Impact of Federal Government Budget Deficits on the Longer-term Real Interest Rate in the U.S.: Evidence Using Annual and Quarterly Data, 1960-2013

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1 Introduction

There was a brief experience of federal government budget surpluses in the U.S. during the FY1998 through FY2001 period. However, given the 2001 recession, sluggish economic growth following 2001, and budgetary demands involving income tax cuts during the Bush Administration as well as the "war on terrorism" in the aftermath of the terrorist attacks on U.S. soil on September 11, 2001, the prospect and reality of large federal government budget deficits reappeared during FY 2002. As Krueger (2003) observed, federal budget deficits in the U.S. re-emerged as a major economic concern by 2003. These budget deficits increases were subsequently exacerbated due to various factors, including the "wars" and military conflicts in Iraq and Afghanistan as well as in Pakistan. Moreover, during and in the aftermath of the so-called "Great Recession," factors such as the $787 billion "stimulus package" passed by the U.S. Congress under newly inaugurated President Obama in February, 2009 and the massive expansion of the food stamp program (now referred to as "SNAP," for "supplemental nutritional assistance program") and Medicaid (health care for the poor), those budget deficits have risen to all-time highs since the experience of World War II, logically making them an even greater economic concern.

The impact of central government budget deficits on interest rate yields has been studied extensively. This is especially true for the case for federal budget deficits in the U.S. but applies to other nations as well, including G8 nations such as the United Kingdom, Italy, Germany, and France and non-G8 nations such as Greece. This literature is especially rich since the early 1980s (Al-Saji, 1992, 1993; Barth, Iden and Russek, 1984, 1985, 1986; Cebula, 1992, 1997, 2005, 2013; Cebula and Cuellar, 2010; Ewing and Yanochik, 1999; Findlay, 1990; Gale and Orszag, 2003; Gissey, 1999; Hoelscher, 1983, 1986; Johnson, 1992; Kiani, 2009;Ostrosky, 1990; Saltz, 1998; Swamy, Kolluri, and Singamsetti, 1990; Tanzi, 1985; Zahid, 1988). Interestingly, a commonplace finding by most of these studies is that federal/central government budget deficits raise longer term interest rate yields while not significantly affecting short term rate yields. Since capital formation is presumably much more affected by *longer term* than by *short term* rates, it has been argued in certain other studies that budget deficits *may* lead to the "crowding out" of private investment, particularly in the form of “transactions crowding out” (Carlson and Spencer, 1975; Cebula, 1997; Ewing and Yanochik, 1999; Gale and Orszag, 2003).

During recent years, the impact of budget deficits on interest rate yields has received only limited attention in the literature. Accordingly, in view of the resurgence of large federal budget deficits in the U.S., this exploratory study seeks to provide updated evidence as to the effect of the federal budget deficit on the *ex post real* interest rate yield on ten year Treasury notes, i.e., on the longer term (as opposed to shorter term) *ex post real* interest rate yield.

Unlike most previous studies, the present empirical analysis investigates this deficit/interest rate issue for a period exceeding the last half century, i.e., this study considers the issue in question over a relatively long time frame, one beginning with the year 1960. Furthermore, focusing on a *longer term real* interest rate rather than a *longer term nominal* interest rate reflects the fact that private-sector, i.e., firms', investment is presumably much more influenced by *real* than by *nominal* interest rates. Related to this perspective, consider the observation by Cecchetti (2006, p. 555), that "…the economic decisions of households to save and of firms to invest depend on the *real* interest rate…" Similarly, Mishkin (2013, p. 609) observes the traditional view is that "…a fall in real interest rates…lowers the cost of borrowing, causing a rise in investment spending…and consumer durable expenditure…" According to the "conventional wisdom" then, the higher the *ex post* real longer term rate of interest, the lower the present value of investment for firms and hence the lower the rate of investment in new plant and equipment, *ceteris paribus*. In addition, consumer purchases of durable goods (especially housing), is likely also a decreasing function of the *ex post* real longer term rate of interest, *ceteris paribus*. Thus, it follows that the higher the *ex post real longer term interest rate*, the lower the expected level of economic activity (Taylor, 1999) as a result of "crowding out" of private investment and consumer durable goods purchases (Carlson and Spencer, 1975; Cebula, 1997; Ewing and Yanochik, 1999; Gale and Orszag, 2003).

