MONEY, DEFICIT AND PUBLIC DEBT IN THE UNITED STATES

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Abstract—This study estimates the underlying parameters in a dynamic game between the fiscal and monetary authorities over the determination of public debt. These estimates reveal the policymakers' attitudes towards the goal of stabilizing the time path of public debt. The central finding is that, in the United States, during the 1955–85 period, this goal has been pursued by the fiscal authority but not by the central bank. Monetary policy has not monetized the stock of public debt outstanding, whereas cyclically adjusted, net of interest fiscal deficits have been reduced to offset increases in the stock of debt in circulation.

I. Introduction

ACCORDING to standard theoretical models, the macroeconomic consequences of fiscal deficits depend on the expected impact of the deficit on future monetary and fiscal policies. But what is such an impact? This question has seldom been asked in isolation. The existing literature has investigated in detail the consequences of deficits in regimes where either the monetary or the fiscal authority is precommitted—cf. Barro (1979) and Sargent and Wallace (1981), respectively. But neither regime corresponds to institutional features that have a real world counterpart. In nearly all industrial countries, neither the fiscal nor the monetary authorities can precommit to a specific future course of action. Moreover, in many of these countries, monetary and fiscal policies are decentralized between two relatively independent authorities with possibly conflicting objectives. In such a setup, future policies must be viewed as the equilibrium outcome of a dynamic game between the two authorities.

This is the point of view taken in this paper. Specifically, we estimate empirically the underlying parameters in a dynamic game over the determination of public debt. The two players are the monetary and fiscal authorities in the United States for the period 1955–85. The main purpose is to find out whether the regime prevailing in the United States during this time is best approximated by a "Ricardian" regime where monetary policy is dominant, or instead by a regime à la Sargent and Wallace (1981), where fiscal policy is dominant and deficits are eventually monetized. Since, as stated above, policy precommitments were technologically unfeasible in the United States over this time period, this question can be answered only by estimating the policymakers' preferences. Hopefully such estimates can reveal the attitude of the two policymakers towards the goal of stabilizing public debt.

The central finding of the paper is that, during the period 1955–85, the burden of stabilizing public debt fell exclusively on the fiscal authority. The cyclically adjusted fiscal deficit net of interest payments is negatively related to the stock of public debt outstanding at the beginning of each year, and so is the creation of monetary base. Thus, there is strong evidence that fiscal deficits were reduced when the stock of public debt inherited from the past increased. And there is no evidence of debt monetization on the part of the monetary authorities.

A second interesting result is that Democratic administrations have systematically pursued more expansionary fiscal and monetary policies than Republican administrations. This confirms similar findings reported in some recent studies of the U.S. political business cycle.

The paper outline is as follows. Section II illustrates the game theoretic model. The model is then solved analytically in section III, and its estimates are presented in section IV. The results are interpreted and discussed in section V. Section VI

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contains some sensitivity analysis. The conclusions are summarized in section VII.

II. The Theoretical Model

In order to focus on the choice of public financial policies, the strategic interaction between the monetary and fiscal authorities is artificially separated into two stages. In the first stage, the two policymaking authorities are supposed to choose optimal reference paths for their policy instruments and for public debt, so as to achieve standard macroeconomic or political objectives. In the second stage, the two authorities are modelled as trying to achieve the best tradeoff between the (possibly mutually exclusive) goals of minimizing the deviations of their actual policy instruments and of public debt from their respective optimal reference paths. In this second stage, both authorities are subject to only one constraint: namely, the dynamic budget constraint. The theoretical and empirical analysis that follows focuses almost exclusively on the second of these two stages.[1]

This artificial separation of the strategic interaction into two stages serves two purposes. First, it enables us to compute a closed form solution for the reduced form coefficients of the dynamic game. This in turn allows a direct estimate of the key parameters of the policymakers' loss functions. Second, it isolates the only theoretical constraints on which we have sharp prior beliefs, namely those derived from the government budget constraint. The remaining constraints, which relate to the reduced form equations characterizing the economy and which make use of much more unreliable prior information, can thus be neglected without losing the possibility of making inferences about the policymaker's preferences.

Without this two-stage separation, the reduced form of the dynamic game would still be the same as that estimated in section IV below. However, the coefficients of such a reduced form would be harder to interpret, since they would contain parameters that refer to both the policymakers' preferences and the structure of the macroeconomy.

Throughout the paper, all variables are scaled to nominal income. The policy instruments chosen by the monetary and fiscal authorities are the change in the monetary base, m, and the fiscal deficit net of interest payments and cyclically adjusted, f, respectively. The optimal reference paths for such instruments, chosen in the first stage of the policy decision process, are denoted by $\bar{m}_t$ and $\bar{f}_t$. They are assumed to be contingent on a vector of macroeconomic and political variables, x_t, that will be defined in section IV below:

$$\bar{m}_t = \alpha_0 + \alpha_1 x_t$$
$$\bar{f}_t = \beta_0 + \beta_1 x_t. \qquad (1)$$

α_i and β_i, $i = 0, 1$ are vectors of constant parameters. For notational simplicity, and with no loss of generality, the optimal reference path for public debt is taken to the zero.[2]

