Government borrowing and tax-adjusted real and nominal interest rates

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Abstract:
The purpose of this paper is to test for the effect of Federal Government budget deficits on one-year tax-adjusted nominal and real interest rates in an IS-LM-AS model. The results suggest that the specification of the dependent variable is a crucial issue in the debate over the linkage between deficits and interest rates, The evidence shows a positive and significant effect of various measures of the Federal Government deficit and debt on the real tax-adjusted Treasury bill rate in both the levels and the first-differenced equations but not on the nominal tax-adjusted rate. The positive and significant deficit-debt coefficients are also confirmed when the first-differenced equation is estimated by instrumental variables and when the equation is estimated over various time periods. Thus, there is robust evidence of a positive linkage between federal government borrowing and the tax-adjusted real but not nominal interest rates.

Article:

I. INTRODUCTION

The size of the Fisher effect and the related issue of the variation in the real interest rate has often been debated on the basis of a single equation estimation of a nominal interest rate equation derived from a macroeconomic model. Besides the varying effect on real rates from inflationary expectations, movements in the real interest rate have been explained by the inclusion of such variables as a supply shock, inflation uncertainty, the Mundell (1963) and Tobin (1965) real balance effect, monetary and fiscal policy variables, and a marginal tax rate in an IS-LM-AS macro-economic model.[1]

Recent empirical work has investigated the influence of monetary policy on real interest rates. Clarida and Fried-man (1983, 1984) have suggested that the low growth of real balances resulting from the Federal Reserve's shifts in monetary policy have been a contributing factor to the high level of short-term nominal interest rates in the early 1980s, Huizinga and Mishkin (1984, 1986) and Walsh (1987) have argued that the change in the operating procedures of the Federal Reserve have resulted in statistically significant shifts in the stochastic process of real interest rates. Peek and Wilcox (1987) include a monetary policy reaction function parameter in their model and report improved out-of-sample forecasts of the nominal interest rate during the first half of the 1980s. Therefore, shifts in monetary policy have been found to affect both real and nominal interest rates in the early 1980s.

The effect of fiscal policy and federal budget deficits on real interest rates is subject to considerable debate. Evidence of a positive linkage between deficits and nominal interest rates is presented by Barth *et al.* (1985), Feldstein (1986), deLeeuw and Holloway (1985), Zahid (1988) and Holloway (1988).[2] However, there is accumulating evidence supporting the Ricardian equivalence proposition that budget deficits have no effect on real or nominal interest rates. Plosser (1982, 1987) has investigated the response of asset prices to monetary and fiscal policy changes in an efficient capital market model. He tests for the effect of unanticipated changes in both fiscal and monetary policy and finds no significant relationship between unanticipated changes in the deficit and changes in asset prices during the holding period. Evans (1985) provides evidence that there is no positive and significant relationship between deficits and nominal and real ex-post interest rates. Evans (1987a) reinforces this conclusion by showing that past and expected budget deficits have no effect on nominal or ex-post interest rates. Finally, Evans (1987b) shows that there is no positive effect on nominal interest rates from unanticipated deficits in six countries.[3]

The purpose of this paper is to investigate the effect of federal government budget deficits on one year tax-adjusted yields on Treasury bills. In order to investigate the linkage between federal deficits and interest rates a government budget constraint is included in an IS-LM-AS model previously employed by Sargent (1973) and Makin (1983) and developed in Section II. Nominal and real tax-adjusted interest rate equations are derived from the model in order to test for the effect of unanticipated monetary growth, federal budget deficits, inflationary expectations, inflation uncertainty, and export demand on interest rates within the context of a Keynesian model.[4]

The results reported in Section III show that measures of the budget deficit have a negative and significant coefficient when a tax-adjusted nominal interest rate is estimated as the dependent variable. These results are consistent with the observed inverse relationship between nominal interest rates and the budget deficit over the business cycle. The deficit measures, however, are shown to have a positive and significant coefficient when a tax-adjusted real interest rate is estimated as the dependent variable for both log-level and first-difference specifications. These results are also robust to the estimated sample period and are consistent with the theoretical relationship of both loanable funds and portfolio stock adjustment models. Concluding remarks are presented in Section IV.

II. THE MODEL

The model is an extension of Makin's IS-LM-AS model with the addition of a government budget constraint. The real sector of the economy is modelled by the following equations where non-income induced expenditures are written as

$$I_t = \alpha_0 - \alpha_1 r_t^e - \alpha_2 V_\Pi + \alpha_3 EX_t + \alpha_4 G_t + e_{It} \, (\alpha_i > 0) \qquad (1)$$

where I_t is the log of total, real non-income induced expenditures, r_t^e is the ex-ante, after-tax real interest rate, V_Π, is a measure of inflation uncertainty in period t,G_t is the log of real government purchases, EX_t is the log of real exports and e_{it} are normally distributed, zero-mean error terms for equations numbered one to six. An increase in inflation uncertainty will increase the uncertainty of the present value of the future stream of earnings from investment projects which will reduce investments and the real interest rate.