Furthermore, the focus of this study is on the *ex post* real interest rate rather than the *ex ante* real interest rate. This is because there is controversy regarding the choice/specification of an inflation-expectations variable (Swamy, Kolluri, and Singamsetti, 1990; Cebula, 1998). For example, one possible way to measure expected future inflation is provided by the Federal Reserve Bank of

Philadelphia (2013) in the form of the well-known Livingston survey data of expected future inflation. 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, the present study defines the *real* rate of interest solely in terms of the *ex post real* rate.

Using annual data, this study initially investigates the period 1960 through 2013 in order to provide at least preliminary *contemporary* insights into whether federal budget deficits have elevated real longer term interest rates in the U.S. over an extended time period. Section 2 of this study provides the loanable funds framework adopted, and Section 3 defines the specific variables in the empirical model and describes the data. Using that data, Section 4 provides the empirical results of autoregressive, two stage least squares (2SLS) estimations in terms of the *ex post* real ten year U.S. Treasury note rate for the 1960-2013 time period. As a modest test of the robustness of the results and model over time, the model is subsequently estimated with annual data for two additional time periods, 1971-2013 and 1980-2013. In Section 5, an additional set of estimation results is provided for the period 1960-2013, in this case involving quarterly data; this estimation is used to confirm yet again the basic conclusions found in the initial estimation (one that used annual data). Conclusions are found Section 6.[1]

2 The Framework: Determinants of the *Ex Post* Real Interest Rate Yield on Ten Year U.S. Treasury Notes

Based extensively on Barth, Iden, and Russek (1984; 1985; 1986) and Hoelscher (1986), as well as Al-Saji (1993) and Cebula (1997), to identify the determinants of the *ex post* real interest rate yield on ten year Treasury notes, a loanable funds model is adopted in which the real longer term interest rate yield is, assuming all other bond markets are in equilibrium, determined by:

$$D + MY = TDEFY \qquad (1)$$

where:

D = private sector domestic demand for ten year Treasury notes;

MY = a measure of the relative magnitude of the domestic money supply (M2), expressed as a percent of GDP;

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1 Interestingly, this study significantly extends a very recent exploratory note by Cebula (2013), which addressed the possible impact of deficits on the *nominal* interest rate yield on Moody's Aaa-rated corporate bonds over the 1973-2012 period using annual data. Unlike the present study, the Cebula (2013) analysis does not adopt the *ex post real* interest rate yield on ten year Treasury notes as the dependent variable. Furthermore, unlike the present study, the study by Cebula (2013) also overlooks the first two years immediately following the U.S. abandonment of Bretton Woods (1971 and 1972) and does not consider the period from 1960 through 1970 either. Furthermore, also unlike the present study, the Cebula (2013) study contains (except for the change in per capita GDP variable) different explanatory variables, namely, expected inflation, the *ex ante* real three month T-bill rate, and the monetary base over GDP in lieu of the variables in equation (4) of the present study; furthermore, Cebula (2013) does not include an estimate involving quarterly data. Another very recent related study by Cebula and Foley (2013) addresses the impact of deficits on the *nominal* long term fixed-rate mortgage interest rate and its specification (including an expected inflation variable, a measure of the nominal cost of funds, and the real GDP growth rate), differs

TDEFY = the total federal budget deficit, expressed as a percent of GDP;

In this framework, it is hypothesized that:

$$D = D\,(RTEN, RBaa, RTHREE, RTXFR, CHPCGDP),\ D_{RTEN} > 0,\ D_{RBaa} < 0,\ D_{RTHREE} < 0,$$

$$D_{RTXFR} < 0,\ D_{CHPCRGDP} > 0 \qquad (2)$$

where:

RTEN = the annual average *ex post* real interest rate yield on ten year Treasury notes;

RAaa = the annual average *ex post* real interest rate yield on Moody's Baa-rated corporate bonds;

RTHREE = the annual average *ex post* real interest rate yield on three year Treasury notes;

RTXFR = the annual average *ex post* real interest rate yield on high grade municipal bonds; and

CHPCRGDP = the change in per capita real GDP.

