs, and debt is given as a share of output. We include four lags of each variable together with a constant and remove a linear time trend from all variables except the debt ratio.[11]

As discussed above, earlier studies such as Blanchard and Perotti (2002) and Fatás and Mihov (2001) have reported a substantial increase in private consumption in response to a government spending shock.[12] However, new evidence by Perotti (2005) and Mihov (2003) suggests that the transmission of fiscal shocks changed substantially in the early 1980s. In order to trace these changes, we consider a sample split around the year 1980. However, the possibility of structural breaks in other economic areas should be taken into account, as well. Specifically, given the prominent role of monetary policy in our subsequent analysis, we decide to end the first sample in 1979:2, i.e. just before the beginning of the Volcker chairmanship. The second sample then starts in 1983:1, i.e. just after the Volcker disinflation period. This sample split also seems appropriate with respect to the evidence on two other phenomena that are relevant for our study, namely the financial liberalization occurring in the early 1980s and the general changes in business-cycle dynamics dated, again, in the early- to mid-1980s. Hence we estimate VARs on U.S. time series data for the two samples: 1957:1-1979:2 (S1) and 1983:1-2004:4 (S2).

3.2 Empirical impulse responses

Figure 1 displays the impulse response functions of all five variables to a one percent increase in government spending for both S1 (left column) and S2 (right column). While the solid crossed lines indicate point estimates, the shaded areas represent symmetric 90 percent confidence intervals, computed by bootstrapping based on 1,000 replications.

In the first row, the response of government spending can be seen to display greater persistence in S1 compared to S2. This is in line with an earlier finding reported by Perotti (2005). Output, shown in the next row, features impact (maximum) increases of 0.33 (0.51) percent in S1 and of 0.20 (0.25) percent in S2. The responses are significant in both samples, but only in S1 does the increase stay significant for an extended period of about two years. The response of the real wage is reported in the third row. Here a significant increase can be observed only for the first sample. Note that this seems consistent with the findings reported by other studies that cover longer sample periods. Specifically, Galí, López-Salido and Vallés (2005) also report an increase in the real wage on the basis of a VAR on U.S. data from 1954-1998. The results for the period 1960-1996 examined by Fatás and Mihov (2001), in turn, depend on the precise wage measure under study. While most of the measures rise in response to a spending shock, only manufacturing wages do so significantly.

The fourth row depicts the response of consumption. Although the point estimates for the first few periods look rather similar, the response is significantly positive in S1 for about two years, but not so in S2. This accords qualitatively with the earlier findings of Mihov (2003) and Perotti (2005) regarding a weaker response of private consumption in S2 relative to S1. However, the most striking difference across samples consists in the much greater persistence of the effect in S1.

The last set of panels pertain to the response of government debt (measured at the end of the period) as a ratio of GDP. Here the differences across samples are most remarkable: in S1 the debt ratio falls significantly in response to an increase in government spending, whereas in S2 a significant increase in the debt ratio can be observed. This finding seems again consistent with Perotti (2005), although he does not consider debt but tax revenues in the VAR. Specifically, Perotti notes that the cumulative net tax response to a spending shock is typically positive in S1 and negative in S2.[13]

Another way to summarize the evidence is provided by table 1, which reports the cumulated impulse responses, for 4, 12 and 20 quarters for all variables and both samples. Standard errors computed by bootstrapping based on 1,000 replications are reported below the respective point estimates. Most interestingly, the cumulative responses of consumption and output after 20 quarters in S2 are less than half the cumulative responses in S1. Substantial differences are also apparent for government spending itself and even more for the cumulative wage response. The right column of table 1 reports the differences in the cumulative responses between both samples. For all variables and at almost all horizons, the differences amount to at least one to two standard errors.

Overall, our results add corroborating evidence to the observations reported by Perotti (2005) and Mihov (2003). A comparison of both samples points towards a substantial change in the transmission of spending shocks. In particular, the responses of output and consumption are less significant and less persistent in the post-1980 sample. Government spending itself also shows less persistence in S2. Likewise, real wages increase over an extended period in S1 but only briefly in S2. Lastly, the responses of government debt indicate a change in the financing of a typical government spending shock: while in S1 an increase in government expenditure is associated with a fall in the debt ratio, in S2 the opposite holds, indicating a greater reliance upon deficit financing.

4 Estimating the Structural Model

4.1 Minimum distance strategy

The next step of our analysis consists in matching empirical (VAR) and theoretical (DSGE) impulse responses in order to obtain estimates for the parameters of our model. Rotemberg and Woodford (1997) were the first to suggest this minimum distance technique in the context of DSGE models. Similar approaches have subsequently been applied by Amato and Laubach (2003), Boivin and Giannoni (2003) and Christiano, Eichenbaum and Evans (2005).

Generally, one important question in minimum distance estimation concerns the issue of which moments or auxiliary statistics to match. From an econometric point of view, the moments used in estimation should be as informative as possible, in the sense of bearing strong and distinct relationships with each of the structural parameters. Unfortunately, it is often difficult to evaluate this property in a stringent way. In addition, this is not the only relevant criterion for choosing moments. From an economic point of view, the moments should also be important in their own right. This means, in particular, that they should represent aspects of the data on which economic interest is centered, e.g. because they are clearly linked with important theories or because they matter most for economic policy.

In the case of fiscal policy that we study, a crucial issue is the response of output and its components to a shock in government spending. Moreover, since the real wage plays a central role in the transmission of fiscal shocks in our theoretical model (see Section 2.6), its behavior is of particular interest, as well. Indeed, both the direction and the size of these responses represent important benchmarks on which to measure the descriptive quality of competing models. Accordingly, we consider, as the relevant feature to match, the full set of empirical impulse response functions presented in the previous section. Note that in doing so we concentrate on the propagation of one particular shock, whose identification is consistent with both our theoretical model and a number of prominent contributions in the empirical literature. Consequently, this strategy allows us to avoid making restrictive assumptions on the nature and interaction of all other possible shocks in the economy, as would be required, for example, in maximum likelihood estimation.

Formally, define Ψ^e to be the empirical impulse response function characterizing the data. Note that it is not a raw moment but a transformation of the estimates obtained from a VAR that nests the log-linearized model. The model itself, in turn, assigns to each admissible vector of structural parameters θ a theoretical impulse response function $\Psi^t = \Psi(\theta)$. The binding function $\Psi()$ must be assumed to be injective to ensure identification. We obtain an estimate for the parameter vector of interest, $\widehat{\theta}$, by minimizing the weighted distance between empirical and theoretical impulse response functions, i.e. Ψ^e and Ψ^t:

$$\widehat{\theta} = \arg\min \left(\Psi^e - \Psi(\theta)\right)' W \left(\Psi^e - \Psi(\theta)\right), \tag{17}$$

where W represents a positive definite weighting matrix.

As the relationship between structural parameters and the implied impulse response functions is non-linear, we rely on numerical methods to obtain a solution for (17). Basically, $\Psi(\theta)$ is evaluated repeatedly for different parameter vectors θ until the closest fit with the empirical impulse responses, Ψ^e, has been obtained.