Equation 2 models the sum of savings and imports as

$$S_t = \delta_0 + \delta_1 y_t - \delta_2 (m_t - p_t) - \delta_3 V_\Pi + e_{2t} (\delta_i > 0) \qquad (2)$$

where S_t is the log of real total savings and imports, y_t is the log of real GNP, and (m_t - p_t) is real money balances (m_t is the log of M_1 and p_t is the log of the GNP deflator). An increase in V_Π, where inflation uncertainty may be a measure of risk, will cause risk-averse savers to increase the real return from savings necessary to maintain the same flow of funds. Therefore, the inflation uncertainty variable will have an ambiguous effect in the model. An increase in V_Π both depresses investment and the real interest rate while increasing risk requiring a higher real interest rate to attract the same level of savings. The increase in risk resulting from an increase in the uncertainty of inflation rates and volatility of interest rates may be a cause for the higher level of real interest rates in the early 1980s.

Equation 3 models tax revenue as

$$T_t = \xi_0 + \xi_1 y_t + e_{3t} \, (\xi_1 > 0) \qquad (3)$$

where T_t is the log of the total net tax revenue. The log of the total income-induced non-expenditure on domestic output (Z_t) is the sum of Equations 2 and 3:

$$Z_t = S_t + T_t \qquad (4)$$

A simple budget constraint can be written as

$$\Delta B_t = G_t - T_t = G_t - \xi_0 - \xi_1 y_t - e_{3t} \qquad (5)$$

where ΔB_t is the change in the outstanding stock of nominal government debt.

Real sector equilibrium is determined by substituting Equations 2 and 3 into Equation 4, equating Equations 1 and 4, and substituting into Equation 5 in order to obtain Equation 6 which is written in inverse form so that r_t^e becomes the dependent variable:

$$r_t^e = y_0 + y_1 y_t + y_2(m_t - p_t) + y_3 \Delta B_t + y_4 EX_t + y_5 V_\Pi + u_t^5 \quad (6)$$

The monetary sector is modelled by the following LM equation:

$$m_t - p_t = \beta_0 + \beta_1 y_t - \beta_2 i(1 - \tau) + e_{4t}(\beta_i > 0) \quad (7)$$

where τ is the marginal tax rate and the opportunity cost variable is the tax-adjusted nominal short-term interest rate $i(1 - \tau)$.6 The tax-adjusted Fisher equation can be written as

$$i_t(1 - \tau) - \pi_t^e = r_t^e \quad (8)$$

where π_t^e is the expected rate of inflation.

The aggregate supply equation is a Lucas supply function that includes a distributed lag effect of unanticipated money growth on real GNP as a result of inventory adjustments or price stickiness (e.g. Blinder and Fischer, 1981):

$$y_t = y_{nt} + \sum_{i=0}^{n} \phi_I [m_{t-i} - E(m_{t-i})] + e_{5t}(\phi_i > 0) \quad (9)$$

where y_{nt} is the log of the full employment level of real GNP that is equal to $\theta_0 + \theta_1 TT$ (TT is a time trend). The monetary surprise designated below as m_i^u is unanticipated money growth $[(m_{t-i} - E(m_{t-i})]$.

The IS-LM-AS model can be solved by substituting Equation 8 into Equation 7 and then substituting Equations 7 and 9 into Equation 6 to yield:

$$r_t^e = \psi_0 + \psi_1\theta_1 TT + \psi_1 \sum_{i=o}^{n} \phi_i m_i^u - \psi_2 \pi_t^e + \psi_3 EX_t + \psi_4 \Delta B_t + \psi_5 V_\Pi + v_t^7 \quad (10)$$

Substituting Equation 10 into the Fisher Equation 8 and setting $i^* = i_t(1 - \tau)$ yields a nominal interest rate equation of the form

$$i^* = \psi_0 + \psi_1\theta_1 TT + \psi_1 \sum_{i=o}^{n} \phi_i m_i^u + (1 - \psi_2)\pi_t^e + \psi_3 EX_t + \psi_4 \Delta B_t + \psi_5 V_\Pi + v_t \quad (11)$$

Tax-adjusted nominal interest rates are positively related to exports which is a measure of exogenous demand and a fiscal policy variable which is a measure of deficit spending. The coefficient for inflationary uncertainty isembiguous and the coefficient for inflationary expectations $(1 - \psi_2)$ is less than one. The effect of the monetary surprise in the contemporaneous and lagged periods is ambiguous. On one hand, monetary shocks will increase real income which will lead to increased savings and a lower real interest rate. On the other hand, monetary shocks will increase real income which leads to an increased demand for real balances and a higher real interest rate. While a negative liquidity effect has often been documented by empirical work, Mishkin (1981, 1982), Melvin (1983) and Mehra (1985) have found evidence of a vanishing liquidity effect.