According to the model, the private sector demand for ten year notes is an increasing function of RTEN, *ceteris paribus*, since bond buyers prefer a higher real rate of return. On the other hand, the higher the *ex post* real interest rate yield on Moody's Baa-rated corporate bonds, the lower the private sector demand for ten year Treasury notes as bond buyers at the margin substitute these corporate bonds for the Treasury notes, *ceteris paribus*. Similarly, the higher the *ex post* real interest rate yield on three year Treasury notes, the lower the demand for U.S. Treasury notes, *ceteris paribus*, as private investors substitute these notes for the ten year Treasury notes. Furthermore, the higher the real (tax free) interest rate yield on high grade municipal bonds, the lower the demand for ten year U.S.

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extensively from equation (4) of the present study. It also deals solely with the period 1970-2008.

Treasury notes, *ceteris paribus*, as private investors substitute high grade municipal bonds for the ten year Treasury notes. Finally, following Barth, Iden and Russek (1984) and Hoelscher (1986), the variable CHPCRGDP is included in the analysis to capture any accelerator effects of real GDP changes on aggregate investment demand. According to Barth, Iden, and Russek (1984) and Hoelscher (1986), the expected sign on this partial is positive. This is because as the CHPCRGDP rises, the available supply of private sector funds also rises, some of which is expected to be directed to the purchase of ten year Treasury issues.

Substituting equation (2) into equation (1) and solving for RTEN yields:

RTEN = f (TDEFY, MY, RBaa, RTHREE, RTXFR, CHPCRGDP)

such that: $f_{TDEFY} > 0$, $f_{MY} < 0$ $f_{RBaa} > 0$, $f_{RTHREE} > 0$, $f_{RTXFR} > 0$, $f_{CHPCRGDP} < 0$ (3)

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, *ceteris paribus*. The expected sign on the money supply variable (MY) is negative because the greater the magnitude of the money supply relative to GDP, the greater the offset to new government debt issues, i.e., greater money supply availability presumably helps to offset the interest-rate effects of budget deficits, *ceteris paribus*. The hypothesized signs on the three partial derivatives f_{RBaa}, f_{RTHREE}, and f_{RTXFR} are all positive. These hypothesized signs reflect the fact that ten year Treasury notes *compete* with (a) Moody's Baa-rated bonds, (b) three year Treasury notes, and (c) high grade municipal bonds. Consequently, if the real interest rate yield rises on either the Moody's Baa-rated bond, or on the three year Treasury note, or on the high grade municipal bond, so too must the real interest rate yield on ten year Treasury notes. Finally, given the expectation that $D_{CHPCRGDP} > 0$ (Barth, Iden, and Russek, 1984; Hoelscher, 1986), it follows that the expected sign on the partial $f_{CHPCGDP}$ is negative, *ceteris paribus*.

3 Variables and Annual Data: *Ex Post* Real Interest Rate Yield on Ten Year Treasury Notes

Predicated upon the model shown above in equation (3), the estimations provided in this study involve the following model:

$$RTEN_t = \alpha_0 + \alpha_1\ TDEFY_t + \alpha_2\ MY_{t-1} + \alpha_3\ RBaa_t + \alpha_4\ RTHREE_t + \alpha_5\ RTXFR_{t-1} + \alpha_6\ CHPRCGDP_{t-1} + \alpha_7\ AR(1) + u_t \quad (4)$$

where:

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

α_0 = constant term;

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

MY_{t-1} = the ratio of the average nominal M2 money supply in year t-1 to the nominal GDP in year t-1, expressed as a percent;

$RBaa_t$ = the *ex post* real average interest rate yield on Moody's Baa-rated corporate bonds in year t, expressed as a percent annum;

$RTHREE_t$ = the *ex post* real average interest rate yield on three year U.S. Treasury notes in year t, expressed as a percent per annum;

$RTXFR_{t-1}$ = the *ex post* real average interest rate yield on high grade municipal bonds in year t-1, expressed as a percent per annum;

$CHPCRGDP_{t-1}$ = the change in per capita real (2005 dollars) GDP over year t-1;

AR (1) = the autoregressive term; and

u_t = the stochastic error term.

