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ALTERNATIVE MODES OF DEFICIT FINANCING AND ENDOGENOUS MONETARY AND FISCAL POLICY 1923-1982

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ABSTRACT

This paper first investigates the effects of alternatives modes of deficit financing on the unemployment rate, inflation rate, and the real interest rate, within the framework of a small complete macroeconomic model. Secondly, it examines the nature of monetary and fiscal reaction functions. The two periods 1923-1960 and 1961-1982 are considered, with substantial differences in behavior and policy being shown to exist between them. The most important conclusion is that long-run monetary neutrality properties shown to exist over the latter period are not intrinsic to the economy, but rather are the result of the stabilization policies being conducted over that period.

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1. INTRODUCTION

In a recent paper, Turnovsky and Wohar (1984) (henceforth T-W) use annual data over the period 1923-1982 to test econometrically a number of monetarist propositions.[1] As the empirical evidence suggests the existence of a structural break in the data around 1960, they examine these propositions for the two subperiods 1923-1960 and 1961-1982.[2] They conclude that the results for the latter period provide convincing support for the propositions they examine. In particular, the long-run neutrality of money, which was previously demonstrated by Stein (1978), is shown to hold over this period. However, T-W present further evidence to suggest that this neutrality is essentially generated by government policy in effect over this period and is *not* an intrinsic property of the economic structure.

The results obtained for the early period 1923-1960 are less supportive of these same propositions. Although some still do hold, the key ones pertaining to the long-run neutrality of money are not satisfied.

Although most of their analysis focuses on the effects of changes in the monetary growth rate on unemployment and inflation, T-W also give brief consideration to the hypothesis that: "government expenditures which are not financed through money creation have relatively negligible effects upon the rates of unemployment and inflation." They test this proposition by considering the statistical significance of government purchases of goods and services, which is included in the unemployment equation. This method of testing the proposition is not entirely satisfactory, since no effort is made to decompose government purchases of goods and services into those which are financed by money creation and those which are financed by newly-issued bonds.

This paper has two major objectives. The first is to test the above proposition within the framework of a small complete macroeconomic model. In particular, this study investigates the effects of alternative modes of deficit financing on the rate of unemployment, the inflation rate, and the real interest rate. It accepts the findings of T-W and others regarding the structural break which appears to have occurred around 1960 and compares the nature of the effects over the two subperiods 1923-1960 and 1961-1982.

The second objective of this paper is to examine the nature of the government monetary and fiscal reaction functions in greater detail. The main purpose of this is to show more precisely how the interaction between monetary and fiscal policy, together with the structural relationships in the economy, generate the long-run neutrality properties obtained by Stein and T-W over the more recent period.

The large Federal deficits since the 1974-1975 recession have rekindled interest in the economic consequences of both the size of the government deficit and its mode of financing. A key issue motivating this has been the question of "crowding out." Several authors have developed theoretical models directed at this issue and at comparing the effects of bond-financed and money-financed government expenditures on the rate of inflation; see, e.g., Blinder and Solow (1973), Pyle and Turnovsky (1976) for early examples. The general conclusions of these, and subsequent studies are not unambiguous; it is clear that the effects are sensitive to the structure of the model.

Given the inclusive theoretical work, it is surprising to note that little empirical work has been directed at this specific issue. Stein (1976) provides the first empirical investigation which focuses on the effects of debt finance. Examining the period 1961-1973, he finds that a debt-financed increase in the government deficit, resulting from a tax reduction, will reduce inflation and increase unemployment. That is, debt-financed fiscal policies crowd out an even greater amount of private spending. He concludes that only budget deficits financed through money creation will effectively increase aggregate demand. Maital (1979) finds that including an inflationary expectations proxy in Stein's model strengthens these findings. Butkiewicz (1981), using data over the period 1960(I) through through 1976(IV), tests for crowding out in an alternative model and also re-estimates Stein's model for an extended time period, with mixed results. Debt growth is found to increase real output growth significantly, to have a positive but insignificant impact on employment, and to reduce inflation. The first effect contradicts crowding out, but the second supports it. Barro (1980) finds that unanticipated debt growth is expansionary in that it increases output and reduces unemployment. Desai and Blake (1982) re-estimate Stein's (1976) model by a maximum likelihood technique and contradict his results. Thus, in short, the efficacy of money-financing vs. bond-financing remains an open question.

Previous studies have been conducted using limited samples of postwar data. Except for Butkiewicz, all use par value of debt, rather than market values. Recent estimates of market values of federal debt (Seater (1981), Cox and Hirschorn (1983), and Butkiewicz (1983)) facilitate the construction of a series of the market value of debt extending over the period 1923-1982. The tests conducted in this study use annual data over this period, which incorporates a much wider range of experience, including the depression and wartime financing.

Although most economists speak of endogenous stabilization policy, very few incorporate this aspect into their empirical work. In recent years, the authors of numerous econometric studies of fiscal and monetary policies have warned that the policy variables they are treating as exogenous should perhaps be treated as endogenous, if in fact the stabilization authorities were pursuing an active countercyclical policy during the period in question.[3] Furthermore, it monetary and fiscal authorities do react systematically to economic events, it is important that each policy maker be aware of the reaction function of the other, in order that policy making be properly coordinated. One of the contributions of this study is to examine the interrelationships between these two policy instruments, particularly during the recent period.

The remainder of the paper is structured as follows. Section 2 presents a small macroeconomic model which forms the basis for our analysis. The estimating equations are derived in Section 3 while the estimating procedures used are discussed in the following section. The empirical results for the two periods are discussed in Sections 5 and 6, respectively, and the conclusions are presented in the final section. A detailed description of the data together with their sources, is given in an Appendix.

2. THE THEORETICAL FRAMEWORK

In this section we outline the theoretical framework underlying our subsequent empirical analysis. It is a conventional macroeconomic model, similar to that developed by Turnovsky (1977) and used by T-W, although unlike the latter it is necessary to include the government budget constraint, wealth effects, and policy specifications, in order to incorporate those aspects we wish to consider. Expressed in discrete time, it consists of the following equations:

Goods Market

$$Y = F(U) \qquad F' < 0 \tag{1a}$$

$$Z_t = D(Y_t - T_t, r_t - \pi^*_{t+1,t}, W_{t-1}/P_t) + G_t \qquad 0 < D_1 < 1, \quad D_2 < 0, \quad D_3 > 0 \tag{1b}$$

$$Y_t - Y_{t-1} = \gamma(Z_{t-1} - Y_{t-1}) \qquad 0 < \gamma < 1 \tag{1c}$$

Money Market and Wealth

$$M^d_t/P_t = L(Y_t, r_t, W_{t-1}/P_t) \qquad L_1 > 0, \quad L_2 < 0, \quad 0 < L_3 < 1 \tag{2a}$$

$$M^s_t = m(r_t)MB_t \tag{2b}$$

$$M^s_t = M^d_t \tag{2c}$$

$$W_t = MB_t + B_t \tag{2d}$$

Price Adjustment and Inflationary Expectations

$$\pi^e_t = a_0 + a_1 U_{t-1} + a_2(Z_{t-1} - Y_{t-1}) + a_3 \pi^*_{t,t-1} \qquad a_1 < 0, \quad a_2 > 0, \quad 0 < a_3 \leq 1 \tag{3a}$$

$$\pi_t - \pi_{t-1} = \rho(\pi_t^e - \pi_{t-1}) \qquad 0 < \rho < 1 \tag{3b}$$

$$\pi^*_{t,t-1} = \mu_{t-1} \tag{3c}$$

Government Sector

$$\frac{MB_t - MB_{t-1}}{P_t} + \frac{q_t(Q_t - Q_{t-1})}{P_t} = \text{DEF}_t \tag{4a}$$

$$\text{DEF}_t = G_t + r_t B_{t-1}/P_t - T_t \tag{4b}$$

$$T_t = \tau(Y_t + r_t B_{t-1}/P_t) \qquad 0 < \tau < 1 \tag{4c}$$

$$\Delta\left[\frac{MB_t}{P_t}\right] = b_0 + b_1\text{DEF}_t + b_2U_t + b_3\pi_t + b_4\mu_t \tag{4d}$$

$$b_1 > 0, \quad b_2 > 0, \quad b_3 < 0, \quad b_4 > 0$$

G_t specified below (4e)

where

Z_t = real aggregate demand at time t,

Y_t = real output at time t,

r_t = nominal interest rate at time t,

$\pi^*_{t+1,t}$ = expected rate of inflation formed at time t, for the period (t, t+1),

W_t = nominal wealth at time t,

P_t = GNP deflator at time t (price level at time t),

G_t = real government purchases of goods and services,

M_t^d = nominal money demand at time t,

M_t^s = nominal money supply at time t,

MB_t = nominal monetary base at time t,

DEF_t = the real government deficit at time t,

Q_t = the physical quantity of government bonds held by the domestic public at time t,

q_t = price of government bonds at time t,

$B_t = q_t Q_t$ = nominal market value of government bonds held by the domestic public at time t,

U_t = unemployment rate at time t,

μ_t = rate of nominal monetary growth at time t,

π_t^e = "equilibrium" rate of inflation at time t,

π_t = actual rate of inflation at time t,

T_t = federal tax revenue, measured in real terms.

