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*Federal Deficits and Short-Term Interest Rates**

This paper analyses empirically, using multivariate Granger-causality tests, the effects of federal deficits on short-term interest rates. Four deficit measures—the national income accounts measure, a flow-of-funds measure, the cyclically-adjusted deficit, and the change in the market value of privately held federal debt—are separately considered. Additional variables suggested by theory as important determinants of interest rates are considered along with the deficit measures. Quarterly data for the period 1957–1984 are employed in the tests. The multivariate tests suggest that none of the deficit measures Granger-cause the interest rate.

1. Introduction

The impact of federal government budget deficits on interest rates has received increased attention in recent years. The unusually high level of market interest rates in the past several years has prompted a search for an explanation of why market interest rates have remained at high levels despite the marked decline in the rate of inflation. The combination of high market rates with the sharp decline in inflation means that real interest rates have risen. One factor frequently mentioned as contributing significantly to the high levels of interest rates is the size of federal budget deficits which, both in absolute value and measured relative to GNP, are unusually high.

Several theoretical models have been employed to analyze the effects of deficits on real interest rates. The familiar loanable funds model predicts (in the absence of debt monetization) substantial effects of large deficits on interest rates.[1] However, as Brunner (1984)

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[1]The evidence on monetization is mixed. The studies of Froyen (1974), Barro (1977; 1978), Niskanen (1978), McMillin–Beard (1980), McMillin (1981), Hamburger–Zwick (1981), Levy (1981), Dewald (1982), Barth, Sickles, and Weist (1982), Blinder (1982), and Allen and Smith (1983) suggest some monetization. The studies of Gordon (1977), McMillin–Beard (1982), and Dwyer (1982) suggest nonaccommodation by the Federal Reserve.

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notes, portfolio analysis suggests that interest rates are determined, not by flow demand and supply as in the loanable funds model, but by stock demand and supply. In this approach, deficits alter interest rates by altering the real stock of debt outstanding. This approach is consistent with either a significant or a negligible effect of deficits on interest rates, depending upon the sizes of the accumulated stock of debt and the deficit. Finally, the Ricardian equivalence hypothesis discussed by Bailey (1972) and Barro (1974) suggests that deficits have no effect upon interest rates since, in order to provide funds to pay the future taxes required to meet interest payments on government debt, private sector savings rise commensurately with the increased demand for funds associated with the sale of bonds. Given this theoretical ambiguity, it would appear that the effect of federal deficits on interest rates is an empirical question. The available empirical evidence provides mixed estimates of the impact of these deficits on interest rates. Some studies suggest that increases in deficits raise interest rates while others suggest no impact.[2]

The aim of this paper is to analyze empirically the impact of federal deficits on interest rates. The approach taken in this paper is quite different from that of previous analyses. Several deficit measures are considered, and multivariate Granger–causality tests are employed to determine whether interest rates are significantly influenced by federal deficits as well as by real output, inflation, money growth, interest rate volatility, and supply shocks. However, the single equation approach used here provides no evidence on feedback from interest rates to the other variables considered. The one-sided distributed lag test suggested by Granger (1969) is employed. But, rather than employing a common lag length for all variables in these tests, an atheoretical statistical technique is used to determine the appropriate lag length for each variable.[3] A multivariate approach rather than a bivariate interest rate-federal deficit

[2]Evidence of a positive effect of deficits on interest rates is reported in Makin (1983) and Makin–Tanzi (1983). Evidence of no effects is presented in Plosser (1982), Hoelscher (1983), U.S. Treasury (1984), and Evans (1985). In fact, in some cases, Evans finds a negative effect on interest rates. Concise summaries of previous studies are provided in U.S. Treasury (1984) and Congressional Budget Office (1984).

[3]As is well known, the notion of Granger–causality is not uncontroversial. For a discussion see Zellner (1979). Dwyer (1982) used causality tests to analyze the effect of government debt on interest rates as well as other macroeconomic variables. Dwyer's analysis is performed within the context of a vector autoregression (VAR) with a common lag length for all variables. The use of the common lag length is discussed later in this paper. Dwyer does not find a significant effect of deficits on interest rates. However, he does not examine alternative deficit measures.

framework is employed in order to reduce the potential problems that omitted variables present for Granger–causality tests. A bivariate analysis may lead to inappropriate conclusions about the causal relations between interest rates and federal deficits if relevant variables are omitted from consideration.[4]

The next section of the paper describes the data employed and the specification of the equations used in the multivariate Granger–causality tests. The results of these tests are presented and analyzed in Section 3. A summary and conclusions follow in Section 4.

2. Data Description and Test Equation Specification

The focus of attention in this study is the three-month Treasury bill rate. This is similar to the recent studies of Wilcox (1983), Hoelscher (1983), Makin (1983), Peek-Wilcox (1983), and Makin-Tanzi (1983) which focus upon a short–term nominal rate. Thus, although the previous discussion concentrated on the real interest rate, no attempt is made here to construct a measure of the real rate by subtracting a measure of the expected rate of inflation from the nominal rate. Unless rising deficits lead to perverse declines in the expected rate of inflation, these deficits must raise nominal interest rates in order to raise real rates. Furthermore, the rate of inflation is controlled for in the multivariate Granger–causality tests.

Several deficit measures are considered in the analysis. The first is the national income accounts deficit that is the focus of most of the public attention on the deficit. However, as Hamburger–Zwick (1981) note, this measure is on an accrual rather than a cash flow basis. Consequently, they suggest that a better measure of the

[4]The effects of omitted variables are discussed briefly in Sims (1972). For a more complete treatment, see Lutkepohl (1982).

