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Fiscal Policy in the New Neoclassical Synthesis

We analytically derive the cyclical effects of fiscal policy shocks in a New Neoclassical Synthesis model. Price stickiness has the consequence that a rise in government demand affects labor demand, while at the same time the usual wealth effect boosts labor supply. The strength of the demand effect depends on the response of the real interest rate governed by the monetary policy regime. When the central bank controls money growth, fiscal expansions are deflationary and might even be contractionary, whereas output, wages, and, inflation can increase when the rise in the real interest rate is dampened by an interest rate rule. However, price stickiness alone is not sufficient to explain a rise in consumption as predicted by Keynesian theory.

WHAT ARE THE EFFECTS of changes in government expenditure on the business cycle? Historically, two different and mutually incompatible strands of theories have been advanced to answer this question. Broadly characterized, there is the Keynesian tradition, on the one hand, as captured in the familiar textbook IS-LM Phillips-curve model, with its focus on the relevance of aggregate demand disturbances on cyclical conditions. Expansionary fiscal policy is viewed exclusively as an exogenous increase in aggregate demand, allowing demand-constrained firms to sell more output, thus boosting income, employment, and, by the multiplier effect, consumption, because the inflexibility of goods prices that prevails in the short-run makes output demand determined. Prices adjust only gradually and mainly follow the cost push from increasing wages, as typically captured in some versions of a Phillips-curve specification.

On the other hand, the effects of fiscal policy have been studied more recently in purely real dynamic general equilibrium models with optimizing agents and fully flexible prices, e.g., by Baxter and King (1993). Here, the central mechanism by which fiscal policy influences the private economy is the negative wealth effect implied by the tax financing of rising government expenditure, which with standard preferences, induces a decrease in private consumption along with an increase in

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labor supply, thus raising output and employment while lowering wages. This chain of events, which we will sometimes simply abbreviate as the "wealth effect" in what follows, is thoroughly different from the aggregate demand effect story, as any change in output and employment induced by fiscal policy is due to the optimal response of household labor supply. Consequently, the predictions of the neoclassical general equilibrium model are directly opposed to those of Keynesian theory with respect to some important variables like wages and private consumption.

Unfortunately, empirical evidence to date is not very helpful in discriminating between theories, as there are two sets of studies finding incompatible and mutually exclusive results, apparently due to methodological differences. Ramey and Shapiro (1998), Edelberg et al. (1999), and Burnside, Eichenbaum, and Fischer (1998), using dummy variables to represent exogenous fiscal spending surges in specific historical episodes, find consistently that real wages fall while employment rises, and the first two studies also find decreasing private consumption. In contrast, studies using a VAR approach roughly produce the opposite result: Rotemberg and Woodford (1992) and Fatas and Mihov (2000) find that most measures of real wages increase after positive fiscal shocks, along with output and employment, and the latter authors also report, as do Blanchard and Perotti (1999) and Mountford and Uhlig (2000), that private consumption rises robustly with public spending.

On the theoretical side, however, recently a consensus model has emerged, which has been labelled "New Neoclassical Synthesis" (NNS, henceforth) by Goodfriend and King (1997).[1] The approach consists of combining the neoclassical dynamic optimizing general equilibrium framework with short-run nominal price stickiness. Recent research in this area, particularly that of McCallum and Nelson (1999), has shown that much of the intuition gained from the simple IS-LM model carries over to the NNS model, as far as the effects of monetary policy are concerned.

The present paper extends this analysis to fiscal policy and asks how far the NNS model can provide a microfoundation for the Keynesian view. More generally, we wish to uncover the way in which the presence of price stickiness matters for understanding cyclical effects of fiscal policy. As stickiness makes nominal variables important, it is natural to expect the interaction of fiscal policies with monetary policies to play a key role in the answer. Therefore, we compare results for two different monetary regimes in a cash-in-advance model with Calvo (1983)–Yun (1996) staggered price setting. These two examples are in confrontation with each other because of their prominence in the literature on monetary policy. In the first, the central bank lets the nominal money stock grow at a constant exogenous rate. In the second, it sets the nominal interest rate in reaction to expected inflation and output.

Our main results follow from the distinction that a positive shock to government spending basically exerts two effects: the first is an expansionary influence on output supply via the familiar effect on labor supply. The second is an increase in aggregate demand made possible by an incomplete crowding out of private consumption. While both effects tend to raise output, their relative size determines whether prices rise or fall. With monopolistic competition, labor demand is derived from goods demand. If prices are sticky, the real wage rises (falls) whenever the result of the shock is inflationary (deflationary); the inflation outcome, in turn, is governed by monetary policy through the influence it has on the strength of the demand effect in this case. We analytically show that a fiscal expansion inevitably has deflationary consequences for an exogenous money growth regime, as our cash-in-advance specification implies that output can only rise if prices drop. With interest rate setting, in contrast, the rise in aggregate demand is not constrained but instead accommodated by money supply. We show that a fiscal expansion raises wages and inflation if the central bank does not react too strongly to changes in output. This is the case because the crucial variable for the adjustment is the real interest rate, which determines the consumption path and, consequently, the magnitude of the aggregate demand effect, while the shift of the consumption/leisure plan induced by nominal interest rate changes never overturns this effect. Hence, strongly expansionary effects of a government spending shock are the result only if monetary policy limits the real interest rate increase. In a model version with capital accumulation, investment expenditures decline in response to a positive fiscal spending shock in all cases, as the rise in the real interest rate forces the shadow price of capital down. Aggregate demand (now including investment expenditures) and output can now even contract when real interest rates increase sharply.

The rest of this paper is organized as follows. Section 1 presents a simple NNS model that can be solved analytically because we abstract from capital accumulation and interest rate smoothing. Section 2 discusses the results. For comparison, in Section 3 a calibrated version of a larger model that incorporates these features is evaluated numerically. In both cases, results are presented separately for different monetary policies. Section 4 gives a summary and concludes.

1. THE MODEL

In this section we present a basic sticky price model that allows the analysis of shocks to government spending financed in a lump-sum fashion. Money demand is introduced via a cash-in-advance constraint. Firms are assumed to be monopolistically competitive and to adjust prices according to Calvo's (1983) price staggering formulation. Here, we keep the model simple in order to solve it analytically before turning in Section 3 to a version where capital accumulation is present and which can therefore more usefully be calibrated to empirical observations. In each case, the discussion highlights the differences in the models' behavior under a monetary policy that exogenously sets nominal money growth to one that sets the nominal interest rate in response to inflation and output.

