On the Nominal Interest rate Yield Response to Net Government Borrowing in the U.S.: An Empirical Analysis with Robustness Tests

Alexander, Gigi and Foley, Maggie

Jacksonville University, Jacksonville University

11 June 2014

On the Nominal Interest Rate Yield Response to Net Government Borrowing in the U.S.: An Empirical Analysis with Robustness Tests

Gigi Alexander & Maggie Foley

Abstract.
This study provides current empirical evidence on the impact of net U.S. government borrowing (budget deficits) on the *nominal* interest rate yield on ten-year Treasury notes. The model includes an *ex ante* real short-term real interest rate yield, an *ex ante* real long-term interest rate yield, the monetary base as a percent of GDP, expected future inflation, the percentage growth rate of real GDP, net financial capital inflows, and other variables. This study uses annual data and then uses quarterly data for the periods 1971-2008 and 1971-2012. Autoregressive two-stage least squares estimates imply that the federal budget deficit, expressed as a percent of GDP, exercises a positive and statistically significant impact on the nominal interest rate yield on ten-year Treasury notes. Robustness tests are provided in an Appendix.

Keywords nominal interest rate; ten-year U.S. Treasury note yield; budget deficits

JEL Classification codes E43, E52, E62

1 Introduction

The interest rate impact of central government budget deficits has been studied extensively. Studies of this topic have assumed a wide variety of models, techniques, and study periods (Al-Saji, 1992, 1993; Barth, Iden and Russek, 1984, 1985, 1986; Barth, Iden, Russek, and Wohar, 1989; Cebula, 1997B, 2005; Cebula and Cuellar, 2010; Cukierman and Meltzer, 1989; Feldstein and Eckstein, 1970; Findlay, 1990; Gale and Orszag, 2003; Hoelscher, 1983, 1986; Holloway, 1988; Johnson, 1992; Kiani, 2009; Ostrosky, 1990; Tanzi, 1985; Zahid, 1988). Many of these studies find that budget deficits raise longer-term rates of interest while not significantly affecting short-term, i.e., under one year from issuance to date of maturity, rates of interest. Since capital formation is presumably much more affected by longer-term than by short-term interest rates, the inference has often been made that government budget deficits may lead to "crowding out" (Carlson and Spencer, 1975; Cebula, 1985).

This interest rate/deficit literature has focused typically upon the yields on U.S. Treasury bills, U.S, Treasury notes, and U.S. Treasury bonds, as well as yields on Moody's Aaa-rated and Baa-rated corporate bonds. The yield on tax-free bonds has been examined, arguably in part because of its potential impact on income tax evasion (Cebula, 1997A, 2004). In recent years, however, the impact of budget deficits on interest rate yields has received very only limited attention in the scholarly literature. Accordingly, this study provides current evidence as to the effect of the federal budget deficit on the yield on intermediate-term debt issues of the U.S. Treasury, namely, the nominal interest rate yield on ten-year Treasury notes.

In particular, first using annual and then using quarterly data, this study investigates two periods, 1971 through 2008, and 1971 through 2012, in the pursuit of providing *contemporary* insights into whether federal budget deficits have in fact elevated intermediate-term interest rate yields in the U.S. We begin with 1971 because in August of 1971 the U.S. abandoned the Bretton Woods agreement, i.e., abandoned the convertibility of the U.S. dollar for gold, thereby bringing the Bretton Woods system to a *de facto* end (Cebula, 1997B). Ending the first study period with 2008 makes this study relatively current and hence pertinent. Moreover, ending the first study with the year 2008 can be regarded as appropriate if for no other reason because it was only in late November of 2008 that the Federal Reserve shifted from its traditional open market operations and initiated its "quantitative easing" policies. Indeed, the first of these quantitative easing policies, QE (1), involved significant and unprecedented Federal Reserve purchases of mortgage-backed securities, which by June, 2010 had totaled $2.1 trillion. In November of 2010, another stage of quantitative easing, QE (2), began and resulted in $600 billion of such purchases. Finally, beginning in September of 2012, stage QE (3) began, initially involving $40 billion per month of such purchases and escalating to $85 billion per month thereof as of December, 2012. Thus, the second study period includes not only the entire initial study period but also four full years during which the U.S. economy experienced both quantitative easing *and* huge (relative to GDP) federal budget deficits. By separately estimating the model for (and examining the findings for) these two study periods, we can engage in at least some degree of isolation of the quantitative easing policies and their possible effects (along with the large federal budget deficits that accompanied these new monetary policies) to provide at least preliminary insights into the following question: "What has been the impact of budget deficits on intermediate-term interest rates in the U.S. over the last 40 years?"

Section 2 of this study provides the basic framework for the empirical analysis, an open-economy loanable funds model reflecting dimensions of the works of Barth, Iden and Russek (1984; 1985; 1986), Barth, Iden, Russek, and Wohar (1989), Hoelscher (1986), Koch (1994), Cebula (2005), Cebula and Cuellar (2010), and others. Section 3 defines the specific variables in the empirical model and describes the data *initially* used, which is annual. Section 4 provides the empirical results of autoregressive, two stage least squares estimations using annual data for the periods 1971-2008 and 1971-2012, whereas section 5 provides the empirical results of autoregressive, two stage least squares estimations of the basic model (using quarterly data *and* a different measure of expected future inflation variable) for the periods 1971.1-2008.4 and 1971.1-2012.4. An overview of the study findings can be found in Section 6. ARCH (Autoregressive Conditional Heterskedasticity) estimates are provided in the Appendix as robustness tests.

2 The Model

In developing the underlying framework for the empirical analysis, we first consider the following inter-temporal government budget constraint:

$$ND_{t+1} = ND_t + G_t + F_t + AR_tND_t - T_t \quad (1)$$

where:

ND_{t+1} = the national debt in period t+1

ND_t = the national debt in period t

G_t = government purchases in period t

F_t = government non-interest transfer payments in period t

AR_t = average effective interest rate on the national debt in period t

T_t = government tax and other revenues in period t

The *total* government budget deficit in period t (TD_t), which is the deficit measured considered in this study, is simply the difference between ND_{t+1} and ND_t:

$$TD_t = ND_{t+1} - ND_t = G_t + F_t + AR_tND_t - T_t \quad (2)$$

Based extensively on Barth, Iden, and Russek (1984; 1985; 1986), Barth, Iden, Russek, and

Wohar (1989), and Hoelscher (1986), as well as Koch (1994), Cebula (1997; 2005), and Cebula and Cuellar (2010), this study seeks to identify determinants of the nominal interest rate yield on ten-year U.S. Treasury notes, including the impact of the federal budget deficit on same. To do so, a loanable funds model is adopted in which the nominal intermediate-term (in this study, ten-year) interest rate yield is, assuming all other bond markets are in equilibrium, determined by an equilibrium of the following form:

$$D + MY = TDY - NCIY \tag{3}$$

where:

D = private domestic demand for ten-year U.S. Treasury notes

MY = the monetary base, expressed as a percent of real GDP, adopted as a measure of the available potential domestic money supply

