What Accounts for the Changes in U.S. Fiscal Policy Transmission?*

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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 period. 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 periods by matching impulse responses. Model-based counterfactual experiments suggest that most of the changes in fiscal policy transmission are accounted for by increased asset market participation and the more active monetary policy of the Volcker-Greenspan period.

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 on this issue has flourished, as well. In a seminal study based on vector autoregressions (VARs) for a long postwar sample, Blanchard and Perotti (2002) provide evidence indicating a positive response of consumption and output to a one-time fiscal shock. Specifically, the authors analyze U.S. time series data from 1960 to 1997 and find a spending multiplier for consumption between one third and one. Similar findings are also reported by Fatás and Mihov (2001) and Galí, López-Salido, and Vallés (2007). Other more recent empirical studies, however, suggest that the transmission of fiscal policy shocks may have actually changed around the early 1980s. Indeed, both Perotti (2005) and Mihov (2003) provide fresh VAR-based evidence for the U.S. 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 U.S. monetary policy differed substantially before and after the 1980s. This change may have affected more generally the transmission of shocks in the economy. 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 more recent period. A third explanation stresses the role of private consumption behavior by pointing out the possible consequences arising from increased asset market participation. In fact, retail financial markets were subject to significant restrictions until the late

1970s. Bilbiie and Straub (2006) argue that these restrictions may have effectively prevented a large fraction of households from smoothing consumption in the desired way. Shut out from 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 (2007) and Bilbiie and Straub (2004). 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 financial liberalization occurring 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). Thus, the evolution of household finance competes with changes in monetary and fiscal policies as candidate explanations for the observed decline in the effects of U.S. government spending.

The objective 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 (2004) 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 supplementing 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 government spending effects on output, wages, and private consumption. S1 and S2 constitute appropriate samples for our study, because they allow us to characterize fiscal transmission *before* and *after* any of the potentially important changes to monetary policy, government spending, financial markets, and the business cycle in general. In a 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. Section 7 provides a conclusion.

2 The Model

The model, which draws on both Galí, López-Salido, and Vallés (2007) and Bilbiie and Straub (2004), 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 who set prices on a staggered basis. Moreover, the model specifies two policy-makers: a monetary authority sets its policy instrument, the nominal interest rate; and 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 (2007).[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 condition

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

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

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

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:

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

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 that 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 $g_t = \left(G_t - G \right) / G$, 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: $D_{s,t} = D_t + \tau \left(Y_t - Y \right) = G_t - T_t - \tau Y$. 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 $\hat{b}_t \equiv B_t / \left(P_{t-1} Y_{t-1} \right)$ is real debt divided by last period's output, so that it remains a state variable. Rules of this type have been studied extensively, including by 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 determines 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. To begin with, consider the case in which utility is separable ($\sigma \to 1$).[7]

The standard prediction is for higher government spending to depress the consumption of asset holders. The reason is the 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, such as Baxter and King (1993) and Linnemann and Schabert (2003). They generally induce a crowding-out of private consumption in response to higher government spending.

By contrast, our model allows for total private consumption to increase in response to a government spending shock, provided that there is a strong enough rise 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.[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), the real wage may increase enough to raise aggregate consumption. Note, however, that even a strong increase in the real wage does not necessarily have this effect. Indeed, higher real wages also drive up marginal costs and thus reduce profits, further weighing on the consumption of asset holders. In addition, although 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. 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, $\sigma > 1$ 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.

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 Fiscal Policy Transmission

3.1 VAR specification

Having introduced our theoretical model, we now turn to the empirical characterization of fiscal transmission. Specifically, we propose a VAR framework to obtain estimates of the empirical impulse response functions associated with a government spending shock. Because our ultimate goal is to estimate the structural parameters of our model by matching theoretical and empirical impulse responses, we have to ensure that the empirical framework actually captures the dynamics implied by our theory. In other words, the log-linear theoretical model ought to be nested in the VAR. This has two implications.