An alternative to the single equation approach that would provide evidence on feedback among the variables would be to estimate vector autoregressive systems. However, since four different deficit measures and two different sample periods are employed, specification, estimation, and diagnostic checking of eight vector autoregressive systems using the procedure described in the text would be prohibitively expensive. As a consequence, the single equation approach which provides evidence on direct Granger–causality from the independent variables to the interest rate is used.

Finally, the results may be sensitive to the specification of the dependent variable. The atheoretical statistical technique used is often sensitive to the stationarity of the data (see Hsiao (1981)), and hence care is taken to insure that a stationary interest rate series is employed.

deficit is the funds raised in credit markets by the federal government from the flow–of–funds accounts. Furthermore, this measure is more comprehensive than the national income accounts deficit since it includes debt issued by federal agencies. This is the second measure used in this study and is referred to as the flow–of–funds deficit. Since the first two measures are affected by cyclical swings in economic activity as well as by changes in expenditure and tax programs, the cyclically–adjusted deficit is also considered. Each deficit measure is scaled by nominal potential output which is constructed as the product of the implicit GNP deflator and real potential GNP.

The deficit measures just described are measures of the real deficit and hence, at least to some extent, adjust for the effects of inflation on the federal budget. However, it has recently been argued that these measures do not adequately account for the effects of inflation on the federal budget since the inflation tax on outstanding government bonds is not incorporated into these measures. Inflation tends to raise market interest rates and thereby to reduce the real market value of outstanding government debt. There is thus a transfer of wealth from bondholders to the government, and, it is argued, this wealth transfer should be counted as government revenue. A deficit measure that does incorporate this effect is the change in the real market value of privately held federal debt. This measure, scaled by real potential GNP, is employed as an alternative to the measures previously described. For further discussion of the measurement of the deficit, see Siegel (1979), Dwyer (1982), and Eisner–Pieper (1984).

The additional variables employed in the multivariate Granger–causality tests are those frequently hypothesized to be important determinants of interest rates. (See, for example, Wilcox (1983), Makin–Tanzi (1983), and Peek–Wilcox (1983).) The growth rate of $M1$ is employed as one of these variables as is the rate of change in the implicit GNP deflator. This latter variable can be thought of as a proxy for the expected inflation rate which affects interest rates via the Fisher effect. When the inflation rate is controlled for, an increase in $M1$ should, at least in the very short-run, through the liquidity effect, reduce the interest rate. The higher growth in money may, over time, even when past inflation is controlled for, directly raise inflation expectations and interest rates. (See Mullineaux (1980).) The gap between real output (measured by real GNP) and real potential output (measured by real potential GNP) as a proportion of real potential GNP is included to capture any accelerator effects on investment demand (see Makin–Tanzi (1983)). An increase in this variable will stimulate investment spending, and the increased demand for capital is expected to raise the level of the interest rate.

Following Wilcox (1983), a measure of supply shocks is also considered. If, as recent estimates of production functions suggest, energy and capital are net complements, the supply shocks like those engineered by OPEC in the 1970s reduce the demand for capital and hence tend to reduce the interest rate. At the same time, however, the increase in the price level generated by the reduction in aggregate supply caused by an adverse supply shock reduces real money balances. Within a simple IS–LM model with unchanged expectations of inflation, the decline in real balances in turn tends to raise the interest rate. The net effect on the interest rate is thus ambiguous. The supply shock variable used here is a relative price type measure and is defined as the ratio of the rate of change in the import price deflator to the rate of change in the GNP deflator and is similar to that used by Wilcox. The underlying notion is that the import price deflator should respond to alterations in world materials supply.[5]

Finally, a measure of interest rate volatility is included. Consideration of this variable is important in light of the increased volatility in interest rates following the October, 1979 change by the Federal Reserve from a federal funds rate operating guide to a reserves–oriented operating guide. Friedman (1982) argues that the greater volatility in interest rates has increased the risk borne by participants in financial markets and that the resulting increased risk premium has raised interest rates. The measure of interest rate volatility used is similar to the measure suggested by Evans (1984).

[5]Data sources are: Citibase–nominal GNP, implicit GNP deflator, national income accounts deficit, cyclically–adjusted deficit, three–month Treasury bill rate, implicit import price deflator, and *M*1. Real potential GNP was provided by the Federal Reserve Bank of St. Louis. Total funds raised in credit markets by the federal government was supplied by the Flow–of–Funds Division, Board of Governors of the Federal Reserve System. The change in the real market value of privately held federal debt was constructed from the series in Table 6 of Cox (1985). All data with the exception of the three–month Treasury bill rate and the market value of government debt are seasonally adjusted at the source. The debt data are adjusted using TSP.

Preliminary results were unchanged when the ratio of the producer price index for fuel and related products and power to the business sector price deflator was used in place of the supply shock variable described in the text.

Specifically, $SRTB_t = \left[1/4 \sum_{i=1}^{4} (DLRTB_{t-i} - \overline{DLRTB}_t)^2\right]^{1/2}$ where $SRTB(t)$ = the standard deviation of the change in the log of the three-month Treasury bill rate over the previous four quarters, $DLRTB_{t-i}$ = the change in the log of the three-month Treasury bill rate in quarter $t - i$, and $\overline{DLRTB}_t$ = the mean of the change in the log of the three-month Treasury bill rate over the previous four quarters $\left(\overline{DLRTB}_t = (1/4) \sum_{i=1}^{4} DLRTB_{t-i}\right)$.