The ex-ante tax-adjusted interest rate (r_t^e) is unobservable, but following Mishkin (1981) and Huizinga and Mishkin, r_t^e can be decomposed into

$$r_t^e = i_t^e(1 - \tau) - \pi_t^e \quad (12)$$

where i_t^e is the expected nominal interest rate during period t. The ex-post tax-adjusted real interest rate epr_t *is*

$$epr_t = i_t(1 - \tau) - \pi_t \quad (13)$$

where π_t is the actual inflation rate.

Following Mishkin and Huizinga and Mishkin substitute Equation 12 into Equation 13, so that the ex-post tax-adjusted real interest rate can be written as

$$epr_t = r_t^e + \varepsilon_{1t} + \varepsilon_{2t} \quad (14)$$

where $\varepsilon_{1t} = i_t - i_t^e$ and $\varepsilon_{2t} = \pi_t - \pi_t^e$ are forecasting errors and small changes in τ are assumed to be perfectly forecasted to simplify the analysis. Assuming the rationality of expectations, the forecast errors are uncorrelated with the information set (Φ_t available to economic agents at the beginning of period t for forecasting, Therefore

$$E(\varepsilon_{1t} \mid \Phi_t) = E(\varepsilon_{2t} \mid \Phi_t) = 0 \quad (15)$$

and epr_t denoted as r_t^* can serve as an unbiased estimate of the ex-ante tax-adjusted interest rate, r_t^e.

Equation 11 can be substituted into Equation 13 where π_t, is measured by the first-difference of the log of the GNP deflator and π_t is assumed to be equal to π_t^e to obtain Equation 16:

$$r^* = \psi_0 + \psi_1\theta_1 TT + \psi_1\sum_{i=o}^{n} \phi_i m_i^u - \psi_2\pi_t^e + \psi_3 EX + \psi_4\Delta B_t + \psi_5 V_\Pi + v_t \quad (16)$$

where r* is the real ex-post tax-adjusted interest rate.[8,9]

Table 1. *Equation 11: tax-adjusted nominal interest rate*

Deficit	α	T	D	m_0^u	m_1^u	m_2^u	π^e	EX	V_Π	R^2/SE	DW/ρ
ND	3.33	−0.01	−0.03	−5.22	1.27	−2.78	0.11	0.02	0.002	0.53	1.84
	(1.69)	(0.48)	(2.28)	(0.58)	(0.13)	(0.27)	(0.88)	(4.14)	(0.14)	0.68	0.72
RD	3.70	−0.02	−0.02	−5.26	1.51	−5.30	0.12	0.02	0.001	0.52	1.80
	(1.89)	(0.67)	(1.92)	(0.57)	(0.16)	(0.53)	(0.90)	(3.97)	(0.12)	0.69	0.72
ADEF	3.35	−0.01	−0.01	−6.72	1.08	−12.38	0.14	0.02	−0.003	0.52	1.83
	(1.65)	(0.45)	(1.77)	(0.74)	(0.11)	(1.24)	(1.11)	(4.18)	(0.27)	0.69	0.72
TDEBT	13.00	−0.07	−0.14	−7.61	1.70	−11.75	0.18	0.03	−0.001	0.58	1.83
	(3.01)	(2.30)	(2.26)	(0.83)	(0.17)	(1.19)	(1.42)	(4.82)	(0.59)	0.69	0.68

t-statistics are in parentheses.
ND = the change in the seasonally adjusted net federal debt.
RD = the change in the deflated value of the seasonally adjusted net federal debt.
ADEF = deLeuuw and Holloway's cyclically adjusted measure of the deficit.
TDEBT = the stock of the national debt divided by potential nominal GNP

Ex-post real interest rate equations have been estimated by Huizinga and Mishkin (1984, 1986), but they do not derive their equation from a structural model and do not adjust for taxes. The present macroeconomic model suggests that both a nominal tax-adjusted and an ex-post real tax-adjusted interest rate (Equations 11 and 16) can be estimated to test for the effect of unanticipated monetary growth and budget deficits together with the effect of inflationary expectations, inflation uncertainty and exports on interest rates.