TDY = net government borrowing, measured by the federal budget deficit (as above), expressed as a percent of real GDP

NCIY = net financial capital inflows, expressed as a percent of real GDP

In this framework, it is hypothesized that:

D = D (RTEN, Y, EARSTBR, EARLTBR, PE),

$$D_{RTEN} > 0,\ D_{Y} > 0,\ D_{EARSTBR} < 0,\ D_{EARLTBR} < 0,\ D_{PE} < 0 \tag{4}$$

where:

RTEN = the interest rate yield on ten-year U.S. Treasury notes

Y = the percentage growth rate of real GDP

EARSTBR = the *ex ante* real interest rate yield on high quality (and hence close-substitute) short-term bonds

EARLTBR = the *ex ante* real interest rate yield on high quality (and hence close-substitute) long-term bonds

PE = the currently expected percentage future inflation rate, i.e., for the upcoming period

Following the conventional wisdom, it is expected that the demand for ten-year Treasury notes is an increasing function of the yield on those notes, RTEN (Barth, Iden, and Russek, 1984; 1985; 1986; Hoelscher, 1986; Koch, 1994; Cebula and Cuellar, 2010). Next, it is hypothesized that the greater the percent growth rate of real GDP (Y), the higher the demand for ten-year Treasury notes, *ceteris paribus*, since such a circumstance more rapidly increases the potential pool of funds available for purchasing those notes (Hoelscher, 1986; Cebula, 2005). It is further hypothesized that, paralleling Barth, Iden, and Russek (1984; 1985), Cebula (1997B; 2005), Hoelscher (1986), and Koch (1994), the real domestic demand for ten-year Treasury notes is a decreasing function of the *ex ante* real short-term rate, which in this case is the *ex ante* real three-month Treasury bill rate. In other words, as EARSTBR increases, *ceteris paribus*, bond demanders/buyers at the margin substitute shorter-term issues for longer-term issues in their portfolios. Similarly, it is hypothesized that, in principle paralleling Barth, Iden, and Russek (1984; 1985), Cebula (1997B; 2005), and Hoelscher (1986), the demand for ten-year Treasury notes is a decreasing function of one or more alternative high quality long-term interest rate yields, in this case represented by the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds (EARLTBR), *ceteris paribus*. Finally, according to the conventional wisdom, the private demand for intermediate-term bonds, such as ten-year Treasury notes, is a decreasing function of expected inflation (PE), *ceteris paribus* (Barth, Iden, and Russek, 1984; 1985; 1986; Hoelscher, 1983; 1986; Ostrosky, 1990; Koch (1994); Gissey (1999); Cebula, 2005; Kiani, 2009; Cebula and Cuellar, 2010).

Substituting equation (4) into equation (3) and solving for RTEN yields:

$$RTEN = f\,(TDY, MY, EARSTBR, EARLTBR, Y, PE, NCIY) \qquad (5)$$

where it is hypothesized that:

$$f_{TDY} > 0,\ f_{MY} < 0\ f_{EARSTBR} > 0,\ f_{EARLTBR} > 0,\ f_{Y} > 0,\ f_{PE} > 0,\ f_{NCIY} < 0 \qquad (6)$$

The first of these expected signs is positive to reflect the conventional wisdom that when the government attempts to finance a budget deficit, it forces interest rate yields upwards as it competes with the private sector to attract funds from the financial markets, *ceteris paribus*. The expected sign on the money supply variable (MY) is negative because the greater the available money supply relative to GDP, the greater the offset to debt issues, i.e., greater money supply availability presumably helps to offset interest rate effects of budget deficits, *ceteris paribus*. It is noteworthy that the empirical results are effectively identical if the M2 measure of the money supply as a percentage of GDP is adopted in place of MY; nevertheless, the MY variable is adopted because it more directly reflects quantitative easy policies. The expected sign on the net capital inflows variable is negative because the greater the ratio of net capital inflows to GDP, the greater the extent to which these funds absorb domestic debt (Koch, 1994; Cebula and Belton, 1993; Cebula and Cuellar, 2010). The introduction of this variable into the model acknowledges the nature of the global economy and global financial markets. Finally, the expected signs on $f_{EARSTBR}$, $f_{EARLTBR}$, f_Y, and f_{PE} follow logically from equation (4).

3 Specification of the Variables

Given the presence of the expected inflation rate and two *ex ante* real interest rates as explanatory variables in the model, the first step in the analysis is to develop a useful empirical measurement of *expected inflation*. Indeed, this first step is necessary to the measurement of the variables EARSTBR, EARLTBR, and PE. The measurement of this variable is described by equation (7) below for the case of annual data; estimates based thereupon are provided in section 4 of this study. Section 5 of this study estimates the same basic model but it adopts a different measure of expected inflation (PE) and hence differently measured values for EARSTBR and EARLTBR as well.

Proceeding, one possible way to measure expected inflation is to adopt the well-known Livingston survey data. However, as observed by Swamy, Kolluri, and Singamsetti (1990, p. 1013), there may be serious problems with the Livingston series:

> Studies by some psychologists have shown that the heuristics people have available for forming expectations cannot be expected to automatically produce expectations that come anywhere close to satisfying the normative constraints on subjective probability judgments provided by the Bayesian theory…failure to obey these constraints makes Livingston…data incompatible with…stochastic law...

Accordingly, rather than using the Livingston series, the study adopts, for the estimates using annual data, a linear-weighted-average (LWA) specification involving actual current and past inflation (of the overall consumer price index, CPI) to construct the values for the *expected (future) inflation rate* in each period t, PE^{t+1}_{t}. In particular, to construct the values for the current year's (year t's) *expected future* (i.e., for next year, year t+1) inflation, the following approach is adopted (Cebula, 1992; Al-Saji, 1992; 1993; Koch, 1994):

$$PE^{t+1}_{t} = (3PA_t + 2PA_{t-1} + PA_{t-2})/6 \qquad (7)$$

where:

PA_t = the *actual* percentage inflation rate in the current year (t);

PA_{t-1} = the *actual* inflation rate in the previous year (t-1); and

PA_{t-2} = the *actua*l inflation rate in year t-2.

Clearly, this construct weights current inflation more heavily that previous period inflation in quantifying the inflationary *expectation* for the subsequent period. Given this measurement of expected future inflation, in the annual data model, variable $EARSTBR_t$ = the nominal interest rate yield on three-month Treasury bills in year t minus PE^{t+1}_{t}, while variable $EARLTBR_t$ = the nominal interest rate yield on Moody's Aaa-rated long-term corporate bonds in year t minus PE^{t+1}_{t}. Interestingly, before proceeding, despite its technical limitations, it is observed that adoption of the Livingston series in place of the formulation in equation (7) yields nearly identical results and the same overall conclusions as those obtained here.