Our choice of the weighting matrix W is guided by the idea of giving greater weight to impulse responses that are more precisely estimated. Thus we opt for the diagonal matrix W^{diag} whose diagonal entries are the reciprocal values of the variance of the empirical impulse responses. Using this weighting matrix ensures that the theoretical impulse responses are made to be as close to the empirical ones as possible, in terms of point-wise standard deviations. Finally, regarding the length of the impulse response series, we decide to consider the first 16 quarters for all five variables.

Standard errors for $\widehat{\theta}$ are computed using the following expression for the asymptotic variance of our estimator, taken from Wooldridge (2002):

$$\widehat{Avar}\left(\widehat{\theta}\right) = \left(G'WG\right)^{-1}\left(G'W\widehat{\Sigma}WG\right)\left(G'WG\right)^{-1}. \tag{18}$$

where $G = \nabla_\theta \Psi^t$ represents the Jacobian of the impulse response function generated from the model and $\widehat{\Sigma}$ denotes the bootstrap-estimated variance matrix of the impulse responses.

4.2 Parametric setup

We partition the parameters of our structural model in three groups. The first group comprises parameters that can be fixed before the actual estimation exercise, because their values are uncontroversial or easily inferred from first moments of the data. Specifically, this is true for the time discount rate β which we set to $1.03^{-1/4}$, matching the inverse of the steady-state gross real rate of return at quarterly frequency. Further, we set the share of government expenditure in GDP, G_Y, to 0.2 and the steady-state tax rate, τ, to 0.3. Together with the assumption that the steady-state share of debt is zero, $B_{PY} = 0$, these pin down lump-sum transfers in steady state. The elasticity of substitution ε is chosen such that the markup in steady state equals 20 percent. Lastly, we assume that, in steady state, agents spend one fourth of their time endowment working.

All remaining parameters could, in principle, be estimated using our minimum distance strategy.

However, given the set of moments we exploit, certain parameters would not be particularly well identified, so we find it preferable to fix them at values that have been established in the previous literature. This also helps us to keep the dimension of our optimization problem tractable. Specifically, we fix α, the probability that prices are not changed in a given period, at 0.85, a value in the middle of the range reported for different specifications by Galí and Gertler (1999), who apply single-equation estimation techniques to the New Keynesian Phillips curve.[14] Similarly, we fix σ, which measures the inverse of the intertemporal elasticity of substitution, at a conventional value of two.

The third set of parameters comprises those that we actually seek to estimate. These are: the Taylor rule coefficient ϕ_π, the parameters governing fiscal policy, i.e. $\rho_1, \rho_2, \phi_g, \phi_b$ and η, as well as the share of non-asset holders, λ. All of these parameters are allowed to vary across the two samples. In total, we thus provide estimates for 14 parameters.

Finally, we have to consider that certain parameter configurations could imply equilibrium indeterminacy in our theoretical model.[15] In this case, we resort to the *minimal state variable* criterion suggested by McCallum (1999) in order to select an equilibrium and compute the corresponding impulse responses.

5 Results

Table 2 provides the results of our estimation exercise for both samples. Standard errors are reported below the respective point estimates. Almost all parameters are estimated with satisfactory precision, although the differences between estimates for the two samples tend to remain below the usual levels of statistical significance. Importantly, note that the set of estimates imply a determinate equilibrium for each sample, despite our estimation procedure allowing for indeterminacy.

Perhaps the most interesting single parameter, the estimated extent of asset market participation differs considerably across periods. Specifically, the share of consumers who do not smooth consumption by trading in assets is estimated at a significant $\widehat{\lambda} = 0.51$ in S1 and at insignificant 0.35 in S2. This finding is consistent with the notion that access to asset markets has widened over the last two decades, with potentially important consequences for the transmission of fiscal policy. In our view, the increase in asset market participation that speaks from our exercise can be related to important institutional changes occurring at the beginning of the 1980s. Some of the suggestive evidence regarding these changes was already mentioned in the introduction; for further details see Mishkin (1991) and Bilbiie and Straub (2004a). Overall, the micro evidence on financial market participation seems neatly in line with our estimation results.

With respect to monetary policy, we detect a considerable change in the way the nominal interest rate is adjusted in response to expected inflation, the parameter ϕ_π being estimated at 1.01 for S1 and 1.77 for S2. Note again in this context that our estimate of ϕ_π has not been restricted to be greater than one and that parameter configurations implying equilibrium indeterminacy have been admitted throughout. Still, our procedure turns out to deliver an estimate that actually implies a determinate and unique equilibrium.[16] Interestingly, the estimates are even fairly close to those reported by Clarida, Galí and Gertler (2000). Using single equation techniques, these authors report an implied long-run response coefficient of 1.58 for a post-82 sample, while their corresponding estimate for data up to 1979 is 0.83. In line with the literature, our results thus suggest that the Fed has adopted a stronger anti-inflationary stand under Chairmen Volcker and Greenspan compared to their predecessors in the 1960s and 1970s.

Turning to the parameters characterizing fiscal policy, note first that the estimates for ϕ_b of -0.07 and -0.11 in sample S1 and S2, respectively, imply a tendency towards debt stabilization: in response to a higher level of debt the structural deficit is reduced in both samples. The order of magnitude of these estimates is in line with results obtained by Bohn (1998) using single equation techniques. The second important fiscal-policy parameter, ϕ_g, governs the degree of deficit finance associated with a government spending shock. Here, we observe a substantial change across samples, the estimate rising from 0.17 to 0.64, suggesting an increase in the reliance on deficits to finance an extra spending unit. This result clearly reflects the strong increase in debt which, according to the empirical impulse responses, follows a sudden increase in government spending in S2 but not in S1. Next, the autoregressive parameter η is estimated to increase from 0.50 to 0.71 from S1 to S2, implying greater persistence of deficits in the second sample. These values are higher than the 0.25 reported in Galí and Perotti (2003), who use single-equation techniques and allow the deficit to respond to the output gap instead of government spending. Finally, ρ_1 is estimated to be 1.03 (S1) and 0.64 (S2), while ρ_2 is estimated to be -0.07 (S1) and 0.27 (S2). These coefficients sum up to 0.96 and 0.91, respectively, indicating the higher persistence of the spending response in S1.

Taken together, our estimation exercise provides a set of parameter values that strike us as plausible and insightful. The estimates indicate that the principal changes from S1 to S2 consist of widened private access to asset markets, more hawkish monetary policy, and a greater degree of deficit finance. The goal of the next section will be to relate these changes in institutions and policies to the differences in fiscal transmission that are visible from the empirical impulse responses in figure 1. Specifically, in a model-based counterfactual analysis we attempt to evaluate which of the three factors - asset markets, monetary policy, or fiscal policy itself - have been pivotal for the observed decline in the effects of government spending on the U.S. economy. For this exercise to be meaningful, we would like our model to give a reasonably good account of the dynamic responses in the data. The low criterion function minima reported in table 2 already suggest that the theoretical impulse responses do not differ too much from the empirical ones in terms of point-wise standard deviations. Graphically, the good fit can be seen from figure 1, where we reproduce the impulse responses implied by the parameter estimates of table 2 (straight lines). The figure clearly shows that the model accounts quite well for the VAR-based evidence on fiscal transmission. Both the magnitude and the persistence of the impulse responses are replicated, and the model-based responses remain consistently within the empirical confidence intervals. While in S1 fiscal policy has a strong and persistent effect on output, wages and consumption, these effects are less significant and considerably less persistent in S2. The behavior of debt in the data is also matched by the model responses.