First, the identifying restrictions we use in our VAR have to be consistent with the theoretical model. In the relevant empirical literature, 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. This is achieved by estimating a recursive VAR where government spending is ordered first, and interpreting the residual from the first equation as a structural innovation to government spending. Following Perotti (2005), such an interpretation can be justified on the grounds 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, we specify the VAR to include all state variables from the theoretical model. The solution of the log-linearized model implies a state-space system in which all variables are functions of the current state only. In our case, the set of state variables comprises current government debt and its lagged value along with the lagged value of output as well as the current value and first two lags of government spending.[10] 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.

Apart from government debt, government spending, and output, we also include private consumption and the real wage in the VAR. The response of private consumption represents a focal point of the debate on fiscal policy transmission, providing a strong rationale for including this variable. The real wage response, in turn, plays an important role in the transmission of spending shocks. Thus, our VAR comprises five variables. 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]

Our sample choice reflects the hypothesis of a structural break in the early 1980s. As discussed above, early studies such as Blanchard and Perotti (2002) and Fatás and Mihov (2001) report a substantial increase in private consumption in response to a government spending shock.[12] However, more recent 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, taking also into account the possibility of structural breaks in other economic areas. 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 starts in 1983:1, i.e., just after the Volcker disinflation period. This sample split also conforms with 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 dashed lines indicate point estimates, the shaded areas represent symmetric 90 percent confidence intervals, computed by bootstrapping based on 1,000 replications.

$<$ figure 1 about here $>$

In the first row, the response of government spending can be seen to display greater persistence in S1 than in 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 appears consistent with the findings reported by other studies that cover longer sample periods. Specifically, Galí, López-Salido, and Vallés (2007) 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 the opposite is true. This finding seems again consistent with Perotti (2005) who finds that the cumulative net tax response to a spending shock is typically positive in S1 and negative in S2.[13]

$<$ table 1 about here $>$

Another way to summarize the evidence is provided by Table 1, which reports cumulative impulse responses for 4, 12, and 20 quarters for all variables and both samples. Bootstrapped standard errors are provided below the respective point estimates. Most strikingly, 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 and even more for the cumulative wage response. The last column of Table 1 reports the differences in the cumulative responses between both samples. For most variables and horizons, the differences amount to at least one to two standard errors.

Overall, our results corroborate the evidence reported by Perotti (2005) and Mihov (2003). A comparison of both samples points to 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 (2006), and Christiano, Eichenbaum, and Evans (2005).

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 that they should represent aspects of the data on which economic interest is centered, for example, because they are clearly linked with important theories or because they matter most for economic policy.

We consider the impulse responses for all five VAR variables as the relevant feature to match. 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—together with the dynamics of the initial fiscal shock—represent important benchmarks on which to measure the descriptive quality of competing models. Accordingly, we build our matching exercise on the full set of empirical impulse response functions presented in the previous section. In so doing 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 this 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 parameters 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 such cases, 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.

$<$ table 2 about here $>$

Starting with the parameter λ, we observe that 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 an insignificant 0.35 in S2. This qualitative finding is remarkably consistent with the microeconomic evidence cited earlier that access to asset markets widened in the wake of important institutional changes in the early 1980s, with potentially important consequences for fiscal policy transmission.

With respect to monetary policy, we note 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 at 1.77 for S2. It bears emphasizing 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, we obtain estimates that imply a determinate and unique equilibrium for both periods.[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-1982 sample, while their corresponding estimate for data up to 1979 is 0.83. Our results thus suggest that the Fed adopted a stronger anti-inflationary stance under Chairmen Volcker and Greenspan compared to their predecessors in the 1960s and 1970s, in line with the literature. Nevertheless, we also explored the robustness of our results with respect to specifying the coefficients of the monetary policy rule prior to the estimation. In this variant of the model, we borrowed the precise monetary policy rule estimated by Clarida, Galí, and Gertler (2000). This rule allows for interest rate smoothing and a response not only to expected inflation but also to the output gap. The resulting estimates for the remaining parameters of the model are very similar to the results reported here and available upon request.