1.1 Households

Throughout the paper, nominal variables are denoted by uppercase letters, while real variables are denoted by lowercase letters. The typical household is infinitely lived and seeks to maximize the expected value of a discounted stream of instantaneous utilities $u(.)$:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t u(c_t,1-l_t)\right],\ \beta \in (0,1)\ , \tag{1}$$

where E_0 is the expectation operator conditional on the time 0 information set and β is the discount factor. For analytical simplicity, instantaneous utility, $u(.)$, is separable between private consumption, c, and leisure $1 - l$, where l is working time:

$$u(c_t,1-l_t) = \frac{{c_t}^{1-\sigma}}{1-\sigma} + \gamma\frac{(1-l_t)^{1-\sigma_1}}{1-\sigma_1},\quad \gamma > 0\ , \tag{2}$$

where σ, $\sigma_1 > 1$ are the inverses of the intertemporal elasticities of substitution of consumption and leisure, respectively. At the beginning of period t the household owns the entire stocks of money M_t and of government bonds B_t in the economy. It then receives a lump-sum government transfer worth $P_t\tau_t$ in nominal terms (where P is the aggregate price level). When the goods market opens, consumption expenditures are not allowed to exceed the after tax money holdings of the household,

$$P_t c_t \leq M_t + P_t\tau_t\ . \tag{3}$$

There is actually no consensus in the literature about the precise specification of a cash-in-advance constraint. One often finds that the end-of-period stock of money, M_{t+1}, enters the constraint, which is hardly consistent with the interpretation that money serves as a means of payment.[2] On the other hand, assuming that only the beginning-of-period stock of money, M_t, enters the cash constraint has the counterintuitive implication that consumption must decline in real terms when monetary policy is expansionary, as a higher price level lowers real balances, M_t/P_t. In Specification (3), which is a conventional textbook example (see, e.g., Walsh 1998), a money expansion increases the transfer, which consists of seignorage net of government expenditures and, therefore, relaxes the constraint such that the household raises its consumption expenditures in equilibrium.

The household further receives labor income, $P_t w_t l_t$ (where w is the real wage), and residual profits, Ω_{it}, from the entire portfolio of monopolistically competitive firms, indexed by $i \in (0, 1)$. Finally, the good market closes and the financial market opens where funds can either be invested in nominal riskless one-period bonds, B_{t+1}, providing a gross payoff, $R_{t+1}B_{t+1}$, in period $t + 1$, where R is the gross nominal interest rate or can be transferred to the next period as money holdings, M_{t+1}. The household maximizes Expression (1) by choosing c_t, l_t, B_{t+1}, and M_{t+1} subject to its cash-in-advance Constraint (3) and its flow budget constraint,

$$M_{t+1} + B_{t+1} + P_t c_t \leq P_t w_t l_t + R_t B_t + M_t + P_t\tau_t + \int_0^1 \Omega_{it} \mathrm{d}i\ , \tag{4}$$

for a given initial value, A_0, of financial wealth, $A_0 = M_0 + B_0$. The first order conditions are

$$\lambda_t = c_t^{-\sigma}/R_t \, , \tag{5}$$

$$w_t\lambda_t = \gamma(1 - l_t)^{-\sigma_1} \, , \tag{6}$$

and

$$\lambda_t = \beta E_t[\lambda_{t+1}R_{t+1}/\pi_{t+1}] \, , \tag{7}$$

where λ_t and $\pi_t = P_t/P_{t-1}$ denote the Lagrange multiplier on the budget constraint and the gross inflation rate, respectively. Furthermore, in an optimum with $R_t > 1$, the cash-in-advance Constraint (3) holds with equality. From Equations (5) and (6), the household's consumption/leisure choice is distorted by the presence of a positive nominal interest rate because leisure is a credit good while consumption is a cash good. Finally, the transversality condition, $\lim_{t\to\infty}\beta^t u_{ct}A_t/P_t = 0$, is required to hold.

1.2 Firms

The final good is an aggregate of a continuum of differentiated goods, each of which is produced by one of the monopolistically competitive firms indexed with $i \in (0, 1)$, the aggregator being $y_t^{(\varepsilon-1)/\varepsilon} = \int_0^1 y_{it}^{(\varepsilon-1)/\varepsilon} \mathrm{d}i$, $\varepsilon > 1$, where y is the quantity of the final good, y_i the amount of the variant produced by firm i, and ε is the constant elasticity of substitution between any two variants. Let P_i and P denote the price of good i set by firm i and the price index for the final good. The demand for each differentiated good is derived by minimizing the total costs of obtaining y subject to the aggregator formula, leading to the demand curve $y_{it} = (P_{it}/P_t)^{-\varepsilon} y_t$. For the price index, P, of the final good, cost minimization implies $P_t^{1-\varepsilon} = \int_0^1 P_{it}^{(1-\varepsilon)} \mathrm{d}i$. A monopolistically competitive firm produces good i using only labor[3] according to

$$y_{it} = l_{it} \, . \tag{8}$$

Nominal price stickiness is introduced in form of the Calvo (1983)–Yun (1996) staggered price setting model. Each period, firms may reset their prices with the probability $1 - \phi$ independent of the time elapsed since the last price setting. The fraction ϕ of nonadjusters set their prices mechanically according to $P_{it} = \pi P_{it-1}$, where π denotes the steady state value of gross inflation (variables without a time subscript are used to denote steady state values throughout). It is well known from the literature (see, e.g., Yun, 1996, or Gali, 2001) that in this model profit maximization of symmetric firms ultimately leads to a condition that can be expressed as a dynamic equation for the aggregate inflation rate,

$$\hat{\pi}_t = \theta\, \hat{mc}_t + \beta E_t[\hat{\pi}_{t+1}], \quad \theta \equiv (1 - \phi)(1 - \beta\phi)\phi^{-1} > 0 \, , \tag{9}$$

where mc_t is the average of the firms' real marginal costs (the inverse of the average price–marginal cost markup); throughout, for any variable x_t, the notation $\hat{x}_t$ means the percent deviation of x_t from its steady state value, x, such that $\hat{x}_t = \log(x_t/x)$. All firms face an identical production technology and the same costs for their factor inputs. In view of this symmetry the cost minimizing aggregate labor demand is

$$w_t = mc_t \,. \tag{10}$$

Thus, due to constant returns to labor, the wage is identical to real marginal costs, which outside a steady state move with inflation.

1.3 Government

The government issues money and nominal riskless one-period bonds and redistributes the receipts net of government spending, g, as lump-sum transfers, τ, to the private sector. The government's flow budget constraint is thus given by

$$P_t\tau_t + P_t g_t + M_t + R_t B_t = B_{t+1} + M_{t+1} \,. \tag{11}$$

The government is assumed to satisfy the solvency constraint $\lim_{i\to\infty} B_{t+i} \Pi_{v=1}^{i} R_{t+v}^{-1} = 0$. The monetary authority follows one of two stylized policy rules: the first is to let the nominal money stock grow at a constant rate, μ, so that

$$\mu = M_{t+1}/M_t \,, \tag{12}$$

given an initial value M_0; hence, as the price level is predetermined, so are real balances in this case. The other policy rule is characterized by interest rate setting, where the gross nominal rate, R_{t+1}, is set at the end of period t based on expectations of next period inflation and output according to

$$\hat{R}_{t+1} = \rho_\pi E_t \hat{\pi}_{t+1} + \rho_y E_t \hat{y}_{t+1}, \quad \rho_\pi > 1, \quad \rho_y \geq 0 \,, \tag{13}$$

which is an example of a forward looking interest rate rule (see Clarida, Gali, and Gertler, 1999, 2000).[4] The restriction $\rho_\pi > 1$ in Equation (13) is imposed as recent work on interest rate rules shows that it ensures equilibrium uniqueness (Benhabib, Schmitt-Grohe, and Uribe, 2001, Gali, 2001, Woodford, 2001); we, too, find that this restriction leads to uniqueness in all relevant cases. Real government expenditures are exogenous and follow a first order autoregressive process,

$$\log g_t = \rho \log g_{t-1} + (1 - \rho)\log g + \eta_t, \quad \rho \in (0, 1) \,, \tag{14}$$

where the shock, η, has an expected value of 0 and is serially uncorrelated.