Equation (1a) describes the production function in terms of an inverse relationship between real output and unemployment. Aggregate demand is defined in (1b), as a positive function of real disposable income and wealth and a negative function of the real interest rate.[4] Equation (1c) specifies a simple lagged adjustment process in output; excess demand for output at time $t-1$ leads to an increase in output during the following period.

The demand for real money balances is specified in (2a) as a positive function of real income and wealth and a negative function of the nominal interest rate. The money supply, described by (2b), equals the product of the money multiplier, which is a function of the nominal interest rate, and the monetary base. Money market equilibrium is specified in (2c), while nominal private wealth is defined in (2d) to be the sum of base money and the private sector's holdings of government bonds.[5]

Equation (3a) specifies that the "equilibrium" rate of inflation--the rate of inflation after all lags have been worked through--depends inversely upon the rate of unemployment and positively upon the excess demand for output, both lagged by one period, together with the expected rate of inflation for the present period. Equations of this type are common in the macro literature.[6] They can be justified in various ways, including as being the reduced form of an expectations-augmented Phillips curve, coupled with a simple price mark-up rule. The absence of money illusion would of course requite $a_3 = 1$. But the sample set used in this study extends over a long time horizon over part of which at least previous empirical studies of price and wage determination do not necessarily support this restriction. Equation (3b) describes a simple lagged adjustment equation for inflation, analogous to that of output, (1c). It postulates that the observed rate of inflation adjusts towards the equilibrium defined in (3a).

Inflationary expectations are postulated in equation (3c) to depend upon the immediate past rate of nominal monetary growth. This assumption, which is quite widely adopted in the literature, provides a direct link between the rate of monetary growth and the short-term rate of inflation; see e.g. Buiter and Miller (1981). At the same time, this hypothesis is arbitrary and alternative specifications of inflationary expectations were tried. In particular, as one measure we used the estimated value of π_t, obtained by regressing π_t on all predetermined and exogenous variables, giving a quasi-rational expectations measure. The results using this measure were not particularly successful and accordingly we have opted for the specification in (3c).

The government sector is spelled out in equations (4). The government budget constraint is defined in (4a), with the deficit (expressed in real terms) being specified in (4b). Real tax collection is specified in (4c), with both current income and interest income being taxed at a fixed rate τ. Equation (4d) postulates the government's monetary reaction function. The coefficient b_1 reflects the extent to which the deficit is money-financed, while the inclusion of the variables U_t, π_t, and μ_t, reflects the ways in which monetary policy is being conducted for stabilization purposes. The assumption $b_2 > 0$ means that as the unemployment rate rises, the monetary authorities expand the real monetary base, thereby adopting a countercyclical policy. The negative coefficient on π_t means that as the current inflation rate increases, the real monetary base is contracted, in order to reduce inflationary pressures. But $b_3 < 0$ can also be viewed as a form of accommodating monetary policy. All other things equal, as the current rate of inflation rises, real wealth declines, thereby reducing the demand for real monetary balances. The monetary authorities accommodate this by engaging in monetary contraction, thereby maintaining money market equilibrium. The positive coefficient on the rate of monetary growth also reflects two effects. First, as the money supply increases, the authorities increase the money base in order to meet the needs of banks. Also, the increased monetary growth rate raises the expected inflation rate for the next period, reducing the current real interest rate, thereby stimulating the demand for output, and hence output itself. This in turn raises the transactions demand for money and again the monetary authorities accommodate by expanding the base.[7]

Note that the government budget constraint (4a), together with the monetary base rule (4d) implies an adjustment in the stock of government bonds. Finally, in the absence of any firm guide, we choose not to specify an adjustment for real government expenditure at this point. While the rules we estimate for monetary and fiscal policy are ad hoc, their structure is generally consistent with that implied by linear-quadratic stabilization theory; see Turnovsky (1977). More specifically, the model we shall develop below reduces to a pair of linear difference equations in U_t and π_t; see equations (19) and (20) below. If we assume that policy makers wish to minimize a quadratic loss function involving U_t and π_t, then the optimal policy rules for the decision variables MB_t/P_t and G_t will be linear functions of the current state of the system, U_t, π_t, and all other predetermined and exogenous variables. Not all of these, however, prove to be statistically significant, and they are therefore omitted from the resulting equations reported below.[8]

This completes the specification of the model and at this point two aspects of it should be noted. First, the wealth measure introduced into the aggregate demand and money demand functions include government bonds; this is in contrast to the Ricardian view. Secondly, while the model is *ad hoc*, it seems a reasonable one. We should acknowledge that alternative combinations of assumptions regarding (i) the formation of expectations and (ii) lags in adjustment can lead to observationally equivalent systems. Since our ultimate concern is with reduced form equations, the exact mechanism is not the key issue.[9]

3. DERIVATION OF ESTIMATING EQUATIONS

The procedure we adopt is to express the system in terms of four linearized equations in U_t, π_t, r_t, and MB_t/P_t. This involves the following steps:

(i) Substitute the expressions for M_t^s and M_t^d from (2a), (2b) into the money market clearing condition (2c) to yield

$$m(r_t)MB_t/P_t = L[Y_t, r_t, W_{t-1}/P_t] \tag{5}$$

Solve (5) for r_t in terms of Y_t, MB_t/P_t, and W_{t-1}/P_t to yield the function

$$r_t = r(Y_t, MB_t/P_t, W_{t-1}/P_t) \tag{6}$$

(ii) Linearize W_{t-1}/P_t about W_{t-1}/P_{t-1} and substitute for Y_t from (1a) and W_{t-1}/P_{t-1} from (2d) and obtain the equation[10]

$$r_t = \phi(U_t, MB_t/P_t, MB_{t-1}/P_{t-1}, B_{t-1}/P_{t-1}, \pi_t) \tag{7}$$

(iii) Linearize B_{t-1}/P_t about B_{t-1}/P_{t-1} and substitute for Y_t from (1a) and r_t from (6) to yield the following function for tax payments

$$T_t = \tau\psi[U_t, MB_t/P_t, MB_{t-1}/P_{t-1}, B_{t-1}/P_{t-1}, \pi_t] \tag{8}$$

(iv) Solve for $X_t \equiv Z_t - Y_t$ by substituting Y_t from (1a), r_t from (7), T_t from (8), W_{t-1} from (2d), and $\pi^*_{t+1,t}$ from (3c) into (1b); linearize W_{t-1}/P_t about W_{t-1}/P_{t-1} and lag the resulting equation to obtain

$$\begin{aligned} X_{t-1} &\equiv Z_{t-1} - Y_{t-1} \\ &= D\ [F(U_{t-1}) - \tau\psi(U_{t-1}, MB_{t-1}/P_{t-1}, MB_{t-2}/P_{t-2}, B_{t-2}/P_{t-2}, \pi_{t-1}), \\ &\quad \phi(U_{t-1}, MB_{t-1}/P_{t-1}, MB_{t-2}/P_{t-2}, B_{t-2}/P_{t-2}, \pi_{t-1}) - \mu_{t-1}, \\ &\quad MB_{t-2}/P_{t-2}, B_{t-2}/P_{t-2}, \pi_{t-1}] + G_{t-1} - F(U_{t-1}) \\ &\equiv X(U_{t-1}, MB_{t-1}/P_{t-1}, MB_{t-2}/P_{t-2}, B_{t-2}/P_{t-2}, \pi_{t-1}, \mu_{t-1}, G_{t-1}) \end{aligned} \tag{9}$$

Linearizing (9), we obtain

$$Z_{t-1} - Y_{t-1} = e_0 + e_1 U_{t-1} + e_2(MB_{t-1}/P_{t-1}) + e_3(MB_{t-2}/P_{t-2}) + e_4(B_{t-2}/P_{t-2}) + e_5\mu_{t-1} + e_6\pi_{t-1} + e_7 G_{t-1} \tag{10}$$

For compactness, designate (10) as $Q(.)$.