In the second stage of the policymaking decision process, the time path of x_t (and hence of $\bar{m}_t, \bar{f}_t$) is taken to be exogenous, and the two authorities are supposed to minimize the following loss functions. The central bank chooses m_t to minimize:

$$V^M(d_0) = \frac{1}{2}E\left\{\sum_{t=0}^{\infty}\rho^t\left[(m_t - \bar{m}_t)^2 + \tau d_t^2\right]\right\},$$
$$1 > \rho > 0, \tau \geqq 0, \quad (2)$$

subject to the government budget constraint, to the process generating the time path of f_t—yet to be specified—and to the initial condition d_0. The variable d_t denotes the stock of public debt held by the private sector at the beginning of period t, and $E\{\cdot\}$ is the expectations operator. The fiscal authority chooses f_t to minimize:

$$V^F(d_0) = \frac{1}{2}E\left\{\sum_{t=0}^{\infty}\rho^t\left[(f_t - \bar{f}_t)^2 + \lambda d_t^2\right]\right\},$$
$$1 > \rho > 0, \lambda \geqq 0, \quad (3)$$

also subject to the government budget constraint, to the process generating m_t and to the initial condition d_0.

Thus, as stated above, both authorities wish to minimize the deviations of their instruments of economic policy from their respective reference paths. At the same time, they also wish to maintain public debt as close as possible to its own target path, for notational simplicity taken to be zero. The preferences about d, for both fiscal and monetary authorities, can be justified on three

[1] For a game theoretic analysis of the first stage of a dynamic game between the monetary and fiscal authorities, see Pindyck (1976).

[2] Alternatively, all variables can be interpreted as being expressed in deviation from the reference path for public debt.

grounds. First, in the absence of lump sum taxes, a larger stock of public debt implies larger tax distortions in order to pay interest on the debt. Second, whenever the interest rate fluctuates, the fluctuations of taxes needed to pay for the debt are larger the larger is the stock of public debt outstanding. Third, higher levels of d can be associated with lower rates of capital accumulation or with higher levels of private external debt, as for instance in Blanchard (1985). The assumption that the desired value of d is the same for both players simplifies notation and computations, with practically no loss of generality.

The parameters τ and λ reveal the policymakers' attitudes towards the goal of stabilizing public debt. For $\tau \to 0$ and λ large and positive, the equilibrium of the game resembles a "Ricardian regime" where monetary policy is dominant. Conversely, if τ is large and positive and $\lambda \to 0$, fiscal policy is dominant and the burden of stabilizing public debt falls exclusively on monetary policy.

The stock of public debt in circulation is determined by the government budget constraint:[3]

$$d_{t+1} = rd_t + f_t - m_t + e_t \tag{4}$$

where e_t is the cyclical component of the fiscal deficit net of interest payments, and $r = (1 + n)/(1 + g)$, n being the real rate of interest net of taxes and g the rate of growth of real output (recall that all variables are scaled to nominal income). The hypothesis that r is a constant parameter implies that there is a flat demand for public debt. This assumption is needed in order to have a linear dynamic, and can be interpreted as an approximation to a more complicated model.

Finally, the law of motion of the variables e_t (in (4)) and x_t (in (1)) is summarized by the following exogenous linear stochastic process:

$$e_t = \gamma_0 + \gamma_1 e_{t-1} + \gamma_2 x_{t-1} + u_t$$
$$x_t = \delta_0 + \delta_1 e_{t-1} + \delta_2 x_{t-1} + v_t \tag{5}$$

where δ_2 is a matrix with eigenvalues inside the unit circle, γ_1, δ_1, and λ_2 are scalars or vectors all smaller than 1 in absolute value, and u_t and v_t are mutually and serially uncorrelated random variables.

[3] Implicit in (4) is the assumption that changes in the foreign component of the monetary base and off budget items are both zero.

III. The Analytical Solution

Since the dynamic game described in the previous section is linear-quadratic, a closed form solution can be computed. This is done in this section, under the assumptions that both players have symmetric information, that they move simultaneously (i.e., they behave as Nash players) and are restricted to choosing strategies that depend linearly on the past history of the game only through the state variable d_t.[4]

In conformity to the institutional setup of the United States and of most industrial countries, it is assumed that neither player can precommit to a time path of future actions. Thus, at each stage of the game both players reoptimize, in light of what happened in the previous stage. The equilibrium notion incorporating this assumption is that of Feedback-Nash equilibrium. This equilibrium is defined as follows: Each player's decision rule is the optimal response to the opponent's decision rule. In choosing his optimal response, each player is taking into account that his own current action influences the future actions of the opponent, through its effect on the state variable, public debt. That is, the opponent's decision rule, and not its future actions, is taken as given. Since the equilibrium strategies can also be computed by means of dynamic programming methods (see Tabellini, 1986) and since they are contingent on the current value of the state variable, they are based on optimal future behavior both on and off the equilibrium path. Hence, this feedback-Nash equilibrium is subgame perfect and, *a fortiori*, it is also dynamically consistent. Since the game is linear-quadratic, this is also the only subgame perfect Nash equilibrium defined on the linear strategies given below.[5]

The information set of both policymakers at time t is supposed to contain x_{t-1} and e_{t-1}, but not the current realization of the shocks u_t and v_t in (5). Under these assumptions, it is plausible to conjecture that the equilibrium strategies will take

[4] This last assumption is needed in order to have a unique equilibrium, and is the natural one to impose in the context of linear-quadratic dynamic games.