The expected signs on the coefficients in equation (4) are, as follows:

$$\alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_5 > 0, \alpha_6 < 0 \quad (5)$$

The budget deficit and M2 money supply are scaled by GDP because the sizes of the budget deficit and money supply should be judged relative to the size of the economy (Ostrosky, 1990; Cebula, 1997; Saltz, 1998). As a reflection of the efficiency of U.S. financial markets. the dependent variable in this system, $RTEN_t$, is expressed as contemporaneous with three of the explanatory variables: the *ex post* real average annual interest rate yield on Moody's Baa-rated corporate bonds, $RBaa_t$; the federal budget deficit, as a percent of GDP, $TDEFY_t$; and the *ex post* real average annual interest rate yield on three-year Treasury notes, $RTHREE_t$. Given these contemporaneous components of this specification, the possibility of simultaneity bias arises, which in turn mandates the adoption of instrumental variables. The instrument chosen for the variable $RBaa_t$ was the two-year lag of the *ex post* real average annual interest rate yield on three-month U.S. Treasury bills,

$RTBR_{t-2}$; the instrument chosen for the deficit variable $TDEFY_t$ was the two-year lag of the percentage annual average civilian unemployment rate, UR_{t-2}; and the instrument chosen for the $RTHREE_t$ variable was the percentage growth rate of real GDP lagged two years, $RGDPGR_{t-2}$. The choice of instruments was based on the finding that $RTBR_{t-2}$ was highly correlated with the $RBaa_t$ variable (r=0.856), the finding that UR_{t-2} was highly correlated with the $TDEFY_t$ variable (r=0.604), and the finding that the $RGDPGR_{t-2}$ was highly correlated with the variable $RTHREE_t$ (r=0.647), whereas these instruments were uncorrelated with the error terms in the system. The interest rate variable RTXFR was lagged one year to avoid multi-collinearity 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-4, B-42, B-64, B-69, B-73, B-79, B-95) and the Federal Reserve System (2014). The group unit root test reveals that the variables in this model are stationary in levels for the 1960-2013 study period. Descriptive statistics for each of the variables in the model for the 1960-2013 period are found in Table 1.

4 Empirical Findings Using Annual Data

Empirical findings involving annual data are provided in this section of the study for three time periods. The first is the longest time frame alluded to in the Introduction, namely, 1960-2013, covering over half a century (n=54). The second, whose purpose is in part to test the consistency and resiliency of the findings for this longer period, covers the years 1971-2013 (n=43). The final time frame investigated deals with the period 1980-2013 (n=34).

The Period 1960-2013

The autoregressive 2SLS estimate of equation (4) is provided in Table 2, where estimated coefficients, t-values, and prob. values are provided and where the Newey and West (1986) heteroskedasticity correction has been adopted. In Table 2, all six 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 10% level. Only the estimated coefficient on the variable $CHPCRGDP_{t-1}$ fails to be statistically significant at the 10% level, a result found in Barth, Iden and Russek (1984), Hoelscher (1986), and elsewhere in the deficit-interest rate literature. The DW statistic is 1.95, so that there is no gross evidence of an autocorrelation problem. The J-statistic is statistically significant at the 5% level, attesting to the dependability of the estimation, while the instrument rank is 14.

For the 1960-2013 study period, the coefficient on the money supply variable, MY_{t-1}, is negative but statistically significant at only the 10% level, implying, albeit weakly, that the higher the ratio of the M2 money supply relative to GDP, the lower the *ex post* real interest rate yield on ten year Treasury notes; clearly, this empirical result cannot be regarded as compelling empirical evidence of this impact of monetary policy. The coefficient on the *ex post* real interest rate yield on Moody's Baa-rated corporate bonds ($RBaa_t$) is positive, as hypothesized, and statistically significant at the 1%

level, implying that the higher this *ex post* real interest rate yield, the higher the *ex post* real interest rate yield on ten year Treasury notes. This finding presumably reflects competition between long term corporate bonds and ten year Treasury notes. The estimated coefficient on the *ex post* real three year Treasury note interest rate yield is also positive and statistically significant at the 1% level, as hypothesized, implying that the higher the value of the variable $RTHREE_t$, the higher the *ex post* real interest rate yield on ten year Treasury notes. This finding presumably is a consequence of market competition, in this case between three year and ten year Treasury notes. The estimated coefficient on the $RTXFR_{t-1}$ variable is positive and statistically significant at the 1% level, a finding also suggestive of market competition, in this instance between ten year Treasuries and high grade municipals. Thus, the higher the value of $RTXFR_{t-1}$, the higher the value of $RTEN_t$. Finally, the coefficient on the budget deficit variable, $TDEFY_t$, is positive and statistically significant at the 1% level. Thus, the higher the federal budget deficit (as a percent of GDP), the higher the *ex post* real interest rate yield on ten year Treasury notes. This finding is in principle consistent with a variety of empirical studies of the U.S. involving *earlier and shorter* time periods, including Al-Saji (1993), Barth, Iden and Russek (1984, 1985, 1986), Cebula (1997, 2005, 2013), Cebula and Cuellar (2010), Findlay (1990), Gissey (1999), Hoelscher (1986), Kiani (2009), and Saltz (1998), among others.