In any case, based upon the framework expressed above, the autoregressive, two stage least squares (2SLS) estimation initially involves the following linear model:

$$RTEN_t = \alpha_0 + \alpha_1 TDY_t + \alpha_2 MY_t + \alpha_3 EARSTBR_t + \alpha_4 EARLTBR_t + \alpha_5 Y_{t-1} + \alpha_6 PE^{t+1}_t + \alpha_7 NCIY_{t-1} + \alpha_8 AR(1) + u_t \quad (8)$$

where:

$RTEN_t$ = the nominal average interest rate yield on ten-year U.S. Treasury notes in year t, expressed as a percent per annum;

α_0 = the constant term;

TDY_t = the ratio of the nominal federal budget deficit in year t to the nominal GDP in year t, expressed as a percent;

MY_t = the ratio of the monetary base in year t to the nominal GDP in year t, expressed as a percent;

$EARSTBR_t$ = the *ex ante* real average interest rate yield on three-month Treasury bills in year t, expressed as a percent annum;

EARLTBR = the *ex ante* real average interest rate yield on Moody's Aaa-rated long-term corporate bonds in year t, expressed as a percent per annum;

Y_{t-1} = the percentage growth rate of real GDP in year t-1;

PE^{t+1}_t = the expected future inflation rate of the CPI, i.e., for year t+1, as formulated in year t, expressed as a percent per annum;

$NCIY_{t-1}$ = the ratio of net financial capital inflows into the U.S. in year t-1, expressed as a percent of the GDP in year t-1;

AR(1) = autoregressive term; and

u_t = the stochastic error term.

The budget deficit is scaled by GDP, as are the monetary base and net capital inflows; this is because the sizes of the budget deficit, the monetary base, and net capital flows should be judged relative to the size of the economy (Hoelscher, 1986; Cebula, 1997B; 2005; Holloway, 1986; Ostrosky, 1990). The dependent variable in this system, $RTEN_t$, is expressed as contemporaneous with the budget deficit variable (TDY_t), as well as with the monetary base variable (MY_t), the expected future inflation variable ($PE^{t+1}{}_t$), the *ex ante* real three-month Treasury bill interest rate yield variable ($EARSTBR_t$), and the *ex ante* real interest rate yield on Moody's Aaa-rated long-term corporate bonds variable ($EARLTBR_t$). Given that the data are annual and given the fact that financial markets are quick-acting markets, such contemporaneous specifications are not uncommon in this literature (Hoelscher, 1986; Ostrosky, 1990; Koch, 1994; Cebula, 1997B; 2005; Cebula and Cuellar, 2010).

Given the contemporaneous components of the specification in equation (8), the possibility of simultaneity bias naturally arises, which in turn mandates the choosing of instrumental variables for each of the five right-hand side variables in question. The five instruments chosen were, as follows: the two-year lag of the annual civilian unemployment rate (UR_{t-2}) for TDY_t; the three-year lag of the *actual* annual inflation rate of the CPI (PA_{t-3}) for $PE^{t+1}{}_t$; the two-year lag of the Moody's

Baa-rated corporate bond interest rate yield (Baa_{t-2}) for MY_t; the two-year lag of the nominal six-month Treasury bill interest rate yield (SIX_{t-2}) for $EARSTBR_t$; and the two-year lag of the nominal average interest rate yield on new fixed-rate 30 year mortgages ($MORT_{t-2}$) for variable $EARLTBR_t$. The choice of instruments for these variables was based on the fact that in each case, the lagged instrument was highly correlated with the explanatory variable in question whereas the instruments in question were uncorrelated with the error terms in the system.

The real GDP growth rate variable, Y_{t-1}, and the net capital inflow variable, $NCIY_{t-1}$, are both lagged one period in order to avoid multicollinearity problems. The data for all of the variables in this analysis were obtained from the Council of Economic Advisors (2013, Tables B-1, B-2, B-35, B-42, B-64, B-71, B-73, B-79). For the interested reader, descriptive statistics for each of the variables expressed in equation (8) are provided in Table 1 for the both the 1971-2008 and 1971-2012 study periods. Finally, group unit-root testing reveals the variables in the model are stationary in levels.

4 Estimation Results with Annual Data: 1971-2008 and 1971-2012

In this section, empirical results are presented using annual data for two periods, 1971-2008 and 1971-2012. Estimations of the same model (using quarterly rather than annual data), except for a re-specified inflationary expectations variable and hence for re-specified EARSTBR and EARLTBR variables as well, are provided in section 5 of this study.

The 1971-2008 Period with Annual Data

The autoregressive 2SLS estimate of equation (8) is provided in column (a) of Table 2, where terms in parentheses are t-values. In column (a) of Table 1, all seven of the estimated coefficients on the explanatory variables exhibit the expected signs, with five of these seven coefficients being statistically significant at the 1% level, one being statistically significant at the 5% level, and one being statistically significant at the 10% level; only the coefficient on the Y_{t-1} variable fails to be statistically significant at the 10% level. Furthermore, as shown in Table 3, there is no indication of an autocorrelation problem.

In this estimate, the estimated coefficient on the monetary base *(de facto* available money supply) variable, MY_t, is negative, as expected, and statistically significant at the 1% level, implying that a higher ratio of the monetary base relative to GDP acts to reduce the nominal interest rate yield on ten-year U.S. Treasury notes. The estimated coefficient on the *ex ante* real short-term interest rate variable, $EARSTBR_t$, is positive, as hypothesized, and statistically significant at the 1% level, implying that the higher the *ex ante* real interest rate yield on three-month Treasury bills, the higher the nominal interest rate yield on ten-year notes. This finding presumably reflects competition between the ten-year Treasury note and counterpart short-term financial instruments. Similarly, the coefficient on the variable $EARLTBR_t$ is also positive, as hypothesized, and statistically significant at the 1% level, implying that the higher the *ex ante* real interest rate on long-term Moody's Aaa-rated corporate bonds, the higher the level of the nominal interest rate yield on ten-year Treasury notes, presumably because of competition between ten-year Treasury notes and long-term financial instruments. The estimated coefficient on the expected inflation variable, PE^{t+1}_t, is also positive, as expected (conventional wisdom), and statistically significant at the 1% level, implying that the higher the expected future inflation rate, the greater the nominal interest rate yield on ten-year Treasury bonds. Next, the estimated coefficient on the net capital inflows variable, $NCIY_{t-1}$, is negative, as expected and statistically significant at the 8% level, implying (albeit un-compellingly in this estimate) that such capital flows may act to absorb domestic debt and reduce the interest rate on that debt, i.e., on ten-year Treasury notes, in this case.

Finally, the estimated coefficient on the budget deficit variable is positive and statistically significant at the 1% level. Thus, it appears that after allowing for a variety of other factors, the higher the federal budget deficit (as a percent of GDP) the higher the nominal interest rate yield on intermediate-term, i.e., in this case, on ten-year U.S. Treasury notes. This finding is consistent with a variety of empirical studies of earlier periods, including Al-Saji (1992, 1993), Barth, Iden and Russek (1984, 1985, 1988), Barth, Iden, Russek, and Wohar (1989), Cebula (1997B), Cebula and Belton (1993), Cebula and Cuellar (2010), Findlay (1990), Gale and Orszag (2003), Gissey (1999), Hoelscher (1986), Johnson (1992), Kiani (2009), Tanzi (1985), and Zahid (1988).