6 Model-Based Counterfactual Analysis

One neat implication of working with a structural model of the macroeconomy is that well-defined policy experiments can be considered in a way that is less prone to the Lucas critique than counterfactual simulations of reduced-form models. Specifically, keeping constant the model structure and deep parameters across samples, we are in a position to explore various possible causes for the apparent changes in the transmission of fiscal shocks. To do so, we rely on counterfactual experiments similar in spirit to the exercises provided by Boivin and Giannoni (2003) and Stock and Watson (2003) in the context of monetary policy.

Basically, we seek to assess three hypotheses for why fiscal policy may have weaker effects in S2: i) changes in the conduct of fiscal policy as reflected in the estimated parameters $\{\eta, \rho_1, \rho_2, \phi_g\}$; ii) changes in the monetary regime as reflected in the parameter ϕ_π; iii) an increase in asset market participation, i.e. the estimated fall in λ.[17] Of course, the full extent of changes between S1 and S2 can only be accounted for by simultaneous variation of all estimated parameters. Put differently, there are possibly important interactions between different parameters, so the observed differences between S1 and S2 are not simply the sum of the effects of univariate parameter changes. Although our subsequent analysis cannot investigate all of the possible cross effects, we consider two distinct experiments involving parameter changes that seem of particular interest.

In the first experiment, we vary one parameter at a time from its estimated S1 value to its estimated S2 value while leaving all other parameters unchanged. The goal is to evaluate the impact on the model's dynamics relative to the fitted S1 impulse responses. In particular, if a given parameter change moves the counterfactual responses close to the fitted S2 curves, it should arguably be interpreted as a key factor driving differences across the two samples. In the second, complementary experiment we vary, each time, all parameters except one from their estimated S1 to S2 values, thereby assessing the degree to which the transmission of fiscal shocks would differ from what is actually observed in S2, had one parameter of interest stayed unchanged at its S1 value. Among other things, we expect this experiment to reveal which parameter changes may be relatively unimportant for the overall change in transmission from S1 to S2.

Figures 2 and 3 contain the results for the first and second experiment, respectively. To illustrate what is to be accounted for, i.e. the differences in propagation according to our estimates, the first column of each figure displays the theoretical impulse responses of all five variables based on the respective parameter estimates for S1 and S2. As stated before, all variables display much less persistent responses in S2, with the response of the debt ratio even changing sign.

To begin with, consider the experiment depicted in figure 2. The panels in column b) display the responses corresponding to the S1 parameter estimates along with the first set of *counterfactual responses*. The latter result from an evaluation of the model based on all parameters taking their S1 values except λ, which is reduced from 0.51 to its S2 value of 0.35. This experiment is meant to gauge the effect of a counterfactual increase in asset market participation from 49 to 65 percent in the early sample. As a main result, the responses can be seen to exhibit substantially lower persistence.[18] Greater asset market participation allows more households to internalize the government budget constraint, reducing the cumulative effects of government spending on consumption, output and the real wage relative to the S1 baseline case. To the extent that the consumption and output responses are muted, the increase in asset market participation works towards explaining the smaller effect of government spending actually observed in S2.

However, this result has to be put into perspective by considering our next experiment. The panels in column c) display the consequences of varying the degree of monetary policy activism, i.e. the effect of increasing ϕ_π from 1.01 to 1.77. Compared to the previous results, the observed change in responses is much more dramatic now, especially for consumption. Clearly, had monetary policy been more anti-inflationary in S1, a typical increase in government expenditure, by inducing inflation, would have triggered higher nominal interest rates and caused households to postpone spending. This would have dampened consumption, output and the real wage enough to drive the responses close to or even below the levels actually observed for S2. In this sense, the estimated change in monetary policy should be seen as a quantitatively powerful factor pushing results in the right direction, i.e. a smaller expansionary impact of government spending after 1980. Notice, however, that the precise shape of the counterfactual responses still differs noticeably from the actual evidence for S2.

The last three columns consider changes in the conduct of fiscal policy itself. First, in column d) we compare the fitted S1 responses with what would have happened if the process of government expenditure had been less persistent. Specifically, we now change both ρ_1 and ρ_2 to their respective S2 values, while all other parameters stay at their S1 levels. It turns out that output increases by less than under the S1 baseline scenario if the lower persistence of the S2 spending process is assumed. The consumption response becomes weaker, as well. Although these effects point in the right direction, they remain relatively limited.

In contrast, changing the value of η from 0.50 to 0.71, i.e. assuming that deficits had been more persistent in S1, would actually amplify the effects of government spending on most variables. This result is shown in column e). Seen in isolation, it does not appear to align with the observed changes in transmission between S1 and S2, except for the mitigating effect on the fall in debt. A similar finding is obtained when we evaluate the consequences of altering the degree of deficit finance. For this purpose, we set the relevant parameter ϕ_g from its S1 value of 0.17 to the higher S2 value of 0.64. The panels in column f) show that, while this change would induce much stronger positive responses of all variables (contrary to what is seen in the data), it is crucial to account for the rise in debt observed in the second sample.

Overall, the first experiment illustrates why the candidate explanations are in fact complementary. Had government spending been as deficit-financed in S1 as in S2 and had deficits been as persistent, the effects of spending shocks would have been even stronger. If, in reality, we find the effects of fiscal shocks to have declined, this indicates the presence of important offsetting factors. In particular, our results suggest that a combination of increased asset market participation and a more active monetary policy have tended to reduce the expansionary impact of government spending shocks.

Figure 3 provides the results of our second experiment, where we assess the impact of a change in all but one parameters from their estimated S1 to S2 values relative to the fitted S2 responses. The main purpose of this exercise is to understand how the transmission of fiscal shocks in S2 would look if one of the estimated parameter changes had not occurred.

Column b) of figure 3 illustrates that, without the change in asset market participation (column b), the impact effect of a fiscal shock would be much lower (and even of the opposite sign) than what is actually observed in S2. Moreover, the shape and persistence of the responses would be severely affected:

all responses increase to much higher values after the first few quarters and remain there throughout the period of interest. This reinforces our previous insight that asset market participation is key to explaining the change in the dynamic pattern and persistence of the responses of consumption, wages and output.

In contrast, ignoring the change in the degree of monetary policy activism (column c) is immaterial for the shapes of the responses - counterfactual and fitted S2 responses are largely parallel - whereas it makes a substantial difference with respect to their magnitude: had ϕ_π remained at its S1 value, the responses of consumption, wage and output would have been higher in S2 than our data show. Consequently, monetary policy is confirmed as a quantitatively important factor driving the differences in the propagation of fiscal shocks between the two samples. The exception is the response of debt, for which the change in ϕ_π seems to be largely irrelevant. Next, column d) displays the effects of leaving out the change in the persistence of shocks. They are mostly similar, if smaller in magnitude, to those in column b). However, the persistence of shocks is crucial for the response of debt, which would look far too persistent in S2 without the estimated change in the stochastic shock process. Lastly, ignoring the change in the persistence of deficits (column e) would imply missing the hump shapes in most responses. The same is also true (and quantitatively more important) for the degree of deficit financing (column f). Importantly, without the different degrees of deficit financing across samples, it is impossible to explain the distinct responses of debt.