(v) The next step is to linearize the production function, yielding

$$\Delta Y_t = \delta \Delta U_t \qquad \delta < 0 \tag{11}$$

Now substituting (11) and (10) into (1c), we obtain the following equation describing the change in unemployment

$$\delta \Delta U_t = \gamma(Q(.)) \tag{12}$$

and substituting for $Q(.)$, we derive the following estimating equation for unemployment

$$U_t = f_0 + f_1 U_{t-1} + f_2(MB_{t-1}/P_{t-1}) + f_3(MB_{t-2}/P_{t-2}) + f_4(B_{t-2}/P_{t-2}) + f_5\mu_{t-1} + f_6\pi_{t-1} + f_7 G_{t-1} \tag{13}$$

This equation is a reduced form of the goods market and financial sector and is therefore essentially an aggregate demand function. It incorporates the endogenous adjustment of taxes and the interest rate. Under plausible conditions, the sign restrictions on the coefficients are:

$$0 < f_1 < 1, \quad f_2 < 0, \quad f_3 \gtrless 0, \quad f_4 \gtrless 0, \quad f_5 < 0, \quad f_6 > 0, \quad f_7 < 0$$

Most of these are clear. It is worth noting that while $f_2 < 0$, $f_3 \gtrless 0$. The reason is that an increase in MB_{t-1}/P_{t-1} lowers the interest rate r_{t-1}, increasing aggregate demand Z_{t-1}, which given the lagged adjustment, lowers the unemployment rate at time t. On the other hand, an increase in MB_{t-2}/P_{t-2} increases the demand for money at time $t-1$, which is contractionary and given the lags raises the unemployment rate the next period. But it also increases the demand for output, which is expansionary, and lowers the unemployment rate. The net effects are therefore ambiguous. In some of our empirical work below, we shall find that f_3 is approximately equal and of opposite sign to f_2, indicating that the unemployment rate responds to the *change* in the real money base. This is perfectly consistent with (13).

Substituting for (3a), (3c), (1c) and (11) into (3b), we obtain the following equation for the rate of inflation

$$\pi_t = \rho a_0 + \rho a_1 U_{t-1} + \rho a_2 \frac{\delta}{\gamma}(U_t - U_{t-1}) + \rho a_3 \mu_{t-1} + (1-\rho)\pi_{t-1} \tag{14}$$

which may be written in the form

$$\pi_t = g_0 + g_1 U_{t-1} + g_2(U_t - U_{t-1}) + g_3 \mu_{t-1} + g_4 \pi_{t-1} \tag{15}$$

This equation is essentially an aggregate supply function, with the sign restrictions on the coefficients being

$$g_1 < 0, \quad g_2 < 0, \quad 0 < g_3 < 1, \quad 0 < g_4 < 1$$

We can also derive an additional estimating equation for π_t by substituting for current unemployment rate U_t from (13) into (15)

$$\begin{aligned} \pi_t &= h_0 + h_1 U_{t-1} + h_2(MB_{t-1}/P_{t-1}) + h_3(MB_{t-2}/P_{t-2}) \\ &\quad + h_4(B_{t-2}/P_{t-2}) + h_5 \mu_{t-1} + h_6 \pi_{t-1} + h_7 G_{t-1} \end{aligned} \tag{16}$$

Equation (16) is a reduced form equation for π_t, expressing it entirely in terms of predetermined or exogenous variables. Being obtained by combining (13) and (15) it includes both demand and supply effects. The coefficients h_i are related to f_i and g_i by the following relationships:

$$\begin{aligned} &h_0 = g_0 + g_2 f_0 && h_4 = g_2 f_4 \gtrless 0 \\ &h_1 = g_1 - g_2(1 - f_1) \gtrless 0 && h_5 = g_3 + g_2 f_5 > 0 \\ &h_2 = g_2 f_2 > 0 && h_6 = g_4 + g_2 f_6 \gtrless 0 \\ &h_3 = g_2 f_3 \gtrless 0 && h_7 = g_2 f_7 > 0 \end{aligned}$$

A consequence of being a hybrid equation, is that the sign restrictions become less clear. For example, one effect of an increase in U_{t-1} is to lower current inflation through the Phillips curve. But at the same time, it leads to a fall in ΔU_t and this is inflationary. Assuming, as seems plausible, that the former effect dominates, then $h_1 < 0$.[Likewise, one effect of an increase in π_{t-1} is to shift the Phillips curve up and this is inflationary. But it also lowers real wealth, thereby reducing aggregate demand and this is deflationary. Again assuming that the former effect is dominant means that $h_6 > 0$.

Since the crowding out issue deals with the effects on investment, it is also necessary to examine the effects of monetary and fiscal policy on the real interest rate. To derive the estimating equation, we first linearize (7) to obtain

$$r_t = k_0 + k_1 U_t + k_2(MB_t/P_t) + k_3(MB_{t-1}/P_{t-1}) + k_4(B_{t-1}/P_{t-1}) + k_5\pi_t \tag{17}$$

Subtracting the expected rate of inflation from (17) and substituting μ_t for $\pi^*_{t+1,t}$ yields the following equation for the real interest rate, i_t

$$i_t = k_0 + k_1 U_t + k_2(MB_t/P_t) + k_3(MB_{t-1}/P_{t-1}) + k_4(B_{t-1}/P_{t-1}) + k_5\pi_t + k_6\mu_t \tag{18}$$

with the sign restrictions being

$$k_1 < 0, \quad k_2 < 0, \quad k_3 > 0, \quad k_4 > 0, \quad k_5 < 0, \quad k_6 < 0$$

These are self-evident. For reasons noted above, in some of our empirical work we find k_3 to be approximately equal in magnitude and opposite in sign to k_2, in which case the real interest rate responds to the *change* in the monetary base. But this is entirely an empirical phenomenon.

For convenience, the equations to be estimated are summarized as follows:

$$U_t = f_0 + f_1 U_{t-1} + f_2(MB_{t-1}/P_{t-1}) + f_3(MB_{t-2}/P_{t-2}) + f_4(B_{t-2}/P_{t-2}) + f_5\mu_{t-1} + f_6\pi_{t-1} + f_7 G_{t-1} \tag{19}$$

$$\pi_t = g_0 + g_1 U_{t-1} + g_2(U_t - U_{t-1}) + g_3\mu_{t-1} + g_4\pi_{t-1} \tag{20a}$$

$$\pi_t = h_0 + h_1 U_{t-1} + h_2(MB_{t-1}/P_{t-1}) + h_3(MB_{t-2}/P_{t-2}) + h_4(B_{t-2}/P_{t-2}) + h_5\mu_{t-1} + h_6\pi_{t-1} + h_7 G_{t-1} \tag{20b}$$

$$\Delta[MB_t/P_t] = b_0 + b_1\text{DEF}_t + b_2U_t + b_3\pi_t + b_4\mu_t \tag{21}$$

$$\begin{aligned} i_t = k_0 + k_1U_t + k_2(MB_t/P_t) + k_3(MB_{t-1}/P_{t-1}) \\ + k_4(B_{t-1}/P_{t-1}) + k_5\pi_t + k_6\mu_t \end{aligned} \tag{22}$$

One important point to observe is that although we have specified a small complete macroeconomic system, there are *no* cross-equation restrictions. The reason is simply that by Walras' law, we have eliminated the bond market. All restrictions implied by aggregating over the markets are reflected in the implied demand function of bonds, which, however, we do not need to consider explicitly.

4. ESTIMATING PROCEDURES

The empirical estimates of equations (19) - (22) are reported in Tables 1-9. Any equation containing an endogenous variable on the right-hand side is estimated by two-stage least squares (2SLS). When such an equation exhibits autocorrelated error terms a two-stage Hildreth-Lu (TSHILU) technique is employed.[11] For equations containing a lagged dependent variable, the Durbin-h test is used to test for first-order autocorrelation.[12] In such equations when autocorrelation is detected, a standard Hildreth-Lu procedure is implemented. When there is no autocorrelation in the error terms, estimation is performed using ordinary least squares (OLS). Whenever parameter estimates are restricted (e.g., restrictions are imposed at times when coefficients indicate that they may be equal and opposite in sign), these restrictions are tested and imposed only if the restriction cannot be rejected.[13]

When reporting the unemployment and inflation equations, the main focus of our analysis, estimates of the general model are given. These are followed by "preferred equations" obtained by deleting insignificant variables and re-estimating the resulting equations. In the case of the reaction functions and the real interest rate equations only the preferred equations are presented, in order to conserve space.

One final point concerns the nature of the dynamic adjustment processes. As noted, our specification of this is arbitrary, although it is hoped that with annual data, one-period lags in the dependent variables would suffice. At the end of their paper, T-W replace the expectations assumption (3c) with an adaptive form. Their results suggest a slower adjustment process during the first period, 1923-1960, than during the second, 1961-1982. In order to allow for this possibility, π_{t-2} and μ_{t-2} are added to both the unemployment and inflation equations. These two variables are found to be significant for the first period, but not for the second, thus lending credence to the hypothesis that the dynamic adjustment in the first period is much slower than that of the second period.

5. EMPIRICAL RESULTS: 1923-1960

We should stress at the outset that the results obtained for the first period are not particularly satisfactory. Thus, while the findings we shall discuss are suggestive and of interest, they must nevertheless be viewed somewhat tentatively.