III. THE RESULTS

Equations 11 and 16 are estimated with the dependent variable being the tax-adjusted nominal one year yield *(i*)* and the ex-post tax-adjusted real one year yield (*r**). The term m_i^u is the error term from estimating $E(m_{t-i})$ by an (0,1,1) ARIMA model based on an in-sample forecast. Similar empirical results occur if the (0,1,1) A RIM A model is employed to forecast one-period ahead out-of-sample values of m_{t-i} in order to generate the forecast errors, m_i^u. The inflationary expectations (π^e) variable and the variance of the expected rate of inflation (V_Π) are from the Survey Research Center of the University of Michigan. The *EX* variable is real exports from the NIPA accounts.

According to the model, the measure of ΔB_t is the nominal value of the federal deficit in period *t.* The appropriate measure of ΔB_t, however, is subject to considerable debate. First, the deficit variable is counter-cyclical which requires that the exogenous portion of the deficit be tested. Second, Dwyer (1982) and Eisner and Pieper (1984) have argued that the correct measure of the deficit should adjust the deficit by a change in the real value of the outstanding stock of government debt resulting from price level and interest rate effects.[10] Finally, the deficit is a flow variable but it may be the size of the stock of the national debt relative to GNP that influences interest rates. As a result, various measures of the federal deficit and debt are tested.

The basic deficit measure implied by the model is the change in the seasonally adjusted net federal debt *(ND).* In addition, the change in the deflated value of *ND (ND/P,* where *P* is the GNP deflator) denoted as RD and the change in the par value of the seasonally-adjusted net federal debt *(ND)* divided by potential nominal GNP denoted as *TD* are tested.[11] Because ΔB_t is endogenous and subject to the cyclical variations in the economy, deLeuuw and Holloway (1986) have constructed a mid-cycle deficit and debt series that is exogenous to the business cycle. Therefore, the cyclically adjusted measure of the deficit *(ADEF)*, the cyclically-adjusted measure of the deficit divided by the GNP deflator *(RADEF),* and the cyclically adjusted measure of the deficit divided by potential nominal GNP *(TADEF)* are also tested.

Two measures of the stock of the national debt are also tested besides these flow variables. These variables are the stock of the national debt divided by potential nominal GNP *(TDEBT)* and the cyclically adjusted stock of the debt divided by potential nominal GNP *(TADEBT).*[12] All of these measures of the deficit and debt are tested but only the significant results are reported.

Equations 11 and 16 are corrected for autocorrelation by the Beach—MacKinnon (1978) technique for the 1962/I-84/IV period. The results for the tax-adjusted one year nominal yield (i*) presented in Table I reveal that the deficit or debt coefficient is negative and significant at the 5% level for four different measures.[13] These measures include three flow variables: the change in the seasonally adjusted net federal debt *(ND)*, the change in the seasonally adjusted real net federal debt *(RD)*, and the cyclically adjusted deficit *(ADEF)*; and one stock variable: the stock of federal debt deflated by potential nominal GNP *(TDEBT)*. Endogenous measures of the deficit such as *ND* and *RD* are countercyclical and vary inversely with interest rates which will cause the deficit coefficient to be downwardly biased.

Table 2. *Equation 16: ex-post tax-adjusted real interest rate*

Deficit	α	T	D	m_0^u	m_1^u	m_2^u	π^e	EX	V_Π	R^2/SE	DW/ρ
RD	6.23	−0.08	0.05	−10.72	−12.52	−65.66	0.28	0.03	−0.08	0.49	2.00
	(2.92)	(2.82)	(2.08)	(0.45)	(0.53)	(2.59)	(0.87)	(5.39)	(2.67)	1.69	0.22
TD	6.47	−0.08	106.12	−8.32	−12.84	−63.32	0.22	0.03	−0.08	0.48	2.00
	(2.88)	(2.67)	(1.72)	(0.34)	(0.54)	(2.48)	(0.68)	(5.42)	(2.62)	1.71	0.23
ADEF	6.43	−0.08	0.02	0.95	−6.99	−43.74	0.08	0.03	−0.06	0.51	1.97
	(2.98)	(2.79)	(1.74)	(0.04)	(0.30)	(1.73)	(0.28)	(4.75)	(1.98)	1.70	0.18
TDEBT	−5.76	−0.00	0.17	1.91	−11.24	−47.94	−0.00	0.02	−0.05	0.50	1.98
	(0.89)	(0.03)	(1.74)	(0.08)	(0.48)	(1.93)	(0.01)	(2.60)	(1.58)	1.70	0.19
TADEBT	−17.93	0.04	0.42	7.79	−8.28	−36.11	−0.26	0.02	−0.02	0.57	1.94
	(2.51)	(0.98)	(3.30)	(0.35)	(0.37)	(1.50)	(0.89)	(3.27)	(0.50)	1.63	0.15

t-statistics are in parentheses.
RD = the change in the deflated value of the seasonally adjusted net federal debt.
TD = the change in the par value of the seasonally adjusted net federal debt divided by potential GNP.
ADEF = deLeuuw and Holloway's cyclically adjusted measure of the deficit.
TDEBT = the stock of the national debt divided by potential nominal GNP.
TADEBT = deLeuuw and Holloway's cyclically adjusted measure of the deficit divided by potential GNP.