In sum, our exercise yields a set of interesting observations. As documented in section 3, the changes in the effects of government spending concern both the magnitude and the dynamic pattern of the impulse responses. Our model-based analysis identifies different key determinants for these two aspects of the change in propagation. Specifically, among the individual parameter changes that we consider, a more active monetary policy appears to be the most powerful factor reducing the effects of fiscal shocks in the second sample. The dampening effect of a tougher anti-inflationary stance is complemented by greater asset market participation and less persistent spending shocks, although the latter two changes are quantitatively less important. Especially the change in asset market participation is, however, crucial to account for the changes in the shape and persistence of the responses of output, consumption and the real wage. Similarly, in order to explain the radically different dynamics of government debt across samples, the change in the degree of deficit financing is paramount. Hence, while none of the candidate explanations can by itself provide a full account of the changes in fiscal transmission, our counterfactual experiments indicate the complementarity of the different factors and identify the specific role played by each of them.

7 Conclusion

In this paper, we make essentially two contributions. First, we add to the emerging evidence that the transmission of government spending shocks in the U.S. economy has changed substantially in the post-1980s. Second, we try to account for these changes by considering a DSGE model whose implications for fiscal transmission are driven by a set of structural and institutional parameters.

To establish the stylized facts of fiscal transmission, we consider a parsimonious VAR that is specified in accordance with our theoretical model. The main finding is that an exogenous increase in government spending leads to a sustained rise in output, consumption and the real wage in the period 1957-79 but has less significant and much less persistent effects on these variables after 1982. Moreover, the financing of government spending shocks appears to have changed, as indicated by the distinct responses of government debt across the two samples. Together, these results confirm earlier studies by Perotti (2005) and Mihov (2003).

Why does U.S. fiscal policy have less expansionary effects in the second sample? Starting from our VAR-based evidence, we try to relate the differences in fiscal transmission to important institutional and policy changes in the U.S. economy. Clearly, our analysis must confront the Lucas critique, so we resort to a structural model. Specifically, we propose a New Keynesian DSGE model that features limited asset market participation as a potential institutional explanation for different degrees of fiscal policy effectiveness. In addition, the model encompasses simple specifications of both fiscal and monetary policies, so several competing hypotheses can be taken into account as to the reasons for the observed change in fiscal transmission.

We take our structural model to the data by matching its implied impulse responses with those obtained from the VAR. In contrast to other applications of minimum distance estimation, we ensure that the model's dynamics are fully nested in the VAR, thus addressing a recent critique of Chari, Kehoe and McGrattan (2005). Our approach provides us with estimates of the key policy and institutional parameters for the two samples, while all deep parameters are held constant. The results suggest that asset market participation increased noticeably in the post-1980s, in line with earlier informal evidence. We also find that government spending has become less persistent but more deficit-financed in the second sample and that monetary policy has become more active.

Given these estimates, we carry out counterfactual experiments within the framework of our structural model. Specifically, we consider the quantitative impact of single policy or institutional reforms in order to evaluate which of the candidate changes in the U.S. economic environment is most powerful in accounting for the differences in fiscal transmission before and after 1980. A ceteris-paribus increase in asset market participation to the level estimated for the second sample leads to somewhat weaker output, consumption and real wage effects of a government spending shock, thus explaining part of the decline in the effects of fiscal shocks. Importantly, it also leads to a change in the shape of the impulse responses consistent with that observed in the data. A similar, if more limited, impact can be ascribed to the estimated change in the persistence of fiscal shocks. However, the most important single determinant for the changes in fiscal policy transmission appears to be the change in monetary policy: apart from its other macroeconomic implications, the stronger anti-inflationary stance of the Volcker-Greenspan period has also acted to reduce the expansionary effects of a surprise increase in government spending. Lastly, changes in the persistence of budget deficits and the degree of deficit financing are another indispensable element of the story, notably to explain the strikingly different dynamics of debt across the two samples. Taken together, these results highlight the importance of considering the interaction of monetary and fiscal policies, on the one hand, and the evolution of financial markets, on the other hand, in order to gain a better understanding of how important shocks are transmitted in the economy.

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Appendix

A Steady State

Here we calculate the coefficients used in the log-linearized version of the model. For any variable X_t, X denotes its steady-state value and X_Y its steady-state share in output, X/Y. The Euler equation (3) implies $1 + r \equiv R = 1/\beta$. From the firm's problem (12), we have for the real wage

$$\frac{W}{P} = \frac{\varepsilon - 1}{\varepsilon}, \tag{19}$$

while production (11) in the steady state implies $Y = N - F$. Defining $\mu = 1/(\varepsilon - 1)$, we rewrite (19) as

$$\frac{W}{P} = \frac{Y + F}{N(1+\mu)} = \frac{Y}{N}\frac{1 + F_Y}{1+\mu}.$$

Profits in the steady state amount to $O = Y - [W/P]\,N$, so that the ratio of profits to output is given by

$$O_Y = \frac{\mu - F_Y}{1+\mu}.$$

We assume that hours are the same for the two groups in the steady state, $N_N = N_A = N$. Because of preference homogeneity (see section 2), we need to ensure that steady-state consumption shares are also equal across groups. This can be seen by comparing (5) with (8) evaluated in the steady state:

$$\frac{C_A}{L} = \frac{1-\tau}{\varphi}\frac{W}{P} = \frac{C_N}{L}$$

implying $C_A = C_N = C$. The steady-state coefficients needed for our log-linear approximation below are fully determined as

$$\begin{aligned}
(1-\tau)\frac{W}{P}\frac{N}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu}; \\
\frac{C_A}{Y} &= (1-\tau)\frac{1}{1-\lambda}\left(1 - \lambda\frac{1+F_Y}{1+\mu}\right) - T_Y; \\
\frac{C_N}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu} - T_Y; \\
T_Y &= G_Y - \tau.
\end{aligned} \tag{20}$$

We thus achieve equalization of steady-state consumption shares by making assumptions on technology. Specifically, we ensure that asset income in steady state is zero. This requires assuming that the fixed cost of production is characterized by: $F_Y = \mu$.[19] Substituting into (20) gives

$$\frac{C_A}{Y} = \frac{C_N}{Y} = C_Y = 1 - \tau - T_Y = 1 - G_Y.$$

Next, we want to find hours in steady state. Given the equalization of hours and consumption between the two groups and normalizing $P = 1$, the intratemporal optimality condition implies

$$\frac{C}{1-N} = \frac{1-\tau}{\varphi} W \Rightarrow (1-\tau) WN - T = \frac{1-\tau}{\varphi} W (1-N).$$

Dividing by Y and using (20) and the expression for the fixed cost we obtain the following expression for steady-state hours:

$$\frac{N}{1-N} = \frac{1}{\varphi} \frac{1-\tau}{1-G_Y}. \tag{21}$$

Given τ and G_Y, we choose steady-state N to match average hours worked. From (21), this implies a unique value for φ.