[5] Tabellini (1986, 1987) compare the feedback-Nash equilibrium of a deterministic version of this same game with other equilibrium notions, both in continuous and discrete time. In particular, Tabellini (1986) characterizes the feedback Stackelberg equilibrium for this same game. The reduced form of such an equilibrium is identical to that derived here.

the following simple form:

$$m_t = \theta_0 + \theta_1 d_t + \theta_2 e_{t/t} + \theta_3 x_{t/t}$$
$$f_t = \pi_0 + \pi_1 d_t + \pi_2 e_{t/t} + \pi_3 x_{t/t} \tag{6}$$

where $e_{t/t}$ and $x_{t/t}$ denote the expectation of e_t and x_t, obtained from (5) and based on the information set at t, and where θ_i and π_i are coefficients yet to be determined.

Substituting (6) into the government budget constraint, (4), we obtain the equilibrium time path of public debt:

$$d_{t+1} = (\pi_0 - \theta_0) + (r + \pi_1 - \theta_1) d_t + (\pi_2 - \theta_2) e_{t/t} + (\pi_3 - \theta_3) x_{t/t} + e_t. \tag{7}$$

The next sections estimate the system of equations made up of (6) and (7). In the remainder of this section we characterize the coefficients θ_i and π_i by solving for the feedback-Nash equilibrium of the game.

The current value Hamiltonian for the central bank can be written, using (2), (4), and (6), as

$$H_t^M = E\Big[\frac{1}{2}(m_t - \bar{m}_t)^2 + \frac{1}{2}\tau d_t^2 - \mu_{1t}\big(d_{t+1} - (r + \pi_1) d_t + m_t - e_t - \pi_0 - \pi_2 e_{t/t} - \pi_3 x_{t/t}\big)\Big] \tag{8}$$

where μ_{1t} is the costate variable for the law of motion of public debt, and where f_t has been substituted by the expression on the right hand side of (6), so as to impose the condition that the central bank chooses a feedback strategy. The first order conditions are

$$m_t = \bar{m}_{t/t} + \mu_{1t}$$
$$\mu_{1t} = \rho \tau d_{t+1/t} + \rho(r + \pi_1)\mu_{1t+1/t} \tag{9}$$

where $\bar{m}_{t/t}, d_{t+1/t}, \mu_{1t+1/t}$ denote the expectations of $\bar{m}_t$, d_{t+1} and μ_{1t+1} based on the information available at time t.

Similarly, the current value Hamiltonian for the fiscal authority is

$$H_t^F = E\Big[\frac{1}{2}(f_t - \bar{f}_t)^2 + \frac{1}{2}\lambda d_t^2 - \mu_{2t}\big(d_{t+1} - (r - \theta_1) d_t - f_t - e_t + \theta_0 + \theta_2 e_{t/t} + \theta_3 x_{t/t}\big)\Big] \tag{10}$$

with μ_{2t} being again the costate variable for public debt. The first order conditions are

$$f_t = \bar{f}_{t/t} - \mu_{2t}$$
$$\mu_{2t} = \rho \lambda d_{t+1/t} + \rho(r - \theta_1)\mu_{2t+1/t}. \tag{11}$$

The dynamic system made up of equations (4), (9) and (11) can be solved by the method of undetermined coefficients. The solution takes the form of equations (6) and (7). The coefficients π_i and θ_i in (6) are the solution to a recursive system of nonlinear equations, available from the authors upon request.

In estimating the model we impose only two equations of this system, namely,

$$\theta_1 = \rho\tau(r + \pi_1 - \theta_1) + \rho\theta_1(r + \pi_1)(r + \pi_1 - \theta_1)$$
$$\pi_1 = -\rho\lambda(r + \pi_1 - \theta_1) + \rho\pi_1(r - \theta_1)(r + \pi_1 - \theta_1). \tag{12}$$

Once we assign a numerical value to the discount factor ρ, these two equations, together with the estimate of r obtained from (7), exactly identify the parameters τ and λ of the policymaker's loss functions.

There are two reasons for estimating the model only subject to (12), rather than to the full system of equations characterizing the π_i and θ_i coefficients. The first reason is computational. Even just deriving a closed form solution for all the θ_i and π_i would be very cumbersome. The second reason is more important. In order to impose all the constraints characterizing the solution to this dynamic game, we would have to estimate (6) and (7) jointly with (1) and (5). However, our confidence on the correct specification of equations (1) and (5) is very weak. We have no theory to guide us on the number of lags or the list of variables to be included. Thus, by estimating τ and λ jointly with (1) and (5), subject to the full system of constraints on θ_i and π_i, we would be increasing the sensitivity of our estimates to the specification uncertainty. By contrast, the two constraints in (12) only contain the parameter r that belongs to the government budget identity (7) (besides the preference parameters τ, λ and ρ). Thus, imposing only these two constraints and jointly estimating (6) and (7) reduces the impact of the specification uncertainty. This is what we do in the next two sections.

