The Nominal Interest Rate Yield Response to Net Government Borrowing: GLM Estimates, 1972-2012

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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 for the period 1972-2012. GLM (Generalized Linear Model) estimates imply, among other things, that the federal budget deficit, expressed as a percent of GDP, exercised a positive and statistically significant impact on the nominal interest rate yield on ten-year Treasury notes over the study period.

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; 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; 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 also been examined, arguably in part because of its potential impact on income tax evasion (Cebula, 1997A; 2004). In recent years, however, the impact of government 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, this study investigates the post-Bretton Woods period from 1972 through 2012, in the pursuit of providing *contemporary* insights into whether federal budget deficits have in fact elevated nominal intermediate-term interest rate yields in the U.S. We begin with 1972 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 study period with the year 2012 makes this study relatively current and hence pertinent. Moreover, ending the study with the year 2012 can be regarded as relevant and important if for no other reason than because it was during the latter part of this period, namely, beginning 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 study period includes four full years during which the U.S. economy experienced both quantitative easing *and* huge (relative to the size of GDP) federal budget deficits.

Thus, this study seeks to provide at least preliminary insights into the following question: "What has been the impact of budget deficits on intermediate-term nominal interest rates in the U.S. over the last 41 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; 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 used. Section 4 provides the empirical results of GLM (Generalized Linear Model) estimations using annual data for the study period1972-2012. Conclusions are found in Section 5.

2 The Model

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

$$ND_{t+1} = ND_t + G_t + F_t + AR_tND_t - T_t \tag{1}$$

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:

$$TD_t = ND_{t+1} - ND_t = G_t + F_t + AR_t ND_t - T_t \tag{2}$$

Based extensively on Barth, Iden, and Russek (1984; 1985; 1986; 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; 1989; 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 private sector real transactions demand for money and the higher the private sector issuance of bonds and consequently the lower the

demand for ten-year Treasury notes, *ceteris paribus* (Hoelscher, 1986; Cebula, 2005). It is further hypothesized that, paralleling Barth, Iden, and Russek (1984; 1985; 1989), 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 interest rate yield, which in this case is the *ex ante* real interest rate yield on three-month Treasury bills. 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 sector 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; 1989; Hoelscher, 1983; 1986; Ostrosky, 1990; Koch (1994); Gissey (1999); Cebula, 2005; 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 funds 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) above.

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; estimates based thereupon are provided in section 4 of this study.

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 (Al-Saji, 1992; 1993;

Cebula, 1992; Koch, 1994):

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

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 future period. Given this measurement of expected

future inflation, 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 quite similar results and the same basic overall conclusions as those obtained here.

In any case, based upon the framework expressed above, the GLM (Generalized Linear Model) estimation initially involves the following linear model:

$$RTEN_t = \alpha_0 + \alpha_1\ TDY_{t-1`} + \alpha_2\ MY_{t-1} + \alpha_3\ EARSTBR_{t-1} + \alpha_4\ EARLTBR_{t-1} + \alpha_5\ Y_{t-1} + \alpha_6\ PE^{t+1}_{t-1}$$

$$+ \alpha_7\ NCIY_{t-1} + u_t \tag{8}$$

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-1} = the ratio of the nominal federal budget deficit in year t-1 to the nominal GDP in year t-1, expressed as a percent;

MY_{t-1} = the ratio of the monetary base in year t-1 to the nominal GDP in year t-1, expressed as a percent;

EARSTBR$_{t-1}$ = the *ex ante* real average interest rate yield on three-month Treasury bills in year t-1, expressed as a percent annum;

EARLTBR$_{t-1}$ = the *ex ante* real average interest rate yield on Moody's Aaa-rated long-term corporate bonds in year t-1, expressed as a percent per annum;

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

PE$^{t+1}_{t-1}$ = the expected future inflation rate of the CPI, i.e., for year t+1, lagged one year, 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; 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 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). Descriptive statistics for each of the variables expressed in equation (8) are provided in Table 1.

4 GLM Estimation Results with Annual Data: 1972-2012

In this section, empirical results are presented using annual data for the study period 1972-2012. The GLM estimation of equation (8) is provided in column (a) of Table 2, where terms in parentheses are

z-statistics. In column (a) of Table 1, all seven of the estimated coefficients on the explanatory variables exhibit the expected signs, with two of these coefficients being statistically significant at the 1% level, two being statistically significant at the 5% level, and two being statistically significant at the 10% level; only the coefficient on the $NCIY_{t-1}$ variable fails to be statistically significant at the 10% level. In addition, it is observed that the LR statistic is statistically significant at far beyond the 1% level and the log likelihood = -50.83, whereas the model convergence was achieved after only one iteration; these three findings lend credibility to the results of the model estimation.

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 2% 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 10% level, implying (albeit modestly) 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 presumably reflects some degree of competition between the ten-year Treasury note and counterpart short-term financial instruments in the marketplace. Similarly, the coefficient on the variable $EARLTBR_t$ is also positive, as hypothesized, and statistically significant at the 4% 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 market 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 (per the 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, but it fails to be statistically significant at even the 10% level. The estimated coefficient on the real GDP growth variable is positive, as expected, and statistically significant at nearly the 5% level, implying that the greater the real GDP growth rate, the higher the nominal interest rate yield on ten-year Treasury notes.

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; 1986; 1989), Cebula (1997B), Cebula and Belton (1993), Cebula and Cuellar (2010), Findlay (1990), Gale and Orszag (2003), Gissey (1999), Hoelscher (1986), Johnson (1992), Tanzi (1985), and Zahid (1988). According to this estimation, if the deficit-to-GDP ratio were to rise by 1%, the yield on ten-year Treasury notes would rise by 23.8 basis points.

