Applied Economics, 1993, **25**, 1013–1022

In search of the motives behind US fiscal macroeconomic policy

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In this paper optimal control techniques are applied to estimate the motives behind US fiscal macroeconomic policy. Starting from a range of possible objectives and given the perception of policy makers about the environment in which they operate, the priorities of policy makers are estimated on the basis of their past actions. Our statistical approach allows for testing the empirical relevance of alternative hypotheses with respect to the objectives of governments. Democratic and Republican administrations are found to aim at different targets. Some support is also found to political business cycle theories.*

I. INTRODUCTION

Do politicians really manipulate the economy in order to get re-elected? Do Democratic and Republican policies actually differ from each other? These are the kinds of question this paper seeks to answer. Reconstructing the economic conditions of the recent past, optimal control techniques are applied to estimate the motives behind past US fiscal macroeconomic policy.

Modelling government behaviour deals with the analysis of the optimization problems governments face. Naturally, models of government behaviour entail a specification of governments' objectives and a specification of their constraints. The usual approach followed in studies on government behaviour is to make assumptions with respect to the objective function of governments and the economic constraints and to examine whether the economic outcomes generated by the resulting model are in fact observed. This approach has the drawback that it does not provide information on the validity of the separate assumptions underlying the theories. For example, the observation that the pattern of a time-series of unemployment rates is in accordance with the political business cycle theory (Nordhaus, 1975) or with the partisan theory (Hibbs, 1976), or with the rational partisan theory (Alesina, 1989) does not 'prove' that governments only aim at increasing their chances of reelection or only aim at partisan goals. A better approach would be to test the main hypotheses of the different theories directly. In this paper such an approach is developed and applied to US fiscal macroeconomic policy.

The key idea behind our approach to modelling government behaviour is that past macroeconomic policies contain information about the objectives of policy makers and their perception of how their actions affect objectives. This approach, known as revealed preference approach, originated with Friedlaender (1973), who first tried to determine preference functions by disentangling estimated reaction functions, whose coefficients are combinations of reduced-form coefficients, reflecting economic constraints, and weights in a quadratic loss function. She showed that preferences of governments could be determined by imposing restrictions on the optimization problems just as long as all weights in the preference function are identified (see also Nijkamp and Somermeyer, 1974). This way of solving the identification problem has two important drawbacks. First, the approach does not allow for testing the results. Second, the approach can only be applied to very specific optimization problems. Soon after Friedlaender's pioneering article, the revealed preference approach went out of fashion.

Because of the development of new solutions for the identification problem raised by the revealed preference approach, the interest in determining revealed preferences has recently revived (see, e.g. Brandsma *et al.*, 1988, Carraro, 1988, Swank, 1989, Swank and Swank, 1991). The principal

*The views expressed here are not necessarily those of the Dutch Central Bank.

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difference between these recent studies and old studies is that in recent studies preferences are not determined analytically, but are assessed by statistical methods. The basic idea, however, that governments minimize a quadratic loss function, expressing their objectives and priorities, subject to economic constraints, representing the working of the economy has been maintained. Government behaviour is modelled in two steps. In the first step an economic model is estimated, aimed at describing the perception of governments of the working of the economy. Given the estimated constraints, the weights in a quadratic loss function are estimated in the second step. The estimation procedure boils down to choosing those weights which maximize the likelihood that the values of instrument variables generated by the model are in fact observed.

This paper is organized as follows. In Section II, the methodology is extensively discussed. Section III discusses the main elements of the government model applied to the US. In this model governments decide on the growth of government expenditures and the way of financing them. In addition, governments may pursue partisan stabilization policies as well as electoral policies. Section IV gives the estimates of the preferences of Democratic and Republican administrations. Furthermore, it reports on various tests performed to examine hypotheses of existing theories of government behaviour. The economic constraints underlying these estimates are derived from an econometric model whose equations are presented in the Appendix. The final section sums up our main conclusions.

II. METHODOLOGY

The main principles of the revealed preference approach can conveniently be explained by considering the optimization problems policy makers are assumed to face. At period $t = 1$, the economic policy problem is formulated as minimizing the expected value of a quadratic loss function, W^e, with respect to a vector of instrument variables, subject to constraints reflecting the perceived impact of instrument variables on the target variables. In symbols

$$\min W_1^e: -1/2 \sum_{t=1}^{T} \frac{1}{(1+\theta)^t} \Big\{ [y_t^e - y_t^d]' \mathbf{Q}_t [y_t^e - y_t^d] + [x_t - x_t^d]' \mathbf{A}_t [x_t - x_t^d] \Big\} \quad (1)$$

subject to

$$y_t^e = \sum_{i=1}^{t} \mathbf{R}_i x_{t+1-i} + s_t \quad (2)$$

where y_t^e is the state vector ($n \times 1$) which contains expected values (denoted by superscript e) of n target variables, x_t is the control vector ($m \times 1$) containing instrument variables and y_t^d and x_t^d are exogenous target vectors corresponding to the state vector and the control vector, respectively. The vector $s_t(n \times 1)$ denotes exogenous influences on the state vector which cannot be controlled by decision makers. The symmetric matrices $\mathbf{Q}_t(n \times n)$ and $\mathbf{A}_t(m \times m)$ show the expected loss caused by a one unit difference of state and control vectors from their target vectors. Time preference of the decision makers is denoted by θ. Together $\mathbf{Q}_t$, $\mathbf{A}_t$, y_t^d, x_t^d and θ represent the preferences of the decision makers. The matrices $\mathbf{R}_i$ ($n \times m$) express the perceived influences of the control vector on the state vector. T is the time horizon of the decision maker.