IV. Estimation

The system of equations (6) and (7) is jointly estimated by maximum likelihood methods. We

TABLE 1.—VARIABLE DEFINITIONS

m_t =	change in the monetary base, adjusted for changes in the reserve. requirement. (Source: Federal Reserve Bank of St. Louis.)
f_t =	cyclically adjusted fiscal deficit net of interest payments. (Source: Survey of Current Business.)
d_t =	stock of public debt held by private investors at the *beginning* of each calendar year. (Source: Banking and Monetary Statistics, Annual Statistical Digest, and Economic Report of the President.)
e_t =	cyclical component of fiscal deficits net of interest payments. (Source: Survey of Current Business.)
x_t =	a vector of the following variables: p_t = yearly CPI rate of inflation. (Source: Citibase.) i_t = nominal interest rate on 6 months Treasury bills (*end* of each calendar year). (Source: IFS Statistics, IMF.) u_t = unemployment rate (*end* of each calendar year). (Source: Citibase.) a_t = dummy variable taking a value of 0 in the years of a Republican administration and a value of 1 otherwise.

first estimate the system unconstrained, and then we impose the linear constraints between the coefficients of (6) and (7).

The data are yearly and cover the period (1955–1985). The variables are defined in table 1. In particular, x_t consists of a set of macroeconomic variables presumably related to the policymakers' goals, such as inflation, unemployment and interest rates. A political dummy variable, a_t, is also included to allow for political influences on monetary and fiscal policies. The variables m, f, d and e are scaled by the log-linear trend of nominal GNP.

The model is estimated in two separate stages. In the first stage, the predicted values $x_{t/t}$ and $e_{t/t}$ are generated by running an ordinary least squares (OLS) regression of (x_t, e_t) on itself lagged one period, and on m_{t-1}, f_{t-1} and d_t.[6] In the second stage, the values of $x_{t/t}$ and $e_{t/t}$ thus generated are used to estimate the system made up of (6) and (7), by means of maximum likelihood methods.

Our measures of $x_{t/t}$ and $e_{t/t}$ can be viewed as instrumental variables for the true but unobservable policymakers' forecasts of x_t and e_t. Conceivably, the policymakers formed their true forecasts of x_t and e_t by conditioning on a larger information set than the one that we used in creating $x_{t/t}$ and $e_{t/t}$. Hence, the residuals of equations (6) and (7) include the measurement errors due to any discrepancy between our instruments, $x_{t/t}$ and $e_{t/t}$, and the true policymakers' forecast of x_t and e_t. However, these measurement errors are uncorrelated with the explanatory variables appearing in (6) and (7). The reason being that all the random regressors that appear in (6) and (7) are also included as explanatory variables in the OLS regressions that generated $x_{t/t}$ and $e_{t/t}$. Hence, by construction, the error terms of (6) and (7) are orthogonal to the random regressors of those same equations.[7]

As explained by Pagan (1984), this truncated two-stage procedure can bias the estimates of the standard errors of the coefficients in (6) and (7).[8] Hence, the t-statistics and the significance tests reported below can also be biased. In order to cope with this problem, we also jointly estimated equations (5), (6) and (7) by means of three-stage least squares (3SLS). The estimates of the coefficients and of the standard errors obtained with 3SLS are almost identical to the estimates obtained from the truncated two-stage procedure that we report in tables 2 and 3. Even though the joint estimate of (5)–(7) with 3SLS eliminates any bias from the estimated standard errors, it enhances the scope of our specification uncertainty

[6] Except for the dummy variable a_t which appears in the vector autoregressions as an explanatory variable, but for which the actual rather than the expected variable is used in estimating (6) and (7). A Lagrange multiplier test modified for small samples (Harvey (1981, p. 177), Kiviet (1981)) cannot reject the hypothesis of no first and second order serial correlation of the residuals of the OLS regressions at the 0.05 level of significance. The results do not change if d_t is dropped from the OLS regressions, but the estimated residuals of these regressions are no longer white noise. Similarly, the results are invariant as to whether m_{t-1} and f_{t-1} are included or not.

[7] See McCallum (1976), Pagan (1984) and, for a similar procedure in estimating the central bank reaction function, Abrams, Froyen and Waud (1980).

[8] The reason being that the error terms of (6) and (7) also include any measurement error relating to our instruments $x_{t/t}$ and $e_{t/t}$.