As is well known, one variable (X) is said to Granger–cause another variable (Y) if the past values of X in conjunction with the past values of Y can be used to predict Y more accurately than can be predicted using just past values of Y. Several procedures have been suggested for empirically implementing the Granger–causality tests; based upon the recent Monte Carlo study of Geweke, Meese, and Dent (1983) which compares alternative procedures, the one–sided distributed lag test of Granger is used. The test presumes the use of stationary data, and typically some transformation of the data must be made in order to achieve stationarity. In a multivariate context, the test would typically be implemented by regressing the interest rate on its own lagged values and lagged values of the other variables, with the same lag length used for all variables. F–tests are used to test for the presence of Granger–causal relations.

A potential problem in the usual implementation of the test is the use of a common lag for all variables. There is generally no a priori reason to believe that the same lag length is appropriate for all variables. If the lag length for one or more variables is under–specified, the coefficient estimates will be biased. The technique used here attempts to avoid this problem by allowing the lag for each variable to differ. In particular, Akiake's final prediction error (FPE) criterion is used to specify the lag length for all right–hand side variables. According to Hsiao (1981, p. 88), the FPE criterion is ". . . appealing because it balances the risk due to the bias when a lower order is selected and the risk due to the increase of variance when a higher order is selected."

After transformation of the variables to achieve stationarity, the first step in the procedure described above is the determination of the own lag length for the interest rate. This is done by varying the lag in the autoregression of the interest rate on its own lagged values from 1 to n where n = highest order lag.[6] The FPE is computed for each lag, and the lag length that minimizes the FPE is selected as the order of the own lag for the interest rate.[7] Bivariate equations are next estimated in which the interest rate is regressed on its own lagged values with the lag length fixed at the previously determined order and on lagged values of the other variables (considered one at a time). The FPE is calculated for each lag, and the lag length that minimizes the FPE is selected as the lag order for that variable.[8]

The next step is the estimation of trivariate equations involving the lagged values of the interest rate and lagged values of two of the other variables under consideration. A problem emerges at this point since the specification of the equation within which the Granger–causality testing will be performed is not, in general, invariant to the order in which the variables are added to the equation. A particular criterion—the specific gravity criterion of Caines, Keng, and Sethi (1981)—is used to determine the order in which the non-interest rate variables are added to the equation. The specific gravity of the interest rate with respect to, for example, inflation is defined as the reciprocal of the FPE in the bivariate interest rate–inflation equation. The specific gravities of the interest rate with respect to the other variables are defined analogously. These variables are ranked in order of increasing specific gravity. The variable with the highest specific gravity is added to the interest rate equation with the lag order from the relevant bivariate equation.

Trivariate equations for the remaining variables are estimated, the FPEs are calculated, and the variables are ranked in order of their specific gravities. The variable with the highest specific gravity is added to the equation, and the procedure continues until all the variables are added to the equation. The end result is four equations; the results at each step of this procedure are summarized in

[6]An n = 15 was predetermined for the specification of the own lag length for the interest rate and for the bivariate equations discussed later in the text. For all subsequent equations, an n = 10 quarters was predetermined since preliminary results suggested lags substantially shorter than 15 quarters.

[7]The FPE is defined for lag k, $k = 1, \ldots, n$, as $\text{FPE}(k) = [(T + k + 1)/(T - k - 1)][\text{SSR}(k)/T]$ where T = number of observations used in estimating the auto-regression and SSR = sum of squared residuals. As Judge *et al.* (1982) note, an intuitive reason for using the FPE is that an increase in the lag length increases the first term but reduces the second term and these opposing forces are balanced when their product reaches a minimum.

[8]The FPE for the bivariate equation is defined for lag l, $l = 1, \ldots, n$, as $\text{FPE}(k,l) = [(T + k + l + 1)/(T - k - l - 1)][\text{SSR}(k,l)/T]$.

TABLE 1[a]. *Specification of the Interest Rate Equation*

	FPE
1. Univariate Equation	
$i(6)$	0.019441
2. Bivariate Equations	
$i(6),m(12)$	0.017682
$i(6),p(3)$	0.017887
$i(6),s(2)$	0.017897
$i(6),v(1)$	0.017975
$i(6),g(1)$	0.018061
$i(6),n(1)$	0.019364
$i(6),f(1)$	0.019537
$i(6),d(1)$	0.019780
$i(6),c(1)$	0.019792
3. Trivariate Equations	
$i(6),m(12),v(7)$	0.015214
$i(6),m(12),s(2)$	0.016244
$i(6),m(12),p(6)$	0.017305
$i(6),m(12),f(1)$	0.017406
$i(6),m(12),g(1)$	0.017508
$i(6),m(12),c(1)$	0.017772
$i(6),m(12),d(1)$	0.017813
$i(6),m(12),n(1)$	0.018007
4. Four Variable Equations	
$i(6),m(12),v(7),s(2)$	0.014605
$i(6),m(12),v(7),g(1)$	0.014822
$i(6),m(12),v(7),n(6)$	0.015194