Makin employs the export variable as an exogenous measure of aggregate demand which is found to be positive and significant. There is no evidence that the monetary surprise coefficients are significant. The π^e coefficient is not significantly different from zero indicating no adjustment of the tax-adjusted nominal short-term interest to inflationary expectations. This evidence is counter to the Fisher hypo-thesis. The constant term, which is the underlying ex-post tax-adjusted real interest rate, ranges between three and four in three of the equations and is significant at the 5% level for a one-tailed test.

The sign and significance of the deficit variable is reversed when the ex-post tax-adjusted real interest rate equation is estimated.[14] The results of estimating Equation 16 are shown in Table 2.[15] Five measures of the deficit are positive and significant at the 5% level of significance for a one-tailed test, These measures include three flow variables: the change in the real seasonally adjusted net federal debt *(RD)*, the change in the seasonally adjusted net federal debt divided by potential nominal GNP *(TD)*, and the cyclically adjusted deficit *(ADEF)*; and two stocks of debt variables: the stock of federal debt *(TADEBT)* and the stock of cyclically adjusted national debt *(TADEBT)* where both measures are divided by potential nominal GNP. The coefficient estimates for *RD*, *ADEF* and *TDEBT* are positive and significant in the ex-post tax-adjusted real interest rate equation rather than negative and significant as reported in the tax-adjusted nominal interest rate equation. Two of the deficit/debt measures — *ADEF* and *TADEBT*—are exogenous and are not subject to simultaneous equations bias.

The results show that the export coefficient remains positive and significant. The third lagged monetary coefficient is negative and significant, though the first and second period lagged coefficients are never significant. The inflation uncertainty (V_Π) coefficient is negative and significant when a deficit rather than a debt variable is estimated. Makin reported negative and significant V_Π coefficients in half of his reported equations, The π^e coefficient is insignificant which is expected given that the dependent variable is the ex-post tax-adjusted real rate. Thus, there is no indication that there is an inverted Fisher effect as found by Carmichael and Stebbing (1983) and Summers (1983) when Equation 16 is estimated.

These nominal and real interest rate results suggest that the specification of the dependent variable is a critical issue in the debate over the linkage between deficits and interest rates. As a diagnostic check of the model (e.g.

Plosser *et al.,* 1982), Equations 11 and 16 are first-differenced and then estimated by OLS. Only one deficit measure is negative and significant in the first-difference version of the tax-adjusted nominal interest rate equation (results are not reported). Six of the different deficit and debt measures are positive and significant at the 5% level for a one-tailed test in the first-difference version of the ex-post tax-adjusted real interest rate equation. These results are reported in the top half of Table 3. Three of the six deficit/debt measures — *RADEF, TADEF* and *TADEBT— are* exogenous and significant which provides further confirmation of a positive linkage between government borrowing and real interest rates.