1.4 Rational Expectations Equilibrium

In order to induce stationarity, the model is expressed in real terms, with $m_t = M_t/P_{t-1}$. We restrict our attention to equilibria where bonds are in zero net supply ($B_t = 0$) and the nominal interest rate has positive values. The former restriction implies that the budget balances in each period, and the latter ensures that the household's cash-in-advance Constraint (3) always binds. Substituting for real marginal costs from Equation (10), labor from Equation (8), the lump-sum transfer from Equation (11), and the shadow price, λ, from Equation (5), we can define the rational expectations equilibrium as a set of sequences $\{\pi_t, w_t, m_t, R_t, y_t, g_t\}$ satisfying (1) the household's first order conditions together with the cash-in-advance constraint and the transversality conditions; (2) the firms' factor demand and optimal pricing conditions; (3) the constant money growth rule or the state contingent interest rate rule; and (4) the aggregate resource constraint, $y_t = c_t + g_t$. In order to analyze the model, we log-linearize the equilibrium conditions around the steady state.

2. RESULTS

2.1 Constant Money Growth

We begin by analyzing the model for the case of an exogenous constant money growth rate. The equilibrium system together with the monetary policy rule, Equation (12), and the shock process, Equation (14), can, when linearized around the steady state, be reduced to

$$(1 + \Psi)\hat{\pi}_t = \left[\beta - \theta\left(\sigma\frac{c + g}{c} - 1\right)\right]E_t\hat{\pi}_{t+1} + \Psi\hat{m}_t - \theta\sigma\rho\,\frac{g}{c}\hat{g}_t\,, \tag{15}$$

$$\hat{m}_{t+1} = \hat{m}_t - \hat{\pi}_t\,, \tag{16}$$

and

$$\hat{g}_t = \rho\hat{g}_{t-1} + \eta_t\,, \tag{17}$$

where $\Psi \equiv \theta[\sigma_1 l/(1 - l) + \sigma(c + g)/c] > 0$. The Model (15)–(17) can be solved analytically; the following proposition summarizes the results.

PROPOSITION 1 (CONSTANT MONEY GROWTH): *In the log-linear approximation to the model with exogenous money, there exists a unique rational expectations equilibrium converging to the steady state if prices are sufficiently rigid so that* $\theta < (1 + \beta)/(\sigma[c+g]/c - 1)$. *The impact multipliers of a shock to government expenditures at time s then are* $\partial\hat{y}_s/\partial\hat{g}_s > 0$, $\partial\hat{\pi}_s/\partial\hat{g}_s < 0$, $\partial\hat{w}_s/\partial\hat{g}_s < 0$, $\partial\hat{c}_s/\partial\hat{g}_s < 0$, $\partial\hat{m}_{s+1}/\partial\hat{g}_s > 0$, *and* $\partial\hat{R}_s/\partial\hat{g}_s > 0$.

PROOF: See Appendix.

The sufficient condition for uniqueness requires price rigidity to be not too small; for the parameters underlying Figure 1, it is fulfilled if $\phi \gtrsim 0.34$, which can, from an empirical point of view, safely be assumed in the light of the estimates made by Gali and Gertler (1999). In Figure 1, the dotted lines represent this model's impulse responses to a 1% shock to η for an example of parameterization (see Section 3). The basic mechanism at work here is the wealth effect on labor supply, according to which a surge in public spending is associated with a reduction in the resources available to the private sector for use as consumption, whereby the representative household reduces its demand for consumption and leisure if both are normal goods, thus raising labor supply (see Baxter and King 1993). Aggregate demand can be shown to rise generally because the increase in government demand will be larger

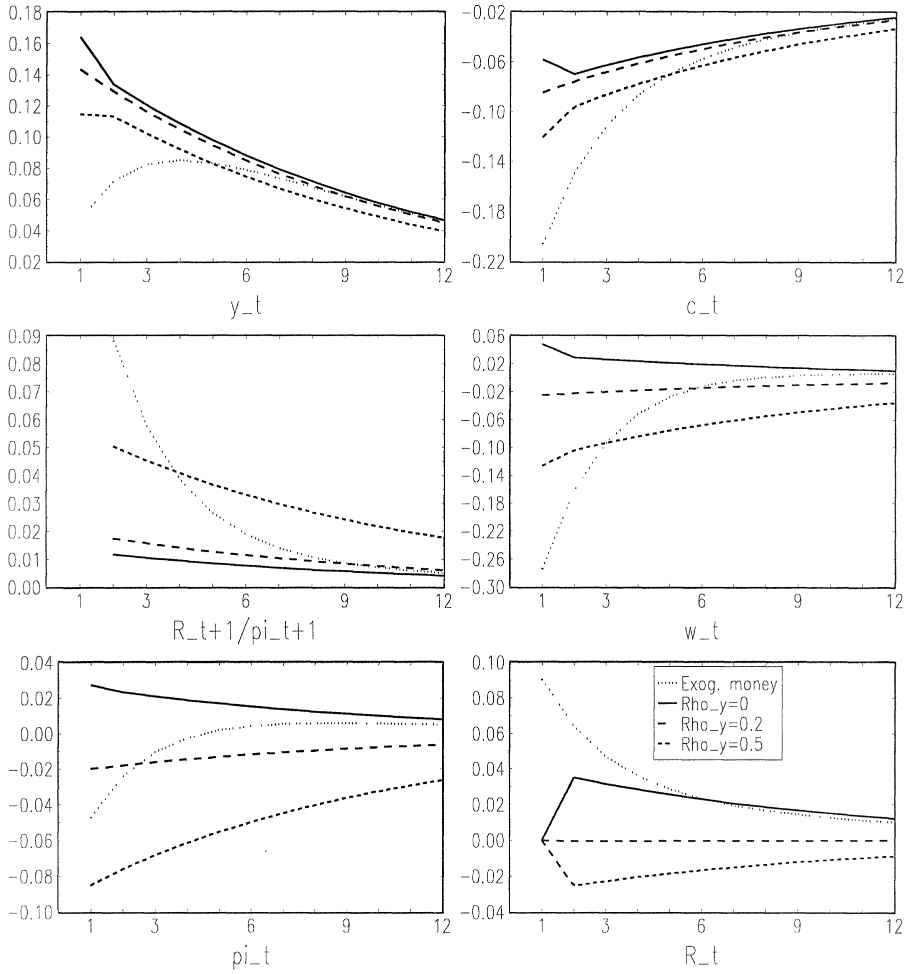

FIG. 1 Percentage impulse responses to 1% shock to g in period 1 (parameter values: $\beta = 1.03^{-1/4}$, $g/(c + g) = 0.21$, $\pi = 1$, $l/(1 - l) = 0.5$, $\sigma = \sigma_1 = 2$, $\rho = 0.9$, $\phi = 0.75$, $\rho_\pi = 1.5$, $\rho_y \in \{0,0.2,0.5\}$)