TABLE 2.—UNCONSTRAINED ESTIMATES OF THE MODEL

$$m_t = \theta_0 + \theta_1 d_t + \theta_2 e_{t/t} + \theta_{31} p_{t/t} + \theta_{32} i_{t/t} + \theta_{33} u_{t/t} + \theta_{34} a_t + \theta_4 t + \theta_5 t^2 + \epsilon_{1t}$$
$$f_t = \pi_0 + \pi_1 d_t + \pi_2 e_{t/t} + \pi_{31} p_{t/t} + \pi_{32} i_{t/t} + \pi_{33} u_{t/t} + \pi_{34} a_t + \pi_4 t + \pi_5 t^2 + \epsilon_{2t}$$
$$d_{t+1} = \eta_0 + \eta_1 d_t + \eta_2 e_{t/t} + \eta_{31} p_{t/t} + \eta_{32} i_{t/t} + \eta_{33} u_{t/t} + \eta_{34} a_t + \eta_4 t + \eta_5 t^2 + \eta_6 e_t + \epsilon_{3t}$$

Explanatory Variables	Endogenous Variables		
	m_t	f_t	d_{t+1}
Intercept	3.416[b]	34.650[b]	25.665[a]
	(0.940)	(10.466)	(10.323)
d_t	−0.047[b]	−0.549[b]	0.547[b]
	(0.016)	(0.173)	(0.171)
$e_{t/t}$	0.127[a]	0.679	0.026
	(0.054)	(0.596)	(0.639)
$p_{t/t}$	−2.830	−39.022[b]	−44.266[b]
	(1.217)	(13.549)	(13.720)
$i_{t/t}$	0.043	0.625	0.953[a]
	(0.039)	(0.431)	(0.433)
$u_{t/t}$	−0.115[a]	−0.997	−0.827
	(0.045)	(0.450)	(0.492)
a_t	0.139[b]	1.019[b]	0.694[a]
	(0.029)	(0.326)	(0.321)
t	−0.168[a]	−2.206[b]	−1.750[a]
	(0.065)	(0.726)	(0.716)
t^2	0.005[a]	0.064[b]	0.054[a]
	(0.002)	(0.020)	(0.020)
e_t	—	—	1.311[b]
			(0.244)
S.E.	0.052	0.583	0.573
D.W.	2.11	1.72	1.84
LM	3.46	0.77	1.25
MLM	1.22	0.25	0.39

Note: Standard errors appear in parentheses. *LM* and $MLM = (T-(k+2))\,LM/(2(T-LM))$ denote, respectively, the Lagrange multiplier statistic and the modified Lagrange multiplier (modified for small samples as in Kiviet (1986) or Harvey (1981)), testing for second order serial correlation. They are asymptotically distributed like $\chi^2(2)$ and $F(2, T-k-2)$, respectively. Based on these statistics, the hypothesis of no second order correlation cannot be rejected at the 0.05 level of significance. Absence of first order serial correlation can also not be rejected for any of the equations.

[a]Significantly different from zero at the 95% confidence interval.
[b]Significantly different from zero at the 99% confidence interval.

concerning the process generating $x_{t/t}$ and $e_{t/t}$ (i.e., concerning equation (5)). For this reason, we choose to give more emphasis to the truncated two-stage estimate than to the 3SLS estimates. It is important to stress, though, that not only the estimated coefficients and most standard errors are almost identical for the two procedures, but also that all the significance tests for the variables of interest are not sensitive to the estimation procedure.

Table 2 reports the unconstrained maximum likelihood estimates of (6) and (7) based on the truncated two-stage procedure. In all three equations, a linear and quadratic time trend were included among the explanatory variables, in order to reduce the danger of spurious correlation in the sense of Granger and Newbold (1974). All significant variables have the expected sign, except for d_t and unemployment in the central bank reaction function.

When the system is reestimated imposing the linear constraints combining the coefficients of (6) with those of (7), these constraints are rejected by a likelihood ratio test. This rejection should not be surprising, given that both m_t and f_t do not correspond exactly to the variables that enter the government budget constraint (unless changes in the foreign component of the monetary base and off-budget items are both zero). However, when only a subset of the parameters in (6) and (7) is constrained, the constraints are accepted. In order to improve the efficiency of the estimates, we imposed the largest subset of the constraints that is accepted by the data.[9] These constrained estimates, reported in table 3, will form the basis of the discussion in the next section.

[9] The likelihood ratio statistic for the five constraints stated in table 3 takes a value of 9.54. This statistic is asymptotically distributed like $\chi^2(5)$. Since $\chi^2(5) = 11.1$ at the 0.05% level of significance, the constraints cannot be rejected.

TABLE 3.—CONSTRAINED ESTIMATES OF THE MODEL

$$m_t = \theta_0 + \theta_1 d_t + \theta_2 e_{t/t} + \theta_{31} p_{t/t} + \theta_{32} i_{t/t} + \theta_{33} u_{t/t} + \theta_{34} a_t + \theta_4 t + \theta_5 t^2 + \epsilon_{1t}$$

$$f_t = \pi_0 + \pi_1 d_t + \pi_2 e_{t/t} + \pi_{31} p_{t/t} + \pi_{32} i_{t/t} + \pi_{33} u_{t/t} + \pi_{34} a_t + \pi_4 t + \pi_5 t^2 + \epsilon_{2t}$$

$$d_t = (\pi_0 - \theta_0) + (r + \pi_1 - \theta_1) d_t + \eta_2 e_{t/t} + (\pi_{31} - \theta_{31}) p_{t/t} + (\pi_{32} - \theta_{32}) i_{t/t} + (\pi_{33} - \theta_{33}) u_{t/t} + (\pi_{34} - \theta_{34}) a_t + \eta_4 t + \eta_5 t^2 + \eta_6 e_t + \epsilon_{3t}$$

