New Evidence on the Interest Rate Effects of Budget Deficits and Debt

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Abstract

Estimating the effects of government debt and deficits on Treasury yields is complicated by the need to isolate the effects of fiscal policy from other influences. To abstract from the effects of the business cycle, and associated monetary policy actions, on debt, deficits, and interest rates, this paper studies the relationship between long-horizon expected government debt and deficits, measured by CBO and OMB projections, and expected future long-term interest rates. The estimated effects of government debt and deficits on interest rates are statistically and economically significant: a one percentage point increase in the projected deficit-to-GDP ratio is estimated to raise long-term interest rates by about 25 to 30 basis points. Under plausible assumptions these estimates are shown to be consistent with predictions of the neoclassical growth model.

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1 Introduction

Much controversy surrounds the quantitative effects of government debt and deficits on long-term real interest rates. Economic theory provides different answers depending on issues such as whether deficits reflect changes in government expenditures or shifts in the timing of taxes, and on the planning horizon of households who hold government debt and pay taxes. One might hope that empirical evidence could be brought to bear on this question, but here the results are just as ambiguous. One major obstacle in obtaining empirical estimates is the need to isolate the effects of fiscal policy from the many other factors affecting interest rates. The most obvious of these factors is the state of the business cycle. If automatic fiscal stabilizers raise deficits during recessions, while at the same time long-term interest rates fall due to monetary easing, deficits and interest rates may be negatively correlated even if the partial effect of deficits on interest rates – controlling for all other influences – is positive.

This paper proposes to address this identification problem by focusing on the relationship between long-horizon forecasts of both interest rates and fiscal variables. Deficits and interest rates expected to prevail several years in the future are presumably little affected by the current state of the business cycle, thus greatly reducing the reverse-causality effects induced by countercyclical monetary policy and automatic fiscal stabilizers. Of course, there are many conceivable factors that jointly determine fiscal variables and interest rates, and it is unlikely that a reduced-form regression would ever completely overcome this endogeneity problem, but focusing on long-horizon forecasts is an important step in the right direction. Moreover, deficits projected several years into the future may be informative about the longer-run fiscal position, and may therefore approximate investors' expectations about the eventual level of government debt relative to GDP. Such measures of expectations thus hold out the prospect of uncovering any causal relationship from fiscal variables to interest rates.

Expectations of future fiscal policy are proxied in this paper by projections published by the Congressional Budget Office (CBO) and the Office of Management and Budget (OMB) for the federal government's unified budget deficit, the stock of federal government debt held by the public, and other fiscal variables, all expressed as percentages of the respective agency's own projection of GNP or GDP. The forecast horizon is five years in the future, which is the longest horizon for which a reasonably long time series of projections is available. Consistent with the use of 5-year-ahead projections of fiscal variables by the CBO and the

OMB, the analysis focuses on expectations of future nominal interest rates derived from forward rates 5 to 14 years ahead embedded in the term structure of interest rates.

The results reported below show that a percentage point increase in the projected deficit-to-GDP ratio raises the 10-year bond rate expected to prevail five years into the future by 24 to 40 basis points; a typical estimate is about 30 basis points. The estimates are very precise compared to most of the literature mentioned below. Similarly, a percentage point increase in the projected debt-to-GDP ratio raises future interest rates by about 4 to 5 basis points, and these estimates are statistically significant, too. Importantly, these estimates are shown to be robust along many dimensions. Moreover, under plausible assumptions about the persistence of changes in projected deficits, the estimated 30 basis point effect on interest rates of a percentage point increase in the projected deficit-to-GDP ratio is shown to be consistent with the 4-to-5 basis point effect of an increase in the projected debt-to-GDP ratio.