$i(6),m(12),v(7),p(3)$	0.015277
$i(6),m(12),v(7),d(7)$	0.015369
$i(6),m(12),v(7),f(1)$	0.015465
$i(6),m(12),v(7),c(1)$	0.015496
5. Five Variable Equations	FPE
$i(6),m(12),v(7),s(2),p(6)$	0.014126
$i(6),m(12),v(7),s(2),g(1)$	0.014425
$i(6),m(12),v(7),s(2),n(8)$	0.014451
$i(6),m(12),v(7),s(2),d(7)$	0.014630
$i(6),m(12),v(7),s(2),c(6)$	0.014811
$i(6),m(12),v(7),s(2),f(1)$	0.014840
6. Six Variable Equations	
$i(6),m(12),v(7),s(2),p(6),g(1)$	0.013952
$i(6),m(12),v(7),s(2),p(6),n(8)$	0.014062
$i(6),m(12),v(7),s(2),p(6),d(2)$	0.014176
$i(6),m(12),v(7),s(2),p(6),c(1)$	0.014355
$i(6),m(12),v(7),s(2),p(6),f(1)$	0.014361
7. Seven Variable Equations	
$i(6),m(12),v(7),s(2),p(6),g(1),n(8)$	0.014113
$i(6),m(12),v(7),s(2),p(6),g(1),d(1)$	0.014184
$i(6),m(12),v(7),s(2),p(6),g(1),f(1)$	0.014193
$i(6),m(12),v(7),s(2),p(6),g(1),c(1)$	0.014212

NOTE: [a]The variables are defined as: i = interest rate, m = money supply, v = interest rate volatility, s = supply shock, p = inflation rate, g = output gap, n = national income accounts deficit, d = change in the market value of government debt, f = flow-of-funds deficit, and c = cyclically-adjusted deficit. Data transformations for each variable are given in the text. Lag lengths are in parentheses beside each variable.

Table 1. F–tests of the joint significance of the lagged values for each variable can now be performed within the context of these equations.

3. Empirical Results

The results from the specification of the interest rate equations are presented in this section as are the results of the Granger–causality tests. The equations are estimated using quarterly data over the period 1957:*i*–1984:*iv*. The start of the sample periods reflects the necessity of examining relatively long lag lengths in specifying the interest rate equations (lag lengths of 15 quarters were examined in specifying the own lag length for the interest rate and in the bivariate equations) and the desire to avoid using any pre–Treasury–Fed Accord data. Beginning the regressions in 1957:*i* allows several years transition from the Accord and sufficient data to still compute lags of 15 quarters. Ending the sample in 1984:*iv* allows the inclusion of recent experience with very large deficits. The equations are also specified over the period 1957:*i*–1979:*iii* to see if inclusion of the post–October, 1979 data have any influence on the causality results.

The following equations were specified and estimated using ordinary least squares:

$$i_t = a_{0,1} + a_{1,1}^{6}(L)i_t + a_{2,1}^{12}(L)m_t + a_{3,1}^{2}(L)s_t + a_4^{1}(L)g_t + a_{5,1}^{6}(L)p_t + a_{6,1}^{7}(L)v_t + a_{7,1}^{1}(L)f_t + e_{1t} \qquad (1)$$

$\bar{R}^2 = 0.588 \qquad SE = 0.104 \qquad Q(30) = 17.78$

$$i_t = a_{0,2} + a_{1,2}^{6}(L)i_t + a_{2,2}^{12}(L)m_t + a_{3,2}^{2}(L)s_t + a_{4,2}^{1}(L)g_t + a_{5,2}^{6}(L)p_t + a_{6,2}^{7}(L)v_t + a_{7,2}^{8}(L)n_t + e_{2t} \qquad (2)$$

$\bar{R}^2 = 0.609 \qquad SE = 0.101 \qquad Q(30) = 14.38$

$$i_t = a_{0,3} + a_{1,3}^{6}(L)i_t + a_{2,3}^{12}(L)m_t + a_{3,3}^{2}(L)s_t + a_{4,3}^{1}(L)g_t + a_{5,3}^{6}(L)p_t + a_{6,3}^{7}(L)v_t + a_{7,3}^{1}(L)c_t + e_{3t} \qquad (3)$$

$\bar{R}^2 = 0.587 \qquad SE = 0.104 \qquad Q(30) = 17.67$

$$i_t = a_{0,4} + a_{1,4}^{6}(L)i_t + a_{2,4}^{12}(L)m_t + a_{3,4}^{2}(L)s_t + a_{4,4}^{1}(L)g_t$$

$$+ a_{5,4}^{6}(L)p_t + a_{6,4}^{7}(L)v_t + a_{7,4}^{1}(L)d_t + e_{4t} \quad (4)$$

$$\bar{R}^2 = 0.588 \qquad SE = 0.104 \qquad Q(30) = 17.56$$

where SE = standard error of the regression, $i_t = (1 - L)ln\ RTB_t$, $m_t = (1 - L)\dot{M}1_t$, $s_t = (1 - L)(\dot{IP}/\dot{P})_t$, $g_t = (1 - L)[(RY_t - RYP_t)/RYP_t)]$, $p_t = (1 - L)\dot{P}_t$, $v_t = (1 - L)SRTB_t$, $f_t = (1 - L)(FFB_t/NYP_t)$, $n_t = (1 - L)(SURN_t/NYP_t)$, $c_t = (1 - L)(CSUR_t/NYP_t)$, $d_t = (1 - L)(DRMV_t/RYP_t)$, L = lag operator, RTB = three–month Treasury bill rate, $\dot{M}1$ = growth rate of $M1$ ((1 − $L)lnM1$), $\dot{IP}$ = rate of change in the import price deflator ((1 − $L)ln$ import price deflator), $\dot{P}$ = inflation rate ((1 − $L)ln$ implicit GNP deflator (IPD)), RY = real GNP, RYP = real potential GNP, $SRTB$ = standard deviation of the change in the log of RTB, FFB = flow–of–funds borrowing by the federal government, $SURN$ = national income and product accounts surplus, $CSUR$ = cyclically–adjusted deficit, $DRMV$ = change in real market value (last month of quarter) of privately held federal debt, and NYP = nominal potential GNP constructed by multiplying IPD times RYP. The first difference operator was applied to all series to transform them to stationary series. A regression of these transformed series on a constant and time yielded insignificant coefficients on time while similar regressions of the untransformed series indicated the presence of trend. Box–Pierce Q–statistics (lag = 30) were computed from the residuals of Equations (1)–(4), and no evidence of serial correlation was found.