A. Unemployment Equation

It should be noted that equation (i), which corresponds to the general model (19), and which excludes μ_{t-2} and π_{t-2}, exhibits the presence of autocorrelation. When these two variables are added to this equation (not reported), the presence of autocorrelation disappears.[14] This is an indication that the exclusion of these variables is a misspecification of the dynamics. Very few of the variables appearing in (i) are significant. The lagged unemployment rate in the unreported augmented equation has a coefficient which is insignificantly different from unity. When the insignificant variables are deleted and the restrictions on the coefficients, which are suggested by the data and tested for, are imposed, the resulting preferred equation is (ii). This suggests an extremely simple relationship linking the change in the unemployment rate to the *change* in the monetary growth rate, with a one-period lag. In the short run, a one percentage point increase in the monetary growth rate (lagged) will lead to a decline of about

TABLE 1

UNEMPLOYMENT EQUATION: 1923-1960[a]

General Model (HL)

$$(i) \quad U_t = \underset{(2.527)}{6.484} + \underset{(.161)}{.616}\, U_{t-1} - \underset{(.217)}{.038}\, (MB/P)_{t-1} - \underset{(.204)}{.058}\, (MB/P)_{t-2}$$
$$+ \underset{(.015)}{.003}\, (B/P)_{t-2} + \underset{(.211)}{.076}\, \pi_{t-1} - \underset{(.135)}{.150}\, \mu_{t-1} + \underset{(.015)}{.013}\, G_{t-1}$$

$R^2 = .845$ S.E. = 2.340 Dh = 3.152

$$\hat{e}_t = \underset{(.146)}{.460}\, \hat{e}_{t-1}$$

Preferred Equation (OLS)

$$(ii) \quad U_t - U_{t-1} = \underset{(.063)}{-.213}\, (\mu_{t-1} - \mu_{t-2})$$

$R^2 = .234$ S.E. = 5.844 Dh = .660

[a]In Tables 1-9, numbers in parentheses denote standard errors of estimates.

.2 percentage points in the rate of unemployment. The steady-state relationship implied by (ii) yields no information about the long-run rate of unemployment; any rate of unemployment is consistent with (ii).

B. Inflation Equation

The general inflation equation corresponding to (20b) is presented in (iii), with no variable appearing statistically significant. As was the case for the general unemployment equation, the inclusion of μ_{t-2}, and π_{t-2} adds significantly to the explanatory power. Deleting the insignificant variables from this latter (unreported) equation, we obtain the preferred equation (iv). This equation finds the current rate of inflation to be a function of the one and two year lagged rates of inflation, together with the change in the real monetary base, also lagged one year.[15] Note that this equation suggests that a 1 percent increase in the real monetary base leads to about a .22 percentage point increase in the rate of inflation, in the short run.[16] In the long run there is no effect.

Equation (v) is the preferred equation for the specification of the inflation equation presented in (20a). This is the form estimated by Turnovsky and Wohar (1984) in their model which excludes wealth. It indicates that in the short run a one percentage point increase in the unemployment rate will lead to about a 1.1 percentage point decrease in the current inflation rate. But again this effect is purely transitory.

In order to choose between the two alternative forms of inflation equations (iv), (v), we apply the Davidson-MacKinnon (1981) test.[17] The result of this indicates that neither specification can be rejected in favor of the other. Both specifications embody essentially the same information about the inflation rate. In (iv) this information appears directly, in (v) it enters via the current unemployment rate.

Indeed, despite their apparent difference, the two equations have generally similar characteristics. Combining (v) with the unemployment equation (iii), one finds that a one percentage point increase in the monetary growth rate leads to a .22 percentage point increase in

TABLE 2

INFLATION EQUATION: 1923-1960

General Model (OLS)

$$(iii)\quad \pi_t = \underset{(2.493)}{-3.568} + \underset{(.347)}{.332}\,\pi_{t-1} + \underset{(.194)}{.053}\,U_{t-1} + \underset{(.322)}{.455}\,(MB/P)_{t-1} - \underset{(.319)}{.355}\,(MB/P)_{t-2} + \underset{(.017)}{.008}\,(B/P)_{t-2} + \underset{(.215)}{.083}\,\mu_{t-1} - \underset{(.019)}{.029}\,G_{t-1}$$

$R^2 = .506$ S.E. = 15.528 Dh = *

Preferred Equations (OLS)

$$(iv)\quad \pi_t = \underset{(.150)}{.873}\,\pi_{t-1} - \underset{(.126)}{.280}\,\pi_{t-2} + \underset{(.131)}{.426}\,[(MB/P)_{t-1} - (MB/P)_{t-2}]$$

$R^2 = .522$ S.E. = 15.222 Dh = −.389

$$(v)\quad \pi_t = \underset{(.399)}{-1.107}(U_t - U_{t-1})$$ (TSHILU)

$R^2 = .417$ S.E. = 3.904 Dh = ** DW = 2.11

$$\hat{e}_t = \underset{(.121)}{.680}\,\hat{e}_{t-1}$$

*See footnote 12.

**See footnote 11.

the short-run rate of inflation. On the other hand, combining (iv) with the monetary base reaction function (vi), one finds that a one percentage point increase in the monetary growth rate leads to a .111 percentage point increase in the short-run rate of inflation. Furthermore, both (iv) and (v) indicate that the steady-state rate of inflation is zero. Thus whatever the short-run effects of changes in the monetary growth rate (or other variables) on the inflation rate may be, both specifications indicate that they are purely transitory.

Combining the preferred unemployment equation (ii) with either (iv) or (v), suggests that the period 1923-1960 is characterized by an approximately zero long run rate of inflation--i.e., a stable price level--with an indeterminate rate of unemployment, or at least not one that we can determine from this model. Thus while (v) indicates the existence of a short-run tradeoff between inflation and unemployment, this is only transitory. The long-run Phillips curve is *horizontal*, with a zero rate of inflation. Thus in the long run, both the unemployment rate and the inflation rate are independent of the monetary growth rate. Thus while the monetary growth rate exertss transitory effects on both the unemployment and inflation rates, the early period would appear to be one in which "monetarist" mechanisms do not operate in a permanent way.

Although this period is not monetarist in the sense of satisfying the crucial long-run neutrality propositions, it does satisfy the monetary proposition asserting that only the influence of money-financed expenditures have significant effects on inflation and employment.[18] This claim can be seen by noting that neither real government purchases of goods and services, nor the real stock of bonds appears significantly in either the unemployment or inflation equations. The absence of these variables suggests that, during this period, real government purchases of goods and services financed by either bonds or taxes have negligible effects on unemployment or inflation. On the other hand, money-financed purchases have a direct impact on inflation, via their effect on the change in real money base, as seen in (iv). They have an indirect effect on the unemployment rate. This operates via the effect of the change in the real money base, through the money multiplier on the rate of monetary growth, which in turn has been seen to have significant short-run effects on unemployment; see (ii).

C. Reaction Functions

The preferred monetary reaction function is reported in (vi).[19] This equation suggests that 5.7 cents of every dollar of the real deficit is monetized. The unemployment variable is not significant, and is omitted from this equation. The current inflation rate and the monetary growth rate, the latter being treated as a proxy for inflationary expectations, are both significant and have the signs hypothesized in our discussion of Section 2. Note that a one percentage point increase in the expected rate of inflation leads to a .26 percentage point increase in the real monetary base, while a one percentage point increase in current inflation leads to a .63 percentage point decline in the real monetary base.

Our attempts to estimate a reaction function for government expenditure were not particularly satisfactory.[20] Thus we draw the conclusion that only monetary policy appeared to be used for stabilization purposes over this period. Real government expenditures were set independently and since they did not appear to influence inflation or unemployment, they had negligible effect on the performance of the economy.

D. Real Interest Rate

Equation (vii) presents the preferred equation for the real interest reate over the early period. While this is not central to our discussion, it is of some interest, especially in light of the crowding out issue. In estimating (22) there is the practical matter of choosing an appropriate measure of the real interest rate. Two most natural and widely used measures include $r_t - \pi_t$, $r_t - \mu_t$, and both of these were used. However, the results were not satisfactory for either period. We therefore chose to measure the real interest rate by the dividend-price ratio, which is less volatile than these other measures and proves to be more satisfactory, particularly in the latter period. This measure will serve as an adequate proxy for the real

TABLE 3

MONETARY REACTION FUNCTION: 1923-1960

(TSHILU)

(*vi*) $$(MB/P)_t - (MB/P)_{t-1} = \underset{(.016)}{.057}\,(\mathrm{DEF}/P)_t + \underset{(.093)}{.261}\,\mu_t - \underset{(.122)}{.634}\,\pi_t$$

$R^2 = .846$ S.E. = 2.030 Dh = ** DW = 1.59

$$\hat{e}_t = \underset{(.148)}{.430}\,\hat{e}_{t-1}$$

**See footnote 11.

TABLE 4

REAL INTEREST RATE EQUATION: 1930-1960

(TSHILU)

(*vii*) $$i_t = \underset{(1.036)}{5.652} - \underset{(.062)}{.175}\,[(MB/P)_t - (MB/P)_{t-1}] + \underset{(.071)}{.203}\,\pi_t$$

R^2 = .501 S.E. = .877 Dh = ** DW = 1.97

$$\hat{e}_t = \underset{(.104)}{.830}\,\hat{e}_{t-1}$$

**See footnote 11.

rate, provided the real capital gain is expected to be constant in each period, which of course is a somewhat restrictive assumption. The data used were on a composite index of 500 Standard and Poor's common stocks and are available only since 1928. Hence our early period is somewhat truncated.