To demonstrate the resiliency of these results showing that (among other things), in the U.S., federal budget deficits have exercised a positive impact on intermediate-term interest rates, we initially undertake two modestly different additional autoregressive 2SLS estimates. The first of these estimates is shown in column (b) of Table 2. In this estimate, the statistically insignificant variable Y_{t-1} has been deleted from the basic model. As shown in column (b), all six of the estimated coefficients exhibit the expected signs, with four of the six statistically significant at the 1% level and two statistically significant at the 5% level or beyond.

According to these results, the nominal interest rate yield on ten-year Treasury notes is a decreasing function of the monetary base as a percent of GDP (at the 2.5% statistical significance level) and the net capital inflows variable (at the 4% statistical significance level), while being an increasing function of expected inflation (at the 1% statistical significance level), the *ex ante* real three-month Treasury bill rate (at the 1% statistical significance level), and the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds (at the 1% statistical significance level). Clearly, these results are entirely consistent with those for the ten-year U.S. Treasury note yield found in column (a) of Table 2. Moreover, once again, the federal budget deficit, expressed as a percent of GDP, exercises a positive and statistically significant (at the 1% statistical significance level) impact on the nominal ten-year Treasury note yield.

In another demonstration of the resiliency of the basic model and its fundamental findings, we replace the variable Y_{t-1} with the variable CHPCRGDP, defined here as the change in per capita real GDP between the previous year (t-1) and the current year (t). This specification actually more closely follows that in Hoelscher (1986) than does the adopted initial variable, Y_{t-1}, the percentage change in per capita real GDP in year t-1. In any case, in column (c) of Table 2, the autoregressive, 2SLS estimate of the basic model with this substitution is provided.

In column (c) of Table 2, all seven of the estimated coefficients exhibit the hypothesized signs, with six being statistically significant at the 1% level and one being statistically significant at the 2% level. Thus, this estimation implies that the nominal interest rate yield on ten-year U.S. Treasury notes is a decreasing function of the monetary base as a percent of GDP (at the 1% statistical significance level) and the net capital inflows variable (at the 1% statistical significance level), while being an increasing function of expected inflation (at the 1% statistical significance level), the *ex ante* real three-month Treasury bill rate (at the 1% statistical significance level), the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds (at the 1% statistical significance level), the change in per capita real GDP (at the 2% statistical significance level), and-finally-the federal budget deficit as a percent of GDP (at the 1% statistical significance level). Clearly, these results are consistent with those for the ten-year U.S. Treasury note yield found in column (a) of Table 2.

In closing this sub-section of the study, it is noted that the basic model yields consistent results for variations of the basic model. Indeed, the specification shown in column (c) of Table 2 may yield the most robust results of all. In any event, the evidence would seem to clearly indicate that, among other things, the federal budget deficit in the U.S. exercised a positive and statistically significant impact upon the nominal ten-year Treasury note interest rate yield over the 1971-2008 study period. The following sub-section of this study investigates empirically whether this conclusion is reached for the longer period ending at the end of year 2012, during which quantitative easing as well as huge federal budget deficits (relative to GDP) were experienced in the U.S.

The 1971-2012 Period with Annual Data

In this sub-section of the study, we empirically investigate the impact of federal budget deficits over the 1971-2012 study period, a period in which (beginning in November, 2008) the Federal Reserve pursued a new policy initiative, i.e., quantitative easing, as briefly described in the Introduction to this study. In addition, the years 2009-2012 were periods of unusually high federal budget deficits relative to GDP (10.1%, 9.0%, 8.7%, and 7.8% for FY 2009, FY2010, FY2011, and FY 2012, respectively). In any case, the autoregressive 2SLS estimate of equation (8) for 1971-2012 is provided in column (a) of Table 4. In column (a) of Table 4, all seven of the estimated coefficients on the explanatory variables exhibit the expected signs, with four of these coefficients being statistically significant at the 1% level and one being statistically significant at the 5% level; the coefficients on the Y_{t-1} and $NCIY_{t-1}$ variables fail to be statistically significant at the 10% level. Once again, group unit-root testing reveals the variables in the model are stationary in levels. Finally, there is no indication of a multicollinearity problem with the model for the study period.

In this estimate for the 1971-2012 study period, the estimated coefficient on the monetary base *(de facto* available money supply) variable, MY_t, is negative and statistically significant at the 1% level, implying that a higher ratio of the monetary base relative to GDP acts to reduce the nominal interest rate yield on ten-year U.S. Treasury notes. The estimated coefficient on the *ex ante* real short-term interest rate variable, $EARSTBR_t$, is positive, as expected, and statistically significant at the 5% level, implying that the higher the *ex ante* real interest rate yield on three-month Treasury bills, the higher the nominal interest rate yield on ten-year Treasury notes. This finding conforms to the hypothesized relationship proffered in this study and presumably reflects competition between the ten-year Treasury note and shorter-term financial instruments. The coefficient on the variable $EARLTBR_t$ is also positive and statistically significant at the 1% level, implying that the higher the *ex ante* real interest rate on long-term Moody's Aaa-rated corporate bonds, the higher the level of nominal interest rate yield on ten-year Treasury notes, presumably also because of competition, in this case, between ten-year Treasury notes and longer-term financial instruments. The estimated coefficient on the expected inflation variable, $PE^{t+1}{}_t$, is also positive, as expected, and statistically significant at the 1% level, implying that the higher the expected inflation rate, the greater the nominal interest rate yield on ten-year Treasury notes.

Finally, the estimated coefficient on the budget deficit variable for the 1971-2012 study period is positive and statistically significant at the 1% level, with effectively the same size coefficient as was obtained for the 1971-2008 study period. Thus, it appears that after allowing for a variety of other factors, the higher the federal budget deficit (as a percent of GDP) the higher the nominal interest rate yield on intermediate-term, i.e., in this case, on ten-year U.S. Treasury notes. This finding for the period ending with 2012 is consistent not only with the results in columns (a), (b), and (c) of Table 2, but also with a host of empirical studies of earlier periods, including Al-Saji (1992, 1993), Barth, Iden and Russek (1984, 1985, 1988), Barth, Iden, Russek, and Wohar (1989), Cebula (1997B), Cebula and Belton (1993), Cebula and Cuellar (2010), Findlay (1990), Gale and Orszag (2003), Gissey (1999), Hoelscher (1986), Johnson (1992), Koch (1994), Kiani (2009), Tanzi (1985), and Zahid (1988).

Paralleling the procedure undertaken for Table 2 of this study for the 1971-2008 period, in order to demonstrate the resilience of the findings in column (a) of Table 4 showing that (among other things), in the U.S., federal budget deficits exercised a positive impact on intermediate-term interest rates for the 1971-2012 period, we provide two additional autoregressive 2SLS estimates. The first of these autoregressive 2SLS estimates is shown in column (b) of Table 4. In this estimate, the variable Y_{t-1} has been deleted from the basic model. As shown in column (b), all six of the estimated coefficients exhibit the expected signs, with four of the six statistically significant at the 1% level and two statistically significant at the 5% level.