than the decrease in private consumption. But the increase in aggregate goods demand is less than the increase in goods supply from the shock's effect on labor supply, so that prices start falling. This can be seen from the cash-in-advance constraint, which is, by combination of Constraint (3) and Equation (11), $P_t(c_t + g_t) = M_{t+1}$ in nominal terms. With M_{t+1} exogenously given and a rise in $c_t + g_t = l_t$, the price level will unambiguously have to fall, and inflation will drop below steady state. But although all firms would like to cut prices, some cannot do so immediately because of the assumption of temporary price stickiness, so they respond by reducing their output and therefore labor demand. This depresses wages, which is consistent with the result from the Phillips curve, Equation (9), that less than normal inflation must be driven by lower real marginal cost. To sum up, output rises while consumption, wages, and inflation decline. Finally, the tax implications of the fiscal shock directly lead to a negative growth of the marginal utility of wealth, λ. By Equation (7), this is associated with an increase in the real interest rate, $E_t[R_{t+1}/\pi_{t+1}]$. Because output can only expand to the extent that inflation falls, and the latter is limited by price stickiness, consumption must decrease strongly, which explains the size of the real interest rate surge.

2.2 Interest Rate Policy

The equilibrium system together with the interest rate policy rule, Equation (13), and the shock process, Equation (14), can be reduced to a system of inflation, consumption, and the nominal interest rate that can be solved analytically. Of course, as nominal money is endogenous in this model variant, the cash-in-advance constraint is not restrictive and can be left out, as the nominal money stock adjusts passively to the quantity demanded.

$$\hat{\pi}_t - \beta E_t\hat{\pi}_{t+1} = \theta\left[\hat{R}_t + \left(\frac{c}{c+g}\sigma_1\frac{l}{1-l} + \sigma\right)\hat{c}_t + \left(\frac{g}{c+g}\sigma_1\frac{l}{1-l}\right)\hat{g}_t\right], \tag{18}$$

$$\sigma(E_t\hat{c}_{t+1} - \hat{c}_t) = \hat{R}_t - E_t\hat{\pi}_{t+1}, \tag{19}$$

$$\hat{R}_{t+1} = \rho_\pi E_t\hat{\pi}_{t+1} + \rho_y E_t\left(\frac{c}{c+g}\hat{c}_{t+1} + \frac{g}{c+g}\hat{g}_{t+1}\right), \tag{20}$$

and

$$\hat{g}_t = \rho\hat{g}_{t-1} + \eta_t. \tag{21}$$

For the general case the results are analytically less clear-cut than in the previous section's model. We therefore start by discussing the simpler case where $\rho_y = 0$. This case, while special, is, however, important, as it has featured prominently in theoretical discussions of interest rate policy recently (see Benhabib, Schmitt-Grohe, and Uribe, 2001, Carlstrom and Fuerst, 2001). Empirically, some studies estimate a very small ρ_y (see Ireland, 2000, Clarida, Gali, and Gertler, 1998). Furthermore, the results we find for the $\rho_y = 0$ case remain qualitatively unaltered for the case of ρ_y being not "too large," in a sense made explicit below. The following proposition summarizes the results.

PROPOSITION 2 (INTEREST RATE POLICY, $\rho_y = 0$): *In a rational expectations equilibrium of the log-linear approximation to the interest rate policy model with* $\rho_\pi > 1$ *and* $\rho_y = 0$ *converging to the steady state, the impact multipliers of a shock to government expenditures at time s are* $\partial\hat{y}_s/\partial\hat{g}_s > 0$, $\partial\hat{\pi}_s/\partial\hat{g}_s > 0$, $\partial\hat{w}_s/\partial\hat{g}_s > 0$, $\partial\hat{c}_s/\partial\hat{g}_s < 0$, $\partial\hat{R}_{s+1}/\partial\hat{g}_s > 0$ *and* $\partial\hat{m}_{s+1}/\partial\hat{g}_s > 0$.

PROOF: See Appendix.

In Figure 1, the solid lines illustrate this model's impulse responses to a one time 1% shock to η. As can be seen from the figure, output, inflation, wages, and the nominal and real interest rates rise, while consumption falls.[5]

Where does the difference to the exogenous money model derive from? Once again, the adjustment starts with the wealth effect of increased taxation: given that leisure and consumption are normal, both will be reduced in a first step, accompanied by a future decline in the marginal utility of wealth, λ. The increase in labor supply implies that at given real wage costs a larger amount of output can be produced. While the reduction in consumption reduces demand, the positive effect of increased public spending dominates so that aggregate demand, $c_t + g_t$, always rises. But now the central bank accommodates the additional money demand forthcoming by letting the money stock expand, inducing firms to react to the increase in aggregate demand by raising their prices. More formally, from Equation (7), the necessary increase in the real interest rate, $E_t[\hat{R}_{t+1} - \hat{\pi}_{t+1}]$, that follows from the negative growth to steady state of the marginal utility of wealth, λ, requires a rise in inflation, since from the interest rate rule, $E_t[\hat{R}_{t+1} - \hat{\pi}_{t+1}] = (\rho_\pi - 1)E_t\hat{\pi}_{t+1}$. The hump-shaped pattern of consumption is, from Equation (19), explained by the positive dependence of its growth rate on $\hat{R}_t - E_t\hat{\pi}_{t+1}$, where R_t is predetermined in the impact period, so that rising inflation will initially require a negative growth rate of consumption.

Because of price stickiness, however, some firms cannot adjust prices immediately and instead respond by raising output even more, which requires hiring additional labor. The latter, in turn, is only feasible in light of the household's optimality conditions if real wage offers increase. Technically, the Phillips curve, Equation (9), implies that positive inflation must be driven by real marginal cost increases. The eventual reaction of the real wage and, identically, real marginal cost, is the sum of the negative partial effect from the increase in labor supply and the positive partial effect from the rise in labor demand. The latter dominates in this model because the policy rule ensures that the real interest rate increase is relatively small and aggregate goods demand can thus expand strongly.[6] Finally, the rise in inflation is associated with a rise in the nominal interest rate, leading to a shift in the consumption/leisure plan such that the extent of the increase in labor supply, and therefore the quantitative importance of the deflationary partial impact it has, is offset.