B Log-Linearized Equilibrium

A local approximation of the model outlined in section 2 around its non-stochastic steady state delivers a system of linear difference equations that can be solved numerically. We outline the log-linear equations in this appendix. Small letters denote the log-deviation of a variable from its steady-state value, while $\hat{b}_t = B_t / (P_{t-1} Y_{t-1})$, $\pi_t = \log(P_t/P_{t-1})$ and $w_t = \log((W_t/P_t)/(W/P))$. Given the process (15) and a shock to government spending, ε_t, we consider the sequence for the set of variables

$$\left\{ c_{A,t}, c_{N,t}, c_t, y_t, \pi_t, r_t, w_t, n_{A,t}, n_{N,t}, n_t, \hat{d}_{s,t}, \hat{b}_t, t_t \right\}_{t=0}^{\infty}$$

that satisfies 13 conditions/definitions to be listed in turn.

First, linearizing the Euler equation (3) and substituting steady-state hours from (21) gives

$$\begin{aligned} c_{A,t} &= E_t c_{A,t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1}) \\ &\quad + \left(1 + \frac{T_Y}{1-G_Y}\right)\left(\frac{1}{\sigma} - 1\right)(E_t n_{A,t+1} - n_{A,t}). \end{aligned}$$

For $\sigma > 1$, the elasticity of consumption growth $(E_t c_{A,t+1} - c_{A,t})$ to hours growth $(E_t n_{A,t+1} - n_{A,t})$ is positive. In addition, the elasticity of consumption to the real interest rate is given by $1/\sigma$. The labor choice of asset holders (5), in log-deviations from steady state, satisfies

$$\frac{N}{1-N} n_{A,t} = w_t - c_{A,t}.$$

The linearized first-order condition and budget constraint, (8) and (7), for non-asset holders read as

$$\begin{aligned} \frac{N}{1-N} n_{N,t} &= w_t - c_{N,t}, \\ (1 - G_Y)\, c_{N,t} &= (1-\tau)\,(w_t + n_{N,t}) - T_Y t_t. \end{aligned}$$

From these two equations, we obtain a reduced-form labor supply for non-asset holders. Specifically, we have

$$n_{N,t} = \frac{\varphi}{1+\varphi} \frac{-T_Y}{1 - G_Y + T_Y} (w_t - t_t).$$

Since $-T_Y > 0$, hours of non-asset holders respond positively to increases in the real wage, w_t, and taxes relative to their steady-state value, $T_Y t_t$.

Labor market clearing, using $N_A = N_N = N$, implies

$$n_t = \lambda n_{N,t} + (1-\lambda)\, n_{A,t},$$

while aggregate consumption is given by

$$c_t = \lambda c_{N,t} + (1-\lambda)\, c_{A,t}.$$

Up to a first-order approximation, the aggregate production function (11) reads as

$$y_t = (1 + F_Y)\, n_t.$$

A log-linear approximation of the price setting problem (12), together with the definition of the price level, implies

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} w_t.$$

Next, consider the government sector. An approximation to the government budget constraint (14) divided by output gives

$$\beta\hat{b}_{t+1} = \hat{b}_t + G_Y g_t - T_Y t_t - \tau y_t.$$

In turn, an approximation to the definition of the structural primary deficit divided by output $\hat{d}_{s,t}$ is given by

$$\hat{d}_{s,t} = G_Y g_t - T_Y t_t.$$

Our specification of the deficit rule (16) reads as

$$\hat{d}_{s,t} = \eta\hat{d}_{s,t-1} + \phi_g G_Y g_t + \phi_b \hat{b}_t.$$

The monetary policy rule (13), in log deviations, is given by

$$r_t = \phi_\pi E_t \pi_{t+1}.$$

Finally, good market clearing implies

$$y_t = G_Y g_t + (1 - G_Y) c_t.$$

C A Model with Money

The purpose of this appendix is to show that the principal implications of our model remain unaffected if we allow for money holdings by both agents and adopt a particular scheme for rebating seigniorage revenues. This setup gives non-asset holders some room for smoothing consumption by holding money. Suppose that utility is separable in money balances, so that the period utility for agent $j \in \{A, N\}$ is given by

$$U\left(C_{j,t}, L_{j,t}, \frac{M_{j,t}}{P_t}\right) = \frac{\left(C_{j,t} L_{j,t}^{\varphi}\right)^{1-\sigma}}{1-\sigma} + h\left(\frac{M_{j,t}}{P_t}\right), h' > 0, h'' < 0,$$

while the budget constraints become, respectively:

$$\begin{aligned} & R_t^{-1} B_{A,t+1} + P_t C_{A,t} + P_t T_t + M_{A,t} \\ = \ & B_{A,t} + M_{A,t-1} + (1-\tau)\left(W_t N_{A,t} + P_t D_{A,t}\right) + P_t S_{A,t}, \\ & P_t C_{N,t} + P_t T_t + M_{N,t} \\ = \ & M_{N,t-1} + (1-\tau) W_t N_{N,t} + P_t S_{N,t} \end{aligned}$$

where $M_{j,t}$ are end-of-period money holdings and $P_t S_{j,t}$ are nominal transfers received from the government due to seigniorage revenues. Because utility is separable in money, the first-order conditions outlined in the main body of the paper do not change. However, there are two additional first-order conditions governing the choice of money holdings $M_{j,t}$. For each agent, $h'(M_{j,t}/P_t) - U_C(C_{j,t}, L_{j,t}) + \beta E_t(P_t/P_{t+1}) U_C(C_{j,t+1}, L_{j,t+1}) = 0$, which leads to a money demand equation:

$$h'\left(\frac{M_{j,t}}{P_t}\right) = \left[1 - \beta E_t \Lambda^j_{t,t+1}\right] U_C(C_{j,t}, L_{j,t}).$$

Since $R_t^{-1} = \beta E_t\left[\Lambda^A_{t,t+1}\right]$, we obtain a standard money demand schedule for asset holders: $h'(M_{A,t}/P_t) = \left[1 - R_t^{-1}\right] U_C(C_{A,t}, L_{A,t})$. Note that this money demand depends negatively on interest rates.

Importantly, non-asset holders' money demand does not depend directly on interest rates. Although $\Lambda^N_{t,t+1}$ is defined similarly to $\Lambda^A_{t,t+1}$, in contrast to the latter it does not constitute a pricing kernel. The money demand of non-asset holders merely specifies the path of money holdings as a function of the entire path of consumption and inflation (and leisure in the non-separable case):

$$h'\left(\frac{M_{N,t}}{P_t}\right) = U_C(C_{N,t}, L_{N,t}) - \beta E_t \frac{P_t}{P_{t+1}} U_C(C_{N,t+1}, L_{N,t+1}). \tag{22}$$

Note that money holdings will increase if present consumption increases and will fall if either future expected consumption or expected inflation increase. This introduces a channel for non-asset holders to smooth consumption that is absent in the cashless model.

In order to complete our description of the equilibrium we need to specify four more conditions, since we have introduced six extra variables: $M_{A,t}$, $M_{N,t}$, M_t, $S_{A,t}$, $S_{N,t}$, S_t and two extra equations governing money demand for each agent. The first two are straightforward. Money market clearing requires: $M_t = \lambda M_{N,t} + (1-\lambda) M_{A,t}$, while the definition of total transfers reads as $S_t = \lambda S_{N,t} + (1-\lambda) S_{A,t}$, which enters the government budget constraint in a straightforward way.