Turning to the parameters characterizing fiscal policy, note first that the estimates for ϕ_b of -0.07 and -0.12 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. Moreover, 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 as the estimate increases from 0.17 to $0.64,$ suggesting a greater reliance on deficits to finance an extra spending unit in S2. This result clearly reflects the strong increase in debt that, 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 rise from 0.51 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 rather than to government spending. Lastly, ρ_1 is estimated to be 1.03 (S1) and 0.64 (S2), while ρ_2 is estimated to be -0.06 (S1) and 0.27 (S2). These coefficients sum up to 0.97 and 0.91, respectively, indicating the higher persistence of the spending response in S1.

Taken together, our estimation exercise provides a set of plausible parameter values. The estimates indicate that the principal changes from S1 to S2 consist of widened private access to asset markets, more active 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 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 (solid lines). 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 advantage of working with a structural model is that we can consider well-defined policy experiments in a way that is less prone to the Lucas critique than counterfactual simulations of reduced-form models. Specifically, we can explore various possible causes for the apparent changes in fiscal transmission, by keeping deep parameters (and the basic model structure) unchanged across samples and focusing on specific changes in other parameters. Thus our counterfactual experiments are similar in spirit to the exercises provided by Boivin and Giannoni (2006) and Stock and Watson (2004) in the context of monetary policy.

To quantify the differences in fiscal transmission across samples, we compute the sum of squared distances between model-based S1 and S2 responses for each of the variables displayed in

Figure 1,

$$\Delta_i \equiv \left(\Psi_i\left(\hat{\theta}_2\right) - \Psi_i\left(\hat{\theta}_1\right)\right)'\left(\Psi_i\left(\hat{\theta}_2\right) - \Psi_i\left(\hat{\theta}_1\right)\right), \tag{19}$$

where $\Psi_i\left(.\right)$ is the impulse response function for variable $i \in \{y, c, w, b, g\}$.[17]

Next, we evaluate the role of different parameters in explaining the observed difference in the transmission mechanism across samples. For this purpose, we vary one parameter at a time from its estimated S1 value to its estimated S2 value while leaving all other parameters unchanged. The impulse responses of this counterfactual economy are compared to those obtained for the S2 parameter estimates. Specifically, we compute the equivalent of (19), now denoted as $\Delta_i^c\left(.\right)$. To the extent that this measure is smaller than the full distance between S1 and S2, Δ_i, the respective parameter may be considered critical in accounting for the change in fiscal transmission between S1 and S2.[18]

< table 3 about here >

The results are displayed in Table 3. Each column provides the distance measures for one of the variables of interest. The first row shows Δ_i, i.e., the distances between the model responses at the S1 and S2 estimates. The second row, in turn, shows $\Delta_i^c(\lambda)$; it pertains to an evaluation of the model where all parameters take on 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. The corresponding impulse responses are displayed in Figure 2 (dashed lines with circle), together with the fitted responses for S1 (solid lines with cross) and S2 (solid lines with square). All distances can be seen to fall substantially, indicating that the simple change in λ helps bring the S1 impulses much closer to their S2 counterparts.[19] In particular, greater asset market participation allows more households to internalize the government budget constraint, thus reducing the cumulative effects of government spending on consumption, output, and the real wage relative to the S1 baseline. This works towards explaining the smaller effect of government spending actually observed in S2.

$<$ figure 2 about here $>$

The third row of Table 3 displays the consequences of varying the degree of monetary policy activism, i.e., the effect of increasing ϕ_π from 1.01 to 1.77. Figure 2 shows the corresponding impulse responses as dashed lines with diamonds. This experiment again goes in the 'right' direction in that it reduces the distances vis-à-vis the S2 responses. Compared to the results for $\Delta_i^c(\lambda)$, the improvement in fit is more pronounced for output and debt and less so for consumption and the real wage. Clearly, had monetary policy been more anti-inflationary in S1, a typical increase in government expenditure would have, ceteris paribus, triggered higher real interest rates and caused households to postpone spending. This would have dampened consumption, output, and the real wage, more closely in line with the responses actually characterizing S2. In this sense, the estimated change in monetary policy activism represents another quantitatively powerful factor explaining the weaker expansionary impact of government spending after 1980. However, Figure 2 reveals that the shape of the counterfactual responses still differs noticeably from the actual evidence for S2; clearly, other factors are needed to account for the full extent of the change in fiscal transmission from S1 to S2.