The loss function includes both instrument and target variables. In this study instrument variables are assumed to have direct welfare effects. Apart from these direct effects, the instrument variables account for multiplicative uncertainty, i.e. uncertainty in the parameters of the model. The constraints, Equation 2, are usually derived from stochastic macroeconomic models, implying that the policy effects on target variables are surrounded by uncertainty. Gordon (1976) pointed out that this type of uncertainty can be taken into account by adding instrument variables to the loss function.

The differences between the optimization problem underlying Friedlaender's approach and the optimization problem underlying the approach proposed in this paper can be illustrated by the above equations. Let us first elaborate on Friedlaender's approach making use of the optimization problem presented above. The optimization problem underlying Friedlaender's approach is a restricted version of the above optimization problem. The main restriction is $T = 1$, implying a static optimization model. As a result θ can be dropped. Furthermore, the matrix $\mathbf{A}$ is assumed to be diagonal and the values of y_t^d and x_t^d are determined on the basis of official planning documents. Now the optimization problem becomes:

$$\min W_t: -\tfrac{1}{2}[(y_t - y_t^d)' \mathbf{Q} (y_t - y_t^d) + (x_t - x_t^d)' \mathbf{A} (x_t - x_t^d)] \quad (3)$$

s.t.

$$y_t = \mathbf{R}_1 x_t + s_t \quad (4)$$

The method starts by estimating the reduced-form equations, which can be derived[1] from minimizing Equation 3 with respect to x_t, subject to Equation 4:

$$x_t - x_t^d = \Pi (y_t - y_t^d) \qquad \Pi = -\mathbf{A}^{-1} \mathbf{R}_1' \mathbf{Q} \quad (5)$$

The number of resulting estimators, $\hat{\Pi}$, is equal to $m \cdot n$. Clearly, this information is not enough to determine $\mathbf{A}$,

[1] In estimating the reduced-form equations, actual values of y_t are used. This implies that the economic constraints have to describe the working of the economy perfectly. Note further that there is a simultaneous bias in the model (Equations 4 and 5).

$\mathbf{R}_1$ and $\mathbf{Q}$ (number of parameters to be determined is equal to $m-1+n\cdot m+\sum(n-i)$). However, *a priori* information is available for the economic model, $\mathbf{R}_1$. This reduces the number of parameters to be determined to $m-1+\sum(n-i)$. For specific values of n and m, $\mathbf{Q}$ and $\mathbf{A}$ can just be identified (Friedlaender chose n = 6 and m = 4). Nijkamp and Somermeyer (1974) followed a slightly different approach in solving the optimization problem. They imposed zero restrictions on $\mathbf{Q}$ and $\mathbf{A}$ as long as the remaining parameters of $\mathbf{Q}$ and $\mathbf{A}$ could exactly be determined from $\hat{\Pi}$. In doing this, Nijkamp and Somermeyer did not choose very specific numbers of instruments and targets, but introduced another arbitrary element in the analysis, namely, the choice of parameters to be set at zero.

Let us now consider the approach for determining the structural parameters proposed. The starting point is solving the optimization problem (Equations 1 and 2). For notational convenience, we define

$$y'=[y_1', y_2', \ldots, y_T'] \quad (6)$$

$$x'=[x_1', x_2', \ldots, x_T'] \quad (7)$$

$$y^{d'}=[y_1^{d'}, y_2^{d'}, \ldots, y_T^{d'}] \quad (8)$$

$$x^{d'}=[x_1^{d'}, x_2^{d'}, \ldots, x_T^{d'}] \quad (9)$$

$$\mathbf{Q}=\begin{bmatrix} \mathbf{Q}_1 & & & \mathbf{0} \\ & (1+\theta)^{-1}\quad \mathbf{Q}_2 & & \\ & & \ddots & \\ \mathbf{0} & & & (1+\theta)^{-T+1}\quad \mathbf{Q}_T \end{bmatrix} \quad (10)$$

$$\mathbf{A}=\begin{bmatrix} \mathbf{A}_1 & & & \mathbf{0} \\ & (1+\theta)^{-1}\quad \mathbf{A}_2 & & \\ & & \ddots & \\ \mathbf{0} & & & (1+\theta)^{-T+1}\quad \mathbf{A}_T \end{bmatrix} \quad (11)$$

$$\mathbf{R}=\begin{bmatrix} \mathbf{R}_1 & & \mathbf{0} \\ & \mathbf{R}_1 & \\ \cdot & & \ddots \\ \mathbf{R}_T & & \mathbf{R}_1 \end{bmatrix} \quad (12)$$

$$s'=[s_1, s_2', \ldots, s_T'] \quad (13)$$

The optimization model can now be written as

$$\min W_1\text{: } -1/2[(y-y^d)'\mathbf{Q}(y-y^d) + (x-x^d)'\mathbf{A}(x-x^d)] \quad (14)$$

s.t.