Thus, according to these particular results, the nominal interest rate yield on ten-year Treasury notes is a decreasing function of the monetary base as a percent of GDP (at the 1% statistical significance level) and the net capital inflows variable (at the 5% statistical significance level), while being an increasing function of expected inflation (at the 1% statistical significance level), the *ex ante* real three-month Treasury bill rate (at the 5% statistical significance level), the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds (at the 1% statistical significance level), and the federal government budget deficit as a percent of GDP (at the 1% statistical significance level). Overall, these results are consistent with those for the ten-year U.S. Treasury note yield found in all three columns of Table 2 as well as column (a) of Table 4. Clearly, once again, the federal budget deficit, expressed as a percentage of GDP, is shown to exercise a positive impact on the nominal ten-year Treasury note yield.

In the second investigation of the basic model and its fundamental findings for the period 1971-2012, we replace the variable Y_{t-1} with the variable CHPCRGDP, defined here as above, namely, as the change in per capita real GDP between the previous year (t-1) and the current year (t). As observed earlier in this study, this specification actually more closely follows that in Hoelscher (1986) than does the adoption of our initial variable, Y_{t-1}. In any case, in column (c) of Table 4, the autoregressive, 2SLS estimate of the basic model with this substitution made is provided.

In column (c) of this Table, all seven of the estimated coefficients exhibit the hypothesized signs, with four being statistically significant at the 1% level, two statistically significant at the 5% level, and one statistically significant at the 8% level. Thus, this estimation implies that the nominal interest rate yield on ten-year U.S. Treasury notes is a decreasing function of the monetary base as a percent of GDP and the net capital inflows variable, while being an increasing function of expected inflation, the *ex ante* real three-month Treasury bill rate, the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds, the change in per capita real GDP, and-finally-the federal budget deficit as a percent of GDP. Clearly, overall, these results are consistent with those for the nominal ten-year U.S. Treasury note yield found in columns (a), (b), and (c) of Table 2 and columns (a) and (b) of Table 4. In other words, the federal budget deficit, expressed as a percent of GDP, is once again found to exercise a positive impact on the nominal ten-year Treasury note yield. Interestingly, the latter result is found to be the case in all of the estimates not only in terms of statistical significance (1%) but also in terms of a relatively stable/uniform coefficient size. Thus, this study finds consistent evidence of the impact of the budget deficit. Indeed, it appears that for every 1% increase in the size of the budget deficit (as a percent of GDP), the nominal interest rate yield rises approximately 20 basis points.

5 Estimates Using Quarterly Data: 1971.3-2008.4 and 1971.3-2012.4

In this section of the study, we re-estimate the model using quarterly data. To do so, however, we must first develop a reasonable measure of expected future inflation based on quarterly data. Following Swamy, Kolluri, and Singamsetti (1990), this study adopts a distributed lag model on actual inflation to construct values for expected future inflation in *quarter t*. In particular, to construct values for PE^{t+1}_t, where subscript t is now quarter t, a four-quarter distributed lag of actual inflation (measured by the annualized percent change of the CPI, 2000=100.00) was used. With PE^{t+1}_t thus newly defined /measured for quarter t, the variable $EARSTBR_t$ = the nominal interest rate yield on three-month Treasury bills in quarter t minus PE^{t+1}_t, while variable $EARLTBR_t$ = the nominal interest rate yield on Moody's Aaa-rated long-term corporate bonds in quarter t minus PE^{t+1}_t.

Given the contemporaneous components of the specification in equation (8), the possibility of simultaneity naturally arises, which in turn mandates the choosing of instrumental variables for each of the five right-hand side variables in question. Given the *four*-quarter distributed lag construct of the expected inflation variable, the five instruments chosen were, as follows: the five-quarter lag of the annual civilian unemployment rate (UR_{t-5}) for TDY_t; the five-quarter lag of the *actual* annual inflation rate of the CPI (PA_{t-5}) for $PE^{t+1}{}_{t}$; the five-quarter lag of the Moody's Baa-rated corporate bond interest rate yield (Baa_{t-5}) for MY_t; the five-quarter lag of the nominal six-month Treasury bill interest rate yield (SIX_{t-5}) for $EARSTBR_t$; and the five-quarter lag of the nominal average interest rate yield on new fixed-rate 30 year mortgages ($MORT_{t-5}$) for variable $EARLTBR_t$. The choice of instruments for these variables was based on the fact that in each case, the lagged instrument was highly correlated with the explanatory variable in question whereas the instruments in question were uncorrelated with the error terms in the system. Meanwhile, the real GDP growth rate variable, Y_{t-1}, and the net capital inflow variable, $NCIY_{t-1}$, are once again both lagged one period in order to avoid multicollinearity problems. The quarterly data were obtained from the Council of Economic Advisors (2013, Tables B-1, B-2, B-35, B-42, B-64, B-71, B-73, B-79) and from earlier editions of this publication (*The Economic Report of the President*) for the years 1975, 1978; 1981, 1984, 1987, 1990, 1993, 1996, 1999, 2001, 2004, 2007, and 2010, respectfully.

Estimates Using Quarterly Data: 1971.3-2008.4

With the variables $PE^{t+1}{}_{t}$, $EARSTBR_t$ and $EARLTBR_t$ recalibrated within the context of the model in quarterly data terms, the autoregressive 2SLS estimate of equation (8) for the period 1971.3-2008.4 is provided in column (a) of Table 5, where terms in parentheses are t-values. In column (a) of Table 5, all seven of the estimated coefficients on the explanatory variables exhibit the expected signs, with three of these coefficients being statistically significant at the 1% level and three being statistically significant at the 5% level; only the coefficient on the Y_{t-1} variable fails to be statistically significant at the 10% level. There is no indication of an autocorrelation problem.

In this estimate, the estimated coefficient on the monetary base *(de facto* available money supply) variable, MY_t, is negative, as expected, and statistically significant at the 5% level, implying that a higher ratio of the monetary base relative to GDP acts to reduce the nominal interest rate yield on ten-year U.S. Treasury notes. Interestingly, we observe that these empirical results are essentially identical if the M2 measure of the money supply, expressed as a percent of GDP, is adopted in lieu of MY_t. The estimated coefficient on the *ex ante* real short-term interest rate variable, $EARSTBR_t$, is positive, as hypothesized, and statistically significant at the 5% level, implying that the higher the *ex ante* real interest rate yield on three-month Treasury bills, the higher the nominal interest rate yield on ten-year notes. This finding presumably reflects competition between the ten-year Treasury note and counterpart short-term financial instruments. Similarly, the coefficient on the variable $EARLTBR_t$ is also positive, as hypothesized, and statistically significant, at the 1% level, implying that the higher the *ex ante* real interest rate on long-term Moody's Aaa-rated corporate bonds, the higher the level of nominal interest rate yield on ten-year Treasury notes, presumably because of competition between ten-year Treasury notes and long-term financial instruments. The estimated coefficient on the expected inflation variable, $PE^{t+1}{}_t$, is also positive, as expected (conventional wisdom), and statistically significant at the 1% level, implying that the higher the expected future inflation rate, the greater the nominal interest rate yield on ten-year Treasury bonds. Next, the estimated coefficient on the net capital inflows variable, $NCIY_{t-1}$, is negative, as expected, and statistically significant at the

5% level, implying that such capital flows act to absorb domestic debt and reduce the interest rate on that debt, i.e., on ten-year Treasury notes, in this case. Finally, the estimated coefficient on the budget deficit variable is positive and statistically significant at the 1% level. Thus, the higher the federal budget deficit (as a percent of GDP), the higher the nominal interest rate yield on intermediate-term, i.e., in this case, on ten-year U.S. Treasury notes.