The last three rows of Table 3 relate to the third hypothesis under consideration, i.e., that the apparent changes in fiscal transmission result from a different conduct of fiscal policy itself. Specifically, the fourth row considers counterfactual responses for an economy like S1 but with a less persistent process of government expenditure, as appears to be characteristic of S2. We thus set both ρ_1 and ρ_2 to their respective S2 values, while keeping all other parameters at their S1 estimates. As a result, the distances for output, consumption, and the real wage fall, whereas the impulse response of government debt moves further *away* from the S2 counterpart. Accordingly, changes in the persistence of government spending seem to operate largely, though not completely, in the right direction. By contrast, changing the value of η from 0.50 to 0.71 actually increases the distances for output, consumption, and the real wage, as the greater persistence of deficits amplifies (rather than mutes) the effects of government spending on these variables. Regarded in isolation, this experiment, therefore, does not align with the observed changes in transmission between S1 and S2, except for response of debt. A similar, yet even more pronounced finding is obtained when we alter the degree of deficit finance, by setting the relevant parameter ϕ_g from its S1 value of 0.17 to the higher S2 value of 0.64. As the last row of Table 3 suggests, this change goes in the wrong direction for all variables except debt, whose S2 response is indeed fitted much more closely.

Taken together, the experiments clearly illustrate the complementarity between the different candidate explanations for the change in fiscal policy transmission. 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 *stronger*, ceteris paribus. If, in reality, we find them to be weaker, there must be important offsetting factors. Our results point to a combination of increased asset market participation and a more active monetary policy as the key factors. While the former seems crucial to account for the changes in the shape and persistence of the responses of output, consumption, and the real wage, the increased monetary activism is pivotal for the general reduction in the effects of fiscal shocks. Another complementary factor is the reduced persistence of spending shocks in S2. At the same time, these changes alone are not able to explain the starkly different response of government debt in S2, for which indeed the change in the degree of deficit financing is crucial.

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 more recent period? 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. 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. This allows us to evaluate several competing hypotheses 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. 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 anti-inflationary.

Given these estimates, we carry out counterfactual experiments within the framework of our structural model. Specifically, we consider the quantitative impact of several distinct policy or institutional changes in order to evaluate their relative role 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 impact 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 spending shocks. Another important determinant for the changes in fiscal transmission appears to be the change in monetary policy: our results suggest that, above and beyond its other macroeconomic implications, the stronger anti-inflationary stance of the Volcker-Greenspan period has also reduced 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 important to explain the strikingly different dynamics of debt across the two samples.

Taken together, these results highlight the importance of considering the interaction between evolving financial markets, on the one hand, and monetary and fiscal policies, on the other hand, in order to gain a better understanding of how important shocks are transmitted in the economy.

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

$$\frac{W}{P} = \frac{\varepsilon - 1}{\varepsilon}, \tag{20}$$

while production (11) in the steady state implies $Y = N - F$. Defining $\mu = 1/(\varepsilon - 1)$, we rewrite (20) 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

$$\begin{aligned} (1-\tau)\frac{W}{P}\frac{N}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu}; \\ \frac{C_A}{Y} &= (1-\tau)\frac{1}{1-\lambda}\left(1-\lambda\frac{1+F_Y}{1+\mu}\right) - T_Y; \\ \frac{C_N}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu} - T_Y; \\ T_Y &= G_Y - \tau. \end{aligned} \tag{21}$$