The results of the Granger–causality tests using Equations (1)–(4) are presented in Table 2. We note that in every case the hypothesis (A.6, B.6, C.6, D.6) that the deficit measure does not Granger–cause the interest rate cannot be rejected. When the effects of money growth, inflation, the output gap, interest rate volatility, and supply shocks are controlled for, it does not appear that deficits have a significant effect upon interest rates. In all cases, the hypotheses that (a) money growth does not Granger–cause the interest rate (A.1, B.1, C.1, D.1), (b) supply shocks do not Granger–cause the interest rate (A.2, B.2, C.2, D.2), and (c) interest rate volatility does not Granger–cause the interest rate (A.5, B.5, C.5, D.5) are all rejected. For the inflation rate, hypothesis B.4 is rejected only at the 10% level; in all other cases the hypotheses A.4, C.4, and D.4 are rejected at the 7% level. For the output gap

TABLE 2. *Multivariate Granger–Causality Tests (Sample Period: 1957:i–1984:iv)*

A. Equation 1 (Deficit Measure = f)		B. Equation 2 (Deficit Measure = n)	
Hypothesis[a]	F–Statistic[b]	Hypothesis	F–Statistic
1. $a^{12}_{2,1}(L) = 0$	2.53 (12,76) [0.01]	1. $a^{12}_{2,2}(L) = 0$	2.04 (12,69) [0.03]
2. $a^{2}_{3,1}(L) = 0$	4.21 (2,76) [0.02]	2. $a^{2}_{3,2}(L) = 0$	4.82 (2,69) [0.01]
3. $a^{1}_{4,1}(L) = 0$	2.44 (1,76) [0.12]	3. $a^{1}_{4,2}(L) = 0$	1.20 (1,69) [0.28]
4. $a^{6}_{5,1}(L) = 0$	2.06 (6,76) [0.07]	4. $a^{6}_{5,2}(L) = 0$	1.84 (6,69) [0.10]
5. $a^{7}_{6,1}(L) = 0$	2.28 (7,76) [0.04]	5. $a^{7}_{6,2}(L) = 0$	3.02 (7,69) [0.01]
6. $a^{1}_{7,1}(L) = 0$	0.21 (1,76) [0.65]	6. $a^{8}_{7,2}(L) = 0$	1.41 (8,69) [0.21]
C. Equation 3 (Deficit Measure = c)		**D. Equation 4 (Deficit Measure = d)**	
Hypothesis	F–Statistic	Hypothesis	F–Statistic
1. $a^{12}_{2,3}(L) = 0$	2.51 (12,76) [0.01]	1. $a^{12}_{2,4}(L) = 0$	2.47 (12,76) [0.01]
2. $a^{2}_{3,3}(L) = 0$	4.21 (2,76) [0.02]	2. $a^{2}_{3,4}(L) = 0$	4.30 (2,76) [0.02]
3. $a^{1}_{4,3}(L) = 0$	2.31 (1,76) [0.13]	3. $a^{1}_{4,4}(L) = 0$	2.46 (1,76) [0.12]
4. $a^{6}_{5,3}(L) = 0$	2.07 (6,76) [0.07]	4. $a^{6}_{5,4}(L) = 0$	2.05 (6,76) [0.07]
5. $a^{7}_{6,3,}(L) = 0$	2.37 (7,76) [0.03]	5. $a^{7}_{6,4}(L) = 0$	2.59 (7,76) [0.02]
6. $a^{1}_{7,3}(L) = 0$	0.11 (1,76) [0.74]	6. $a^{1}_{7,4}(L) = 0$	0.26 (1,76) [0.61]

[a]For each equation the last hypothesis is the deficit measure does not Granger–cause the interest rate (RTB). The remaining hypotheses are (1) $M1$ does not Granger–cause RTB, (2) supply shocks do not Granger–cause RTB, (3) the output gap does not Granger–cause RTB, (4) inflation does not Granger–cause RTB, and (5) interest rate volatility does not Granger–cause RTB.

[b]The degrees of freedom for the F–tests are in parentheses beside the calculated F–statistic. The significance levels of the F–statistics are in brackets beside the degrees of freedom.

variables, hypotheses A.3, C.3, and D.3 are rejected at approximately the 10% level while hypothesis B.3 is not rejected.[9,10] Finally, Equations (1)–(4) are reduced form equations, and, as such, it is difficult to interpret their coefficients. The coefficients are, however, presented in Table 3.

One possible explanation of why the deficit measures did not Granger–cause the interest rate is that the monetary authority took

[9]The interest rate and money stock data used in the tests reported in Table 2 are quarterly averages of monthly data. The interest rate studies cited earlier employed quarterly averaged data. In a recent empirical study conducted within the framework of the efficient markets model, Mishkin (1981) employed end–of–quarter data and reported substantially worse fits for his equations when quarterly averaged data wère employed. In order to determine the sensitivity of the results reported in Table 2 to the use of quarterly averaged data, in preliminary work, the Granger–causality tests were redone using end–of–quarter data for the interest rate and the money supply. However, the Granger–causality results were essentially identical to those reported in the text.