Explanatory Variables	Endogenous Variables m_t	f_t	d_{t+1}
Intercept	3.196[b]	29.981[b]	—
	(0.923)	(9.753)	
d_t	−0.044[b]	−0.485[b]	see r
	(0.015)	(0.162)	
$e_{t/t}$	0.124[a]	0.621	−0.476
	(0.053)	(0.558)	(0.614)
$p_{t/t}$	−2.861[a]	−39.675[b]	—
	(1.198)	(12.767)	
$i_{t/t}$	0.048	0.734	—
	(0.38)	(0.405)	
$u_{t/t}$	−0.112[a]	−0.922	—
	(0.044)	(0.465)	
a_t	0.133[b]	0.894[b]	—
	(0.029)	(0.304)	
t	−0.154[a]	−1.915[a]	−1.803[a]
	(0.064)	(0.677)	(0.685)
t^2	0.005[a]	0.055[b]	0.058[b]
	(0.002)	(0.019)	(0.019)
e_t	—	—	1.827[b]
			(0.239)
r	—	—	0.983[b]
			(0.004)
S.E.	0.053	0.593	0.571
D.W.	2.15	1.63	2.01
LM	2.53	1.83	3.08
MLM	0.86	0.61	1.3

Standard errors appear in parentheses. *LM* and $MLM = (T - (k+2))\, LM/(2(T - LM))$ denote, respectively, the Lagrange multiplier statistic and the modified Lagrange multiplier (modified for small samples as in Kiviet (1986) or Harvey (1981)), testing for second-order serial correlation. They are asymptotically distributed like $\chi^2(2)$ and $F(2, T-k-2)$, respectively. Based on these statistics, the hypothesis of no second order correlation cannot be rejected at the 0.05 level of significance. Absence of first order serial correlation can also not be rejected for any of the equations.

[a]Significantly different from zero at the 95% confidence interval.

[b]Significantly different from zero at the 99% confidence interval.

The coefficient r at the bottom of table 3 is the estimate of the parameter r in the government budget constraint, equation (7). This parameter is the gross nominal interest rate divided by one plus the rate of growth of the trend of nominal GNP. Since the rate of growth of the log-linear trend of nominal GNP during the sample period is 8.2%, the reported estimate of r implies an average nominal interest rate on public debt of 6.3% during the same period—a remarkably plausible value.

Before turning to a more thorough analysis of the results, note that the imposition of the constraints reported in table 3 does not change substantially the estimated coefficients, except for the inflation and unemployment coefficients in the fiscal policy regression.

V. Interpretation of the Results

The focus of the paper is the estimation of the parameters τ and λ in the loss function of the two players. As mentioned in section II, the size of these parameters contains information on whether the central bank has monetized public debt in the period under consideration, and whether the fiscal authority has altered the size of fiscal deficits in order to stabilize public debt. These two parameters can be estimated by exploiting the information contained in the nonlinear equations (12).[10]

When the discount factor ρ is set equal to 0.8, the maximum likelihood estimates of τ and λ

[10] Details of the procedure used to solve (12) are available upon request.

obtained by imposing the nonlinear constraints in (12) and the linear constraints across the coefficients of (6) and (7), as in table 3, are:

$$\begin{array}{cc} \tau & \lambda \\ \hline -.079 & .617 \\ (.043) & (.547) \end{array} \qquad (13)$$

with the standard errors in parentheses.[11] The positive estimated value of λ suggests that the fiscal authority tended to respond to increases in the stock of public debt by reducing the size of structural fiscal deficits net interest payments. The negative estimated value of τ suggests that the central bank did not monetize public debt during the sample period; on the contrary, according to the data, the central bank tended to reduce the creation of monetary base when the stock of debt inherited from the past was unusually high. This pattern also emerges from the estimates reported in both tables 2 and 3. In both tables, π_1 and θ_1 are always negative and significantly different from zero, implying that fiscal deficits and money creation are inversely related to the stock of public debt in circulation. This result is very robust: it emerges from several alternative specifications of the underlying model, and is not altered by the inclusion or the omission of other explanatory variables, nor by changes in the way in which the expected variables included in $x_{t/t}$ are generated —see also section VI below.

The central finding of the paper, thus, is that the burden of stabilizing public debt in the United States during the period 1955–85 seems to have fallen exclusively on the fiscal authority. This result is important for at least two reasons. First, it casts doubts on the relevance of the theoretical debate concerning the potential instability of public debt. A number of influential papers (Sargent and Wallace (1981), McCallum (1981)) have shown that if the real interest rate exceeds the rate of growth of real output, and if the time path of fiscal deficits is predetermined, then a restrictive monetary policy can increase, rather than decrease, the equilibrium rate of inflation. The crucial ingredient generating these results is the hypothesis that monetary policy has to bear the burden of stabilizing public debt because fiscal deficits are exogenous and predetermined. Our estimates suggest that this hypothesis is strongly contradicted by the U.S. empirical evidence: In the period 1955–85, the burden of stabilizing public debt has fallen on fiscal policy, and not on monetary policy. The fiscal authority has set fiscal deficits contingent on the size of the stock of debt outstanding, as predicted by the theoretical model of section II.