In column (b) of Table 5, where the variable Y_{t-1} is deleted from the basic model (as in Tables 2 and 4), all of the estimated coefficients on the explanatory variables exhibit the expected signs, with five of these six coefficients being statistically significant at the 1% level and one being statistically significant at the 5% level. Thus, this version of the basic model yields results that imply, using quarterly data, that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the *ex ante* real interest rate yield on three-month Treasury bills, the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds, and expected future inflation, while being a decreasing function of the monetary base (as a percent of GDP) and net capital inflows (as a percent of GDP). Finally, these results once again find that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the federal budget deficit (expressed as a percent of GDP).

Lastly, there are the quarterly results in which the variable CHPCRGDP, defined here (paralleling Tables 2 and 4) as the change in the annualized per capita real GDP between the previous quarter (t-1) and the current quarter (t) is adopted in place of the percent growth rate of real GDP. The estimates for this re-specification of equation (8) are provided in column (c) of Table 5. In this estimate, six of the seven estimated coefficients are statistically significant at the 1% level, and one is statistically significant at the 2% level. These findings imply that the nominal interest rate on ten-year Treasury notes is an increasing function of the *ex ante* real interest rate yield on three-month Treasury bills, the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds, expected future inflation, and the change in per capita real GDP, while being a decreasing function of the monetary base and net capital inflows. Finally, these results once again find that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the federal budget deficit.

Estimates Using Quarterly Data: 1971.3-2012.4

The estimate of equation (8) for the period 1971.3-2012.4 is provided in column (a) of Table 6, where, all seven of the estimated coefficients on the explanatory variables exhibit the expected signs, with five of these seven coefficients being statistically significant at the 1% level, one being statistically significant at the 5% level, and one, the coefficient on the $NCIY_{t-1}$ variable, being statistically significant at the 6% level.

These quarterly data-based findings for the period 1971.3-2012.4 imply that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the *ex ante* real interest rate yield on three-month Treasury bills, the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds, expected future inflation, and the percentage growth rate of real GDP, while being a decreasing function of the monetary base (as a percent of GDP) and, at the six percent statistical significance level, net capital inflows (as a percent of GDP). Finally, these results once again find that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the federal budget deficit (expressed as a percent of GDP).

In column (b) of Table 6, following the procedure in Tables 2, 4, and 6, the estimate omits the Y_{t-1} variable. In this case, four of the six coefficients are statistically significant at the 1% level, while the remaining two are statistically significant at the 5% level. These results imply that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the *ex ante* real interest rate yield on three-month Treasury bills, the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds, expected future inflation, and the federal budget deficit (as a percent of GDP), while being a decreasing function of the monetary base (as a percent of GDP) and net capital inflows (as a percent of GDP).

Finally, there are the results in column (c) of Table 6, where the coefficients on all seven explanatory variables are statistically significant at the one percent level with the expected signs. These findings imply that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the *ex ante* real interest rate yield on three-month Treasury bills, the *ex ante* real interest rate yield on Moody's Aaa-rated corporate bonds, expected future inflation, and the change in per capita real GDP, while being a decreasing function of the monetary base and net capital inflows. Finally, these results once again find that the nominal interest rate yield on ten-year Treasury notes is an increasing function of the federal budget deficit (expressed as a percent of GDP).

Reflecting upon the results for the budget deficit variable in all three estimates in Table 5 (for

1971.3-2008.4) and all three estimates in Table 6 (for 1971.3-2012.4), it appears that for every 1% increase in the size of the budget deficit (as a percent of GDP), the nominal interest rate yield rises approximately 20-21 basis points. This is comparable to the findings when the model was estimated using annual data.

6 Overview and Perspective

The present study adopts a loanable funds model and, first using annual data and then quarterly data for the periods 1971-2008 and 1971-2012, consistently finds that the nominal interest rate yield on ten-year U.S. Treasury notes is an increasing function of the *ex ante* real three-month Treasury bill interest rate yield, the *ex ante* real interest rate yield on long-term high grade corporate bonds (Moody's Aaa-rated), and expected inflation, while being a decreasing function of the ratio of the monetary base to the GDP level (expressed as a percent) and net financial capital inflows expressed as a percent of GDP. Furthermore, in contrast to the predictions found in Ricardian Equivalence, it also is found consistently that the greater the federal budget deficit (relative to the GDP level), the higher the nominal interest rate yield on ten-year U.S. Treasury notes. More specifically, for every 1% increase in the size of the budget deficit (as a percent of GDP), the nominal interest rate yield rises approximately 19-21 basis points. This finding is consistent with a variety of empirical studies of earlier periods, as observed above.

Thus, it appears that factors elevating the U.S. budget deficit act raise the nominal intermediate-term (ten-year) cost of borrowing, presumably through increasing the competition for loanable funds. Thus, federal government policies that raise the budget deficit cannot be viewed in a vacuum since they may well impact adversely upon the finances of corporations and households and, accordingly, the real investment in new plant and equipment, consumption outlays, real GDP growth, and both the level of employment and rate of employment growth of the U.S.

References

Al-Saji, A (1993) Government budget deficits, nominal and *ex ante* real long-term interest rates in the U.K., 1960.1-1990.2. *Atlantic Economic Journal*, 21: 71-77.

Al-Saji, A (1992) The Impact of government budget deficits on *ex post* real long-term interest rates in the U.K. *Economia Internazionale*, 45: 158-163.

Barth, JR, Iden, G, Russek, FS (1984) Do federal deficits really matter? *Contemporary Policy Issues*, 3: 79-95.

Barth, JR, Iden, G, Russek, FS (1985), Federal borrowing and short-term interest rates: Comment. *Southern Economic Journal*, 52: 554-559.

Barth, JR, Iden, G, Russek, FS (1986), Government debt, government spending, and private sector behavior: Comment. *American Economic Review*, 76: 1115-1120.

Barth, JR, Iden, G, Russek, FS, Wohar, M (1989) Effects of federal budget deficits on interest rates and the composition of domestic output. The Urban Institute, Washington, D.C.

Carlson, KM, Spencer, RW (1975) Crowding out and its critics. *Federal Reserve Bank of St. Louis Review*, 57: 1-19.

Cebula, RJ (1997) An empirical analysis of the impact of government tax and auditing policies on the size of the underground economy. *American Journal of Economics and Sociology,* 56: 173-186.