In the more general case where the central bank sets the nominal interest rate also in response to changes in output ($\rho_y > 0$), the result of Proposition 2 carries over if the coefficient on output in Equation (13) is sufficiently small. For the parameters underlying Figure 1, $\rho_y \lesssim 0.17$ is sufficient. Above this threshold, the responses of inflation and wages change their sign, and as can be seen from the examples shown in Figure 1, for even larger values of ρ_y the nominal interest rate response can become negative too. The reason is that with $\rho_y > 0$ the tight link between changes in inflation and the real interest rate is weakened. Indeed, the latter now is an increasing linear function of inflation and output, not of inflation alone, as, by the monetary policy rule,

$$\hat{R}_{t+1} - E_t\hat{\pi}_{t+1} = (\rho_\pi - 1)E_t\hat{\pi}_{t+1} + \rho_y E_t\hat{y}_{t+1} \,. \tag{22}$$

If a positive fiscal spending shock hits the economy, the real interest rate rises while households reduce consumption. As above, the total effect of increased government spending and decreased consumption on aggregate demand is positive. However, the impact on aggregate demand will be smaller according to Equation (19), as the central bank now lets the real interest rate rise more. The consequence is that the increase in aggregate demand is so weak that the associated increase in production commands less additional labor input than is already provided by the increased labor supply due to the wealth effect, so that prices fall. This is the case displayed in the figure for the examples of $\rho_y = 0.2$ and $\rho_y = 0.5$. Obviously, the effect of output is quantitatively dominant over the one of inflation in the interest rate rule, Equation (22), so that the real interest rate rises indeed by more than in the previous case where $\rho_y = 0$ had been assumed. We summarize these results in the following proposition.

PROPOSITION 3 (INTEREST RATE POLICY, $\rho_y > 0$): *In a rational expectations equilibrium of the log-linear approximation to the interest rate policy model with* $\rho_\pi > 1$ *and* $\rho_y > 0$ *converging to the steady state, the impact multipliers of a shock to government expenditures at time s are* $\partial\hat{y}_s/\partial\hat{g}_s > 0$, $\partial\hat{c}_s/\partial\hat{g}_s < 0$, $\partial\hat{R}_{s+1}/\partial\hat{g}_s > 0$, *and* $\partial\hat{m}_{s+1}/\partial\hat{g}_s > 0$ *if* $\rho_y < \Xi \equiv [(1 - \rho)/\rho][l/(1 - l)]\sigma_1\rho_\pi$. *Furthermore*, $\partial\hat{\pi}_s/\partial\hat{g}_s > 0$, $\partial\hat{w}_s/\partial\hat{g}_s > 0$ *iff* $\rho_y < \Gamma \equiv (\rho_\pi\sigma_1[l/(1 - l)]\theta(1 - \rho) + [(c + g)/c](1 - \rho)\sigma)/(\rho\theta + \rho + \rho\beta(1 - \rho) + \sigma\rho[(1 - l)/(\sigma_1 l)][(c + g)/c] - 1)$.

PROOF: See Appendix.

The parameter restrictions in the proposition clarify the sense in which ρ_y must not be "too large" to let consumption decline and output, money, and the nominal interest rate increase. The sufficient condition $\rho_y < \Xi$ (which is convenient as it includes several different necessary conditions for the individual variables) states that it is the relation between ρ_y and ρ_π that determines whether the influence of output or inflation on the real interest rate dominates. Further, whether ρ_y is small must be gauged in relation to the intertemporal elasticity of substitution of leisure, as a lower elasticity (a higher σ_1) reduces the output reaction. The restriction $\rho_y < \Gamma$ that is necessary and sufficient for a positive reaction of inflation and wages is somewhat complex but is, again, less restrictive for higher ρ_π and a lower intertemporal elasticity, $1/\sigma_1$.[7]

When ρ_y is large, its contractionary impact on aggregate demand can even decrease inflation so strongly that the central bank reacts to a positive fiscal policy shock by actually *lowering* the nominal interest rate. This case is illustrated in Figure 1 for the example $\rho_y = 0.5$. From the discussion above, the central variable for the transmission process is the real interest rate. A high ρ_y means that the real interest rate rises strongly, hence demand rises less, and inflation slumps deeply. The increase in the real rate can thus be brought about exclusively by the deflation, while the nominal interest rate declines. Furthermore, the negative nominal interest rate response exacerbates the increase of labor supply, adding to the deflationary effect.

3. THE MODEL WITH CAPITAL

In order to construct a model that is more useful for confrontation with empirical evidence, we further introduce capital accumulation with adjustment costs in this section. The accumulation equation is

$$k_{t+1} = \Phi\left(\frac{e_t}{k_t}\right)k_t + (1 - \delta)k_t\,, \tag{23}$$

where k is the capital stock and e is investment. The parameter $\delta \in (0, 1)$ is a fixed depreciation rate, and the adjustment cost function $\Phi(e_t/k_t)$ is assumed to be increasing and concave (see, e.g., Abel and Blanchard 1983).[8] The household possesses the entire stock of capital and rents it within each period to the firms, receiving a real rental rate r^k per unit. The model's equilibrium conditions are thus supplemented by the following first order conditions for the household's choice of e_t and k_{t+1},

$$q_t = 1/\Phi'\left[\frac{e_t}{k_t}\right] \tag{24}$$

and

$$E_t\left[\left(r^k_{t+1} + q_{t+1}\left(\Phi\left(\frac{e_{t+1}}{k_{t+1}}\right) - \Phi'\frac{e_{t+1}}{k_{t+1}} + (1 - \delta)\right)\right)\right]q_t^{-1} = E_t\left[\frac{R_{t+1}}{\pi_{t+1}}\right], \tag{25}$$

as well as by the accumulation equation, Equation (23), and the additional transversality condition, $\lim_{t\to\infty}\beta^t u_{c_t} k_t = 0$. Note that the arbitrage condition, Equation (25), relates the expected total return on capital, which consists of the real rental rate, r^k, changes in Tobin's q, and adjustment cost terms, to the expected real interest rate. The production function is $y_{it} = k_{it}^{\alpha} l_{it}^{1-\alpha}$, where $0 < \alpha < 1$, such that the aggregate factor demand functions from the firms' first order conditions are, in a symmetric equilibrium, given by

$$w_t = mc_t(1 - \alpha)k_t^{\alpha} l_t^{-\alpha} \tag{26}$$

and

$$r_t^k = mc_t \alpha k_t^{\alpha-1} l_t^{1-\alpha}. \tag{27}$$

The model's equilibrium conditions are the unchanged household first order conditions, Equations (5)–(7), supplemented by Equations (24) and (25), the cash-in-advance and government budget constraints, Constraint (3) and Equation (11), the accumulation constraint, Equation (23), the Phillips curve, Equation (9), the new factor demand conditions, Equations (26) and (27), the aggregate resource constraint $y_t = k_t^{\alpha} l_t^{1-\alpha} = c_t + g_t + e_t$, and the relevant monetary policy rule.