The last two conditions are slightly more complicated and are related to the government's policy in redistributing seigniorage revenues to each group in the form of transfers. We choose to specify this policy in a way that implies the smallest deviation of this model from both (i) a model without money and with non-asset holders as presented in section 2; and (ii) a model with money in which all agents have access to complete asset markets. Specifically, we assume that each agent j receives back in transfers precisely the amount that has been obtained from him as seigniorage:

$$S_{j,t} = \frac{M_{j,t} - M_{j,t-1}}{P_t}. \tag{23}$$

Note that this is effectively the same assumption as is made in standard monetary models, where everybody holds assets and agents are identical so that the same equality also holds at an aggregate level. In our framework under this assumption, however, money holdings are different across agents, so transfers across agents will also be different. The redistribution scheme in (23) implies that the budget constraint of the non-asset holders is identical to the one before: $P_tC_{N,t}+P_tT_t = (1-\tau)\,W_tN_{N,t}$, whereby consumption tracks disposable income. In fact, all equilibrium conditions of the cashless model are unaffected. The money holdings of asset holders are determined by their money demand equation for a given a path of consumption, leisure and nominal interest rates, while the money holdings of non-asset holders are determined endogenously by their money demand equation for a given path of consumption, leisure and expected inflation.[20]

Notes

[1]Changes in the financial landscape included the phasing-out of 'Regulation Q', which had imposed severe restrictions on the interest paid by commercial banks, a reduced minimum denomination of Treasury bills, the emergence of money market mutual funds, a sharp decrease in trading costs, and a rise in private shareholding. Generally, the introduction and widespread use of new financial instruments and the elimination of ceilings on deposit rates had the effect of (re-)linking saving decisions to market interest rates. For a detailed discussion, see Mishkin (1991).

[2]While these authors are also interested in the response of private consumption to a government spending shock, their analysis is based on a model featuring strong Edgeworth complementarity between private and public spending. Relying essentially on preferences to explain the crowding-in of consumption, this framework strikes us as less suitable for addressing changes in the transmission of fiscal policy over time.

[3]Appendix C shows that the explicit introduction of money into our model would, under reasonable assumptions, not affect our theoretical results on the importance of limited asset market participation for the effects of a government spending shock.

[4]This assumption is also made in the 'liquidity effect' literature - see e.g. Alvarez, Lucas and Weber (2002). The terminology follows Vissing-Jorgensen (2002). In contrast, Galí, López-Salido and Vallés (2005) and Mankiw (2000) distinguish households by their ability to hold physical capital.

[5] Alternatively, one could assume that consumption shares are equalized by lump-sum redistributive taxation in steady state, see Galí, Lopez-Salido and Valles (2005). However, this would imply that asset holders pay permanently higher lump-sum taxes.

[6] Note that, since we assume steady-state debt and deficits to be zero, first-order variations in any of these variables around the steady state are isomorphic to those of variables defined as shares of steady-state output. For example, if $X = 0$, up to first order around this steady state we have $X_t/Y_t \simeq X_t/Y$.

[7] The resulting model is essentially the same as the lump-sum tax version of Bilbiie and Straub (2004b), from which the following discussion draws.

[8] In fact, our estimation exercise will fully address this issue by including the conditional response of the real wage among the relevant features to match.

[9] See Blanchard and Perotti (2002), Fatás and Mihov (2001), Galí, López-Salido and Vallés (2005), and Perotti (2005).

[10] Lagged debt and output appear as state variables, because the lagged structural deficit can be expressed as a function of these variables by virtue of the government budget constraint.

[11] The data are drawn from several sources. From the National Income and Product Accounts (Bureau of Economic Analysis) we obtain real government spending, which is government consumption expenditures and gross investment (A822RX1). Real GDP (A191RX1) and real total personal consumption expenditures (A002RX1) are also taken from the NIPA. The real wage is obtained from the Bureau of Labour Statistics: Nonfarm business real hourly compensation (BLS: PRS84006153). Finally, end-of-period debt figures (total U.S. government debt privately held) come from the International Financial Statistics of the IMF (11188ZF). Private consumption, output and government spending are normalized by the current population level (NIPA: B230RC0).

[12] Alternative identification schemes applied to the same question have led to mixed results. Using sign restrictions, Mountford and Uhlig (2004) find that private consumption increases (falls) after a deficit-financed (balanced-budget) government spending shock, but neither response is significant. Edelberg, Eichenbaum and Fisher (1999) study the response of economic time series to a dummy variable capturing fiscal episodes (Korean and Vietnam wars and Reagan military buildup) and report mixed results regarding different components of private consumption expenditure at different horizons. Overall, the reponse of consumption to a fiscal episode is found to be small in this line of work.

[13]Note that Perotti also calculates the cumulative deficit response and finds it positive in both samples, although much larger in S2 (2.8 vs. 0.8).

[14]We also considered the possibility of a change in α, by imposing 0.77 in S1 and 0.84 in S2, which corresponds to the values reported by Galí and Gertler (1999) for the periods 1960:1-1979:4 and 1980:1-1997:4, respectively. Moreover, we also considered the case of $\alpha = 0.75$ for both samples. Our results proved to be quite robust with respect to these changes.

[15]Indeed, our theoretical model can exhibit equilibrium indeterminacy coming from a variety of interacting sources: monetary policy, debt dynamics, the presence of non-asset holders and non-separability of utility.

[16]Note however that, while ϕ_π was always estimated to be close to unity for S1, some alternative specifications that we considered for robustness yielded estimates slightly below unity. Although in this case the equilibrium is indeterminate under the saddle-path stability criterion, the estimates of the other parameters and the pattern of the impulse response functions were essentially unaltered. We also did not observe any material consequences for the counterfactual experiments discussed below.

[17]Changes in ϕ_b - estimated to be small throughout - appear to be immaterial in accounting for the change in transmission and are, therefore, not considered here.

[18]The obvious exception is the response of government spending, which is only governed by the relevant persistence parameters and thus unaffected by all other parameter changes.

[19]Alternatively we could have assumed as in Gali et al (2005), that steady-state lump-sum taxes achieve this equalization; namely, $T_Y^A = T_Y^N + \frac{1-\tau}{1-\lambda} O_Y$. If the profit share O_Y is non-zero, this would imply that asset holders pay permanently higher *lump-sum taxes*. Our assumption implies that the share of profits in steady state is zero, in line with the evidence and arguments in Rotemberg and Woodford (1995), and hence $T_Y^A = T_Y^N = T_Y$.

[20]The same would hold if the government followed a money supply rule instead of a Taylor rule. For a given growth rate of total money M_t chosen by the government, the interest rate would be pinned down by the money demand equation of asset holders.