This study is by no means the first to use published projections of future budget deficits. Wachtel and Young (1987) use CBO and OMB projections to analyze *changes* in long-term interest rates on the day of the release of the respective projection.[1] Unlike those shown here, their results therefore depend on correctly identifying the unanticipated component of the release. They find that a $1 billion increase in the projected deficit (at that time roughly 0.025 percent of nominal GDP) raises interest rates by between 0.15 and 0.4 basis points, depending on the maturity of the interest rate series and the source of the projections. Their estimates therefore imply an increase in interest rates on the order of 6 to 16 basis points in response to a percentage point increase in the deficit-to-GDP ratio. However, many of their estimates are statistically insignificant.

Cohen and Garnier (1991) and Elmendorf (1993) present results concerning the effect of deficit projections on the change in interest rates between release dates. Like the present one, these studies are based on the weaker assumption (in comparison to Wachtel and Young's) that the deficit projections are good proxies of private agent's expectations of future fiscal policy at the time of the release. The projections used in these studies, as well as in Wachtel and Young, are relatively short – for the current and next fiscal year in Wachtel and Young and in Cohen and Garnier; for up to eight quarters ahead in Elmendorf. Forecasts at this horizon are presumably still affected by the state of the business cycle. Using OMB

[1] Other studies using similar event analysis are Elmendorf (1996) and Kitchen (1996).

projections, Cohen and Garnier find statistically significant effects of a percentage point unexpected (relative to the previous year's projection) increase in the deficit-to-GDP ratio on interest rates on the order of 40 to 55 basis points. Using DRI forecasts, Elmendorf finds a statistically significant increase in interest rates at maturities up to five years of about 50 basis points, but the effects on long-term interest rates are smaller and statistically insignificant. Canzoneri, Cumby, and Diba (2002) use 5-year-ahead and 10-year-ahead CBO projections of cumulative budget deficits and study their effects on the *spread* between 5-year or 10-year, and 3-month Treasury yields. Their estimates are of similar magnitude as those reported in Cohen and Garnier and in Elmendorf, but are considerably more precise.

The present study confirms the importance of carefully measuring long-horizon expectations of deficits and debt for identifying their effects on interest rates.[2] It departs from the previous studies in several respects, notably by using the level of interest rates expected to prevail 5 years ahead as the dependent variable instead of current long-term rates or the slope of the term structure. In comparison to previous studies, it also includes additional variables suggested by economic theory in the regressions. The specifications used in the regressions are introduced in section 2, and empirical results are presented in section 3. As shown there, removing the short end of the yield curve makes an important contribution to the precise measurement of the interest rate effects of the fiscal variables, as does the inclusion of the additional variables.

Because economic models differ in their view on whether deficits or the stock of debt is what matters for interest rate determination, I present results concerning the effects of both projected deficits and projected debt on interest rates. Conditional on the view that what ultimately matters is the stock of debt, Feldstein (1986) argues that empirical estimates of the interest rate effects of *deficits* depend on how persistent these deficits are expected to be. Under this view, the relative magnitudes of the estimated effects of deficits and the estimated effects of debt reported below are shown to be consistent with the observed historical correlation of actual deficits. Finally, the fourth section discusses the predictions of the neoclassical growth model – the simplest general equilibrium framework for this

[2]This point is illustrated in Elmendorf (1993). He examines the findings of studies that proxy for expectations of fiscal variables by using forecasts from VARs (see Plosser 1982, 1987, and Evans 1987). Elmendorf shows that these VAR forecasts are poor compared to projections available at the time, and that the conclusions of these studies are overturned once better measures of expectations are used. For a taxonomy of studies in this area according to their measurement of expectations see Gale and Orzsag (2002).

purpose – for the relationship between the stock of debt and interest rates. Under plausible assumptions, the empirical results are close to the predictions from this model.