For the interested reader, Table 3 provides the correlation matrix for the explanatory variables over the 1960-2013 study period. There is modest evidence of multi-collinearity, i.e., three cases out of 15 pairings. However, in all three cases, the explanatory variables involved are all statistically significant at the 1% level in the estimation. Hence, there does not appear to exist a significant multi-collinearity problem in this model.

The Period 1971-2013

In order to test the consistency and resiliency of the findings for the 1960-2013 study period and arguably also to provide insight into the budget deficit-real interest rate yield relationship during a more recent time period, a second estimate of equation (4) is provided; in this estimate, the study period runs from 1971 through 2013. The choice of 1971 as the beginning of this alternative study period is the fact that the U.S. announced in August of 1971 that it was abandoning the Bretton Woods Agreement. For the interested reader, Table 4 provides descriptive statistics for the variables in the model for this study period. In addition, it is observed that the group unit root test reveals that the variables in this model are stationary in levels for the 1971-2013 study period.

In any case, the autoregressive 2SLS estimate of equation (4) for the period 1971-2013 is provided in Table 5, where estimated coefficients, t-values, and prob. values are provided and where the Newey and West (1986) heteroskedasticity correction has again been adopted. In Table 5, all six 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 two ($CHPCRGDP_{t-1}$ and MY_{t-1}) failing to be statistically significant at the 10% level. The DW statistic is 1.88, so that there is no evidence of an autocorrelation problem. The J-statistic is statistically significant at the 5% level, attesting to the dependability of the estimation.

The coefficient on the *ex post* real interest rate yield on Moody's Baa-rated corporate bonds ($RBaa_t$) is positive and statistically significant at the 1% level, implying that the higher this *ex post* real interest rate yield, the higher the *ex post* real interest rate yield on ten year Treasury notes. As observed earlier, this outcome presumably reflects competition between the markets for long term corporate bonds and ten year Treasury notes. The estimated coefficient on the *ex post* real three year Treasury note interest rate yield is also positive and statistically significant at the 1% level, implying that the higher the value of the variable $RTHREE_t$, the higher the *ex post* real interest rate yield on ten year Treasury notes. Once again, this presumably is a consequence of market competition between these two Treasury notes in the financial marketplace. Similarly, the estimated coefficient on the $RTXFR_{t-1}$ variable is positive and statistically significant at the 1% level, so that the higher the value of $RTXFR_{t-1}$, the higher the value of $RTEN_t$. As in the estimate for 1960-2013, this finding is suggestive of market competition, in this case between ten year Treasuries and high grade municipals. Finally, the coefficient on the federal budget deficit variable, $TDEFY_t$, is positive and statistically significant at the 1% level. Thus, the higher the federal budget deficit (expressed as a percent of GDP), the higher the *ex post* real interest rate yield on ten year Treasury notes. Once again, this finding is consistent with a variety of empirical studies of earlier and shorter time periods, including those by Al-Saji (1993), Barth, Iden and Russek (1984, 1985, 1986), Cebula (1997, 2005, 2013), Cebula and Cuellar (2010), Findlay (1990), Hoelscher (1986), Kiani (2009), and Saltz (1998). Thus, it appears that the results for the 1971-2013 period are entirely consistent with those for the longer study period

1960-2013, thereby lending greater credibility for the latter (exploratory) results.