Table 1: Cumulative Impulse Responses to Spending Shock[a]

Variable	Horizon	S1	S2	S2-S1
spending	4	3.82 (0.45)	2.67 (0.32)	−1.14 (0.56)
	12	10.99 (2.53)	6.40 (1.34)	−4.58 (2.91)
	20	14.32 (4.46)	7.47 (2.59)	−6.84 (5.29)
output	4	1.71 (0.57)	0.94 (0.42)	−0.77 (0.72)
	12	4.50 (1.46)	2.38 (1.41)	−2.12 (2.08)
	20	5.99 (2.14)	2.62 (1.99)	−3.37 (3.00)
real wage	4	0.46 (0.25)	0.50 (0.61)	0.05 (0.67)
	12	2.16 (0.85)	0.34 (1.53)	−1.82 (1.77)
	20	4.06 (1.45)	−0.89 (2.48)	−4.95 (2.93)
consumption	4	0.78 (0.42)	0.70 (0.37)	−0.08 (0.57)
	12	2.74 (1.10)	1.64 (1.39)	−1.10 (1.81)
	20	4.32 (1.62)	1.23 (2.30)	−3.09 (2.89)
debt	4	−0.26 (0.28)	0.94 (0.54)	1.20 (0.61)
	12	−1.64 (1.14)	4.92 (3.02)	6.56 (3.21)
	20	−3.55 (2.13)	8.86 (6.00)	12.41 (6.35)

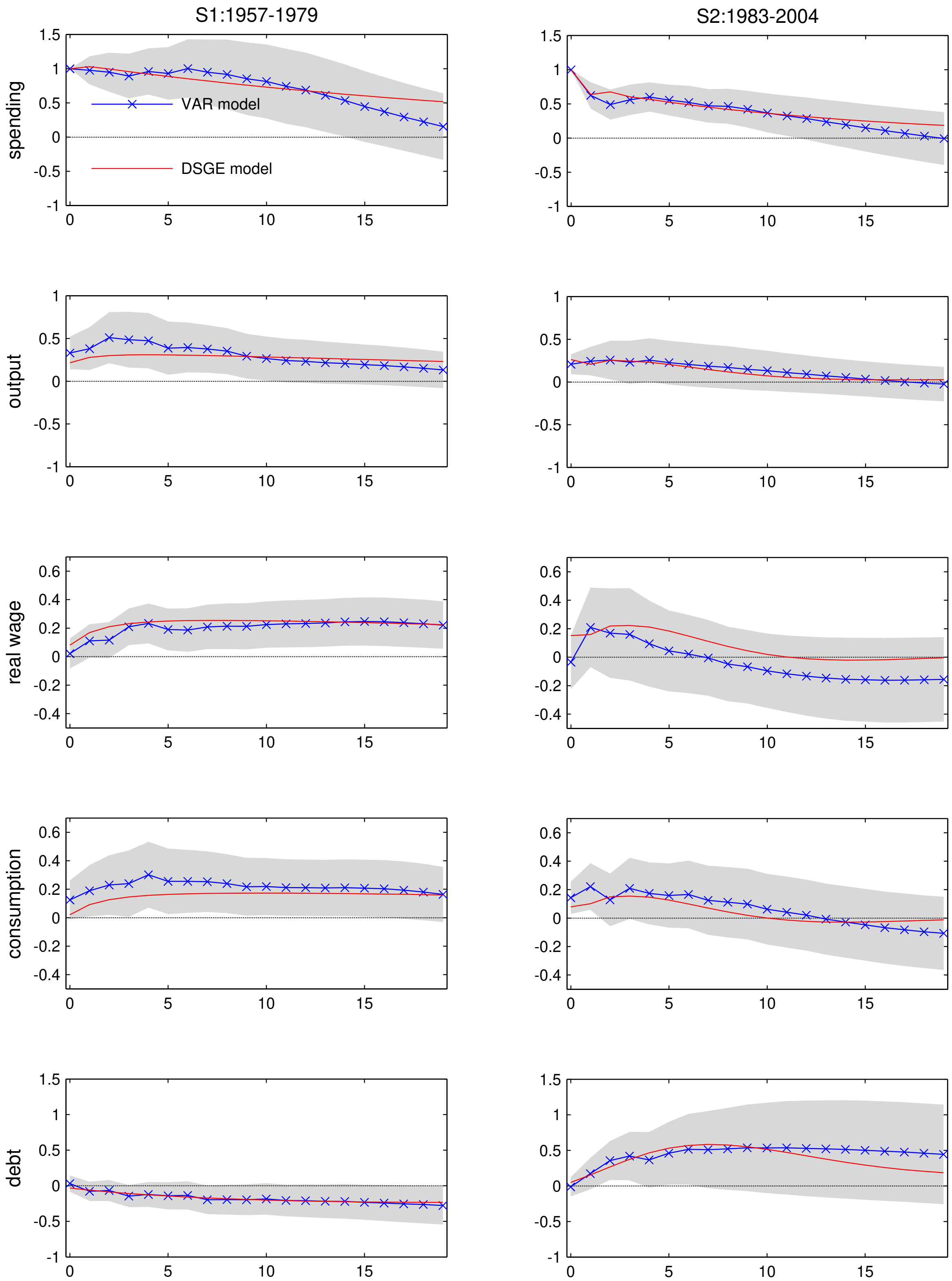
[a]Responses are percent deviations from unshocked path, except for debt, which is percentage points of output. Standard errors obtained by bootstrap are reported in parentheses.

Table 2: Estimated Model Parameters[b]

Parameter	S1	S2
λ	0.509 (0.080)	0.347 (0.258)
ϕ_π	1.012 (0.022)	1.770 (0.756)
ϕ_b	−0.073 (0.232)	−0.117 (0.036)
ϕ_g	0.169 (0.101)	0.640 (0.235)
η	0.503 (0.586)	0.711 (0.302)
ρ_1	1.030 (0.153)	0.638 (0.123)
ρ_2	−0.065 (0.149)	0.270 (0.123)
Loss :	20.0897	19.792