Second, our empirical results indicate that, contrary to some common wisdom, the conduct of monetary policy does not seem to have been constrained by the behavior of the fiscal authority. Previous studies found some existence of a contemporaneous positive correlation between money creation and fiscal deficits.[12] Our estimates indicate that when the stock of debt, rather than the flow of deficits, is included as an explanatory variable in the central bank reaction function, the evidence that the Federal Reserve engaged in a policy of debt monetization disappears.

In this respect, it can be argued that our results are too strong: a negative (though statistically insignificant) estimated value of τ is of difficult economic interpretation within the framework of this model, since it implies that the central bank prefers an explosive path for public debt. One possible explanation in line with the theoretical framework of this paper is that the two policymakers are engaged in a game of asymmetric information. Specifically, suppose that the fiscal authority is imperfectly informed about the true preferences of the central bank. Then in equilibrium the central bank would optimally exploit its informational advantage, by trying to establish a reputation as a tough player. This might involve

[11] If the discount factor, ρ, is decreased below 0.8, both τ and λ increase further in absolute value. Vice versa, if ρ is increased, the estimates of τ, λ drop in absolute value. The estimates of all the remaining coefficients are unaffected by changes in ρ. It is worth noting that the estimates of τ and λ reported in (13) are not significantly different from zero. This contrasts with the estimates of π_1 and θ_1 reported in table 3, that instead are highly significant. From an algebraic point of view, θ_1 and π_1 can only be different from zero if τ and λ are not zero (see equation (12)). Hence, the hypothesis that τ and λ are significantly different from zero can be rejected by the results of table 3, but not according to those reported in (13). This discrepancy may be due to approximation errors involved in estimating the standard errors shown in (13), since the model is highly nonlinear in τ and λ.

[12] The existing literature is far from unanimous, however: Hamburger and Zwick (1981), Levy (1981) and Allen and Smith (1983) all find evidence of a positive correlation between M1 or base growth and federal deficits in the post World War II period. But Niskanen (1978), Dwyer (1982) and Joines (1985) do not.

simulating a preference for a large stock of debt outstanding, so as to force the fiscal authority to maintain a small budget deficit.[13] A second possible explanation for the negative estimate of τ is that it may reflect a time-aggregation bias: whereas fiscal policy decisions are taken on a yearly basis, this is not true of monetary policy. Hence, estimating the central bank reaction function on yearly data may introduce a bias in the estimate of τ. It is not difficult to conceive of examples in which this bias can be negative. Alternatively, this negative estimate of τ might indicate that the central bank decision process cannot be broken down into two separate stages as we assumed in solving the game. In this case, the reduced form coefficient θ_1 would no longer be a monotonic function of τ, and we would lose the possibility of making inferences about the central bank preferences (see also the discussion in section II).

In order to assess the sensitivity of the estimate of λ with respect to this potential problem, the model was reestimated imposing the constraint $\tau = 0$ (or, equivalently, $\theta_1 = 0$). Some of the estimated coefficients of the central bank reaction function change, and the constraint is rejected. However, the estimated coefficients of the remaining two equations in the model, and in particular the estimates of λ and r, are virtually unaffected.

Our estimates of the policy reaction functions also identify the influence of some political variables on both monetary and fiscal policy. The most robust of these results is the positive and significant estimate of the coefficient on the dummy variable a, which emerges from almost all of the alternative specifications of the model. This dummy takes on a value of 1 in the years of a Democratic administration, and zero otherwise. Hence, the estimates indicate that Democratic administrations have systematically had larger fiscal deficits and larger money base creation than Republican administrations. This finding is consistent with some of the existing empirical literature (Alesina and Sachs (1988), Alesina (1988), Hibbs (1977), Havrilesky 1985)). Alesina (1987) presents a theoretical model which generates exactly this prediction. The model is a game theoretic version of an argument originally put forward in Hibbs (1977): The political base of the Democratic party is such that Democratic administrations are more inclined than Republican administrations to pursue expansionary monetary and fiscal policies. This prediction is confirmed by the estimates reported in tables 2 and 3. However, a variable reflecting the political composition of Congress (constructed according to the methods used in Laney and Willett (1983)) is never significant in any of the policy reaction functions. This suggests that political influences on monetary and fiscal policy come mostly from the administration and not from the legislature.

Finally, our results also point out that monetary policy has accommodated the predicted cyclical component of fiscal deficits, $e_{t/t}$: the estimates of θ_2 are positive and significant in both tables 2 and 3. However, this result is hard to interpret: the positive estimate of θ_2 could simply reflect a countercyclical monetary policy, rather than a systematic policy of monetizing some components of fiscal deficits.[14] Indeed, only the first interpretation is consistent with some recent findings of Joines. Joines (1985) shows that, even though there is a positive relationship between the size of fiscal deficits and the creation of monetary base, this relationship disappears when a time trend is added to the regressions. Joines concludes that the correlation between monetary base creation and deficits that has been found by other authors is the result of spurious correlation, rather than of an accommodative behavior on the part of the monetary authorities.

VI. Sensitivity Analysis

In order to further assess the robustness of the results reported in the previous sections, the basic model has been tested to check the constancy of the coefficients and the sensitivity to the dynamic specification. In this section we report on these two issues.