The Period 1980-2013

As observed by Barth (1991), in March of 1980, the Congress passed and the President signed into law the most sweeping de-regulation of the U.S. banking industry in U.S. history. This de-regulation came in the form of the DIDMCA (the Depository Institutions De-regulation and Monetary Control Act of 1980). Among its many components was the provision phasing out (by April 1, 1986) of "Regulation Q," which had set ceilings on the interest rates financial institutions in the U.S. could pay on deposits. Another provision of the DIDMCA was one that eliminated statutes prohibiting "usury," thereby enabling interest rates to rise to true market values. Furthermore, this banking system de-regulation was further reinforced by the implementation of another federal statute, the GSDIA (Garn-St. Germain Depository Institutions Act of 1982), which de-regulated savings and loan institutions and permitted them to issue adjustable rate mortgages. Thus, it is reasonable to scrutinize the budget deficit-real interest rate linkage in light of these developments in U.S. financial markets. For the interested reader, it is observed that the group unit root test reveals that the variables in this model are stationary in levels for the 1980-2013 study period. Finally, the descriptive statistics for the 1980-2013 study period are provided in Table 6.

The autoregressive 2SLS estimate of equation (4) for the period 1980-2013 is provided in Table 7, where estimated coefficients, t-values, and prob. values are provided and where the Newey and West (1986) heteroskedasticity correction has been adopted. In Table 7, all six 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 one being statistically significant at the 5% level. Two of the six coefficients, $CHPCRGDP_{t-1}$ and MY_{t-1}, fail to be statistically significant at even the 10% level. The DW statistic is 1.85, so that there is no evidence of an autocorrelation problem. In addition, the J-statistic is statistically significant at the 5% level.

Thus, once again, it is found that, this time for the period beginning in 1980, the *ex post* real interest rate yield on ten year U.S. Treasury notes is an increasing function of $RTHREE_t$, $RBaa_t$, and $RYTF_{t-1}$. In addition, and more relevantly in view of the objective of this study, the *ex post real* interest rate yield on ten year U.S. Treasury notes is found to be an increasing function (at beyond the 5% statistical significance level) of the federal budget deficit (expressed as a percent of GDP).

5 Empirical Findings Using Quarterly Data, 1960.1-2013.4

In this section of the study, the basic model is re-estimated for the 1960-2013 time period using quarterly data. The actual study period thus runs from quarter 1960.1 through quarter 2013.4. The model being estimated in this case directly parallels that in equation (4) above and is given by:

$$RTEN_t = \alpha_0 + \alpha_1\ TDEFY_t + \alpha_2\ MY_{t-1} + \alpha_3\ RBaa_t + \alpha_4\ RTHREE_t + \alpha_5\ RTXFR_{t-1}$$
$$+ \alpha_6\ CHPRCGDP_{t-1} + \alpha_7\ AR\ (1) + u_t \qquad (5)$$

where:

$RTEN_t$ = the *ex post* real average interest rate yield on ten year U.S. Treasury notes in quarter t, expressed as a percent per annum;

α_0 = constant term;

$TDEFY_t$ = the ratio of the nominal federal budget deficit in quarter t to the nominal GDP in quarter t, expressed as a percent;

MY_{t-1} = the ratio of the average nominal M2 money supply in quarter t-1 to the nominal GDP in quarter t-1, expressed as a percent;

$RBaa_t$ = the *ex post* real average interest rate yield on Moody's Baa-rated corporate bonds in quarter t, expressed as a percent annum;

$RTHREE_t$ = the *ex post* real average interest rate yield on three year U.S. Treasury notes in quarter t, expressed as a percent per annum;

$RTXFR_{t-1}$ = the *ex post* real average interest rate yield on high grade municipal bonds in quarter t-1, expressed as a percent per annum;

$CHPCRGDP_{t-1}$ = the change in per capita real (2005 dollars) GDP over quarter t-1, expressed as an annual rate;

AR (1) = the autoregressive term; and

u_t = the stochastic error term.

Once again, the group unit root test reveals that the variables in this model are stationary in levels for the 1960.1-2013.4 study period. Naturally, the three instruments, $RTBR_{t-2}$, UR_{t-2}, and $RGDPGR_{t-2}$, are values for quarter t-2, with the variables $RTBR_{t-2}$ and UR_{t-2} each expressed as a percent per annum.

The autoregressive 2SLS estimate of equation (5) is provided in Table 8, where estimated coefficients, t-values, and prob. values are provided and where the Newey and West (1986) heteroskedasticity correction has been adopted. In Table 8, all six 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 two of the six coefficients, $CHPCRGDP_{t-1}$ and MY_{t-1}, failing to be statistically significant at even the 10% level. The DW statistic is 1.86, so that there is no evidence of an autocorrelation problem. In addition, the J-statistic is statistically significant at the 5% level.