Cebula, RJ (1992) Central government budget deficits and ex ante real long-term interest rates in Italy: an empirical analysis for 1955-1989. *Metroeconomica*, 43: 393-402.

Cebula, RJ (1985) The crowding out effect of fiscal policy. *Kyklos*, 38: 435-438.

Cebula, R.J. (1997A). "An empirical analysis of the impact of government tax and auditing policies on the size of the underground economy," *American Journal of Economics and Sociology,* 56 (2): 173-186.

Cebula, RJ (1997B) An empirical note on the impact of the federal budget deficit on ex ante real long-term interest rates, 1973-1995. *Southern Economic Journal*, 63: 1094-1099.

Cebula, RJ (2005) Recent evidence on the impact of the primary deficit on nominal longer-term Treasury note interest rate yields. *Global Business & Economics Review*, 7: 47-58.

Cebula, RJ (2004) Income tax evasion revisited: The impact of interest rate yields on tax-free Municipal Bonds. *Southern Economic Journal*, 71 (2): 418-423.

Cebula, RJ, Belton, WJ (1993) Government budget deficits and interest rates in the United States: Evidence for closed and open economies put into perspective. *Public Finance/Finances Publiques*, 48: 188-209.

Cebula, RJ, Cuellar, P (2010) Recent evidence on the impact of government budget deficits on the *ex ante* real interest rate yield on Moody's Baa-rated corporate bonds. *Journal of Economics and Finance*, 34: 301-307.

Council of Economic Advisors. (2013). Economic report of the president, 2013. Washington, D.C: U.S. Government Printing Office.

Cukierman, A, Meltzer, A (1983) A political theory of government debt and deficits in a Neo-Ricardian framework. *American Economic Review*, 79: 713-732.

Feldstein, M, Eckstein, O (1970) The fundamental determinants of the interest rate. *Review of Economics and Statistics*, 52: 362-375.

Findlay, DW (1990) Budget deficits, expected inflation, and short-term real interest rates. *International Economic Journal*, 4: 41-53.

Gale, W.G, Orszag, PR (2003) Economic effects of sustained budget deficits. *National Tax Journal*, 49: 151-164.

Gissey, W (1999) Net Treasury borrowing and interest rate changes. *Journal of Economics and*

Finance, 23: 211-219.

Hoelscher, G (1983) Federal borrowing and short-term interest rates. *Southern Economic Journal*, 50: 319-333.

Hoelscher, G (1986) New evidence on deficits and interest rates. *Journal of Money, Credit, and Banking*, 18: 1-17.

Holloway, TM (1986) The cyclically adjusted federal budget and federal debt: Revised and updated estimates. *Survey of Current Business*, 66: 11-17
.

Holloway, TM (1988) The relationship between federal deficit/debt and interest rates. *The American Economist*, 32: 29-38.

Johnson, CF (1992) An empirical note on interest rate equations. *Quarterly Review of Economics and Finance*, 32: 141-147.

Kiani, KM (2009) Federal budget deficits and long-term interest rates in the USA. *Quarterly Review of Economics and Finance*, 34 (3): 301-307.

Koch, JV (1994) Federal budget deficits, interest rates, and international capital flows: A further note, *Quarterly Review of Economics and Finance*, 32: 117-120.

Ostrosky, AL (1990) Federal budget deficits and interest rates: Comment. *Southern Economic Journal*, 56: 802-803.

Swamy, PAVB, Kolluri, BR, Singamsetti, RN (1990) What do regressions of interest rates on deficits imply? *Southern Economic Journal*, 56: 1010-1028.

Tanzi, V (1985) Fiscal deficits and interest rates in the United States. *I.M.F. Staff Papers*, 33: 551-576.

Zahid, K (1988) Government budget deficits and interest rates: The evidence since 1971 using alternative deficit measures. *Southern Economic Journal*, 54: 725-731.

Table 1. Descriptive Statistics

Variable	1971-2008 (Annual Data) Mean	Standard Deviation	1971-2012 (Annual Data) Mean	Standard Deviation
RTEN	7.348	2.630	6.91	2.851
TDY	2.492	1.903	3.102	2.639
MY	57.68	11.06	67.111	31.608
EARSTBR	1.096	2.049	0.834	2.127
EARLTBR	3.737	2.332	3.655	2.268
Y	2.329	1.258	2.561	1.397
PE^{t+1}	4.677	2.695	4.400	2.700
NCIY	1.936	1.709	2.010	1.714

Table 2. Autoregressive 2SLS Estimation Results, 1971-2008, Annual Data

Variable\column	(a)	(b)	(c)
Constant	2.51	2.41	1.55
TDY	0.201***	0.201***	0.203***
	(3.55)	(3.87)	(5.34)
MY	-0.041***	-0.0366**	-0.031***
	(-2.71)	(-2.42)	(-3.04)
EARSTBR	0.311***	0.313***	0.292***
	(2.75)	(2.89)	(3.97)
EARLTBR	0.584***	0.582***	0.62***
	(4.84)	(5.33)	(8.32)
Y	6.214	-------	-------
	(0.70)		
CHPCRGDP	-------	-------	379.7**
			(2.55)
PE^{t+1}	0.901***	0.895***	0.918***
	(19.76)	(17.47)	(26.74)
NCIY	-0.107*	-0.084**	-0.152***
	(-1.85)	(-2.16)	(-5.05)
AR (1)	-0.468**	-0.423**	-0.648***
	(-2.31)	(-2.02)	(-4.42)

DW	2.10	2.11	2.28
Rho	-0.05	-0.05	-0.14

Dependent Variable: $RTEN_t$ Terms in parentheses are t-values.. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.

Table 3. Correlation Matrix among Independent Variables, 1971-2008

	TDY	MY	EARSTBR	EARLTBR	Y	NCIY	PE^{t+1}
TDY	1.000						
MY	-0.199	1.000					
EARSTBR	-0.068	-0.449	1.000				
EARLTBR	0.231	-0.248	0.379	1.000			
Y	-0.389	-0.111	0.366	0.121	1.000		
NCIY	-0.144	0.431	0.042	0.125	0.099	1.000	
PE^{t+1}	0.213	-0.302	-0.265	0.569	-0.192	-0.428	1.000

Table 4. Autoregressive 2SLS Estimation Results, 1971-2012, Annual Data

Variable\column	(a)	(b)	(c)
Constant	0.877	0.809	0.563
TDY	0.187***	0.201***	0.213***
	(3.22)	(3.96)	(4.45)
MY	-0.0147***	-0.0168***	-0.0167***
	(-2.85)	(-4.25)	(-4.38)
EARSTBR	0.298**	0.306**	0.256**
	(2.03)	(2.12)	(1.98)
EARLTBR	0.650***	0.637***	0.672***
	(4.41)	(4.41)	(5.37)
Y	-7.54	-------	-------
	(-0.72)		
CHPCRGDP	-------	-------	276.04*
			(1.81)
PE^{t+1}	0.938***	0.951***	0.945***
	(21.23)	(18.31)	(19.57)
NCIY	-0.062	-0.083**	-0.155**
	(-1.14)	(-2.09)	(-2.33)
AR (1)	-0.146	-0.159	-0.134
	(-0.53)	(-0.58)	(-0.49)

DW	2.02	2.03	2.05
Rho	-0.01	-0.02	-0.03

Dependent Variable: $RTEN_t$. Terms in parentheses are t-values. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.