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: $F_Y = \mu$.[20] Substituting into (21) 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 (21) and the expression for the fixed cost we obtain the following expression for steady-state hours:

$$\frac{N}{1-N} = \frac{1}{\varphi}\frac{1-\tau}{1-G_Y}. \tag{22}$$

Given τ and G_Y, we choose steady-state N to match average hours worked. From (22), 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 $\hat{b}_t = B_t/\left(P_{t-1}Y_{t-1}\right)$, $\pi_t = \log(P_t/P_{t-1})$, and $w_t = \log\left((W_t/P_t)/\left(W/P\right)\right)$. 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 (22) gives

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

For $\sigma > 1$, the elasticity of consumption growth $\left(E_t c_{A,t+1} - c_{A,t}\right)$ to hours growth $\left(E_t n_{A,t+1} - n_{A,t}\right)$ 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

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

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

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

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

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

while aggregate consumption is given by

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

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

$$y_t = \left(1+F_Y\right) n_t.$$

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

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

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:

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

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):

$$h'\left(\frac{M_{N,t}}{P_t}\right) = U_C(C_{N,t}, L_{N,t}) - \beta E_t \frac{P_t}{P_{t+1}} U_C(C_{N,t+1}, L_{N,t+1}). \tag{23}$$

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:

$$S_{j,t} = \frac{M_{j,t} - M_{j,t-1}}{P_t}. \tag{24}$$

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 (24) implies that the budget constraint of the non-asset holders is identical to the one before: $P_t C_{N,t} + P_t T_t = (1-\tau) W_t N_{N,t}$, 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.[21]

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Notes

[1] Changes in the financial landscape included the phasing-out of ’Regulation Q’, which had imposed tight 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 not affect, under reasonable assumptions, 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, for example, Alvarez, Lucas, and Weber (2002). The terminology follows Vissing-Jorgensen (2002). In contrast, Galí, López-Salido, and Vallés (2007) and Mankiw (2000) distinguish households by their ability to hold physical capital.

[5]We assume equal steady-state consumption shares to enhance tractability. Bilbiie (2007) shows that allowing for different consumption shares has little bearing on the quantitative behavior of the model. Given that we solve a linearized version of the model around its deterministic steady state, it is also reassuring to observe that there is some evidence that the ratio of (per-capita) consumption between asset holders and non-asset holders is stationary. Although time-series data on consumption of the two groups are hard to construct, a close proxy can be found in the work of Mankiw and Zeldes (1991), who study the consumption of stockholders and non-stockholders for the period before 1984. They find that even though per-capita consumption levels seem to differ somewhat, growth rates are comparable.

[6]Because 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 (2004), from which the following discussion draws.

[8]See the discussion in Christiano and Eichenbaum (1992). In fact, our estimation exercise fully addresses 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 (2007), 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 produced 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 response 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 considered the case of $\alpha = 0.75$ for both samples. Our results proved to be quite robust with respect to these changes.

[15]Indeed, equilibrium indeterminacy may arise from a variety of interacting sources in our model: 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]A measure based on the absolute value (rather than the square) of distances delivers essentially the same results.

[18]Note that the full extent of changes between S1 and S2 can only be accounted for by simultaneous variation of all estimated parameters, with potentially important cross effects. A more detailed discussion is provided in Bilbiie, Meier, and Müller (2006).

[19]An exception is the response of government spending, which is governed only by the relevant persistence parameters and thus unaffected by variation in λ. For this reason, this variable is not displayed in Figure 2.

[20]Alternatively we could have assumed, as in Galí, López-Salido, and Vallés (2007), 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 $T_Y^A = T_Y^N = T_Y$.