We find the real interest rate to be negatively related to the change in the real monetary base, and positively related to the current rate of inflation. The negative coefficient of -.175 on current real base, MB_t/P_t, reflects the familiar negative relationship between money supply and interest rate. The positive coefficient on lagged real base, MB_{t-1}/P_{t-1}, reflects the wealth effects in the demand for money.[21] Given the money supply, as the lagged money base and hence W_{t-1} increases, the demand for money rises and this requires a rise in the interest rate to occur, in order for money market equilibrium to prevail. The positive relationship between the real interest rate and the current rate of inflation is puzzling and violates the sign restriction noted below equation (18). One possible explanation is that it is reflecting the monetary reaction function. If the rate of inflation increases, the current real monetary base is reduced, thereby reducing the real money supply and putting upward pressure on the interest rate.

6. EMPIRICAL RESULTS: 1961-1982

By contrast, the results for the latter period are much stronger. The first point to note is that the dynamic adjustment process for this period is much faster. Evidence for this is provided by the fact that additional lagged variables in the unemployment and inflation equations are insignificant and do not increase the explanatory power of these equations. This more rapid adjustment is consistent with the findings of our earlier study.

A. Unemployment Equation

The general unemployment equations is reported in (viii), with the preferred equation being given by (ix). In this latter equation, the unemployment rate depends significantly upon its own lag, the past inflation rate, the past level of real government expenditure, and the past

TABLE 5

UNEMPLOYMENT EQUATION: 1961-1982

General Model (HL)

(*viii*)
$$U_t = \underset{(5.578)}{7.264} + \underset{(.102)}{.511}\, U_{t-1} - \underset{(.230)}{.514}\, (MB/P)_{t-1} + \underset{(.288)}{.547}\, (MB/P)_{t-2}$$
$$- \underset{(.005)}{.005}\, (B/P)_{t-1} + \underset{(.240)}{.266}\, \pi_{t-1} + \underset{(.193)}{.179}\, \mu_{t-1} - \underset{(.014)}{.031}\, G_{t-1}$$

$R^2 = .913$ S.E. = .605 Dh = –.916

Preferred Equation (HL)

(*ix*)
$$U_t = \underset{(1.721)}{5.835} + \underset{(.086)}{.532}\, U_{t-1} - \underset{(.118)}{.276}\, [(MB/P)_{t-1} - (MB/P)_{t-2}]$$
$$+ \underset{(.126)}{.432}\, \pi_{t-1} - \underset{(.009)}{.020}\, G_{t-1}$$

$R^2 = .902$ S.E. = .577 Dh = –.245

$$\hat{e}_t = \underset{(.188)}{-.510}\, \hat{e}_{t-1}$$

change in the real monetary base. The form of this last variable is suggested by the fact that $(MB/P)_{t-1}$, and $(MB/P)_{t-2}$ enter (viii) with virtually equal magnitudes and opposite signs.[22] The absence of the monetary growth rate μ_{t-1} in the preferred equation would appear to suggest that it has no direct effect on the rate of unemployment. However, when taken in conjunction with the monetary and fiscal reaction functions (discussed below), we see that there is an indirect effect as a result of these policy rules.

The coefficient of -.02 on G_{t-1} implies that a 1 percent increase in real government expenditure, financed through either bonds or taxes, will result in about a .05 percentage point decline in the unemployment rate in the short run.[23] This effect translates into an elasticity of about .83. The negative coefficient on $\Delta[MB/P]_{t-1}$ indicates that a one percent increase in the real money base leads to a .219 percentage point reduction in the unemployment rate.[24] Furthermore, if the one percent increase in government expenditure is money-financed, it will lead to a reduction in the unemployment rate of about .72 percentage points, .67 of which is due to the induced monetary expansion.[25] Thus, while bond-financed government expenditure certainly does not completely crowd out private expenditure in the short run, the impact of expansions in government expenditure are significantly more potent if they are money-financed.

We now turn to the steady-state relationship implied by the preferred unemployment equation (ix). This is given by

$$\tilde{U} = 12.469 + .923\tilde{\pi} - .043\tilde{G}$$

and is seen to violate both the long-run neutrality of money and the natural rate hypothesis. In the long run, a one percentage point increase in the rate of inflation, brought about by a one percentage point increase in the monetary growth rate, leads to a .923 percentage point increase in the unemployment rate. Furthermore, a one percent increase in real government expenditure, financed either by taxes or bonds, leads to a .10 percentage point decline in the unemployment rate. However, the fact that inflation (the monetary growth rate) has an adverse effect on the steady state unemployment rate implies that in the long run, any increase in government expenditure, financed through monetary growth, will be less expansionary than if either bond financing or taxation are used.

B. Inflation Equation

The general inflation equation reported in (x) is unsatisfactory; due to multicollinearity, only the lagged unemployment rate is statistically significant. The preferred equation, which we found to be the most satisfactory from an economic viewpoint, is (xi). This equation embodies an acceleration hypothesis, in which the change in the inflation rate is weakly dependent upon the unemployment rate and strongly dependent upon the change in the real monetary base. The short-run tradeoff between the rate of inflation and unemployment implied by this equation is much weaker than in the initial period. By contrast, a one percent increase in the real monetary base leads to a .6 percentage point increase in the rate of inflation, somewhat larger than the corresponding effect over the 1923-1960 period. Finally, observe that there is no direct effect of the monetary growth rate on inflation; it operates indirectly through the monetary reaction function.

C. Policy Reaction Functions

The preferred unemployment equation, (ix), implies that the unemployment rate depends directly upon *both* monetary and fiscal policy. On the other hand, (xi) suggests that inflation depends directly upon only the former, although indirectly on the latter through the unemployment rate. Table 7 reports the preferred equations for the monetary and fiscal reaction functions.

The monetary reaction function generally accords with (4d), except for the fact that the deficit turned out to be statistically insignificant and was dropped. The positive coefficient on the unemployment rate indicates the implementation of countercyclical monetary policy. The variables π_t and μ_t enter with approximately equal magnitudes and opposite signs in the

TABLE 6

INFLATION EQUATION: 1961-1982

General Model (OLS)

$$(x)\quad \underset{}{\pi_t} = \underset{(9.048)}{-25.608} + \underset{(.386)}{.264}\,\pi_{t-1} - \underset{(.190)}{.493}\,U_{t-1} + \underset{(.379)}{.394}\,(MB/P)_{t-1}$$
$$+ \underset{(.455)}{.173}\,(MB/P)_{t-2} + \underset{(.010)}{.007}\,(B/P)_{t-2} - \underset{(.298)}{.117}\,\mu_{t-1} - \underset{(.026)}{.056}\,G_{t-1}$$

$R^2 = .924$ S.E. = .851 Dh = * DW = 1.89

Preferred Equation (OLS)

$$(xi)\quad (\pi_t - \pi_{t-1}) = \underset{(.045)}{-.085}\,U_{t-1} + \underset{(.162)}{.749}\,[(MB/P)_{t-1} - (MB/P)_{t-2}]$$

$R^2 = .517$ S.E. = 1.244 Dh = .214

*See footnote 11.

unconstrained version of this equation and accordingly are introduced as a difference in the preferred equation.

The preferred fiscal reaction function, (xiii) specifies real government expenditure to be a negative function of the change in the real monetary base and a positive function of the monetary growth rate. Equations (xii) and (xiii) together suggest a certain degree of interdependence between fiscal and monetary policy making; fiscal policy depends upon monetary policy, but not vice versa. Indeed, upon closer investigation, these two equations show an assignment of instruments to targets which appear to have been in effect. Substituting the fiscal reaction function (xiii) into the unemployment equation (ix), it is seen that the government expenditures are adjusted to virtually fully outset the effects of the monetary base on unemployment; the coefficient on $\Delta[MB/P_t]$ drops from .276 to about -.02. In effect, monetary policy is directed only towards inflation. At the same time, as the monetary growth rate increases and the inflation rate rises, unemployment increases, and the government responds by increasing its expenditure. To this extent fiscal policy is directed at unemployment.