[10]The tests reported in Table 2 are based on equations in which only lagged values of the deficit measures appear. These results thus provide no evidence on any contemporaneous relation between interest rates and the deficit measures. The presence of a contemporaneous relation was tested by reestimating Equations (1)–(4) with the contemporaneous deficit included along with the lagged deficit measures. *F*–tests indicated that the coefficients on the contemporaneous deficit terms were not significantly different from zero and that the contemporaneous and lagged deficit terms were not statistically significant.

TABLE 3. *Coefficient Estimates*[a]

	Equation 1	*Equation 2*	*Equation 3*	*Equation 4*
constant	0.001(0.07)	0.007(0.52)	0.001(0.06)	0.002(0.20)
$i(t-1)$	0.189(1.78)	0.249(2.22)	0.183(1.74)	0.173(1.63)
$i(t-2)$	−0.601(5.17)	−0.672(5.74)	−0.579(5.18)	−0.564(4.78)
$i(t-3)$	0.220(1.73)	0.238(1.81)	0.212(1.71)	0.189(1.51)
$i(t-4)$	−0.075(0.59)	−0.106(0.81)	−0.070(0.56)	−0.063(0.50)
$i(t-5)$	0.131(1.05)	0.046(0.36)	0.134(1.07)	0.125(1.00)
$i(t-6)$	−0.218(1.76)	−0.190(1.48)	−0.224(1.83)	−0.235(1.92)
$m(t-1)$	0.769(0.41)	0.441(0.23)	0.907(0.48)	0.596(0.31)
$m(t-2)$	5.421(2.22)	5.175(2.08)	5.400(2.20)	5.027(2.05)
$m(t-3)$	10.199(3.62)	9.491(3.19)	10.174(3.58)	9.704(3.42)

TABLE 3. *Coefficient Estimates*[a] *(cont'd)*

	Equation 1	Equation 2	Equation 3	Equation 4
$m(t-4)$	9.231(2.98)	8.403(2.48)	9.188(2.96)	9.769(2.81)
$m(t-5)$	8.305(2.40)	8.349(2.20)	8.069(2.39)	7.431(2.16)
$m(t-6)$	9.520(3.03)	9.278(2.49)	9.439(3.01)	9.061(2.92)
$m(t-7)$	9.808(3.36)	10.563(2.94)	9.794(3.33)	9.372(3.23)
$m(t-8)$	9.746(3.43)	9.654(2.82)	9.612(3.42)	9.174(3.26)
$m(t-9)$	7.862(2.95)	7.698(2.45)	7.852(2.95)	7.853(2.95)
$m(t-10)$	9.308(3.73)	7.840(2.72)	9.282(3.72)	9.241(3.70)
$m(t-11)$	9.235(3.96)	8.780(3.48)	9.260(3.98)	9.313(4.00)
$m(t-12)$	7.098(3.71)	6.741(3.39)	7.035(3.68)	7.034(3.68)
$s(t-1)$	0.011(2.37)	0.013(2.79)	0.012(2.47)	0.012(2.51)
$s(t-2)$	0.011(2.31)	0.011(2.22)	0.011(2.29)	0.011(2.29)
$g(t-1)$	2.037(1.56)	1.521(1.10)	2.000(1.52)	2.045(1.57)
$p(t-1)$	6.357(1.94)	5.136(1.45)	6.778(2.02)	6.590(2.02)
$p(t-2)$	9.109(2.46)	10.562(2.59)	9.171(2.47)	9.213(2.48)
$p(t-3)$	7.119(1.87)	3.967(0.97)	6.950(1.81)	6.919(1.81)
$p(t-4)$	5.032(1.28)	3.298(0.80)	4.987(1.25)	5.415(1.37)
$p(t-5)$	7.724(2.05)	6.987(1.76)	7.552(1.98)	7.600(2.01)
$p(t-6)$	6.013(1.81)	4.812(1.38)	5.978(1.80)	6.018(1.81)
$v(t-1)$	0.998(3.17)	1.033(3.18)	1.026(3.38)	1.070(3.54)
$v(t-2)$	0.090(0.31)	−0.108(0.35)	0.085(0.29)	0.053(0.18)
$v(t-3)$	−0.120(0.42)	0.158(0.51)	−0.120(0.42)	−0.139(0.49)
$v(t-4)$	0.427(1.68)	0.479(1.71)	0.413(1.60)	0.427(1.68)
$v(t-5)$	0.111(0.43)	−0.043(0.15)	0.133(0.52)	0.145(0.56)
$v(t-6)$	0.371(1.58)	0.658(2.59)	0.366(1.55)	0.377(1.60)
$v(t-7)$	−0.160(0.68)	−0.180(0.73)	−0.172(0.73)	−0.180(0.77)
$def(t-1)$	0.374(0.45)	2.017(0.93)	−0.649(0.33)	−0.833(0.51)
$def(t-2)$		−2.132(1.01)		
$def(t-3)$		1.581(0.77)		
$def(t-4)$		3.025(1.48)		
$def(t-5)$		−2.442(1.20)		
$def(t-6)$		3.011(1.50)		
$def(t-7)$		−.316(0.16)		
$def(t-8)$		3.409(1.78)		

[a]Absolute values of t-statistics are in parentheses beside the coefficient estimates. *def* represents the flow-of-funds deficit in Equation 1, the national income accounts deficit in Equation 2, the cyclically-adjusted deficit in Equation 3, and the change in the market value of government debt in Equation 4.

actions that substantially offset the effects of the deficits on interest rates. In fact, although the empirical evidence is not unanimous, many studies suggest a positive linkage between deficits and reserves, the monetary base, or *M*1 (see, for example, McMillin–Beard (1980), McMillin (1981), Hamburger–Zwick (1981), Levy (1981), and Allen–Smith (1983)). Based upon this empirical evidence, the test equations were respecified with money growth omitted. In order to conserve space, the respecified equations are not presented here, but are available upon request from the author. The results of the Granger–causality tests for the deficit variables are identical to those reported earlier, as are the results for supply shocks and the interest rate volatility measure. The hypotheses that inflation does not Granger–cause the interest rate and that the output gap does not Granger–cause the interest rate are rejected in all equations at the 1% and 3% levels, respectively.