[21]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

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)

Notes: Results from estimated VAR model. 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

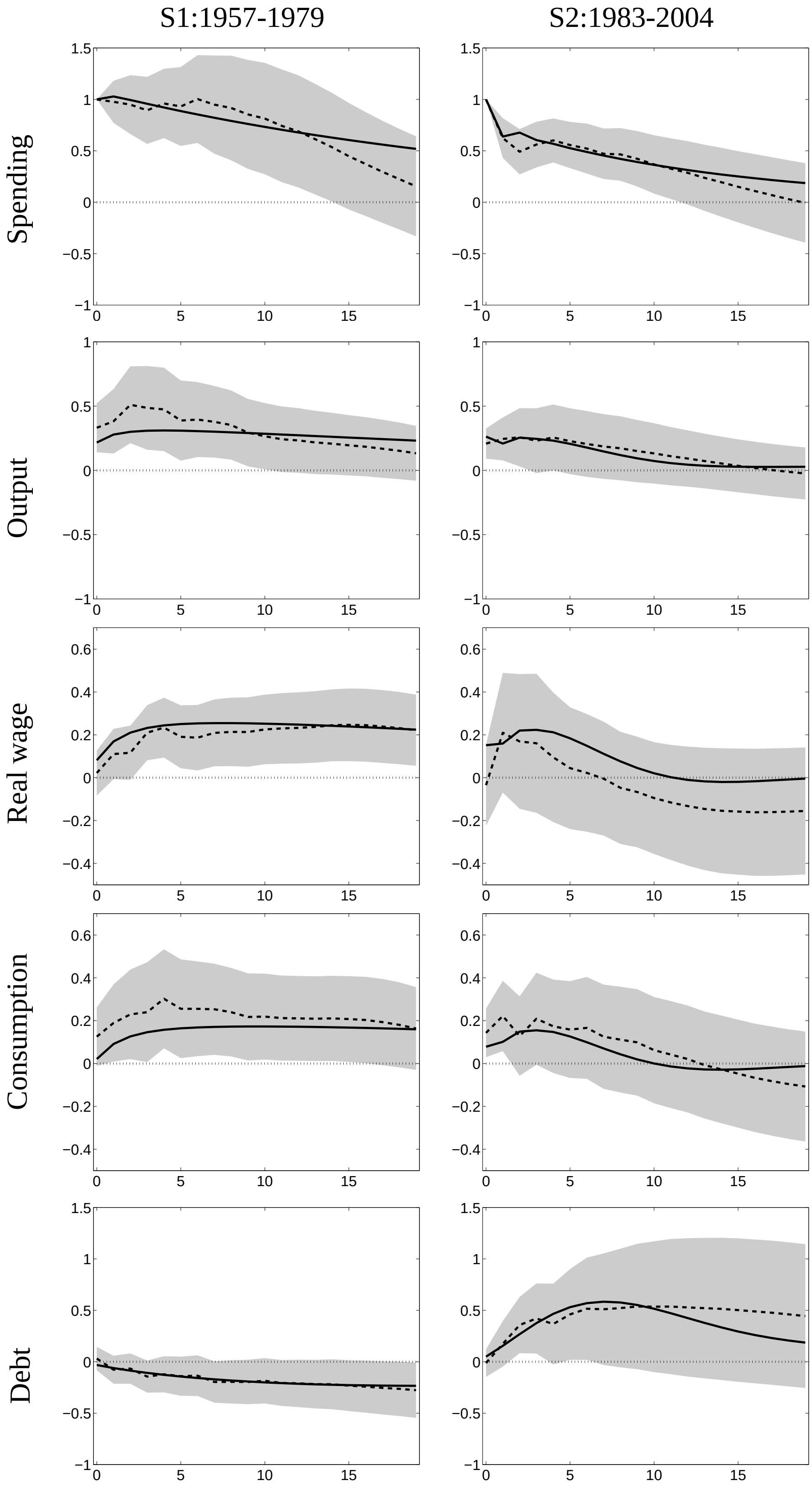
Parameter	S1	S2
λ	0.509 (0.079)	0.347 (0.258)
ϕ_π	1.012 (0.022)	1.771 (0.756)
ϕ_b	-0.070 (0.230)	-0.117 (0.036)
ϕ_g	0.168 (0.099)	0.640 (0.235)
η	0.510 (0.579)	0.710 (0.303)
ρ_1	1.028 (0.153)	0.638 (0.123)
ρ_2	-0.063 (0.150)	0.270 (0.123)
Criterion :	20.089	19.792

Notes: Parameter estimates obtained from matching DSGE and VAR impulse response functions; standard errors are reported in parentheses.