$$y=\mathbf{R}x+s$$

which yields

$$\dot{x}(1)=-[\mathbf{R}'\mathbf{Q}\mathbf{R}+\mathbf{A}]^{-1}\mathbf{R}'\mathbf{Q}(\mathbf{R}x^d+s-y^d)+x^d \quad (15)$$

where $\dot{x}(1)'=[\dot{x}_1(1)', \dot{x}_2(1)', \ldots, \dot{x}_T(1)']$ is the optimal control vector, resulting from minimizing Equation 1 subject to Equation 2 for period 1. Now, $\dot{x}_1(1)$ is carried out.[2] The optimization problem is repeated each period. After k periods, the optimal policy vector $\dot{x}'=[\dot{x}_1(1)', \dot{x}_1(2), \ldots, \dot{x}_1(k)]$ results, which depends on elements in $\mathbf{A}$, $\mathbf{Q}$, $\mathbf{R}$, x^d, y^d, and s. Let us now return to the estimation procedure. In fact, the estimation of the government model runs parallel to the stages macroeconomic policy is assumed to pass through. For each period the economic constraints, $\mathbf{R}$ and s, are estimated, and substituted in Equation 15. To that end, an econometric model aimed at describing the perception of policy makers of the working of the economy is estimated. Then $\dot{x}$ depends on $\mathbf{Q}$, $\mathbf{A}$, x^d and y^d. In determining these parameters, we still face an identification problem. For this reason, we impose the restriction that preferences and target values are stable over time.[3] Furthermore, $\mathbf{Q}$ and $\mathbf{A}$ are assumed to be diagonal. The remaining unknown parameters in Equation 15 are estimated by maximizing the likelihood that policies generated by the model ($\dot{x}$) are in fact observed (FIML).

III. THE GOVERNMENT MODEL

In this section the optimal control approach expounded in the previous section is applied to US government behaviour. Before considering the economic constraints and preference functions making up the optimal control problems, it is desirable to discuss the variables used in the analysis. Two instruments and three targets are included in the model. The instruments used are the growth rate of government expenditures, $\dot{g}$, and the tax burden, τ, defined as tax receipts as a percentage of GNP.[4] The targets used are government financial deficit relative to GNP, F_g, unemployment, u, and inflation, $\dot{p}$.

In modelling government behaviour, we consider three aspects of macroeconomic policy. The first aspect is connected with the responsibility of governments for providing public goods and financing them. In the present model, the government can finance its expenditures by taxes and debt creation. Money printing is ruled out as a means of financing expenditures. Three arguments, $\dot{g}$, τ and F_g, (all in deviation from their desired values) in the loss function represent this aspect of macroeconomic policy. The desired value of τ, τ^d, reflects the desired size of the public sector

[2] $\dot{x}_2(1)', \ldots, \dot{x}_T(1)'$ are plans designed in period 1 for periods 2 to T, which may be adapted in future periods.
[3] In the application of our model to US fiscal policy, we do not estimate all target values.
[4] Ideally, statutary tax rates should be included in the model, but these rates are more difficult to use in small econometric models.

relative to GNP. One may argue that the share of government expenditure in GNP is also a proper measure of the desired size of the government. Our formulation may even suggest that policy makers 'enjoy' levying taxes which, of course, is not intended. However, rational policy makers will realize that levying taxes is the price of providing public goods. Moreover, recent studies on public finance show that rational governments will not adjust tax rates in response to temporary exogenous changes in government expenditures (see, e.g. Van Dalen, 1991). For this reason, we believe that τ^d is a better measure of the desired size of the government than government expenditures relative to GNP. By considering public finance aspects of government decisions in modelling government behaviour, the traditional distinction between instruments and targets fades away. Instruments not only affect targets, but also contribute to social welfare directly. In public choice literature, it is often argued that many, if not all, government's activities have a redistributive component. Usually, a growth in government is regarded as a transfer of income from rich to poor (see, e.g. Meltzer and Richard, 1981). Combining this notion with the basic idea of the partisan theory (Hibbs, 1976; Alesina, 1989) that left-wing administrations promote the interests of low and middle income classes and right-wing administrations promote the interests of high-income classes leads to the hypothesis that for the US Democratic administrations desire a larger size of the government than Republican administrations. In our model, this can be examined by testing the hypothesis that τ^d is higher under Democratic administrations than under Republican administrations. With respect to the public finance activities of administrations, we impose that the government remains solvent in the long run. Then government expenditures should keep pace with government revenues in the long run. For constant tax rates, this implies that $\dot{g}$ should be equal to the long run growth rate of GNP, being approximated by its sample mean (3.1 %) (see the Appendix). For this reason, the desired value of $\dot{g}$, $\dot{g}^d$, is set at 3.1 for both Democratic and Republican administrations.