2 Specification and Data

The empirical method used in this paper is to regress expected future interest rates on projections published by the CBO and the OMB for the deficit-to-GDP ratio and the debt-to-GDP ratio five years ahead, as well as other determinants of long-term interest rates suggested by economic theory. As regards the latter, the Ramsey model of optimal growth, combined with a representative household with CES utility, implies that in steady state the real return on capital net of depreciation is determined by

$$r = \sigma g + \theta \tag{1}$$

where g denotes the net growth rate of per capita consumption, σ is the coefficient of relative risk aversion, and θ is the household's rate of time preference. This relationship suggests that an increase in trend growth should raise the return on capital as well as yields on risk-free Treasury instruments. By contrast, the effect of an increase in risk aversion is less clear. While the real rate of return on capital should rise, equation (1) does not distinguish between the returns on risky and safe assets. An increase in risk aversion might reduce Treasury yields by raising the demand for safe assets relative to that for risky ones. Based on these considerations, the regressions reported in the next section are variants of

$$r_t = \beta_0 + \beta_1 f_t + \beta_2 g_t + \beta_3 e_t + \epsilon_t \tag{2}$$

where r_t is the real Treasury yield expected to prevail at some horizon, f_t is a fiscal variable, e.g. the projected deficit-to-GDP ratio, g_t is a measure of potential GDP growth, and e_t is a measure of risk aversion discussed below.

I now briefly discuss the data used in this study; more details can be found in the appendix. From the CBO, five-year-ahead projections for both the unified budget deficit and GDP (GNP until 1991) are available at an annual frequency from 1976 to 1984, and at a semiannual frequency from 1985 until the most recent projection in January 2004. For the early years, the CBO did not publish projections for federal debt held by the public; those projections are therefore computed by adding the CBO's deficit projections for the current and next five fiscal years to the stock of debt held by the public at the end of the previous

fiscal year. From the OMB, five-year-ahead projections of deficits, debt held by the public, and GNP or GDP are available at an annual frequency from 1983 on. Projections from both agencies for net interest payments and total outlays are also collected to analyze the effects of primary deficits or of outlays and revenues separately.

Figures 1 and 2 show the actual deficit-to-GDP ratios and debt-to-GDP ratios, expressed as percent of GDP, together with CBO's and OMB's five-year-ahead projections. The projections are shown for the (fiscal) year for which they were made. Clearly, both agencies made large forecast errors, but the relevant question for the purpose of this study is whether these agencies' projections accurately reflect market expectations at the time the projections were made. While it is impossible to answer that question directly, arguably these agencies' projections are using most of the information about future deficits and debt available at the time, although in different ways: Whereas the CBO's baseline projections are by statute based on fiscal policies that have been enacted at the time the projection is made, the OMB's projections include certain administration proposals. If market participants believe that the administration's policies are likely to pass as proposed, their expectations may be closer to the OMB's projections; in other instances, they may be closer to the CBO's. It is worth noting that over the sample for which both agencies' 5-year-ahead projections can be evaluated (fiscal years 1988 to 2003), the biases and standard deviations of their forecast errors for the deficit-to-GDP ratio are virtually identical in absolute value (-0.9 percent and 3.1 percent for the CBO, 0.9 percent and 3.1 percent for the OMB). For the debt-to-GDP ratio, the bias of the CBO projections (4.8 percent) is larger in absolute value than that of the OMB projections (-0.9 percent), but the standard deviation of the CBO's forecast errors (10.4 percent) is smaller than the OMB's (11.6 percent). There is no obvious reason why investors should prefer one agency's projections over the other, and below results using both sets of projections will be presented.

For the regressions involving CBO projections, the interest rate data are sampled on the last trading day of the month of the CBO release. For the regressions involving OMB projections, I use the value of interest rates as recorded on the last trading day of February, except in those years in which a new administration took office, when I use observations from the last trading day of March. Three different interest rate series are considered below: the yield expected to prevail five years ahead on a 10-year Treasury note, the yield expected to prevail five years ahead on a 5-year Treasury note, and the (conventional) 10-year constant

maturity Treasury yield.[3] The first two are measured as simple averages of one-year forward rates 5 to 9 years and 5 to 14 years ahead, respectively, calculated from the zero-coupon yield curve.[4] Nominal interest rates are converted into real interest rates using a proxy for 10-year consumer price inflation expectations that is based on survey data for most of the sample; details are provided in the appendix. In some regressions the dependent variable is the real interest rate, whereas in others it is the nominal interest rate; in these latter regressions, inflation expectations are allowed to enter with a coefficient different from 1. The series of nominal interest rates and expected inflation, sampled in the months of annual CBO releases, are shown in Figure 3.