[13] Tabellini (1987) analyzes a two period version of this same model, in which the fiscal authority is uncertain about the true value of τ. For some parameter values a reputational equilibrium with these properties is shown to exist. Loewy (1988) contains a related analysis.

[14] One of the referees suggested the following tentative argument to reconcile the positive estimate of θ_2 with the negative estimate of θ_1. Suppose that public debt is issued by the fiscal authority mainly to finance temporary increases of government expenditures. Suppose further that the central bank pursues a countercyclical monetary policy of stabilizing aggregate demand. In this case, an increase in public debt would be accompanied by a subsequent contraction of money supply, as monetary policy attempts to offset the expansionary effects of fiscal policy.

(i) Constancy of Coefficients

Since the model is estimated over such a long period of time, the hypothesis that the true coefficients have remained constant is very restrictive. This hypothesis has been tested in three ways. First, a Chow test was used to detect a possible structural break in 1973, during the transition from a fixed to a flexible exchange rate regime. The hypothesis of no structural break could not be rejected for any of the equations at the 1% significance level (even though, at the 5% level of significance, there was evidence of a break in the fiscal policy reaction function). Moreover, when a measure of the dollar exchange rate was added as an explanatory variable for the subperiod 1974–85, it turned out to be insignificant.[15] Hence, the monetary regime change does not seem to have altered the behavior of the two policymakers in a significant way.

Second, a procedure suggested by Farley and Hinich (1970) was used to test for changes in the focus parameters τ and λ at unknown points in time. Specifically, the system of equations has been reestimated adding td_t as an additional explanatory variable, t being time. The estimated coefficient of this new variable is significant and positive only in the debt regression. The estimates of θ_1 and π_1 remain significant and actually increase in absolute value. A plausible interpretation of this result is that the parameters τ and λ in the policymaker's loss function have remained constant, but the interest rate has changed over time.

Third, a number of dummies corresponding to the identity of the Federal Reserve Chairman have been tried on the intercept and on the debt coefficient of all three regressions, so as to check whether the underlying parameters have changed under the different chairmen. The results indicate that the Martin chairmanship has been characterized by more restrictive monetary policy than the other three chairmanships (Burns, Miller and Volcker) and that fiscal policy has been tighter in the two years of the Miller chairmanship and looser under Martin.

[15] The measure of the exchange rate included in the regressions was the effective exchange rate in the IFS statistics (MERM). This variable was treated as the other components of the x_t vector, by first running a vector autoregression and then including its predicted value as an explanatory variable in (6) and (7).

(ii) Dynamic Specification

The dynamic specification of the model has been checked in two ways. First, a lagged endogenous variable has been added to each of the regressions (that is, m_{t-1}, f_{t-1} and d_{t-2} have been added to the regressions for m_t, f_t and d_t, respectively). None of these variables turns out to be significant, and the estimates of the remaining coefficients are not affected. In particular, the estimated coefficients of d_t in the monetary and fiscal policy reaction functions, θ_1 and π_1, remain negative and significant.

Second, the linear and quadratic time trends have been dropped from all three regressions. When the unconstrained system is estimated, the debt coefficients in the two policy reaction functions are not substantially affected: θ_1 remains negative and significant and π_1 remains negative, even though it drops slightly and becomes barely insignificant. Furthermore, the estimate of the interest rate r in the debt regression rises to an implausible large value. When this coefficient is constrained to equal the plausible value of 0.98 reported in table 3, the estimate of π_1 rises in absolute value and becomes significant again. However, dropping the time trends makes a difference elsewhere in the regressions, independently of whether or not r is constrained to equal 0.98. The political dummy now becomes insignificant in all three equations. Moreover, the fit of the fiscal policy reaction function deteriorates somewhat and the constraints across equations are overwhelmingly rejected. The same pattern of results emerges when the linear and quadratic time trends are replaced by a lagged endogenous variable.

The inference to be drawn from these results is that: (i) the estimates of the focus coefficients θ_1 and π_1 are robust to the dynamic specification of the model. But (ii) the estimates of the political dummy coefficient and the tests on the validity of the constraints are sensitive as to whether or not a time trend is included in the regressions.

VII. Conclusions

This paper has estimated the monetary policy reaction function jointly with the fiscal policy reaction function and with the law of motion of public debt. By imposing the restrictions derived from the government budget constraint and from the analytic solution of a dynamic game between the two authorities, it has been possible to directly estimate the parameters of the policymakers' loss functions. These estimates reveal the policymakers' attitudes towards the goal of stabilizing the time path of public debt. The central finding of the paper is that, in the United States during the 1955–85 period, this goal has been pursued by the fiscal authority but not by the central bank. According to the empirical evidence, monetary policy has not monetized the stock of public debt outstanding, whereas fiscal deficits (cyclically adjusted and net of interest payments) have been reduced to offset increases in the stock of debt in circulation. Hence monetary policy, and not fiscal policy, seems to be dominant in the current U.S. regime.

Moreover, the empirical evidence suggests that monetary and fiscal policies are influenced by political variables: Democratic administrations have systematically pursued more expansionary policies than Republican administrations.

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