The second aspect of macroeconomic policy being considered concerns stabilization policy. Administrations may use government expenditures and ways of financing them for attempts to offset deviations of unemployment and inflation from their desired values. We have set their desired values at 0. In advance, it is worth noting that small (positive) changes of these values do not affect the main results of this paper. Stabilization policies are often analysed in studies on the partisan theory. The basic assumption underlying these studies is that different unemployment/inflation outcomes affect the income distribution. Low- and middle-income groups are assumed to suffer more from unemployment than high-income groups, whereas high-income groups suffer more from inflation (see Hibbs, 1976). As a consequence, Democratic administrations are expected to attribute higher weight to combatting unemployment than Republican administrations, while Republican administrations are expected to assign higher priority to suppressing inflation.

The aspects of macroeconomic policy discussed so far exclusively pertain to economic targets. Our government model also deals with political targets which brings us to the third aspect of macroeconomic policy being considered. In many studies on government behaviour, it is assumed that governments' primary objective is to survive. In democracies, administrations' chances of survival are closely related to their popularity among voters. In the early seventies, politico-economic models were developed showing the importance of economic outcomes for the popularity of administrations. Mueller (1970) and Kramer (1971) presented estimates of popularity functions, suggesting a negative impact of inflation and unemployment on the popularity of the incumbent. On the basis of these empirical findings, Nordhaus (1975) developed a government model based on the assumption that governments maximize the chances of staying in power. The results of his model are well known. Governments deliberately create economic cycles (political business cycles) with a minimum of unemployment and inflation at election time. The assumption that administrations aim at re-election seems to be in contrast to the assumption that administrations pursue partisan policies. However, in democracies it seems inconceivable that governments do not care about winning elections at all, even if winning elections is not the ultimate goal. In a world where the goals of political parties differ, popularity can be regarded as a means of achieving partisan goals.

A seemingly proper way to examine the relevance of electoral policies in explaining government behaviour is to include a variable representing popularity in the loss function and to add a popularity function to the economic constraints. Such an approach has been followed by Swank (1990a). Unfortunately, this approach raises some serious problems. The first problem is that estimates of conventional popularity functions appear to be very unstable over time. This instability not only concern the magnitude of coefficients but also their signs. Swank (1990b) has presented estimates of popularity functions, suggesting Democratic administrations to benefit from unemployment and Republican administrations to benefit from inflation. These results fly in the face of conventional wisdom and probably do not link up with the perception of policy makers of the working of the economic political system. A second problem is that conventional popularity functions are incompatible with partisan policies. If different political parties aim at different goals, rational voters will use this information in casting their ballots. Introducing elements of the partisan theory into voter models affects the conventional relationship between popularity and economic variables substantially (Swank, 1993).

To circumvent the problems mentioned above, we follow an indirect approach to assessing the relevance of electoral policies. The key idea behind the political business cycle theory is that governments aim at achieving favourable economic conditions at election time. In our model this can be examined by allowing for shifts in the weights attributed to economic targets when elections come near. In addition, we examine whether administrations avoid 'unpopular' policies around election time, such as increasing tax rates.

Let us now consider how the aspects of macroeconomic policy discussed above fit into the optimization problems administrations face. The following quadratic loss function is included in the model:

$$\min W_1^*: \ -\tfrac{1}{2}\sum_{t=1}^{T}\frac{1}{(1+\theta)^t}\Big\{\alpha_{0,j}F_g^2+\alpha_{1,j}u_t^2+\alpha_{2,j}p_t^2 + \alpha_{3,j}(g-3.1)^2+\alpha_{4,j}(\tau_t-\tau_{t,j}^{\mathrm{d}})^2\Big\} \quad (16)$$

$$\alpha_{4,j}=\left(1-\sum_{i=0}^{3}\alpha_i\right)$$

where $\alpha_{i,j}$ is the weight administration j attributes to variable i, $j=\mathrm{d}$ for Democratic administrations and $j=\mathrm{r}$ for Republican administrations. A well-known feature of the quadratic loss function is that its weights can be normalized. In Equation 16 the weights sum to unity. The above loss function contains six unknown parameters for each administration j, which are determined by estimation ($\alpha_{i,j}$ for $i=0$–3, θ and τ_t^{d}). Three parameters refer to government's role of redistributing income, and providing and financing public goods ($\alpha_{0,j}$, $\alpha_{3,j}$ and $\tau_{t,j}^{\mathrm{d}}$). As mentioned before, $\tau_{t,j}^{\mathrm{d}}$ is supposed to express the relative size of the government as desired by administration j. If political parties are partisan in the way discussed before and low- and middle-income classes benefit from a growth in government at the expense of high-income classes, it is expected that $\tau_{t,d}^{\mathrm{d}}>\tau_{t,r}^{\mathrm{d}}$. This is one of the hypotheses to be tested in Section V. $\alpha_{0,j}$ denotes the costs that administrations attach to financing government expenditures by borrowing on the capital market. A relatively low value of $\alpha_{0,j}$ (compared to $\alpha_{4,j}$) implies that administration j prefers financing temporary deviations of government expenditures from their desired value by debt to financing them by taxes. The relative size of $\alpha_{3,j}$ (relative to $\alpha_{0,j}$ and $\alpha_{4,j}$) indicates the adjustment speed of the actual size of the government to its desired size. The easiest way to recognize this is by considering some specific cases. Suppose, for example, that $\tau_t>\tau_t^{\mathrm{d}}$ and that $\alpha_{0,j}$ is high, while $\alpha_{3,j}$ and $\alpha_{4,j}$ are low. In that case, the actual size of the government will rapidly adjust to its desired size, and government expenditures will soon keep pace with government revenues. Now consider the case in which both $\alpha_{0,j}$ and $\alpha_{3,j}$ are high, while $\alpha_{4,j}$ is low. Here the adjustment speed is low, because through F_g, costs are attached to decreasing tax rates. If finally, $\alpha_{3,j}$ is high, while $\alpha_{0,j}$ and $\alpha_{4,j}$ are low, the adjustment speed of government expenditures deviates from the adjustment speed of government revenues. As a consequence, government expenditures would not keep pace with government revenues, and a budget deficit will result.