For trend growth, I use CBO's 5-year-ahead projections of the growth rate of real GNP or GDP as a proxy for agents' views about the trend growth rate of the economy at a given point in time. It is also the growth rate that is consistent with CBO's deficit projections five years ahead. The equity premium, which is used as a proxy for risk aversion, is calculated as the dividend component of national income, expressed as percent of the market value of corporate equity held (directly or indirectly) by households, minus the real 10-year Treasury yield, plus the trend growth rate. I use the value of the equity premium in the quarter prior to the release of the respective budget projections, assuming that this is the best available forecast of this variable five years ahead. Because the equity premium is a function of the real 10-year Treasury yield, the issue of simultaneity of the dependent variable and this measure of the equity premium is addressed below. Both series are shown in Figure 4.

3 Empirical Results

Economic theory is ambiguous about the question whether it is deficits or the stock of government debt (or neither) that matters for interest rate determination. For example, in

[3] Although this study focuses on government yields, it should be noted that the results are likely to carry over to corporate yields. Based on regression analysis, I find no evidence that yield spreads between corporate bonds and Treasuries, adjusted for cyclical variation, are systematically related to projected deficit-to-GDP ratios.

[4] It has often been noted that forward rates are biased predictors of future interest rates, presumably because they include term and/or risk premia. For the 5-year-ahead 10-year interest rate used here, for example, the bias throughout the 1990s is about 2 percent. Because forward rates are affecting *current* interest rates and hence the current cost of capital relevant for business and residential investment, however, the fact that forward rates may not be unbiased predictors of future interest rates is not a concern.

the IS/LM model, in which interest rates are determined by the flow equilibrium of aggregate demand and supply, the deficit-to-GDP ratio is the relevant fiscal variable. Conversely, in the neoclassical growth model the real interest rate is equal to the marginal product of capital and the question therefore turns on the degree to which government debt crowds out private capital.[5] If Ricardian equivalence holds, deficits (or debt) *per se* are not the relevant variable, but the level of government consumption is. If Ricardian equivalence breaks down, the fiscal variable of relevance may depend on the reasons for this failure. For example, in Blanchard's (1985) model of perpetual youth, the relevant variable is the present discounted value of current and future primary deficits, discounted at the household's discount rate that reflects the probability of death. Because this issue remains unresolved, this section presents results for the interest rate effects of both deficits and debt. As argued below, even if the true structural relationship were between the level of debt and interest rates, regressions of expected interest rates on projected deficits may nonetheless be meaningful to the extent that projected deficits are good proxies for agents' expectations of the future stock of debt.

3.1 Interest rates and deficits

The first three columns of Table 1 present results using the real 5-year-ahead 10-year Treasury yield as the dependent variable. It reports the estimated coefficient on the deficit-to-GDP ratio, expressed as a percentage of GDP, trend growth, and the equity premium; the intercept estimate is omitted from all tables. Also shown are the R^2, the standard error of the regression, the Durbin-Watson statistic, and the number of observations. The t statistics are based on standard errors using the Newey-West correction for heteroskedasticity and serial correlation; the lag truncation, based on automatic selection criteria, is 3 for the CBO data, and 2 for the OMB data.[6]

The first column shows the results for the largest data set, the CBO projections including the mid-year updates from 1985 on. The coefficient on the deficit-to-GDP ratio is 0.31, with a standard error less than 0.03. Trend growth and the equity premium enter with statistically significant and economically meaningful coefficients. The Durbin-Watson

[5] An additional issue is whether government debt might "crowd in" private capital, in that an increase of safe assets in households' portfolios raises the demand for risky assets. See Elmendorf and Kimball (2000).