Further credibility is given to these reaction functions by considering them from the viewpoint of optimal stabilization policy. Suppose that the policy maker's objective is to minimize a quadratic loss function of the form

$$a(U_{t+1} - \tilde{U})^2 + (1 - a)(U_{t+1} - U_t)^2 + b(\pi_{t+1} - \mu_t)^2$$

where $\tilde{U}$ is the natural rate of unemployment (calculated below to be around 4.76% for this period), while a and b measure relative costs. This function postulates a desire to: (i) keep the inflation rate close to the monetary growth rate; (ii) keep the unemployment rate close to its natural rate level; (iii) minimize the instability in real activity caused by rapidly changing unemployment. The loss function is minimized by choosing the policy variables $\Delta[MB_t/P_t]$ and G_t subject to the constraints of the system, which are given by the pair of preferred equations (ix) and (xi).

TABLE 7

POLICY REACTION FUNCTIONS: 1961-1982

Monetary Policy (TSHILU)

(*xii*) $(MB/P)_t - (MB/P)_{t-1} = \underset{(.042)}{.118}\, U_t + \underset{(.088)}{.533}\, (\mu_t - \pi_t)$

$R^2 = .786$ S.E. = .667 Dh = ** DW = 2.15

$\hat{e}_t = \underset{(.196)}{.440}\, \hat{e}_{t-1}$

Fiscal Policy (2SLS)

(*xiii*) $G_t = \underset{(11.406)}{179.950} - \underset{(2.821)}{12.789}[(MB/P)_t - (MB/P)_{t-1}] + \underset{(1.877)}{14.564}\, \mu_t$

$R^2 = .828$ S.E. = 217.789 Dh = ** DW = 2.00

**See footnote 11.

Differentiating with respect to $\Delta[MB_t/P_t]$ and G_t respectively, leads to the optimality conditions:

$$\pi_t - .085U_t + .749\Delta[MB_t/P_t] = \mu_t$$

$$5.835 + .532U_t - .276\Delta[MB_t/P_t] + .432\pi_t - .020G_t = a\tilde{U} + (1-a)U_t$$

The first equation yields the monetary reaction function

$$\Delta[MB_t/P_t] = .113U_t + 1.335(\mu_t - \pi_t)$$

Substituting for π_t from the first optimality condition into the second and solving for G_t, we obtain

$$G_t = 50[5.835 - a\tilde{U}] + 50[a - .431]U_t - 29.978\Delta[MB_t/P_t] + 21.6\mu_t$$

Taking $\tilde{U} = 4.76$ (its estimated value) and assuming $a = .431$, U_t is eliminated from this solution, which becomes

$$G_t = 189.17 - 29.978\Delta[MB_t/P_t] + 21.6\mu_t$$

The relative weight $a = .431$ means that squared deviations in unemployment about its natural rate are weighted slightly less than squared changes in unemployment. This does not seem implausible.

These two optimal reaction functions are surprisingly similar to the preferred reaction functions (xii) and (xiii). The same arguments enter, with the coefficients being of the same sign. The magnitudes of the parameters, as one would expect, are different, but not wildly so. Note, in particular, that this form of objective justifies a monetary rule where μ_t and π_t enter as a difference. While we do not want to overemphasize the significance of this exercise, it nevertheless does provide some reassurance as to the plausibility of the estimated policy reaction functions.

D. *Induced Neutrality of Monetary and Fiscal Policy*

The preferred unemployment and inflation equations, (ix) and (xi), indicate that the economy is structurally nonneutral in the long run. Other things equal, changes in the monetary growth rate and government fiscal policy can have long run real effects. But other things do not remain equal and as we have seen, over the period the government has been engaged in a process of stabilization. In this section we demonstrate how the reaction functions (xii) and (xiii), when taken in conjunction with the preferred unemployment and inflation equations, generate reduced form equations which exhibit the long-run neutrality monetarist propositions.

Table 8 yields unemployment and inflation equations obtained, when one substitutes the reaction functions (xii) and (xiii) into (ix) and (xi). These equations, which are essentially those estimated by Stein (1978) as well as T-W, are consistent with the long-neutrality of money and the natural rate hypothesis.[26] The coefficient of unemployment in the inflation equation is negligible, so that in effect the inflation rate is a weighted average of the past inflation and monetary growth rates. We find the steady state of the equations by setting all lagged and current values included in them equal to one another. Moreover, since π_{t-1} and μ_{t-1} enter the unemployment equation with more or less equal and opposite signs, the steady state of these relationships are

$$\tilde{\pi} = \mu$$

$$\tilde{U} = 4.76$$

That is, in the long run, the inflation rate equals the monetary growth rate, while the unemployment rate converges to a natural rate of around 4.76 percent.

Part B of Table 8 presents direct estimates of these same equations, with the insignificant variable deleted from the inflation equation.[27] These results turn out to be virtually identical to those in Part A, showing the same long-run neutrality properties. The inflation rate is a

TABLE 8

A. Implied Reduced Form Unemployment and Inflation Equations 1961-1982

$$U_t = 2.236 + .530U_{t-1} - .302\mu_{t-1} + .443\pi_{t-1}$$

$$\pi_t = .003U_{t-1} + .399\mu_{t-1} + .601\pi_{t-1}$$

B. Direct Estimation of Reduced Form Unemployment and Inflation Equations 1961-1982

(*xiv*) $$U_t = \underset{(.794)}{2.373} + \underset{(.133)}{.518}\, U_{t-1} - \underset{(.101)}{.328}\, \mu_{t-1} + \underset{(.085)}{.454}\, \pi_{t-1}$$ (OLS)

$R^2 = .836$ S.E. = .503   Dh = –.277   (OLS)

(*xv*) $$\pi_t = \underset{(.127)}{.477}\, \mu_{t-1} + \underset{(.125)}{.550}\, \pi_{t-1}$$

$R^2 = .960$ S.E. = 1.505   Dh = .070   DW = 1.97

weighted average of past inflation and monetary growth rates, while the implied natural rate of unemployment is around 4.9%.

Since equations (xiv) and (xv) are appealing forms of the preferred equations, we have performed Davidson-MacKinnon specification tests on the pairs (ix)-(xiv) and (xi)-(xv), respectively. These tests rejected (xiv) in favor of (ix) and (xv) in favor of (xi). Taken in the context of this study, these findings can be interpreted as meaning that the accepted equations (our preferred equations) contain more information about unemployment and inflation than do (xiv) and (xv), which contaminate that information with the reaction functions.

The finding by Turnovsky and Wohar (1984) that the monetarist neutrality propositions, found to hold over the period 1961-1982, can be viewed as being generated by government policy, rather than being intrinsic to the economic structure, is strengthened by the introduction of separate monetary and fiscal reaction functions. It should be emphasized that real government expenditure (financed either by money, bonds, or taxation), is *not* in and of itself ineffective. On the contrary, in the absence of policy reactions, a once and for all increase in government expenditure will have real effects on unemployment, both in the short run and in steady state. But what the policy reaction function (xiii) suggests is that fiscal policy over this period did not in fact remain passive in this way.

In the case of monetary policy, consider e.g. a one-percentage point increase in the rate of monetary growth. In response to this, the monetary reaction function (xii) suggests that the real money base is increased by .533 units. There is also a fiscal response, described by (xiii), and this has two components. On the one hand, the increase in the monetary growth rate encourages an increase in real government expenditure. On the other hand, the fiscal authorities compensate for the expansion in the real money base by decreasing real government expenditure. On balance, the former effect dominates and real government expenditure is increased by around 7.78 units. As a consequence of the expansion in the real money base, the inflation rate in the next period rises by around .4 percentage points. At the same time, the combination of the expansionary monetary and fiscal policies causes the unemployment rate to fall. This, coupled with the rise in the inflation rate, leads to a decline in the increase in the real money base; $\Delta(MB/P)$ drops from .533 to .284. The fiscal authority in turn compensates for this reduction in the rate of increase of the real money base by now increasing its real government expenditure. The reduction in $\Delta(MB/P)$, together with the lagged adjustment in the rate of inflation, means that the inflation rate continues to increase, but at a slower rate. The combination of a less expansionary monetary policy and a more expansionary fiscal policy, together with the rising inflation rate, means that the initial fall in the unemployment rate is reduced. Over time, this switch from monetary policy towards fiscal policy continues, with the result that the inflation rate ultimately converges to the new (higher) monetary growth rate, while unemployment is restored to its original level.[28]

E. Real Interest Rate Equation

The real interest rate equation is reported in (xvi). It is very Fisherian in the sense that the real interest rate is to depend upon only *real* variables and to be independent of nominal variables such as the monetary growth rate or the rate of inflation. This finding also tends to support the general monetarist characteristics of the economy over this period. Loosely speaking, this equation can be interpreted as saying that the real interest rate is determined essentially by effects operating along the economy's IS curve. The positive coefficient on the unemployment rate corresponds to the downward sloping IS curve. The positive coefficients on lagged monetary base and government bonds reflects the fact that as wealth increases, the IS curve shifts out, driving up the real interest rate.