In Equation 16 two weights, $\alpha_{1,j}$ and $\alpha_{2,j}$, refer to stabilization policy. With respect to this aspect of macroeconomic policy, we are particularly interested in: (1) the relevance of stabilization policy in explaining government behaviour, which will be examined by jointly testing the restrictions $\alpha_{1,j}=\alpha_{2,j}=0$ and (2) the relative size of $\alpha_{1,j}$ (relative to $\alpha_{2,j}$) under Democratic and Republican administrations. As mentioned before, the partisan theory predicts $\alpha_{1,\mathrm{d}}/\alpha_{2,\mathrm{d}} > \alpha_{1,\mathrm{r}}/\alpha_{2,\mathrm{r}}$.

In order to find evidence of electoral policies, we test for systematic changes of the parameters of the loss function when elections come near. More specifically, we test for possible tendencies of administrations to reduce tax rates when elections approach and for shifts in the weights.

IV. EMPIRICAL RESULTS

This section reports on the estimates of the parameters in the loss function. In the Appendix the econometric model from which the constraints in the optimization problems are derived is described. In explaining government behaviour, the actions of the policy maker should be seen against the background of his understanding of the economy. For this reason, the model was intended to reflect the policy maker's perception of the economy, rather than the actual working of the economy. By using an econometric model as the constraint set in the policy maker's decision problem, we ignore the Lucas critique. Thus, we assume that the policy maker neglects the effects of his actions on the parameters of the model. We are aware that nowadays this is a rather unconventional assumption. We believe, however, that this concept is a suitable representation for the analysis of past government behaviour. Moreover, we have tested each equation of the model for instability by carrying out a Chow test. None of the equations shows instability. This is an important finding, as model instability would considerably detract from the significance of the optimal control results presented below.

The parameters in the loss function are estimated by full information maximum likelihood. By solving the optimization problems for given values of the parameters for each period, we obtain a series of the growth rate of government expenditures, g, and a series of the tax rate, τ. Through the log-likelihood function, we compare the model predictions with the actual values of g and τ. In fact, the log-likelihood function is written in terms of the parameters in the loss function. The estimation problem now becomes the selection of those values of these parameters which maximize the log-likelihood function. We have used a numerical maximization procedure to solve this problem.

As discussed in Section III, the simplest version of the loss function contains six unknown parameters. We have started the empirical research by estimating these parameters over the entire sample period (1961–88). Next, we have divided the sample period into two parts. The first part concerns periods in which Democratic administrations were in office (1961–68 and 1977–80), and the second part concerns periods in which Republican administrations were in office (1969–76 and 1981–88). For both parts, separate regressions have been performed. Subsequently, we have utilized dummy variables to examine changes of weights and target values, which may result from electoral motives of administrations. In terms of dummy variables, the loss function can be written as

$$\min W_1^e:\ -\tfrac{1}{2}\sum_{t=i}^{T+i}\frac{1}{(1+\theta)^{t-i}}\Big\{[\alpha_{0,j}-\mathrm{dum}_i\cdot(\alpha_{0,j}-\alpha_{0,j}^e)]F_g^2 + [\alpha_{1,j}-\mathrm{dum}_i\cdot(\alpha_{1,j}-\alpha_{1,j}^e)]u_t^2+[\alpha_{2,j}-\mathrm{dum}_i\cdot(\alpha_{2,j}-\alpha_{2,j}^e)]p_t^2+[\alpha_{3,j}-\mathrm{dum}_i\cdot(\alpha_{3,j}-\alpha_{3,j}^e)](g-3.1)^2+\alpha_{4,j}(\tau_t-\tau_{t,j}^d-\mathrm{dum}_i\cdot\tau_{t,j}^e)^2\Big\} \quad (17)$$