Table 5. Estimation Results, 1971.3-2008.4, Quarterly Data

Variable\column	(a)	(b)	(c)
Constant	1.61	2.5	1.63
TDY	0.199***	0.199**	0.202***
	(3.66)	(3.90)	(5.40)
MY	-0.03**	-0.037**	0.032***
	(-2.03)	(-2.50)	(-3.03)
EARSTBR	0.257**	0.316***	0.293***
	(2.07)	(2.90)	(3.89)
EARLTBR	0.654***	0.578***	0.617***
	(4.02)	(5.21)	(7.83)
Y	0.027	-------	-------
	(0.74)		
CHPCRGDP	-------	-------	3.7**
			(2.51)
PE^{t+1}	0.923***	0.892***	0.915***
	(12.12)	(16.70)	(23.69)
NCIY	-0.086**	-0.084**	-0.151***
	(-2.10)	(-2.28)	(-5.30)
AR(1)	-0.299**	-0.0437**	-0.654***
	(-2.11)	(-2.07)	(-4.43)

DW	2.05	2.10	2.18
Rho	-0.03	-0.05	-0.09

Dependent Variable: $RTEN_{t.}$ Terms in parentheses are t-values. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.

Table 6. Estimation Results, 1971.3-2012.4, Quarterly Data

Variable\column	(a)	(b)	(c)
Constant	0.069	0.848	0.459
TDY	0.198***	0.204***	0.206***
	(3.30)	(4.28)	(4.89)
MY	-0.016***	-0.017***	-0.016***
	(-3.58)	(-4.33)	(-6.06)
EARSTBR	0.18*	0.319**	0.29***
	(1.74)	(2.41)	(2.76)
EARLTBR	0.759***	0.627***	0.656***
	(5.71)	(4.67)	(5.75)
Y	0.07***	-------	-------
	(2.93)		
CHPCRGDP	-------	-------	2.88***
			(3.08)
PE^{t+1}	0.986***	0.947***	0.953***
	(19.77)	(18.99)	(21.13)
NCIY	-0.085*	-0.086**	-0.134***
	(-1.97)	(-2.23)	(-4.05)
AR(1)	-0.03*	-0.176*	-0.385*
	(-1.73)	(-1.79)	(-1.96)

DW	2.00	2.03	2.14
Rho	0.00	-0.02	-0.07

Dependent Variable: $RTEN_t$. Terms in parentheses are t-values. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.

APPENDIX: Robustness Testing

In this Appendix to the study, robustness tests of the basic model and its two variations are presented for both study periods. For simplicity, these robustness tests adopt only annual data, although it is noteworthy that the robustness tests using quarterly data yield very similar results, further affirming the robustness of the model. Naturally, these results will be provided upon request.

Table 7 provides a robustness test for the findings and models summarized in Table 2 for the 1971-2008 study period in the form of ARCH (Autoregressive Conditional Heterskedasticity) estimates. These results parallel those found in Table 2, thereby confirming and lending strong support for the basic model and its findings as presented in section 4 above. This robustness test is particularly relevant, in terms of the objective of this study, for the case of the federal budget deficit, whose z-statistic is positive and statistically significant at the 1% level in all three ARCH estimates; furthermore, similarly strong statistical significance is obtained for the monetary base variable.

Table 8 provides robustness tests for the findings and models summarized in Table 4 for the 1971-2012 study period. As shown in Table 8, ARCH estimates paralleling the estimated models found in Table 4 confirm and lend strong support for the basic model and its findings as presented in section 5 above. This finding is particularly relevant for the case of the federal budget deficit, whose z-statistic is positive and statistically significant at the 1% level in all three ARCH estimates; similar statistical significance is obtained for the monetary base variable, which reflects quantitative easing policies. Thus, the results obtained in this study may be considered to be potentially very useful.

Table 7. Autoregressive Conditional Heteroskedasticity (ARCH) Estimation Results, 1971-2008

Variable\column	(a)	(b)	(c)
Constant	0.21	0.61	0.46
TDY	0.151***	0.159***	0.162***
	(3.08)	(3.24)	(3.08)
MY	-0.016***	-0.017***	-0.017**
	(-2.73)	(-39.05)	(-2.13)
EARSTBR	0.195**	0.234***	0.24***
	(2.27)	(2.91)	(3.63)
EARLTBR	0.782***	0.740***	0.762***
	(7.76)	(7.16)	(10.87)
Y	0.032	-------	-------
	(0.84)		
CHPCRGDP	-------	-------	375.4*
			(1.84)
PE^{t+1}	0.991***	0.965***	0.987***
	(18.57)	(14.95)	(24.08)
NCIY	-0.062*	-0.068*	-0.157**
	(-1.83)	(-1.81)	(-2.50)
DW	1.96	2.06	2.05
Rho	0.02	-0.03	-0.03
Variance Equation:	(a)	(b)	(c)
Constant	0.0016	0.00018	-0.0008
	(0.23)	(0.03)	(-0.08)
RESID(-1)^2	-0.208	-0.171	-0.186
	(-1.12)	(-0.88)	(-1.08)
GARCH(-1)	1.301***	1.237***	1.255***
	(3.83)	(3.91)	(3.71)

Dependent Variable: $RTEN_t$. Terms in parentheses are z-statistics. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.

Table 8. Autoregressive Conditional Heteroskedasticity (ARCH) Estimation Results, 1971-2012

Variable\column	(a)	(b)	(c)
Constant	0.069	0.422	0.227
TDY	0.166***	0.156***	0.159***
	(5.45)	(5.44)	(7.76)
MY	-0.014***	-0.015***	-0.013***
	(-6.38)	(-6.37)	(-19.37)
EARSTBR	0.199***	0.239***	0.247***
	(6.36)	(7.91)	(15.04)
EARLTBR	0.782***	0.739***	0.732***
	(19.78)	(17.59)	(18.52)
Y	0.051***	-------	-------
	(2.92)		
CHPCRGDP	-------	-------	169.6***
			(4.21)
PE^{t+1}	0.997***	0.975***	0.973***
	(52.54)	(53.61)	(49.38)
NCIY	-0.077***	-0.064**	-0.111***
	(-3.47)	(-2.41)	(-4.21)
DW	1.99	1.96	2.11
Rho	0.01	0.02	-0.06
Variance Equation:	(a)	(b)	(c)
Constant	0.0005	0.0014	0.021
	(0.20)	(0.63)	(1.12)
RESID(-1)^2	-0.151	-0.164	-0.353
	(-0.88)	(-0.84)	(-0.91)
GARCH(-1)	1.184***	1.194***	1.22***
	(6.75)	(6.29)	(18.11)

Dependent Variable: $RTEN_t$. Terms in parentheses are z-statistics. ***statistically significant at 1% level; **statistically significant at 5% level; *statistically significant at 10% level.