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 nominal intermediate-term interest rates,

we undertake two modestly different additional GLM estimates. The first of these estimates is shown in column (b) of Table 2, where the real GDP growth rate variable is replaced by the variable $CHPCRGDP_{t-1}$, defined here as the change in per capita real GDP between the previous year (t-1) and the current year (t), lagged one year. In column (b) of Table 2, the GLM estimate of the basic model with this substitution is provided. In this estimation, all seven estimated coefficients exhibit the expected signs, and three coefficients are statistically significant at the 1% level whereas two are statistically significant at beyond the 10% level. It is also observed that the LR statistic is statistically significant at far beyond the 1% level and the log likelihood = -52.9, whereas the model convergence was achieved after only one iteration; these three findings lend credibility to the results of the model estimation.

According to these GLM 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), 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 6% statistical significance level), and the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds (at the 8% statistical significance level). Clearly, these results are largely consistent with those for the ten-year U.S. Treasury note yield found in column (a) of Table 2. On the other hand, this GLM estimate finds that the estimated coefficients on both the $NCIY_{t-1}$ variable and the replacement for the real GDP growth variable, $CHPCRGDP_{t-1}$, both failed to be statistically significant at even the 10% level. Nevertheless,

once again, the federal budget deficit, expressed as a percent of GDP, exercises a positive and statistically significant (at the 1% level) impact on the nominal ten-year Treasury note yield. In this case, if the deficit-to-GDP ratio were to rise by 1%, the yield on ten-year Treasury notes would rise by 25 basis points.

The next demonstration of the resiliency of the basic model and its fundamental findings are shown in column (c) of Table 2, where the statistically insignificant capital inflows variable has been dropped from the model and the real GDP growth rate is restored to the model. In this GLM estimation, all six of the estimated coefficients exhibit the hypothesized signs, with two being statistically significant at the 1% level, two being statistically significant at the 2.5% level, and one being statistically significant at the 5% level. Yet again, it is observed that the LR statistic is statistically significant at far beyond the 1% level; furthermore, the log likelihood = -51.79, and the model convergence was achieved after only one iteration. These three findings lend credibility to the results of the model estimation.

Thus, this GLM estimation implies that 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% statistical significance level), while being an increasing function of expected inflation (at the 1% statistical significance level), the *ex ante* real long-term interest rate yield on Moody's Aaa-rated corporate bonds (at the 2% statistical significance level), the percentage real growth rate of real GDP (at the 5% statistical significance level), and-finally-the federal budget deficit as a percent of GDP (at the 1%

statistical significance level). In the latter case, if the deficit-to-GDP ratio were to rise by 1%, the yield on ten-year Treasury notes would rise by 24.3 basis points.

In closing this section of the study, it is also interesting to observe that the estimated coefficient on the total deficit variable is remarkably stable across estimations, falling in the narrow range of 0.238-0.25. Thus, it appears that a 1% increase in the federal budget deficit-to-GDP ratio would be expected to elevate the nominal ten-year Treasury note yield by somewhere between 23.8 basis points and 25 basis points. Alternatively, an increase in the budget deficit-to-GDP ratio of 5% would elicit a rise in the nominal Treasury note interest rate yield of approximately 125 basis points.

This finding of a statistically significant positive impact of the federal budget deficit (expressed as a percent of GDP) on the nominal ten-year Treasury note yield across estimates in Table 2 for the period 1972-2012 is consistent with a host of empirical studies of earlier and generally shorter time periods, including Al-Saji (1992; 1993), Barth, Iden and Russek (1984; 1985; 1986; 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), Tanzi (1985), and Zahid (1988).

5 Overview and Perspective

The present study adopts a loanable funds model and, after applying the GLM estimation to annual data for the period 1972-2012, finds, among other things, in contrast to the predictions found in Ricardian Equivalence, 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 23.8-25 basis points.

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, real investment in new plant and equipment, consumption outlays, real GDP growth, and both the level of the employment rate and rate of employment growth of the U.S. Clearly, policy-makers must revise their actions so as not to generate an unsustainable pattern of deficit-financed government spending.

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Table 1. Descriptive Statistics, 1972-2012 (Annual Data)

Variable	Mean	Standard Deviation
RTEN	6.928	2.885
TDY	3.102	2.639
MY	67.111	31.608
EARSTBR	0.834	2.127
EARLTBR	3.655	2.268
Y	2.561	1.397
PE^{t+1}	4.400	2.700
NCIY	2.010	1.714

Table 2. GLM (Generalized Linear Model) Estimation Results, 1972-2012

Variable\column	(a)	(b)	(c)
Constant	1.70	2.77	0.999
TDY	0.238***	0.25***	0.243***
	(2.57)	(2.57)	(2.60)
MY	-0.023**	-0.027***	-0.022**
	(-2.35)	(-2.77)	(-2.32)
EARSTBR	0.267*	0.327*	0.239
	(1.66)	(1.86)	(1.43)
EARLTBR	0.401**	0.35*	0.446**
	(2.08)	(1.72)	(2.32)
Y	0.151*	-------	0.155**
	(1.90)		(1.98)
CHPCRGDP	-------	120.37	-------
		(0.29)	
PE^{t+1}	0.916***	0.856***	0.977***
	(8.33)	(7.71)	(9.67)
NCIY	-0.137	-0.173	-------
	(-1.33)	(-1.10)	
LR statistic	358.83***	321.14***	349.21***
Iterations for Convergence	1	1	1
N	41	41	41
Family	Normal	Normal	Normal
Log Likelihood	-50.83	-52.9	-51.79

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.