3.1 Parameterization

Most parameter values are standard values known from the business cycle literature (see, e.g., Christiano and Eichenbaum 1992); in particular, we set $\alpha = 0.36$, $\beta = 0.9926$, $\rho = 0.9$, $l = 1/3$, and $\delta = 0.0212$ (one period in the model corresponds to one quarter). Some choices deserve comment, however. The parameters σ and σ_1 are both set to 2; thus, the intertemporal elasticities of substitution of consumption and leisure are better in line with a large body of empirical evidence than the logarithmic benchmark. The elasticity of the price of capital with respect to the investment ratio, $\Phi''(e/k)/\Phi'$ is taken from Bernanke, Gertler, and Gilchrist (1999) to equal –0.25. The probability of a firm being allowed to reset its price in a given period, $1 - \phi$, is 0.25, which is conservative, given the estimates made by Gali and Gertler (1999). The long-run share of government expenditures, g/y = 21%, is taken from Edelberg, Eichenbaum, and Fisher (1999). The steady state inflation rate is set at $\pi = 1.015$, following Yun (1996).

To parameterize monetary policy, we use a constant growth rate of money equal to steady state inflation, and two state-contingent interest rate rules taken from recent estimates (see Table 1), representing the cases of low ρ_y and high ρ_y discussed above. Both imply interest rate smoothing, i.e., the appearance of an autoregressive parameter $\rho_R > 0$ in the interest rate rule, which now reads $\hat{R}_{t+1} = \rho_R \hat{R}_t + \rho_\pi E_t \hat{\pi}_{t+1} + \rho_y E_t \hat{y}_{t+1}$; it is sufficient for determinacy that the nominal interest rate rises more than one to one in response to inflation in the long run, i.e., $\rho_\pi/(1 - \rho_R) > 1$ (see, e.g., Woodford 2001). Table 1 provides the point estimates for two forward looking interest rate rules for the U.S. for different periods. Rule 1 is taken from Clarida, Gali, and Gertler (1998) and refers to the period 1979:1994, while Rule 2 is estimated by Clarida, Gali, and Gertler (2000) for the period 1983:1996.

3.2 Results

The model's equilibrium conditions are linearized around the steady state, and the resulting system is solved numerically using the methods in Uhlig (1999); the equilibrium turns out to be unique for all parameterizations we consider.

Constant money growth. The impulse responses displayed in Figure 2 reveal that the model with exogenous money growth is similar to the model of the previous section, with one crucial exception: output declines in response to a positive fiscal expenditure shock. Again, the shock shifts out the labor supply schedule by making households willing to accept a lower real wage for each level of employment, on

TABLE 1
INTEREST RATE RULE PARAMETERS

	ρ_R	ρ_π	ρ_y
Rule 1 (Clarida, Gali, and Gertler 1998)	0.92	0.143 (1.79)	0.0056 (0.07)
Rule 2 (Clarida, Gali, and Gertler 2000)	0.79	0.454 (2.16)	0.195 (0.93)

NOTE: Long-run coefficients are given in round brackets.

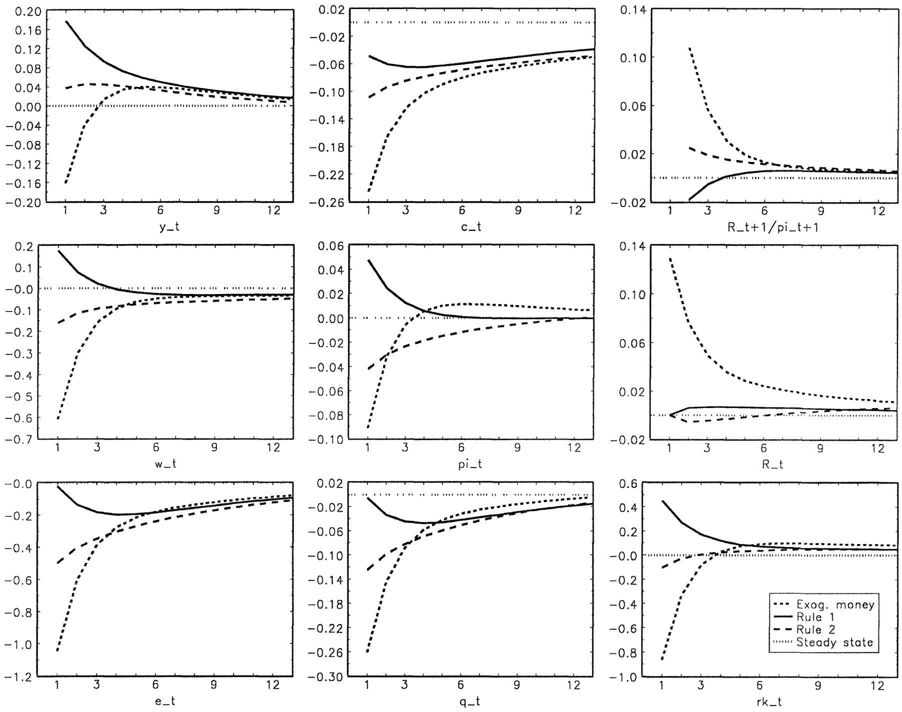

FIG. 2 Percentage impulse responses to 1% shock to g in period 1, model with capital accumulation

the one hand, and decreases private consumption while raising the sum of private and public consumption. The sum, being cash constrained in nominal terms, cannot rise in real terms unless the price level falls. Accordingly, we observe a decline in inflation accompanied by lower real marginal costs. The consumption decline is again associated with a rising real interest rate, which forces q to jump to an equilibrium path converging to the steady state from below. This can be seen from the linearized first order conditions, Equations (23)–(25), which combine to give

$$\hat{q}_t - \beta E_t \hat{q}_{t+1} = -E_t(\hat{R}_{t+1} - \hat{\pi}_{t+1}) + [1 - \beta(1 - \delta)]E_t \hat{r}^k_{t+1}, \tag{28}$$

where we used the property that in the steady state $\Phi' e/k = \delta$ and $q = 1$ hold. Note that the rental rate on capital, r^k, also affects the growth rate of q, but its coefficient in Equation (28) is substantially smaller than the coefficient on the real interest rate. Accordingly, investment expenditures should immediately fall, as can be seen from the linearized first order condition, Equation (24), $\hat{e}_t = -[\Phi'/\Phi''][k/e]\hat{q}_t + \hat{k}_t$, where $\Phi'/\Phi'' < 0$ and k is predetermined.

Investment expenditures are, as implied by the cash-in-advance constraint, Constraint (3), the single credit good within the components of aggregate demand such that changes in the nominal interest rate alone do not affect the investment decision. Nevertheless, the slump of q leads to a sharp decline in investment expenditures;

this is responsible for the fact that aggregate demand, $c + g + e$, and employment now fall in equilibrium.