[6] A caveat in interpreting the t statistics is that augmented Dickey-Fuller tests do not reject the hypothesis of a unit root at the 5 percent level for either the dependent variable or for the regressors. In view of the small number of observations, however, these tests have very low power.

statistics indicate some degree of serial correlation in the residuals. As shown in the second column, omitting the mid-year updates eliminates this problem without significantly affecting the other results; in the following I will focus on the annual CBO data. The third column shows that similar results are obtained using OMB's projections, except that the coefficient on the deficit-to-GDP ratio is larger and not quite as precisely estimated as for the CBO projections.

The use of real interest rates as dependent variable presupposes that changes in inflation expectations move nominal interest rates one-for-one. This relationship may not hold if investors demand higher risk premia on nominal assets when inflation expectations rise to compensate for greater uncertainty about future inflation (see e.g. Okun (1971) and Ball and Cecchetti (1990)). In addition, Feldstein (1976) points out that, because taxes are levied on nominal returns, nominal interest rates have to increase more than one-for-one with expected inflation. Columns 4 to 6 repeat the earlier three regressions, but with nominal expected interest rates as dependent variable, and with inflation expectations included as independent regressor. Consistent with the arguments discussed above, the coefficients on expected inflation are slightly larger than 1. Relative to the earlier regressions in which nominal yields and expected inflation move one for one by assumption, a larger portion of interest rate changes is now attributed to changes in expected inflation. The estimated coefficients on the fiscal variables are slightly smaller than those presented earlier, but still highly significant. The improvement in the R^2 is almost entirely due to the change in the dependent variable, as shown by the nearly unchanged regression standard errors. Because of the economic arguments mentioned before, the following tables focus on results for regressions with nominal yields as dependent variables.

To provide some idea of the interest rate effects predicted by these regressions, consider the CBO's annual projections. Between January 2001 and January 2004, the CBO's 5-year-ahead projection swung from a surplus of 3.8 percent of GDP to a deficit of 1.8 percent. The regression shown in column 5 implies that this swing raised the 5-year-ahead 10-year interest rate by 135 basis points, everything else equal. The swing in the OMB's deficit projection over the same period was smaller (3.9 percent), but given the larger coefficient reported in column 6, the partial effect on the 5-year-ahead 10-year interest rate is 128 basis points, almost the same result.

Table 2 examines the importance of using expected future long-term rates, instead of

current long-term rates, using the annual CBO projections. The dependent variables in the first three regressions are respectively the current 10-year Treasury yield, the spread between the current 10-year yield and the 3-month Treasury bill rate, and the 5-year Treasury yield expected to prevail five years ahead. For convenience, the last column repeats the results shown in the fifth column of Table 1. The spread between the 10-year and 3-month yields, which is one of the dependent variables used by Canzoneri et al. (2002), can be seen as a simpler method of controlling for the short end of the yield curve in comparison to the calculation of expected future interest rates. The results using the conventional 10-year Treasury yield show clearly that controlling for the cyclical variation embedded in the short end of the yield curve is important for identifying the effects of fiscal variables on interest rates.[7] Although the point estimates using the yield spread and the 5-year-ahead 5-year yield are similar to those using the 5-year-ahead 10-year yield, they are not nearly as precise. The same conclusions hold when using OMB instead of CBO projections.[8]