Furthermore, when only data prior to the October, 1979 announcement by the Federal Reserve are used to specify the equations, the Granger–causality results for the deficit measures, money, supply shocks, and interest rate volatility measures are identical to those for the 1957:*i*–1984:*iv* period. The results are quite similar for the inflation variable; for the national income accounts deficit equation and the cyclically–adjusted deficit equation, the hypothesis that inflation does not Granger–cause the interest rate is rejected at the 8% level, and for the other two equations, the hypothesis is rejected at the 10% level. The hypothesis that the output gap does not Granger cause the interest rate is rejected for all equations at the 5% level. These results are available on request.

The stability of the equations over various subperiods of the sample was evaluated using Chow tests. The sample was first split into two subperiods of equal observations. Following Miller (1983) who argued that federal budget policy changed from a regime of approximate budget balance to one of persistent deficits in 1967, the stability of the equations was checked over the periods 1957:*i*–1966:*iv* and 1967:*i*–1984:*iv*. Finally, since deficits rose sharply following the first OPEC oil price hike, the stability of the equations over the periods 1957:*i*–1974:*iv* and 1975:*i*–1984:*iv* was also checked. Because of the number of parameters in the interest rate equations, the Chow test for undersize samples was applied in the latter two cases. The *F*–statistics are reported in Table 4. We see that none of the equations exhibited any coefficient instability over any of the subperiods considered.

TABLE 4. *Coefficient Stability Tests*[a]

Deficit Variable	Time Periods for Stability Tests 1957:i–1970:iv 1971:i–1984:iv	1957:i–1966:iv 1967:i–1984:iv	1957:i–1974:iv 1975:1–1984:iv
(a) Flow of Funds	0.81(36,40)[0.72]	1.01(40,36)[0.49]	1.17(40,36)[0.32]
(b) National Income Account	0.92(43,26)[0.61]	1.09(40,29)[0.42]	0.95(40,29)[0.56]
(c) Cyclically–Adjusted	0.82(36,40)[0.73]	1.02(40,36)[0.48]	1.18(40,36)[0.31]
(d) Change in Market Value of government debt	0.80(36,40)[0.75]	1.07(40,36)[0.42]	1.18(40,36)[0.31]

[a]The degrees of freedom for the *F*–tests are in parentheses beside the calculated *F*–statistic. The significance level of the test is in brackets.

4. Conclusion

This study has analyzed empirically the effects of federal deficits on short–term interest rates as measured by the three month Treasury bill rate. Multivariate Granger–causality tests are employed in the analysis. Four deficit measures—the national income accounts measure, a flow–of–funds measure, the cyclically–adjusted deficit, and a measure that more comprehensively accounts for the effects of inflation on the federal budget (the change in the real market value of privately held federal debt)—were separately considered. The additional variables used in the tests are those frequently suggested by theory as important determinants of interest rates and include money growth, supply shocks, inflation, interest rate volatility, and a measure of real output relative to capacity. Quarterly data for the period 1957:*i*–1984:*iv* are employed in the tests.

The multivariate Granger–causality tests suggest that none of the deficit measures Granger–cause the interest rate. These results are thus not supportive of the loanable funds prediction about the effects of deficits on interest rates; however, they are consistent with the Ricardian equivalence hypothesis and the portfolio approach to interest rate determination. Further distinction between these latter two hypotheses using the methods of this paper would be very difficult and is not attempted here.

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References

Allen, S.D. and M.D. Smith. "Government Borrowing and Monetary Accommodation." *Journal of Monetary Economics* 12 (Nov. 1983): 605–16.

Bailey, M.J. "The Optimal Full–Employment Surplus." *Journal of Political Economy* 80 (July/August 1972): 649–61.

Barro, R.J. "Are Government Bonds Net Wealth?" *Journal of Political Economy* 82 (Nov./Dec. 1974): 1095–1117.

———. "Unanticipated Money Growth and Unemployment in the United States." *American Economic Review* 67 (March 1977): 101–15.

———. "Comment from an Unreconstructed Ricardian." *Journal of Monetary Economics* 4 (August 1978): 569–81.

Barth, J., R. Sickles and P. Wiest. "Assessing the Impact of Varying Economic Conditions on Federal Reserve Behavior." *Journal of Macroeconomics* 4 (Winter 1982): 47–70.

Blinder, A.S. "On the Monetization of Deficits." National Bureau of Economic Research Working Paper No. 1092 (Dec. 1982).

Brunner, K. "Deficits, Interest Rates and Monetary Policy." In *Shadow Open Market Committee Policy Statement and Position Papers* (March 1984): 13–28.

Caines, P.E., C.W. Keng, and S.P. Sethi. "Causality Analysis and Multivariate Autoregressive Modelling with an Application to Supermarket Sales Analysis." *Journal of Economic Dynamics and Control* 3 (August 1981): 267–98.