This autoregressive 2SLS estimate using quarterly data for the 1960.1-2013.4 study period reveals that the *ex post* real interest rate yield on ten year U.S. Treasury notes has been an increasing function of the *ex post* real interest rate yield on Moody's Baa-rated corporate bonds, the *ex post* real interest rate yield on three year Treasury notes, and the *ex post* real interest rate yield on high grade municipal bonds. This estimate also finds that federal budget deficit (relative to the GDP level) exercised a positive and statistically significant impact on the *ex post* real interest rate yield on ten year Treasury notes. Inasmuch as these findings are entirely consistent with the results in this study obtained used annual data for the periods 1960-2013, 1971-2013, and 1980-2013, one could interpret this estimation as a "soft" robustness test of the initial model. Finally, it is observed that, in the interest of space, the results of quarterly estimates for the periods 1971.3-2013.4 and 1980.1-2013.4 are not provided here; however, these results are entirely compatible with their counterpart annual results for these corresponding periods.[2]

6 Conclusion

Using over a half century of data, this empirical study adopts a simple loanable funds to investigate the impact of the federal budget deficits in the U.S. on the *ex post* real interest rate yield on ten year U.S. Treasury notes. Three estimates using annual data for three different time periods (1960-2013, 1971-2013, 1980-2013) are provided; in addition, as a *de facto* modest test of robustness, one additional estimate using quarterly data for the period 1960.1 through 2013.4 is also provided. In each of the four empirical analyses, an autoregressive 2SLS estimate finds that the *ex post* real interest rate yield on ten year U.S. Treasury notes is an increasing function of the *ex post* real interest rate yield on Moody's Baa-rated corporate bonds, the *ex post* real interest rate yield on three year Treasury notes, and the *ex post* real interest rate yield on high grade municipal bonds. This exploratory analysis also finds consistent evidence that federal budget deficit (relative to the GDP level) exercised a positive and statistically significant impact on the *ex post* real interest rate yield on ten year Treasury notes, a finding compatible in principle with a number of earlier studies of shorter time periods, such as those by Al-Saji (1993), Barth, Iden and Russek (1984, 1985, 1986), Cebula (1997, 2005, 2013), Cebula and Cuellar (2010), Findlay (1990), Hoelscher (1986), Kiani (2009), and Saltz (1998), among others.

Thus, it appears that factors elevating the federal budget deficit as a percent of GDP act to raise the *real* cost of borrowing to the U.S. Treasury and hence, ultimately, to the U.S. taxpayer (and,

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2 These results are available upon request.

arguably, vicariously to households in general as well as firms and state and local governments). Given the time periods studied, 1960 through 2013 (and 1960.1-2013.4), 1971 through 2013, and 1980 through 2013, this relationship appears to be an enduring one, one that policy-makers cannot afford to overlook in the long run if the private sector of the economy is to grow and prosper to its potential. Although this study does not argue that the results obtained here necessarily lead to crowding out, certain previous studies finding that budget deficits raise long term interest rates have made such an argument (Carlson and Spencer, 1975; Cebula, 1997; Ewing and Yanochik, 1999; Gale and Orszag, 2003). The present study takes the broader view that more research is necessary in order to link investment in new plant and equipment and other private-sector "candidates" for transactions crowding out to federal budget deficits before crowding out claims can hold credibility.

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Table 1. Descriptive Statistics, 1960-2013, Annual Data

Variable	Mean	Standard Deviation
$RTEN_t$	2.499	2.284
$TDEFY_t$	2.693	2.604
MY_{t-1}	54.211	7.701
$RBaa_t$	4.471	2.415
$RTHREE_t$	1.939	2.049
$RTXFR_{t-1}$	1.835	2.126
$CHPCRGDP_{t-1}$	55.20	52.90

Table 2. AR/2SLS Estimation Results, 1960-2013, Annual Data
Dependent Variable: $RTEN_t$