As discussed earlier, different economic models have different implications for which fiscal variable should matter in the determination of interest rates. Before presenting results for the debt-to-GDP ratio, two alternative variants of the relationship between deficits and interest rates are explored. The first column in Table 3 reports results using the ratio of the primary (instead of the total) deficit to GDP. This variable would be relevant under the view that the debt-to-GDP ratio is the relevant fiscal variable, and that primary deficits are serving as proxy for expectations of the debt-to-GDP ratio to which the economy is converging. Using the primary deficit also addresses the concern of reverse causation from the interest rate to projected deficits through higher outlays on debt service. As shown, the coefficient on the deficit-to-GDP ratio is larger than the one reported in column 5 of

[7] When using the *real* 10-year yield as dependent variable, however, the coefficient on the deficit-to-GDP ratio remains of similar magnitude as that reported in the second column of Table 1, but its t statistic is considerably lower than that reported there. Moreover, as in Table 1, using real yields, i.e. the real 10-year Treasury yield or the real 5-year-ahead 5-year yield, as dependent variable leads to larger coefficients on trend growth that are significant at the 1% level.

[8] The coefficients on trend growth and the equity premium in the spread regression reverse signs, reflecting the negative correlation between the current 10-year yield and the yield spread. The coefficient on the deficit/GDP ratio is substantially smaller than the value of 0.6 reported in Table 2 of Canzoneri et al. (2002). This has little to do with the inclusion of additional regressors in the above specification, but probably reflects the fact that Canzoneri et al. use the *cumulative* five-year deficit projection instead of the projection of the deficit in five years' time.

Table 1, with a similar t statistic. The final two columns in Table 3 address the question whether it is only government consumption, rather than deficits, that affect interest rates by disaggregating the projected deficit into total (or primary) outlays and total revenues. A caveat to the use of total outlays is that a large share of these are transfer payments rather than government purchases of goods and services. Under the Ricardian view, the financing of a given path of government outlays should be of no consequence, and hence the coefficient on total revenues should be 0. As shown, the results strongly reject this view, while all other coefficient estimates, the R^2 and the regression standard errors remain similar to the results from the corresponding deficit regressions. This suggests that the focus on the deficit-to-GDP ratio as the fiscal variable of interest is not misplaced.[9]

3.2 Interest rates and debt

Table 4 repeats the regressions shown in Table 1, with the projected deficit-to-GDP ratio replaced by the ratio of the projected stock of federal debt held by the public to projected GDP. When using the real 5-year-ahead 10-year yield as dependent variable, the effect of a percentage point increase in the projected debt-to-GDP ratio is to raise the expected long-term rate by about 5.5 basis points. These effects are again precisely estimated, more so for the CBO data than for the OMB data. Omitting the CBO mid-year updates again reduces the serial correlation in the error term. As shown in the right half of the table, using the nominal expected long-term rate as dependent variable and including inflation expectations as independent regressor produces coefficient estimates on expected inflation similar to those reported in Table 1, while the coefficients on the debt-to-GDP ratio and their t statistics are slightly reduced. The coefficient estimates on trend growth and the equity premium are also similar to those shown in Table 1. To obtain an impression of the interest rate effects implied by these results, consider again the developments over recent years. Between January 2001 and January 2004 the CBO's projection of the debt-to-GDP ratio five years ahead rose from 9.4 percent to 40.7 percent. Using the coefficient reported in column 5 of 4.1 basis points, the partial effect of the change in the projected debt-to-GDP ratio on the 5-year-ahead 10-year interest rate is 129 basis points, very close to the result

[9]The results shown in table 3 are similar when using the real instead of the nominal five-year-ahead 10-year yield as dependent variable, except that the coefficients on trend growth are larger and significant at the 1% level.

for the deficit-to-GDP ratio reported above.