Interest rate policy. The model's responses to a fiscal policy shock shown in Figure 2 for both the estimated interest rate rules are qualitatively identical to those in the corresponding model version without capital. Recall that in the latter model, inflation, wages, and the nominal interest rate rise for low values of the interest rule's output coefficient, ρ_y, while they decline on impact for higher ρ_y. These results are qualitatively replicated in the present model, where Rule 1 (2) gives an example of the low ρ_y (high ρ_y) type of rule, the long-run output coefficient being 0.07 (0.93).

In distinction from the exogenous money case, output rises as in the model without capital. The reason is that the real interest rate rises much less with interest rate policy, whereby the investment decline is attenuated. In the case of Rule 1, the upward jump in inflation dominates the positive nominal interest rate response, which is now (with $\rho_R = 0.79$) sluggish (in contrast to the previous section's model) and causes an initial contraction of the real interest rate in the first periods before its return to the steady state from above. Consequently, the responses of consumption and investment exhibit a hump-shape.

Figure 2 shows the nominal interest rate to fall initially when the output coefficient in the interest rate rule is large, as in Rule 2 (as was the case above in Section 2.2 for large ρ_y). Nevertheless, the real interest rate response is positive, as the associated decline of inflation is strong enough. The decline of consumption and investment expenditures is monotonic in this case and quantitatively more pronounced than for Rule 1. Aggregate goods demand, however, still rises, in contrast to the exogenous money model, where the even sharper rise in the real interest rate caused consumption and investment to decline so strongly as to actually lower demand. Therefore, although the rise in demand is less than the rise in goods supply so that inflation and the real wage decline, it is still positive, allowing output to rise slightly.

4. CONCLUSION

In this paper, we have studied the effects of fiscal policy in the presence of sticky prices. One question we pursued was whether monopolistic competition between firms and staggered price setting makes fiscal policy look Keynesian, i.e., boosts output, employment, wages, and consumption. The other question was which role the monetary policy regime plays for the results once money begins to matter because of price stickiness.

We found that monetary policy is decisive because of its influence on the real interest rate. Given that the money supply is allowed to accommodate demand, a positive fiscal shock can raise inflation and real wages if the central bank does not respond too strongly to output changes. The real interest rate increase is smallest, and therefore the expansionary effect of a fiscal shock on output is largest, ceteris paribus, if the central bank sets interest rates only in response to inflation expectations. While these effects are compatible with the Keynesian view, it is the unambiguously negative response of private consumption across model specifications that makes the results look essentially neoclassical.

The Keynesian tradition sees fiscal policy exerting a pure aggregate demand effect, with supply following passively; a government spending shock is just an "IS"-shock in this view. The neoclasscial view, by contrast, sees the effect as a pure supply side reaction through the wealth effect, followed by a passive adjustment of demand. The NNS model is a true "synthesis" of these positions: the supply effect is accompanied by a demand effect that can, depending on monetary policy, reduce, overturn, or exacerbate the initial supply response. Which of these theories is correct is too early to say, given the conflicting evidence that recent empirical studies have produced. Our results, however, point to the potential importance of future empirical studies to control for the monetary regime, or changes thereof in the sample period.

APPENDIX

This appendix sketches the proofs to Propositions 1 to 3. A more detailed version of the proof that contains all steps of the derivations is available on the internet as http://www.uni-koeln.de/wiso-fak/feld/fiscalpolicy_appendix.pdf.

PROOF OF PROPOSITION 1: The model can be formulated in the two endogenous variables, m and π, the first of which is a predetermined state variable, while the second can jump. Suppose the model's solution is of the form $\hat{\pi}_t = d_1\hat{m}_t + d_2\hat{g}_t$ and $\hat{m}_{t+1} = d_3\hat{m}_t + d_4\hat{g}_t$, where d_i, $i = \{1,...,4\}$ are to be determined. Applying the method of undetermined coefficients (see McCallum 1983, 1999, Uhlig, 1999) gives d_3 as the stable solution to $d_3^2 - [(a_1+b_1)/a_1]d_3 - 1/a_1 = 0$, as well as $d_1 = 1 - d_3$, $d_2 = c_1/[(-a_1 \ -b_1) + \{a_1(d_3 + \rho)\}]$ and $d_4 = -d_2$, where $a_1 \equiv \theta[\sigma(c + g)/c - 1] - \beta > -1$, $b_1 \equiv -1 - \theta[\sigma_1 l/(1 - l) + \sigma(c + g)/c] < -1$, and $c_1 \equiv -\theta\sigma\rho(g/c) < 0$. For the equilibrium to be unique, one of the roots of the quadratic in d_3 must be less than 1 in absolute value and one must be larger. In any case, both roots will be real, as in the solution to the quadratic, the discriminant $z \equiv [(a_1 + b_1)/(2a_1)]^2 + 1/a_1$ is strictly positive. We want to show that one of the roots is always strictly positive and smaller than 1. Consider first the case $a_1 \in (-1,0)$. In that case, both roots must be positive. It can easily be shown in this case that the smaller root is smaller than one, $0 < [(a_1 + b_1)/(2a_1)] - z^{1/2} < 1$, whereas the larger root is unstable. Next assume that $a_1 > 0$, implying that the roots can be either negative or positive. It can easily be shown in this case that the larger root is strictly positive and smaller than 1. For the smaller root to be outside the unit circle in this case, it is required that $2a_1 < -b_1 + 1$, which is satisfied if we restrict the range of admissible parameter values on $a_1 < 1 \Leftrightarrow \theta < (1 + \beta)/[\sigma(c + g)/c - 1]$. This is the sufficient condition for uniqueness stated in Proposition 1, implying $d_3 \in (0, 1)$ and $d_1 \in (0, 1)$. Further, $d_2 < 0$ since $a_1 > -\beta$, which implies that $d_4 > 0$.

The claims made in Proposition 1 can now be seen to be true, since for a shock in period s we have $\partial\hat{\pi}_s/\partial\hat{g}_s = d_2 < 0$, $\partial\hat{w}_s/\partial\hat{g}_s = [d_2(1 - \beta\rho) - \beta d_4 d_1]/\theta < 0$, $\partial\hat{y}_s/$

$\partial \hat{g}_s = \partial \hat{m}_{s+1}/\partial \hat{g}_s = d_4 > 0$, and, if $a_1 < 1$, $\partial \hat{R}_s/\partial \hat{g}_s = -d_2[(\sigma(c+g)/c - 1)d_3 + (1-\rho)] - \sigma(1-\rho)\partial \hat{c}_s/\partial \hat{g}_s > 0$ and $\partial \hat{c}_s/\partial \hat{g}_s = -d_2(c+g)/c - g/c < 0$.