We find the results of this equation to be quite impressive. It is the only equation in which we find the real stock of bonds to be significant. This equation implies that the only impact of government expenditure on the real interest rate is through its induced effects on the monetary base and bonds, as well as the unemployment rate. To the extent that it raises wealth, increased government expenditure has a positive effect on the real interest rate; to the

TABLE 9

REAL INTEREST RATE EQUATION

Preferred Equation, 1961-1982 (2SLS)

$$(xvi) \quad i_t = \underset{(1.668)}{-11.472} + \underset{(.058)}{.211}\, U_t + \underset{(.015)}{.127}\, (MB/P)_{t-1} + \underset{(.003)}{.017}\, (B/P)_{t-1}$$

R^2 = .888 S.E. = .129 Dh = ** DW = 1.93

**See footnote 11

extent that it lowers the unemployment rate this is offset by a negative effect. Combining equation (xvi) with the unemployment equation (ix) it can be shown that one percent increase in government expenditure which is bond-financed leads to a .031 percentage point increase in the real interest rate. However, a one percent increase in government expenditure which is money-financed, leads to a .157 percentage point increase in the real interest rate. Surprisingly, the crowding out effect, proxied by the real interest rate, and which is only modest under bond financing, is substantially greater under money financing. This is because, even though the (negative) unemployment effect is larger under money financing, the wealth effect, which dominates the unemployment effect in both cases, is more dominant in that case.[29]

7. CONCLUSIONS

The extension of our previous analysis to incorporate a more completely specified government sector not only leads to a substantial improvement in the quality of our results, but also assists in our understanding of them. The results suggest a number of striking differences between the two subperiods 1923-1960 and 1961-1982.

(i) The early period suggested a substantial short-run tradeoff between inflation and unemployment; in the later period this tradeoff is negligible.

(ii) In the early period, the long-run Phillips curve is horizontal at a zero rate of inflation (stable price level); in the later period it is vertical at a natural rate of about 5%.

(iii) In both periods the rate of inflation in the short-run is positively related to the change in the real monetary base, with the effect being somewhat stronger in the more recent period.

(iv) In the early period, the rate of unemployment appears to depend directly upon (and essentially only on) the monetary growth rate; in the later period it depends only indirectly upon this variable, through the monetary reaction function.

(v) The real stock of government bonds does not appear to have a significant impact on the rate of inflation or the unemployment rate in either period. In the early period only money-financed government expenditure has significant effects on unemployment or inflation. In the later period, bond-financed government expenditure does have some effect on unemployment, but much less than if the expenditure is money-financed.

(vi) The absence of a satisfactory fiscal policy reaction function for 1923-1960 suggests that only monetary policy was used for stabilization purposes during that period. The interdependence between the fiscal and monetary reactions for the 1961-1982 period indicates that these policies were more closely related during the later period. Moreover, when taken together, these results suggest an assignment of instruments to targets over the recent past; fiscal policy has been directed at stabilizing unemployment, monetary policy being directed at inflation.

(vii) The existence of a natural rate of unemployment and the neutrality of money, shown to hold for the late period, are not intrinsic to the economy, but rather are the result of the government stabilization policies being conducted over that period.

(viii) It was found that deficits have a small, but significant, impact on the change in the real monetary base during the early period, but not during the later period.

(ix) The results suggest that the dynamics of the first period were much slower than those of the later period. A plausible explanation for this can be given in terms of the different inflationary history characterizing these two periods. During the first period, without the fear of rapidly rising prices, individuals may have found it too costly to form expectations about the future in any sophisticated way and continually adjust their behavior. On the other hand, during the later period, with its rising inflation and concomitant costs to those not anticipating it, it became too costly not to form expectations rapidly and make the appropriate adjustments. Institutions generally have become more geared to adapting to inflation.

One of the major objectives of this study was to examine the impacts of alternative modes of financing deficits. One prevalent, and perhaps surprising, finding was that the bond stock was not found to influence any of the economic magnitudes considered in this study except for a small effect on the real interest rate during the period 1961-1982. One might attempt to explain this absence of bonds in any of the equations by claiming that the wealth effects on consumption were offset by the opposite effects on money demand. One might also attribute this finding to the Ricardian Equivalence Proposition. Although these are all plausible explanations we choose to offer a third possible explanation. Until recently, deficits may have been viewed by economic agents as temporary or cyclical. That is, that existing deficits were the result of wars or recessions and once economic growth increased these deficits would decline substantially. This is underscored by the relatively small Full-Employment deficits that have existed until the end of 1982. However, recently (after 1982) the U.S. has experienced relatively large structural (Full-Employment) deficits well above $100 billion, which are expected to continue for years to come. Of course we will have to wait many years to see the evidence, but, these large structural deficits may lead economic decision makers to change their views of deficits and the effects of alternative modes of financing them. In the future we may find that continuing to finance large deficits by the issuance of bonds will have deleterious effects on economic growth even though this may not have been the case, for the most part, in previous years.

Finally, two limitations of our analysis should be noted. First, it abstracts from physical capital accumulation. The demand side of investment is proxied, at least to some extent, by the real interest rate variable embodied in the demand function. However, the supply effects which operate through the production function are not incorporated in the analysis. In their earlier work, T-W conducted some preliminary tests by modifying the production function to include capital stock. The results in doing this, however, were disappointing. Whether this was due to poor capital stock data or to the inadequate specification of capital in the model is unclear. Secondly, the model assumes that government bonds and corporate equities are perfect substitutes, so that the real rate of return on bonds is the relevant cost of capital. Recent empirical work, however, questions the validity of this assumption. Further consideration of these issues is clearly desirable.

FOOTNOTES

* The constructive comments of two referees are gratefully acknowledged.

1. The propositions tested are stated by Stein (1978). He in turn attributes these views primarily to Brunner (1970) and Friedman (1970, 1973).

2. For details on how the structural break was determined, see Turnovsky and Wohar (1984). Similar breaks have been found by previous authors; see, e.g., Klein (1976), Rea (1983).

3. For a detailed discussion of the econometric problems which arise when one does not incorporate endogenous monetary and fiscal policies into the estimation of macro models see Goldfeld and Blinder (1972).

4. The introduction of real wealth in the form W_{t-1}/P_t can be justified in terms of the end-of-period equilibrium approach; see Turnovsky (1977).

5. In effect we are abstracting from issues relating to the Ricardian equivalence proposition.

6. See, e.g., Solow (1968) and Turnovsky and Wachter (1972).

7. The behavioral function (4d) represent an admittedly simplified version of the money supply process, and exclude important behavioral characteristics of the financial sector that have been analyzed in previous studies (for example, see Brunner and Meltzer (1964), de Leeuw (1965) and Goldfeld (1966)). However, they adequately serve the purpose of allowing the estimation of a money-base reaction function within the context of a model of the economy.

8. The study of reaction functions can be extended in various directions. For example, it would be of interest to analyze reaction functions for the different components of government expenditure, such as social security expenditures, etc. Or, one could investigate rules for endogenizing the tax rate. Detailed studies in these directions, while clearly of interest, lie outside the scope of the present paper.

9. Note that the model also contains q, the price of government bonds. This can be determined as the solution to the asset pricing relationship

$$r_t = 1/q_t + (q^*_{t+1,t} - q_t)/q_t$$

where $q^*_{t+1,t}$ is the forecast of q for time $t+1$, formed at time t.

10.

$$\frac{W_{t-1}}{P_t} \simeq \frac{W_{t-1}}{P_{t-1}} - \frac{W_{t-1}}{(P_{t-1})^2}\Delta P_t \simeq \frac{W_{t-1}}{P_{t-1}}[1 - \pi_t]$$

11. In ordinary least squares equations the Durbin-Watson statistic is generally used to test for autocorrelation. If one of the independent variables is a lagged dependent variable in an OLS regression, the Durbin-h test is used. However, Godfrey (1978) has shown that the Durbin-h test, based on instrumental variable results (as in 2SLS), is not a recommended test for serial correlation. However, by examining the t-statistic for the value of the autocorrelation coefficient obtained from employing the Fair (1970) (i.e., TSHILU) 2SLS autoregressive procedure can give an indication of the presence of serial correlation. If the autocorrelation coefficient is significantly different from zero then the TSHILU technique is employed; otherwise, a standard 2SLS procedure is employed.

12. Durbin (1970) has shown that

$$\text{Dh} = (1 - \frac{\text{DW}}{2})\sqrt{T/(1 - T[\text{var}(\beta_1)])}$$

where DW is the value of the Durbin-Watson statistic, T is the total number of observations, var(β_1) is the variance of the coefficient associated with the lagged dependent variable. Dh is approximately normally distributed with unit variance. The critical value for a level of significance of .05 is 1.645 (-1.645).