Congressional Budget Office. *The Economic Outlook* (Feb. 1984), Appendix A (Deficits and Interest Rates: Empirical Findings and Selected Bibliography): 99–102.

Cox, W.M. "The Behavior of Treasury Securities; Monthly, 1942–1984." *Journal of Monetary Economics* 16 (Sept. 1985): 227–50.

Dewald, W.G. "Disentangling Monetary and Fiscal Policy." Federal Reserve Bank of San Francisco *Economic Review* (Winter 1982): 7–18.

Dwyer, G.P., Jr. "Inflation and Government Deficits." *Economic Inquiry* 20 (July 1982): 315–29.

Eisner, R. and P.J. Pieper, "A New View of Federal Debt and Budget Deficits." *American Economic Review* 74 (March 1984): 11–29.

Evans, P. "The Effects on Output of Money Growth and Interest Rate Volatility in the United States." *Journal of Political Economy* 92 (April 1984): 204–22.

———. "Do Large Deficits Produce High Interest Rates?" *American Economic Review* 75 (March 1985): 68–87.

Friedman, B.M. "Federal Reserve Policy, Interest Rate Volatility, and the U.S. Capital Raising Mechanism." *Journal of Money, Credit and Banking* 14 (Nov. 1982) Part 2: 721–45.

Froyen, R.T. "A Test of the Endogeneity of Monetary Policy." *Journal of Econometrics* 2 (July 1974): 175–88.

Geweke, J., R. Meese, and W.T. Dent. "Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence." *Journal of Econometrics* 21 (Feb. 1983): 161–94.

Gordon, R.J. "World Inflation and Monetary Accommodation in Eight Countries." *Brookings Papers on Economic Activity* 2 (1977): 409–68.

Granger, C.W.J. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." *Econometrica* 37 (July 1969): 424–38.

Hamburger, M.J. and B. Zwick. "Deficits, Money and Inflation." *Journal of Monetary Economics* 7 (Jan. 1981): 141–50.

Hoelscher, G.P. "Federal Borrowing and Short Term Interest Rates." *Southern Economic Journal* 50 (Oct. 1983): 319–33.

Hsiao, C. "Autoregressive Modelling and Money–Income Causality Detection." *Journal of Monetary Economics* 7 (Jan. 1981): 85–106.

Judge, G.G., R.C. Hill, W. Griffiths, H. Lutkepohl, and T.C. Lee. *An Introduction to the Theory and Practice of Econometrics.* New York: John Wiley and Sons, 1982: 713–14.

Levy, M.D. "Factors Affecting Monetary Policy in an Era of Inflation." *Journal of Monetary Economics* 8 (Nov. 1981): 351–73.

Lutkepohl, H. "Non–Causality Due to Omitted Variables." *Journal of Econometrics* 19 (Aug. 1982): 367–78.

Makin, J.H. "Real Interest, Money Surprises, Anticipated Inflation and Fiscal Deficits." *Review of Economics and Statistics* 65 (August 1983): 374–84.

——— and V. Tanzi. "The Level and Volatility of Interest Rates in the United States: The Role of Expected Inflation, Real Rates, and Taxes." National Bureau of Economic Research, Working Paper No. 1167, July 1983.

McMillin, W.D. "A Dynamic Analysis of the Impact of Fiscal Policy on the Money Supply." *Journal of Money, Credit and Banking* 13 (May 1981): 221–26.

——— and T.R. Beard. "The Short–Run Impact of Fiscal Policy on the Money Supply." *Southern Economic Journal* 47 (July 1980): 122–35.

——————. "Deficits, Money and Inflation: Comment." *Journal of Monetary Economics* 10 (Sept. 1982): 273–77.

Miller, P. "Higher Deficit Policies Lead to Higher Inflation." Federal Reserve Bank of Minneapolis *Quarterly Review* 7 (Winter 1983): 8–19.

Mishkin, F.S. "Monetary Policy and Long–Term Interest Rates: An Efficient Markets Approach." *Journal of Monetary Economics* 7 (Jan. 1981): 29–55.

Mullineaux, D.J. "Inflation Expectations and Money Growth in the United States." *American Economic Review* 70 (March 1980): 149–61.

Niskanen, W.A. "Deficits, Government Spending, and Inflation." *Journal of Monetary Economics* 4 (August 1978): 591–602.

Peek, J. and J.A. Wilcox. "The Postwar Stability of the Fisher Effect." *Journal of Finance* 38 (Sept. 1983): 1111–24.

Plosser, C.I. "Government Financing Decisions and Asset Returns." *Journal of Monetary Economics* 9 (May 1982): 325–52.

Siegel, J.J. "Inflation Induced Distortions in Government and Private Saving Statistics." *Review of Economics and Statistics* 61 (Feb. 1979): 83–90.

Sims, C.A. "Money, Income and Causality." *American Economic Review* 62 (Sept. 1972): 540–52.

U.S. Treasury Department, Office of the Assistant Secretary for Economic Policy. *The Effects of Deficits on Prices of Financial Assets: Theory and Evidence*, March 1984.

Wilcox, J.A. "Why Real Interest Rates Were So Low in the 1970s." *American Economic Review* 73 (March 1983): 44–53.

Zellner, A. "Causality and Econometrics." In *Three Aspects of Policy and Policy-Making: Knowledge, Data, and Institutions*. K. Brunner and A. Meltzer, eds. Amsterdam: North–Holland, 1979: 9–54.