Variable	Coefficient	t-value	Prob.
Constant	-0.147	-0.37	0.7128
$TDEFY_t$	0.091***	2.76	0.0085
MY_{t-1}	-0.012*	-1.68	0.0998
$RBaa_t$	0.422***	3.56	0.0009
$RTHREE_t$	0.511***	4.02	0.0002
$RTXFR_{t-1}$	0.076***	4.90	0.0000
$CHPCRGDP_{t-1}$	-158.62	-0.28	0.7801
AR (1)	0.559**	3.39	0.0015
N	54		
DW	1.95		
Rho	0.02		
Inverted Root	0.56		
J-statistic**	12.44		
Instrument Rank	14		

***statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.

Table 3. Correlation Matrix, Explanatory Variables, 1960-2013, Annual Data

	TDEFY	MY	RBaa	RTHREE	RTXFR	CHPCRGDP
TDEFY	1.000					
MY	0.460	1.000				
RBaa	0.279	0.105	1.000			
RTHREE	-0.095	-0.215	0.580	1.000		
RTXFR	0.267	-0.046	0.559	0.579	1.000	
CHPCRGDP	0.354	0.349	0.170	-0.200	0.250	1.000

Table 4. Descriptive Statistics, 1971-2013, Annual Data

Variable	Mean	Standard Deviation
$RTEN_t$	2.564	2.542
$TDEFY_t$	3.191	2.670
MY_{t-1}	57.04	5.179
$RBaa_t$	4.772	2.616
$RTHREE_t$	1.877	2.216
$RTXFR_{t-1}$	1.948	2.188
$CHPCRGDP_{t-1}$	58.30	57.55

Table 5. AR/2SLS Estimation Results, 1971-2013, Annual Data
Dependent Variable: $RTEN_t$

Variable	Coefficient	t-value	Prob.
Constant	-0.24	-0.51	0.6118
$TDEFY_t$	0.118***	2.71	0.0099
MY_{t-1}	-0.009	-1.24	0.2239
$RBaa_t$	0.362***	4.10	0.0002
$RTHREE_t$	0.574***	5.98	0.0000
$RTXFR_{t-1}$	0.077***	4.80	0.0000
$CHPCRGDP_{t-1}$	-249.98	-0.45	0.6563
AR (1)	0.580***	4.00	0.0003
N	43		
DW	1.88		
Rho	0.09		
Inverted Root	0.58		
J-statistic**	13.16		
Instrument Rank	14		

***statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.

Table 6. Descriptive Statistics, 1980-2013, Annual Data

Variable	Mean	Standard Deviation
$RTEN_t$	3.168	2.329
$TDEFY_t$	3.441	2.905
MY_{t-1}	55.82	5.066
$RBaa_t$	5.480	2.262
$RTHREE_t$	2.372	2.307
$RTXFR_{t-1}$	2.805	2.017
$CHPCRGDP_{t-1}$	35.80	6.28

Table 7. AR/2SLS Estimation Results, 1980-2013, Annual Data
Dependent Variable: $RTEN_t$

Variable	Coefficient	t-value	Prob.
Constant	1.434	0.90	0.3751
$TDEFY_t$	0.138**	2.09	0.0461
MY_{t-1}	-0.038	-1.17	0.2505
$RBaa_t$	0.313***	2.94	0.0067
$RTHREE_t$	0.602***	6.00	0.0000
$RTXFR_{t-1}$	0.089***	6.18	0.0000
$CHPCRGDP_{t-1}$	-185.82	-0.24	0.8129
AR (1)	0.396*	1.76	0.0905
N	34		
DW	1.85		
Rho	0.07		
Inverted Root	0.40		
J-statistic**	12.84		
Instrument Rank	14		

***statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.

Table 8. AR/2SLS Estimation Results, 1960.1-2013.4, Quarterly Data
Dependent Variable: $RTEN_t$

Variable	Coefficient	t-value	Prob.
Constant	-0.115	-0.31	0.7549
$TDEFY_t$	0.096***	3.02	0.0042
MY_{t-1}	-0.008	-1.17	0.2466
$RBaa_t$	0.319***	5.25	0.0000
$RTHREE_t$	0.63***	9.99	0.0000
$RTXFR_{t-1}$	0.074***	4.59	0.0003
$CHPCRGDP_{t-1}$	-465.43	-1.01	0.3204
AR (1)	0.513***	3.96	0.0003
N	216		
DW	1.86		
Rho	0.07		
Inverted Root	0.51		
J-statistic**	12.35		
Instrument Rank	15		

***statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.