It is important to note that the Durbin-h test is not valid when T var (β_1) is greater than 1. In this case Durbin proposes an alternative test. We obtain the residual variable $\hat{e}_t$ from the ordinary least squares regression and also create the lagged residual variable $\hat{e}_{t-1}$. We then estimate

$$\hat{e}_t = \alpha_0 + \lambda \hat{e}_{t-1} + \beta_1 Y_{t-1} + \beta_2 X_t + v_t$$

where

Y_{t-1} is the lagged dependent variable,
X_t is the vector of contemporaneous independent variables,
v_t is a normally distributed disturbance term.

If λ is significantly different from zero then we reject the null hypothesis of no first-order serial correlation and must correct for it.

13. The method used for restricting parameter estimates is to introduce a Lagrangian parameter for each restriction (see Pringle and Raynor, 1971). The estimates of these parameters are printed with test statistics. The Lagrangian parameter λ measures the sensitivity of the SSE to the restriction constant. If the restriction constant is changed by a small amount, ϵ, the SSE is changed by $2\lambda\epsilon$. The t ratio tests the significance of the restriction. If λ is zero, the restricted estimates are the same as the unrestricted, and a change in the restriction constant in either direction increases the SSE.

14. Estimates of these general equations are available from the authors upon request.

15. The inclusion of the change in the real money base is suggested by the fact that $(MB/P)_{t-1}$ and $(MB/P)_{t-2}$ enter (iii) with approximately equal and opposite signs. This is equivalent to setting $e_2 = -e_3$ in equation (10). The underlying model is sufficiently general to permit this restriction. In terms of the basic structure

$$e_2 \simeq [-D_1 \tau(B_{t-1}/P_{t-1}) + D_2] \partial r_{t-1}/\partial(MB_{t-1}/P_{t-1})$$
$$e_3 \simeq [-D_1 \tau(B_{t-1}/P_{t-1}) + D_2] \partial r_{t-1}/\partial(MB_{t-2}/P_{t-2}) + \partial D/\partial(MB_{t-2}/P_{t-2})$$

The term $\partial r_{t-1}/\partial(MB_{t-1}/P_{t-1})$ measures the effect of a change in the current real money base on the current interest rate. In effect this represents a downward shift in the LM curve and is negative. Thus, given the signs of D_1, D_2 in (1b), $e_2 > 0$. On the other hand, $\partial r_{t-1}/\partial(MB_{t-2}/P_{t-2})$ measures the effect of the lagged real money base on the current interest rate. This arises through wealth effects in the demand for output and real money balances. These represent upward shifts in both the IS and LM curves, the effects of which are positive. Thus the first component of $e_3 < 0$. The second component of e_3 reflects the wealth effect on the demand for output which is positive. Depending upon the relative shifts it is certainly possible for $e_2 \simeq -e_3$, as the empirical evidence suggests.

16. This semi-elasticity is evaluated at the mean MB_{t-1}/P_{t-1} for the period, which equals $50.753 billion.

17. For a discussion of these particular specification tests and how to implement them, see Davidson and MacKinnon (1981).

18. For the particular definition of the long-run neutrality proposition used in this paper as well as by Stein and others two conditions must be met: (i) the steady-state rate of unemployment must be independent of the steady-state rate of monetary expansion, and (ii) the steady-state rate of inflation must be equal to the steady-state rate of monetary expansion.

19. Observe that the explanatory variables are introduced in the reaction functions contemporaneously, suggesting that these variables are known immediately to the stabilization

authorities. Note, however, that since both the monetary and fiscal reaction functions are estimated using 2SLS procedures, the endogenous variables are in fact replaced by estimates, obtained from the first stage regression. These can be viewed as measuring policy makers' expectations of these variables. Thus the reaction functions can be interpreted as responding to predicted, rather than to realized values.

20. A fiscal reaction function was estimated although not reported in the tables because (G_t) was absent from the preferred inflation and unemployment equations. The preferred equation is as follows

$$G_t = \underset{(39.545)}{185.216} + \underset{(1.259)}{6.301}\,[(MB_t/P_t) - (MB_{t-1}/P_{t-1})] - \underset{(2.963)}{8.693}\,U_t$$

$R^2 = .856$ S.E. = 28.3659 DW = 1.39 Dh = **

$$\hat{e}_t = \underset{(.084)}{.860}\,\hat{e}_{t-1}$$

The wrong sign on the U_t term and the low Durbin-Watson statistic even after using (TSHILU) would tend to indicate a possible misspecification, spurious correlation, or wrong specification of causality.

21. Since in general the different components of wealth need not all have identical effects on the demand for money, this interpretation is not inconsistent with B_{t-1} being insignificant in this equation.

22. The comments in footnote 15 apply here as well.

23. This calculation as well as the corresponding steady-state effect is evaluated at the mean value for the period, G = \$243 (billion).

24. This calculation is evaluated at the mean value of $(MB/P)_{t-1}$ = \$79.454 (billion) over the period.

25.

$$dU = -.276\, d(MB/P)_{t-1} - .02\, dG_{t-1}$$

Setting $d(MB/P)_{t-1} = dG_{t-1}$ and considering a 1% increase in G evaluated at the mean, so that $dG = 2.43$, we find

$$dU = -.296 \times 2.43 = -.72$$

26. These estimates differ slightly from those in our previous paper, due to the updating of the data.

27. When unemployment was added to the inflation equation (xv) it was insignificant and was dropped.

28. The steady state of the model is one in which $U = \tilde{U}$, $\pi = \mu$; we do not require $\Delta[MB/P] = 0$. Indeed, if the government wishes to sustain the unemployment rate at $\tilde{U}$, the monetary reaction function implies that the real monetary base must be allowed to increase steadily. This presents no problem for the steady state of the system defined by the preferred equations (ix) and (xi), since these depend only upon the change in MB/P. However, it appears from the real interest rate equation (xvi) that this is incompatible with a long-run constant real interest rate, since this depends upon the level of MB/P. This need not necessarily be so, since i_t also depends upon the stock of bonds, which for a given real deficit typically will be decreasing steadily to finance the monetary expansion. It is possible for the offset to be sufficiently close so that the net effect of the real monetary base and bonds on the real interest rate are approximately offsetting.

We have also followed a referee's suggestion and imposed as a steady-state condition and introduced a constant into (xi), thereby allowing for a non-zero steady-state unemployment rate. But the overall results did not prove to be satisfactory.

29. These calculations are evaluated at the mean values of G = \$243 (billion) over the period. The effect under bond financing is given by

$$di_t = .211 dU_t + .017 d(B/P)_{t-1}$$

where

$$dU_t = -.02\, dG_{t-1} \quad \text{and} \quad d(B/P)_{t-1} = dG_{t-1} = 2.43$$

The effect under money financing is given by

$$di_t = .211\, dU_t + .127\, d(MB/P)_{t-1}$$

where $dU_t = -.276\, d(MB/P)_{t-1} - .02\, dG_{t-1}$ and $d(MB/P)_{t-1} = dG_{t-1} = 2.43$.

APPENDIX

Description and Sources of Data

P is the implicit price deflator for Gross National Product (GNP) and is computed by dividing GNP in current dollars by GNP in 1972 dollars. Hence, its value is unity in 1972 base period. The rate of inflation

$$\pi_t = (P_t - P_{t-1})/P_{t-1}$$

Sources: 1923-1950 [11], 1951-1982 [12].

M is the annual average of the money supply (M1) measured in billions of current dollars. The monetary growth rate $\mu_t = (M_t - M_{t-1})/M_{t-1}$

Sources: 1923-1959 [10], 1960-1982 [3]

MB is the annual average of the monetary base (high-powered money)

Sources: 1923-1982 [3]

U is civilian unemployment rate (in percent) calculated as the number of persons unemployed divided by the civilian labor force.

Sources: 1923-1929 [7], 1929-1939 [2], 1940-1982 [13]

G is real government purchases of goods and services by federal, state, and local governments and is measured in billions of 1972 dollars.

Sources: 1923-1928 [6], 1929-1950 [11], 1951-1982 [12]

i is the real interest rate proxied by the dividend-to-price ratio on 500 common stocks. It is a composite index of these 500 common stocks.

Sources: 1923-1982 [9]

B is the market value of domestic net federal debt held by the public. Net federal debt is defined as gross federal debt less debt held by agencies and trust funds. The market value of debt is calculated by multiplying the ratio of market to par value by the par value of domestic net federal debt. (June figures are used.)

Par value of net domestic federal debt Sources: 1923–1940 [4]
1941–1982 [3,5]

Ratio of market to par value: Sources: 1923–1957 [8]
1958–1982 [1]

DEF is a measure of the deficit. It is calculated as the difference between Net Federal Debt in period t and Net Federal Debt in period $t-1$. (June figures are used.)

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