Table 3. *First-difference of Equation 16*

Deficit	α	D	m_0^u	m_1^u	m_2^u	π^e	EX	V_Π	SE	DW
OLS results										
RD	−0.27	0.08	27.69	5.82	−40.20	−0.10	0.07	0.01	2.01	2.53
	(1.22)	(3.06)	(1.17)	(0.22)	(1.40)	(0.28)	(2.86)	(0.18)		
TD	−0.25	210.42	27.35	4.41	−37.02	−0.11	0.07	0.01	2.00	2.53
	(1.14)	(3.38)	(1.19)	(0.17)	(1.33)	(0.30)	(2.78)	(0.22)		
RADEF	−0.27	0.03	32.46	4.01	−16.68	−0.18	0.07	0.02	2.07	2.49
	(1.15)	(2.06)	(1.49)	(0.16)	(0.61)	(0.48)	(2.53)	(0.57)		
TADEF	−0.24	0.72	33.01	4.02	−16.57	−0.19	0.06	0.02	2.08	2.49
	(1.07)	(1.90)	(1.52)	(0.16)	(0.62)	(0.51)	(2.51)	(0.58)		
TDEBT	−0.22	0.91	28.07	3.04	−34.60	−0.18	0.07	0.01	2.08	2.59
	(0.98)	(1.72)	(1.21)	(0.13)	(1.22)	(0.50)	(2.65)	(0.36)		
TADEBT	−0.22	1.17	25.15	2.41	−38.69	−0.15	0.06	0.01	2.05	2.62
	(0.98)	(2.01)	(1.12)	(0.10)	(1.38)	(0.42)	(2.57)	(0.29)		
Instrumental variables results										
RD	−0.39	0.14	69.65	32.75	−8.68	−0.83	0.10	0.10	2.24	2.28
	(1.64)	(2.90)	(1.88)	(1.08)	(0.22)	(1.35)	(2.75)	(1.41)		
TD	−0.35	374.75	75.86	33.21	1.99	−0.90	0.09	0.11	2.22	2.28
	(1.47)	(3.11)	(2.01)	(1.10)	(0.05)	(1.48)	(2.71)	(1.51)		
RADEF	−0.38	0.06	53.08	15.17	25.53	−0.72	0.08	0.11	2.22	2.26
	(1.42)	(1.72)	(1.46)	(0.49)	(0.78)	(0.98)	(2.42)	(1.68)		
TADEF	−0.34	1.66	53.68	15.55	26.69	−0.72	0.07	0.11	2.24	2.24
	(1.32)	(1.72)	(1.51)	(0.51)	(0.81)	(0.96)	(2.37)	(1.67)		

t-statistics in parentheses.
RD = the change in the deflated value of the seasonally adjusted net federal debt.
TD = the change in the par value of the seasonally adjusted net federal debt divided by potential GNP.
RADEF = deLeuuw and Holloway's cyclically adjusted measure of the deficit divided by the GNP deflator.
TADEF = deLeuuw and Holloway's cyclically adjusted measure of the deficit divided by potential GNP.
TDEBT = the stock of the national debt divided by potential nominal GNP.
TADEBT = deLeuuw and Holloway's cyclically adjusted measure of the deficit divided by potential GNP.

The results confirm the positive and significant coefficients of four deficit variables, *RD*, *TD*, *RADEF* and *TADEF,* and two stock variables, *TDEBT* and *TADEBT.* Four of these measures are significant in both the level and first-difference form (Tables 2 and 3) of Equation 16: *RD, TD, TDEBT,* and *TADEBT* The export coefficient remains positive and significant but the *V,* and monetary surprise coefficients become insignificant in the first-difference results. Thus, only the deficit and export coefficients maintain their statistical significance in both the levels and first-difference versions of Equation 16.

The first-difference of Equation 16 is estimated by instrumental variables with the assumption that exports, *EX*, is the only exogenous variable. In addition to the first-difference of *EX* and a constant, the one to three period lag of the first-difference of the endogenous right-hand-side variables and the dependent variable, the one to three period lag of the first-difference of the log of government purchases and the GNP deflator, the one and two period lag of the first-difference of *EX,* and a one period lag of the first-difference of the log of real GNP are employed as instruments.[16]

These results (bottom half of Table 3) again confirm the positive and significant relationship between four deficit measures, *RD*, *TD, RADEF,* and *TADEF* and real interest rates, Thus, the *RD* and *TD* coefficients are still positive and significant when they are instrumented to insure exogeneity. The two debt variables, however, did not have significant coefficients. The export coefficient is also positive and significant at the 5% level for a one-tailed test.

Table 4. *OLS estimates of deficit coefficients*

Period	*RD*	*TD*	*RADEF*	*TADEF*	*TDEBT*	*TADEBT*
1962/I–76/IV	0.09	218.02	0.03	0.77	1.05	1.28
	(2.97)	(3.03)	(2.34)	(1.83)	(2.18)	(2.40)
	[2.08]	[2.08]	[2.14]	[2.16]	[2.15]	[2.12]
1964/I–78/IV	0.10	241.99	0.05	1.20	1.26	1.50
	(3.45)	(3.29)	(3.89)	(3.36)	(2.30)	(2.52)
	[2.06]	[2.08]	[2.08]	[2.11]	[2.16]	[2.12]
1966/I–80/IV	0.09	205.62	0.05	1.39	0.65	0.96
	(2.62)	(2.25)	(4.77)	(4.47)	(1.33)	(1.68)
	[2.10]	[2.12]	[2.01]	[2.03]	[2.20]	[2.16]
1968/I–82/IV	0.07	207.10	0.03	1.01	0.55	0.91
	(2.55)	(2.58)	(2.56)	(2.74)	(0.98)	(1.37)
	[2.17]	[2.17]	[2.17]	[2.16]	[2.24]	[2.22]
1970/I–84/IV	0.06	195.58	0.03	1.04	2.45	3.37
	(2.02)	(2.21)	(2.34)	(2.62)	(2.78)	(4.03)
	[2.12]	[2.11]	[2.11]	[2.09]	[2.07]	[1.94]

t-statistics are in parentheses.
Standard errors of the regressions are in brackets.
See notes at the bottom of Table 3.