where $\alpha_{i,j}^e$ measures the influence of electoral motives on the weights and target values in the loss function. Two types of electoral dummies have been considered: dum_i, $i=1$ and 2, $\mathrm{dum}_i=0$ in the first i years of an administration's term and $\mathrm{dum}_i=1$ in the last $4-i$ years. Of course, Equation 17 is a more general specification of the government model (compared to Equation 16). However, there are not enough data to obtain meaningful estimates of Equation 17 for both parts of the sample period. For this reason, we have not estimated all parameters and dummy variables in Equation 17 in one stroke. Instead, we have examined the stability of the weights and target values in two stages. In the first stage, each dummy variable has been separately tested for its relevance. From this stage, it emerged that $\tau_{t,r}^d$, $\alpha_{1,d}$, $\alpha_{2,d}$ and $\alpha_{3,d}$ differed significantly from $\tau_{t,r}^e$, $\alpha_{1,d}^e$, $\alpha_{2,d}^e$, and $\alpha_{3,d}^e$, respectively. In the second stage, each dummy variable has been tested again, but now after relaxing the restrictions $\tau_{t,r}^d=\tau_{t,r}^e$, $\alpha_{1,d}=\alpha_{1,d}^e$, $\alpha_{2,d}=\alpha_{2,d}^e$ and $\alpha_{3,d}=\alpha_{3,d}^e$. These experiments did not suggest other instabilities of the parameters. The estimates furthermore showed that dum_2 is superior to dum_1. Before estimating Equation 17, we have to make an assumption with respect to the time horizon of the policy maker, T. The time horizon denotes how many periods the policy maker looks ahead. For example if $T=2$, in 1970 the policy maker considers policy effects on target variables for 1970 and 1971 only. We have estimated Equation 17 for different values of T. From this analysis, it emerged that $T=3$ leads to a higher value of the log-likelihood function than $T=1$, $T=2$, $T=4$, $T=5$, and $T=6$. For $T>3$ the log-likelihood function appeared to be a decreasing function of T. Next, we have allowed for different time horizons for variables pertaining to stabilization policy and variables pertaining to public finance policy. The highest value of the log-likelihood function was obtained under the assumption $T=2$ for unemployment and inflation and under $T=4$ for the other variables in the loss function. Hence, stabilization policy appeared to be focused on offsetting deviations of target variables from their desired levels in the short run ($T=2$), whereas public finance policy had a longer-run component ($T=4$). The final estimates obtained are presented in Table 1.

Before considering the sizes of the estimated parameters, let us examine whether the preferences of Democratic administrations differ from those of Republican administrations. To that end, we jointly test the restrictions $\alpha_{i,d}=\alpha_{i,r}$ and $\tau_{t,d}=\tau_{t,r}$ (columns 1–3 in Table 1). These restrictions are rejected (χ^2-statistic = 14.25, 5 % critical value = 11.07). Hence, we conclude that Democrats and Republican really differ. In what follows, we will focus on the separate estimates for Democratic and Republican administrations.

Let us now consider the estimates of the parameters. It should be emphasised that the estimated values of the weights have to be interpreted very carefully. The absolute sizes of the parameters do not provide any information, since multiplying the weights by a constant does not change the results.[5]

As discussed in Section III, the parameters can be distinguished by the type of macroeconomic aspect to which they refer. Parameters $\alpha_{0,j}$, $\alpha_{3,j}$, $\alpha_{4,j}$ and $\tau_{t,j}^d$ pertain to government's responsibility for providing and financing public goods. In this respect we have hypothesized that $\tau_{t,d}^d>\tau_{t,r}^d$. The desired size of the government cannot directly be determined from the estimates, due to the shift of $\tau_{t,r}$ in pre-election years. Obviously, a measure of the desired size of the government can be obtained by averaging $\tau_{t,r}^d$, which yields 23.30. This suggests that Republicans aim at a larger size of the government than Democrats, which is in contrast to the hypothesis formulated in the preceding section. Perhaps, this counter-intuitive result is due to the aggregation level of our model. In testing the partisan hypothesis with respect to the size of the government, we have assumed that all government expenditures imply a transfer of income from rich to poor. In fact, many government activities are difficult to categorize in terms of rich and poor. Hence, our results may change if several types of government expenditures are considered.

As to the other aspects of public finance policy included in the model, our results suggest that Republican administrations make use of debt more frequently as a means of financing deviations of government expenditure from its desired value, whereas Democratic administrations prefer using taxes to using debt ($\alpha_{0,d}/\alpha_{4,d}>\alpha_{0,r}/\alpha_{4,r}$)). The adjustment speed of the actual size of the government to its desired

[5]This remark should especially be kept in mind in interpreting the fourth column of Table 1.