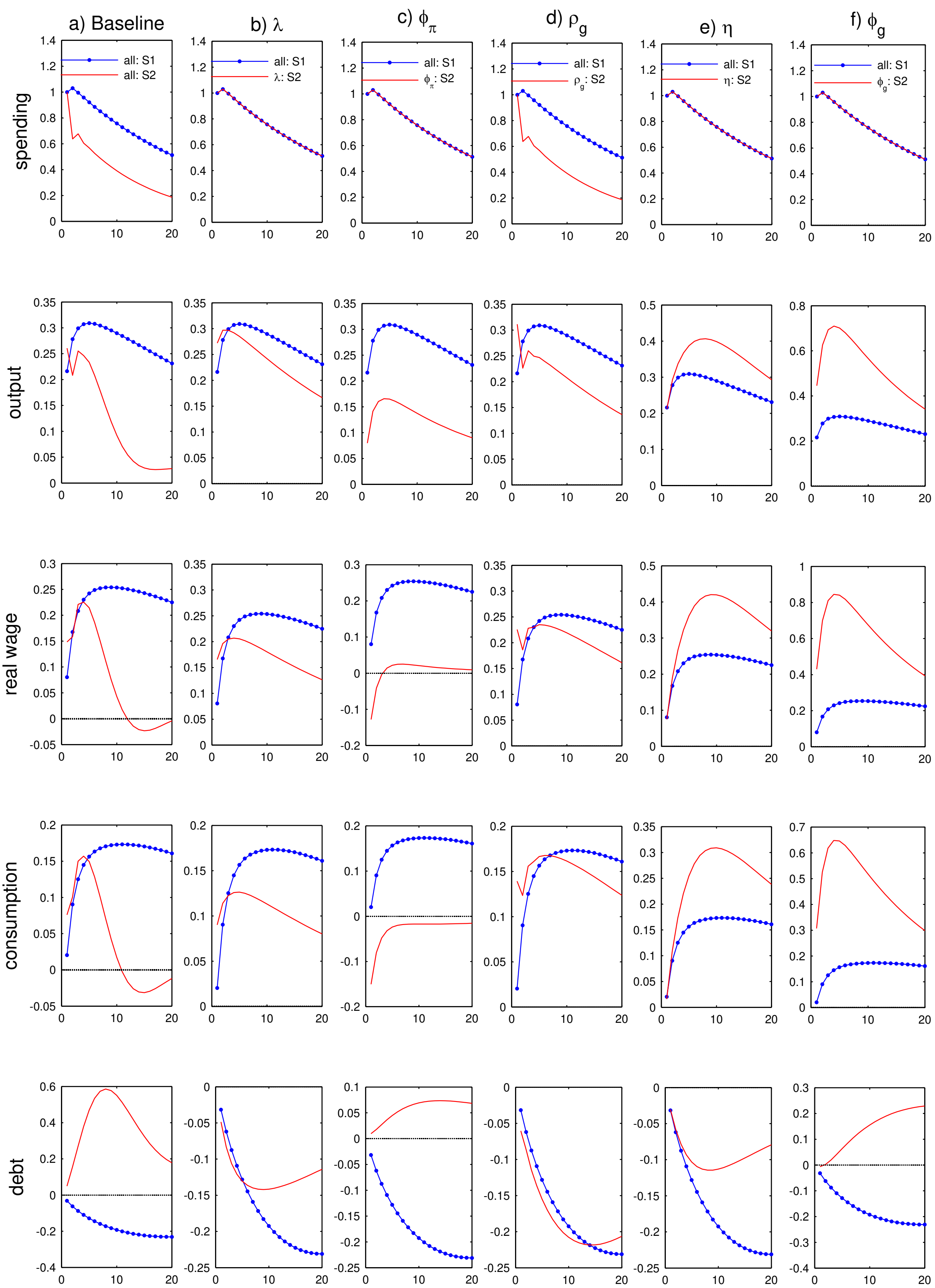
[b]Standard errors are reported in parentheses.

Figure 1: Transmission in estimated VAR and DSGE model



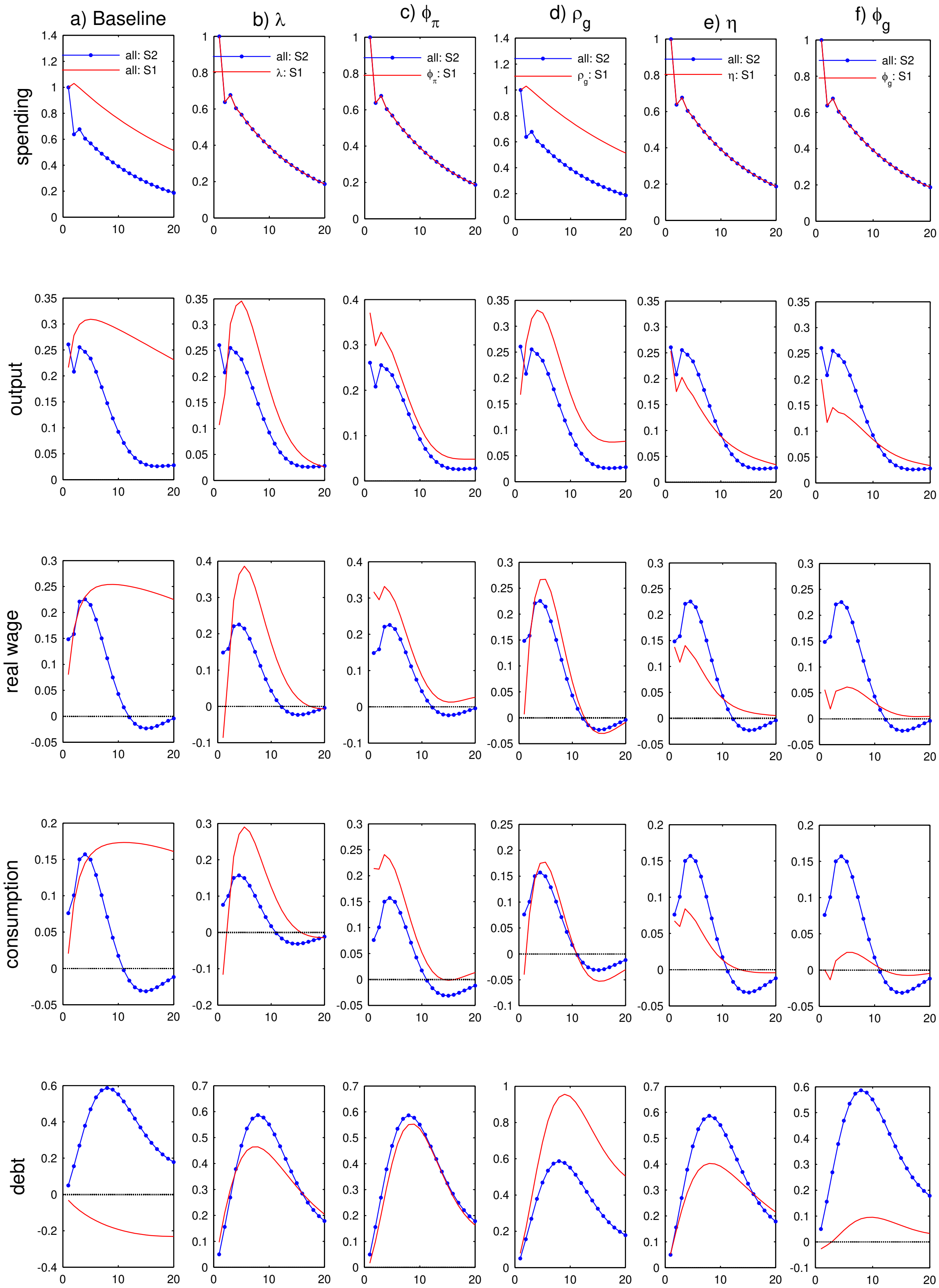
Legend: impulse responses to one percent increase in real government spending. Shaded areas indicate bootstrapped 90 percent confidence intervals. Vertical axes indicate deviations from unshocked path. Horizontal axes indicate quarters. DSGE model simulation based on parameter estimates obtained by matching VAR-responses.

Figure 2: Counterfactuals I - Changing one parameter at a time



Legend: model impulse responses for S1 and S2 parameter estimates (column a)). Columns b) to f) contrast responses resulting from S1 baseline estimate with counterfactual responses resulting from varying each parameter of interest from S1 to S2 estimate.

Figure 3: Counterfactuals II - Changing all parameters except one



Legend: model impulse responses for S1 and S2 parameter estimates (column a)). Columns b) to f) contrast responses resulting from S2 baseline estimate with counterfactual responses resulting from varying each parameter of interest from S2 to S1 estimate.

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