The robustness of the significance of the deficit coefficients to the estimation period can be demonstrated by estimating the first-difference of Equation 16 over a 15 year period that is rolled through time with the addition and deletion of a one year period. Thus, the first 15-year regression is for 1962/I-1976/IV and the last regression is for 1970/I— 1984/IV. The OLS coefficient estimates of each of the six deficit/debt measures that were significant in the first-difference form of Equation 16 is reported together with the deficit coefficient t-statistics in parentheses and the standard error of the regression in brackets.

The results reported in Table 4 for the periods ending in the even years from 1976-84 show that the four deficit coefficients *(RD, TD, RADEF* and *TADEF)* are consistently positive and significant at the 5°/0 level (except for one coefficient estimate).[17] The coefficient estimates of the debt variables *(TDEBT and TADEBT)* are not always significant and exhibit more volatility. The standard errors of the regression for each of the six deficit/debt measures do not exhibit any deterioration with the addition of data for the I980s. The results do show that the positive and significant linkage between deficits and ex-post tax-adjusted real interest rates are not a result of selective reporting of the sample period.

The stability of the coefficient estimates can be tested by the Chow (1960) test. The first-difference of Equation 16 is tested for a breakpoint for every break between 1970/I and 1974/IV for four different deficit measures: *RD, TD, RADEF* and *TADEF.* We fail to reject the null hypothesis of stability of the coefficient estimates because the F-statistic never exceeds the critical value of $F_{8,76}$ for a test at the 5% level of significance. This evidence is consistent with Makin who also fails to reject the null hypothesis of coefficient stability of his equation when the breakpoint was tested at 1969/IV-1970/I for the period 1959/II-1981/IV.

IV. CONCLUSIONS

The empirical evidence reveals a positive and significant linkage between various measures of government borrowing and an ex-post tax-adjusted real interest rate. The real interest results are not sensitive to the specification of the equation in level or first-difference form and are not sensitive to the estimation of the equation by OLS or instrumental variables. In addition, the coefficient estimates exhibit structural stability according to Chow tests. The results are not sensitive to the estimation period when various 15 year periods are estimated. Thus, there is evidence of a positive linkage between federal budget deficits and real interest rates through the shifts in monetary policy by the Federal Reserve in 1979 and 1982.

The empirical evidence cannot serve as a test of the Ricardian equivalence proposition because expected and unexpected components of current and future budget deficits are not tested. The empirical results do suggest that within the framework of a three equation Keynesian IS-LM-AS model there is empirical evidence for the theoretical proposition that deficit spending positively effects a real short-term ex-post tax-adjusted interest rate.

Notes:

[1] See Levi and Makin (1979), Tanzi (1980), Makin (1983), Peek (1982), Peek and Wilcox (1983, 1987), Wilcox (1983a, b, c), and Mehra (1984, 1985).

[2] Mascaro and Meltzer (1983) find no positive effect of debt financing on either a short- or long-term interest rate. Feldstein and Eckstein (1970) find evidence that real per-capita privately owned Federal government debt is positively related to the yield on AAA industrial bonds but these results suffer from autocorrelation. Walsh (1987) finds that including federal purchases of goods and services (but not the federal deficit) results in both fiscal and monetary policy contributing to the movement of real interest rates from 1979/IV to 1984/III.

[3] Makin and Tanzi (1984) find evidence of a positive and significant relationship between unanticipated deficits and the three month Treasury bill rate. Tran and Sawhney (1988) find a positive and significant relationship between the excess federal deficit over personal savings and the AAA corporate bond rate and the rate on ten-year treasury bonds.

[4] The paper does not test for Ricardian equivalence. Deficit-financed government spending can have a positive effect on real interest rates according to the Ricardian equivalence proposition whereas tax-induced spending will not have any effect. Hence evidence of a positive effect between deficits/debt and real interest rates presented in this paper does not refute the evidence presented by Evans, Plosser and others. Testing the Ricardian equivalence proposition with measures of government purchases and measures of the deficit/debt that are positive and significant represents future research.