Table 1. *Estimates of weights and target values*

	Electoral policy excluded			Electoral policy included	
	Both	*dem*	*rep*	*dem*	*rep*
Budget deficit					
$\alpha_{0,j}$	0.19 (0.11)	0.23 (0.09)	0.17 (0.10)	0.28 (0.10)	0.16 (0.09)
Unemployment					
$\alpha_{1,j}$	0.28 (0.27)	0.28 (0.14)	0.27 (0.13)	0.18 (0.08)	0.27 (0.12)
$\alpha^e_{1,j}$				0.48 (0.19)	
Inflation					
$\alpha_{2,j}$	0.21 (0.15)	0.19 (0.15)	0.27 (0.14)	0.00 (0.08)	0.29 (0.12)
$\alpha^e_{2,j}$				0.51 (0.21)	
Government exp.					
$\alpha_{3,j}$	0.08 (0.06)	0.07 (0.06)	0.03 (0.02)	0.02 (0.01)	0.02 (0.02)
$\alpha^e_{3,j}$				0.09 (0.02)	
Tax rate					
$\alpha_{4,j}$	0.24	0.23	0.25	0.08	0.25
Discount rate					
θ	0.20 (0.21)	0.46 (0.38)	0.00 (0.00)	0.13 (0.09)	0.01 (0.02)
Desired value tax rate					
$\tau^d_{t,j}$	23.10 (0.30)	22.66 (0.33)	23.36 (0.21)	22.37 (0.31)	23.83 (0.35)
$\tau^e_{t,j}$					22.76 (0.36)
Loglik	−44.14	−15.45	−22.24	−7.46	−19.48

Figures in parentheses denote standard errors. The first row presents the estimates obtained over the entire sample period, without discriminating between democratic and republican policy. Loglik is the value of the log-likelihood function.

size appears to be lower under Democratic administrations. This emerges from the relative values of $\alpha_{0,j}$, $\alpha_{3,j}$ and $\alpha_{4,j}$ (see Section III).

The differences between Democratic and Republican administrations are more profound with respect to stabilization policy. Parameters $\alpha_{1,j}$ and $\alpha_{2,j}$ represent this aspect of macroeconomic policy. The partisan theory predicts that $\alpha_{1,d}/\alpha_{2,d} > \alpha_{1,r}/\alpha_{2,r}$. When electoral motives are considered, the relative priority of Democratic administrations concerning reducing unemployment and inflation changes over time. Democratic administrations are found to assign higher priority to unemployment relative to inflation than Republican administrations both in the first part and the second part of their term. Hence, Democrats are found to be more concerned about unemployment than Republicans, whereas Republicans are found to be more concerned about inflation. The differences in priorities are more profound in the first part than in the second part of administration's terms. The importance of stabilization policy in explaining government behaviour can be examined by jointly testing the restrictions $\alpha_{1,j}=\alpha_{2,j}=0$. These restrictions are soundly rejected for both Republicans and Democrats ($j=r$, χ^2-statistic = 26.83: $j=d$, χ^2-statistic = 16.71, 1 % critical value = 9.21, 13.28, respectively).

Let us now consider electoral motives. As is mentioned before, three weights and one target value appear to be unstable over time, $\tau^d_{t,r}$, $\alpha_{1,d}$ $\alpha_{2,d}$ and $\alpha_{3,d}$. Republican administrations desire to decrease tax rates by about 1.1 percentage point when elections come near. Our results, furthermore, suggest that Democratic administrations assign higher priority to stabilization targets in pre-election years than in post-election years. These results are in accordance with the main hypothesis of the political business cycle theory that governments aim at low unemployment and low inflation near election time. Note further that Democratic policy deviates less from Republican policy in the two years before election date than in the two years after election date. This result is in line with the hypothesis of median voter theories.

V. CONCLUSIONS

In this paper optimal control techniques have been applied to estimate the motives behind US fiscal macroeconomic policy. Starting from a range of possible objectives and given the perception of policy makers about the environment in which they operate, the priorities of policy makers have been estimated on the basis of their past actions. Our statistical approach allows for testing the empirical relevance of alternative hypotheses with respect to the objectives of governments. In the application to government behaviour in the US, three aspects of macroeconomic policy have been considered. The first aspect is connected with government's responsibility for providing and financing public goods. The second aspect concerns stabilization policy and the third aspect pertains to electoral policies.

The estimates of the weights and target values in a quadratic loss function provide strong support to the partisan theory: Democratic and Republican administrations have been found to aim at different targets. Democratic administrations have been found to assign higher priority to reducing unemployment and to attribute lower weight to suppressing inflation than Republican administrations. The hypothesis that Democratic administrations aim at a larger size of the government than Republican administrations has not been supported by our results. Some support has also been found to political business cycle theories. Republican administrations aim at reducing tax rates when election comes near, and Democratic administrations appear to be more concerned about unemployment and inflation in pre-election years than in post-election years.

APPENDIX

The appendix briefly discusses the model from which the economic constraints in the government model are derived. For a more detailed discussion of the model, we refer to Swank and Swank (1991). The model consists of 11 equations of which eight are stochastic, covering production growth, capacity utilization, unemployment, price formation, exchange rate determination, budget deficit, money market and capital market. The stochastic equations were estimated with ordinary least squares (non-linear least squares in the case of u and M_1). This seems appropriate as the model's matrix of coefficients of contemporaneous endogenous variables is sparse.

For each estimated equation, we present the conventional test statistics: t-ratios (in parentheses under the regression parameters), the coefficient of determination adjusted for degrees of freedom (R^2), the standard error of estimate adjusted for degrees of freedom (S_e) and the Durbin–Watson statistic (DW) or Durbin's h. Furthermore, we computed for each equation the Q-statistic of Box and Pierce (1970) for ten autocorrelations, and we performed a test on heteroscedasticity (F_h) developed by Pagan *et al.* (1983). Finally, we tested each equation for instability (F_C) by carrying out a Chow test (Chow, 1960). All estimated equations pass the Box–Pierce test, the test for heteroscedasticity and the test for instability. A description of the variables are presented at the end of the Appendix.