Table 3: Differences in Fiscal Policy Transmission

	i				
	Spending	Output	Real wage	Consumption	Debt
Δ_i	1.96	0.44	0.50	0.28	5.77
$\Delta_i^c(\lambda)$	1.96	0.25	0.21	0.11	5.03
$\Delta_i^c(\phi_\pi)$	1.96	0.10	0.31	0.24	2.23
$\Delta_i^c(\rho_g)$	0.00	0.14	0.34	0.23	6.10
$\Delta_i^c(\eta)$	1.96	0.96	1.37	0.81	4.63
$\Delta_i^c(\phi_g)$	1.96	3.23	5.76	3.61	1.59

Distances are computed according to (19) for the first 16 quarters after the shock. Counterfactual distance measures refer to comparisons between S2 impulse responses and those obtained for a counterfactual economy where one particular parameter is set at its S2 estimate while the other parameters are kept at their S1 estimates.



S1:1957-1979
S2:1983-2004
Spending
Output
Real wage
Consumption
Debt

Figure 1:

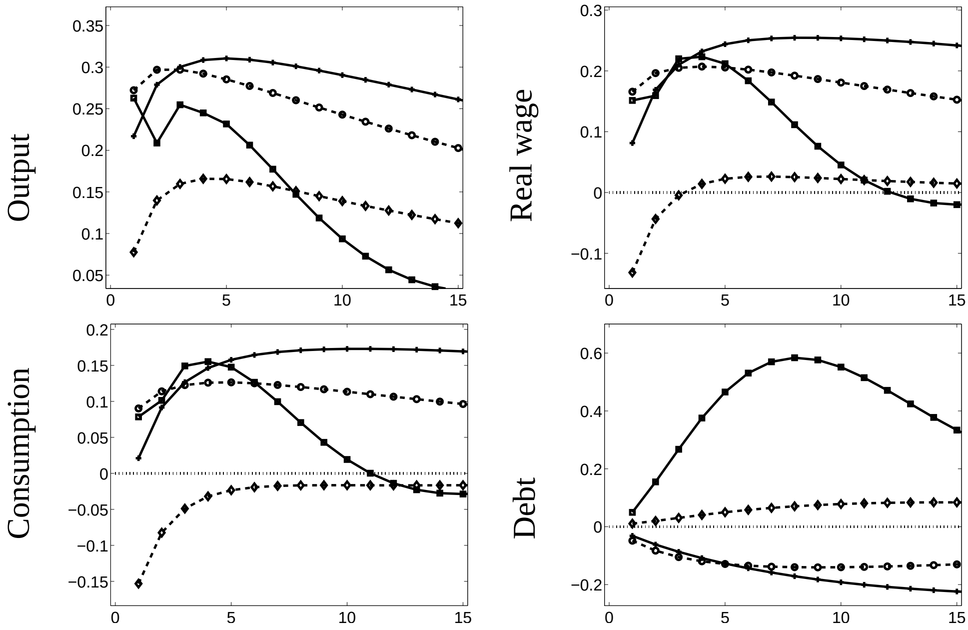

Output
Real wage
Consumption
Debt
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5
10
15
0.3
0.2
0.1
0
−0.1
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
0.6
0.4
0.2
0
−0.2

Figure 2:

Captions for figures:

Figure 1. Transmission in estimated VAR and DSGE model. Impulse responses to one percent increase in real government spending. Dashed line: VAR; shaded areas: bootstrapped 90 percent confidence intervals; solid line: DSGE model. 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. Estimated vs. counterfactual responses. Solid with cross: S1; solid with square: S2; dashed with circle: asset market participation as in S2; dashed with diamond: monetary policy as in S2.