[5] The coefficients are as follows: $y_0 = (\alpha_0 - \delta_0)/\alpha_1$, $y_1 = -(\delta_1/\alpha_1)$, $y_2 = \delta_2/\alpha_1$, $y_3 = \alpha_3/\alpha_1$, $y_4 = \alpha_4/\alpha_1$, $y_5 = (\delta_3 + \alpha_2)/\alpha_1$, and $u_t = (e_{1t} - e_{2t})/\alpha_1$ where $y_{1,2,3,4} > 0$, y_5 is ambiguous and $\Delta B_t = G_t - \xi_0 - \xi_1 y_t - e_{3t}$.

[6] The tax rate (τ) is Seater's (1985, Table 1) annual average marginal federal personal income tax on adjusted gross income centred on the third quarter and interpolated for the other quarters. The data for 1981-1984 (the most recent year data are available) are computed by the author,

[7] The coefficients are as follows: $Z = 1/(1 + y_2\beta_2) > 0$; $K = (y_1 + y_2\beta_1)$ is indeterminant; $\psi_0 = (y_0 + y_2\beta_0 + K0_0)Z$, $\psi_1 = KZ$, $\psi_2 = Zy_2\beta_2$, $\psi_3 = Zy_3$, $\psi_4 = Zy_4$, and $\psi_5 = Zy_5$, where $\psi_{1,2,3,4} > 0$ and ψ_5 is ambiguous. The error term, v_t , is equal to $(u_t + y_2 e_{4t} + Ke_{5t})Z$.

[8] Blinder (1980) and Fischer (1981) discuss the biases of using the CPI to measure the inflation rate. Alternative measures of inflation have been employed by a number of authors. For example, Huizinga and Mishkin (1984) have tested ex-post real interest rate equations with alternative price indices. Hafer and Hein (1985) use the GNP deflator to compute the rate of inflation in their study of inflation forecasts. Clarida and Friedman (1984) use the growth of the GNP deflator as one of six variables in their vector autoregressive model. Mills and Stephenson (1987) argue that wholesale rather than retail prices which include mortgage payments and indirect taxes are a better measure of inflation for the United Kingdom.

[9] Allen (1989) has shown that the forecasts (π_t^e) are an unbiased estimate of the rate of inflation as measured by the GNP deflator. The π_t^e coefficient in Equation 16 is not constrained to be one because π_t^e enters as a right-hand-side variable.

[10] The Eisner and Pieper (1984) data series that make the interest rate and price level adjustments are available only on an annual basis and are not tested.

[11] The seasonally adjusted net par value of the federal debt is obtained from the St Louis Federal Reserve Bank. Potential nominal GNP is equal to the GNP deflator (base year = 1982) times potential real GNP (Gordon, 1984, Table A2). The Cox and Hirschhorn (1983, Table 5) data of the market value of gross federal debt *(CDEBT)* available through 1980 was employed to construct three other measures: the change in *CDEBT*, the change in the deflated value of *CDEBT*, and the change in CDEBT divided by potential nominal GNP. The Cox—Hirschhorn measures were never statistically significant.

[12] See deLeuuw and Holloway (1986), Table 3 for the cyclically adjusted measure of the deficit and Table 5 for the stock of the actual debt and the cyclically adjusted stock of debt.

[13] These same deficit coefficients are negative and significant if the dependent variable is the nominal one year treasury bill rate.

[14] The Goldfeld—Quandt (1965) test reveals heteroskedastic errors for Equation 11 where the dependent variable is *i** as the null hypothesis of constant variance of the error terms is rejected. The F-statistic is always greater than two for each of the equations estimated in Table 1 where the critical value for $F_{35, 35}$ is 1.76 at the 5% level of significance. The null hypothesis is not rejected for Equation 16 because the F-statistic is less than 1.1 for each of the equations estimated in Table 2.
[15] The lag length of the monetary surprise can vary from zero to four without affecting the significance of the reported deficit coefficients in Table 2.
[16] The instrumental variables meet the necessary condition that they are uncorrelated with the error terms. The errors from the OLS estimation of the first-difference of Equation 16 were regressed against the instrumental variables and no t-statistic of any individual coefficient estimate is greater than 1.96. Second the F-statistics are 1.73 *(RD),* 1.59 *(TD),* 1.67 *(RADEF),* and 1.65 *(TADEF).* The critical value for $F_{25,66}$ is 1.68 at the 5% level and 2.03 at the I % level. We fail to reject the null hypothesis that the coefficient estimates of the instruments are equal to zero at the 1% level and at the 5% level for the *TD, RADEF* and *TADEF* measures of the deficit.
[17] The deficit coefficients for these four variables are also significant for the 15 year estimates ending in the odd-numbered years that are not reported. If instrumental variables are employed, the coefficient estimates of these four deficit measures are positive and significant for a one-tailed test at the 5% level except in one case.

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