Proof of Proposition 2: The model can be formulated in the two endogenous variables, c and π, of which both can jump as none is predetermined. Suppose the model's solution is of the form $\hat{\pi}_t = d_1\hat{g}_t + d_5\hat{R}_t$, $\hat{c}_t = d_2\hat{g}_t + d_6\hat{R}_t$, and $\hat{R}_{t+1} = d_3\hat{R}_t + d_4\hat{g}_t$. Applying the method of undetermined coefficients (see McCallum, 1983, 1999, Uhlig, 1999) gives $d_1 = \xi_2\ (\rho - 1)(\xi_1\rho_\pi - \sigma\theta\rho_\pi + \sigma)/\Delta > 0$, $d_2 = \xi_2\rho(\rho_\pi - 1)/\Delta < 0$, $d_3 = 0$, $d_4 = \xi_2\rho\rho_\pi(\rho - 1)\sigma/\Delta > 0$, $d_5 = -\xi_1/\sigma + \theta < 0$, and $d_6 = -1/\sigma < 0$, where $\xi_1 \equiv \theta\sigma_1[l/(1-l)][c/(c+g)] + \theta\sigma > 0$, $\xi_2 \equiv \theta\sigma_1[l/(1-l)][g/(c+g)] > 0$, and $\Delta \equiv \xi_1(\rho - \rho_\pi) - (\rho - 1)\sigma(\beta\rho + \rho_\pi\theta - 1) < 0$, with $\rho_\pi > 1$.

The claims made in Proposition 2 can now be seen to be true, since for a shock in period s we have $\partial\hat{\pi}_s/\partial\hat{g}_s = d_1 > 0$, $\partial\hat{w}_s/\partial\hat{g}_s = [d_1(1-\beta\rho) - \beta d_4 d_5]/\theta > 0$, $\partial\hat{R}_{s+1}/\partial\hat{g}_s = d_4 > 0$, $\partial\hat{y}_s/\partial\hat{g}_s = \partial\hat{m}_{s+1}/\partial\hat{g}_s = [c/(c+g)]d_2 + g/(c+g) > 0$, and $\partial\hat{c}_s/\partial\hat{g}_s = d_2 < 0$.

Proof of Proposition 3: Applying the same approach as above in the proof of Proposition 2, but for the general case $\rho_y > 0$, we find that the solutions for d_3, d_5, and d_6 are unchanged, while the remaining coefficients are more complex than before. In particular, $d_1 = \Psi_1/\Delta$, $d_2 = \Psi_2/\Delta$, and $d_4 = \Psi_4/\Delta$, where $\Psi_1 \equiv \xi_2\sigma\rho_y\ [c/(c+g)]\{1 - \rho(1 + \beta(1-\rho) + \theta)\} - \sigma^2\theta\rho\rho_y[g/(c+g)] + \xi_2\sigma^2(1-\rho)\{\xi_2\rho_\pi\,[c/(c+g)] + \sigma\} \lesseqgtr 0$, $\Psi_2 \equiv \rho\{\xi_2\ ([c/(c+g)]\rho_y - \rho_\pi\sigma + \sigma) - [g/(c+g)]\rho_y\ (\xi_1 - \sigma(\beta\rho + \theta - 1))\} < 0$, and $\Psi_4\ (\rho\{(\xi_2\,[c/(c+g)] - \xi_1\,[g/(c+g)])\rho\rho_y + (\rho - 1)\sigma([g/(c+g)](\beta\rho - 1)\ \rho_y - \xi_2\rho_\pi)\} \lesseqgtr 0$, $\Delta \equiv \sigma\{\xi_1\ (\rho_\pi - \rho) + (\rho - 1)\sigma(\beta\rho + \rho_\pi\theta - 1) - [c/(c+g)]\rho_y(\beta\rho + \rho\theta - 1)\} \lesseqgtr 0$, with $\rho_\pi > 1$, and ξ_1 and ξ_2 defined as above in the proof of Proposition 2. While $\Psi_2 < 0$ is evident, the signs of Ψ_1, Ψ_4, and Δ are unclear in general. There is, however, a sufficient condition that allows determination of the signs: suppose that ρ_y is small enough to ensure $\rho_y < \Xi \equiv [(1-\rho)/\rho][l/(1-l)]\sigma_1\rho_\pi$. In this case, it follows that $\Psi_4 > 0$ and $\Delta > 0$. Hence, $\rho_y < \Xi$ is sufficient for $d_2 < 0$ and $d_4 > 0$. Finally, the coefficient d_1 is nonnegative if and only if $\rho_y < \Gamma \equiv (\rho_\pi\sigma_1[l/(1-l)]\theta(1-\rho) + [(c+g)/c](1-\rho)\sigma)/(\rho\theta + \rho + \rho\beta(1-\rho) + \sigma\rho[(1-l)/(\sigma_1 l)][(c+g)/c] - 1)$, provided that the denominator of Γ is positive.

The claims made in Proposition 3 can now be seen to be true since for a shock in period s we have $\partial\hat{c}_s/\partial\hat{g}_s = d_2 < 0$, $\partial\hat{R}_{s+1}/\partial\hat{g}_s = d_4 > 0$, $\partial\hat{y}_s/\partial\hat{g}_s = \partial\hat{m}_{s+1}/\partial\hat{g}_s = [c/(c+g)]d_2 + g/(c+g) > 0$ if $\rho_y < \Xi$, and $\partial\hat{\pi}_s/\partial\hat{g}_s = d_1 > 0$, $\partial\hat{w}_s/\partial\hat{g}_s = [d_1(1-\beta\rho) - \beta d_4 d_5]/\theta > 0$ if and only if $\rho_y < \Gamma$.

NOTES

1. Interchangeably, the terms "New-Keynesianism" (e.g., Hairault and Portier, 1993, Clarida, Gali, Gertler, 1999), "Neo-Monetarism" (Kimball 1995), or "Optimizing IS-LM" model (McCallum and Nelson 1999) have been proposed.
2. Carlstrom and Fuerst (2001) call the latter timing convention a "cash-when-I'm-done" constraint.

3. Linear production is chosen in order to preserve constant returns to scale, which is necessary to avoid the complexities of firm heterogeneity that would arise if marginal cost depended on the level of labor input.

4. As an anonymous referee pointed out, the interesting comparison is between a non-accomodating versus accomodating policy; the interest rate rule is certainly only an example of the latter type.

5. We do not offer a formal proof of uniqueness but refer to a large literature proving equilibrium determinacy in models of interest rate policy under the condition that the policy is active in the sense $\rho_\pi > 1$, which is assumed to be fulfilled here. Numerical checks suggest that the equilibrium with active policy is indeed unique for all parameterizations we tried.

6. The unambiguous rise in the real wage is clearly particular to the assumption of constant returns. With decreasing returns, the sign of the wage response would depend on parameters.

7. For the parameters underlying Figure 1 (where $\sigma_1 = 2$), the critical upper bound is $\Gamma \approx 0.18$; for highly inelastic labor, e.g., $\sigma_1 = 5$, it is much larger, $\Gamma \approx 3.68$.

8. In a steady state, where $e/k = \delta$, it is assumed that $\Phi(\delta) = \delta$ and $\Phi'(\delta) = 1$ hold, such that Tobin's q will be equal to 1.

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