Exchange rate

$$\underset{(7.1)}{e=7.45}+\underset{(1.7)}{17.14}\ln(mw/\mathrm{GDP})-\underset{(-7.3)}{141.64}D_3\ln q$$
$$+\underset{(9.4)}{7.08}\,(rl-rl_{-1})_{-0.67}$$

D_3 = distributed lag: 0.2, 0.6, 0.2

Sample period: 1971–88.

$R^2=0.87$	$\mathrm{DW}=2.09$	$F_h(3,13)=0.7$
$S_e=3.07$	$Q(10)=3.9$	$F_c(4,9)=1.5$

Government financial deficit (relative to GDP)

$$F_g = g/\mathrm{GDP}-\tau+\rho+\phi$$

Net interest payments by the government (relative to GDP)

$$(\rho-\rho_{-1})=\underset{(-5.6)}{-0.11}+\underset{(7.1)}{0.05}\,F_{g-0.5}+\underset{(4.4)}{0.03}\,(rs-rs_{-1})_{-0.5}$$
$$+\underset{(7.6)}{0.27}D_4\,(rl-rl_{-1})$$

D_4 = Distributed lag:

0.18, 0.16, 0.15, 0.13, 0.11
0.09, 0.07, 0.05, 0.04, 0.02

Sample period: 1955–88.

$R^2=1.00$	$\mathrm{DW}=1.74$	$F_h(3,27)=0.1$
$S_e=0.06$	$Q(10)=7.8$	$F_c(4,23)=2.7$

Long-term interest rate

$$rl=\underset{(4.1)}{1.04}+\underset{(8.1)}{0.44}\,rs+\underset{(3.0)}{0.60}\,risk+\underset{(2.1)}{0.28}F_g+\underset{(2.4)}{0.26}rl_{-1}$$

Sample period: 1957–88.

$R^2=0.98$	$h=-0.1$	$F_h(4,27)=2.5$
$S_e=0.45$	$Q(10)=9.2$	$F_c(5,22)=0.4$

where risk is

$$risk=\left[\tfrac{1}{4}\sum_{i=1}^{4} rs_{-i}^{2}-\tfrac{1}{16}\left(\sum_{i=1}^{4} rs_{-1}\right)^{2}\right]$$

Money demand

$$\begin{aligned}\ln(ml/p) &= \underset{(-0.4)}{-0.19}+\underset{(4.9)}{0.11}\ \ln \mathrm{GDP}-\underset{(-3.8)}{0.008}\,rs\\ &+\underset{(10.9)}{0.90}\ln(ml/p)_{-1}\quad -\underset{(-5.1)}{0.13}(shift-\underset{(10.9)}{0.90}\,shift_{-1})\end{aligned}$$

Sample period: 1954–79.

$R^2=1.00$ $h=-0.3$ $F_h(4,21)=0.2$
$S_e=0.012$ $Q(10)=10.5$ $F_c(5,22)=0.3$

List of symbols

$$\dot{x}=(x-x_{-1})/x_{-1}$$

IFS denotes International Financial Statistics, published by the IMF. SCB refers to the Survey of Current Business, published by the US Department of Commerce.

D_i	distributed lag function
e	effective exchange rate (index: 1985 = 1). Source: IFS.
F_g	government financial deficit, as a percentage of gross national product at current prices. Source: SCB.
g	government purchases of goods and services at constant prices of 1982 (billions of US dollars). Source: SCB.
ρ	net interest paid by the federal government, as a percentage of gross national product at current prices. Source: SCB.
ml	Money: *ml* (billions of US dollars, averages of daily figures). Source: SCB.
mw	volume of world trade: world imports at constant dollar prices of 1985 (billions of US dollars). Source: IFS.
p	price of gross national product (index: 1982 = 1). Source: SCB.
q	rate of capacity utilization (index normalized over sample period: average = 1). Source: Federal Reserve Bulletin.
rl	long-term interest rate: long-term government bond yield (percentages, averages of daily figures). Source: IFS.
rs	federal funds rate (percentages, averages of daily figures). Source: IFS.
$risk$	risk premium term: 4-year moving standard deviation of the federal funds rate. Source: calculated.
$shift$	dummy capturing the shift in deposit demand over 1974–76. Source: Brayton and Mauskopf (1985, pp. 207, 278).
τ	tax burden: personal tax and non-tax receipts plus corporate profits tax accruals plus indirect business tax and non-tax accruals minus subsidies, as a percentage of gross national product at current prices. Source: SCB.
GDP	gross domestic product at constant prices of 1982 (billions of US dollars). Source: SCB.
ϕ	other net government expenditures, as a percentage of gross national product at current prices. Source: calculated.

ACKNOWLEDGEMENTS

We are indebted to an anonymous referee for useful suggestions.

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