Is the result that the estimated coefficients on the deficit-to-GDP ratio are about six times as large as the ones on the debt-to-GDP ratio economically plausible? If increases in deficits were serially uncorrelated, so that the effect of a projected increase in the deficit on the stock of debt in subsequent years would be simply one for one, the coefficients on the deficit-to-GDP ratio and the debt-to-GDP ratio ought to be the same. But consider the opposite extreme, in which every increase in projected deficits is expected to be permanent. The steady-state effect on the debt-to-GDP ratio of a permanent one percentage point increase in the deficit-to-GDP ratio is $(1 + g)/g$ percent, where g is the net growth rate of nominal GDP. Over the sample 1976-2003, this growth rate averaged about 8 percent per year, implying that the coefficient on the deficit-to-GDP ratio ought to be 13.5 times as large as the coefficient on the debt-to-GDP ratio. The fact that the estimated coefficients on the deficit-to-GDP ratio are about six times as large as those on the debt-to-GDP ratio is consistent with the view that investors perceive increases in projected deficit-to-GDP ratios as highly persistent, but not strictly permanent. In fact, the serial correlation coefficient of the actual deficit-to-GDP ratio over the sample 1976 to 2003 is 0.84, which implies that on average a percentage point innovation in the deficit-to-GDP ratio leads to an ultimate increase in the debt-to-GDP ratio of 1/(1-0.84) or 6.25 percent, exactly in line with the empirical results.

Table 5 considers the importance of using expected future instead of current interest rates by repeating the regressions reported in Table 2, with the projected debt-to-GDP ratio instead of the deficit-to-GDP ratio as fiscal variable. Again the results demonstrate that controlling for the short end of the yield curve improves the precision of the coefficient estimates.

3.3 Robustness of the results

Two issues related to including trend growth and the equity premium in the regressions are addressed in Table 6. The first is how omitting one or both of these variables affects the estimated coefficients on the fiscal variables. To be concise, results are shown for both deficits and debt as fiscal variable, and only for annual CBO data. The first two columns show results when both trend growth and the equity premium are omitted from the regression, and the next two columns show results when only the equity premium is

omitted. Comparing those results to the ones shown in column 5 of Tables 1 and 4, we find that the coefficients on both fiscal variables remain quite similar whether one or both of the non-fiscal regressors are omitted, but are less precisely estimated. However, the coefficients on trend growth are essentially zero when the equity premium is omitted. Thus both the theoretical reasons discussed in the previous section and the empirical results suggest that controlling for trend growth and risk aversion is important.[10]

A different concern is that the equity premium contains the real 10-year Treasury yield, and is therefore correlated with the residual. It should be noted, however, that the real 10-year Treasury yield entering the calculation of the equity premium is the average yield during the quarter preceding the release of the CBO or OMB projections, consistent with the timing of the data on equity returns (see section 2). Nonetheless, the last two columns of Table 6 report results from regressions in which I use the equity premium in the quarter prior to the *previous* projection release (i.e. lagged by approximately one year) as instrument for the current equity premium. Except for lower t statistics of the coefficients on trend growth and the equity premium, the results, especially those concerning the fiscal variables, are nearly identical to those shown in column 5 of Tables 1 and 4.

A final issue addressed here is the stability of the coefficient estimates over various subsamples. There might be some concern that the early 1980s, which were a time of surging deficits and real interest rates, might be largely responsible for the findings reported here. I address this issue by performing rolling regressions, using the nominal 5-year-ahead 10-year yield as dependent variable. For this purpose I use the CBO projections including the semi-annual updates to have the largest possible number of observations available. In each regression 12 years of the total sample are omitted. Thus, the first regression runs from 1976:1 to 1992:1 (given that 9 semi-annual updates are missing in the early years, this sample includes 24 observations), and the last from 1988:1 to 2004:1, including 33 observations but excluding the first half of the 1980s. Figure 5 shows the coefficient on the deficit-to-GDP ratio for each of these 25 regressions at the date at which the respective regression sample ends, as well as the 2 standard error interval around the coefficient estimates. For comparison, the horizontal line represents the full-sample coefficient estimate. Figure 6 provides the same information for the coefficient on the debt-to-GDP ratio. As shown in the

[10] Qualitatively similar results obtain when using OMB projections; in particular, the reduced precision of the estimates means that the coefficients on the fiscal variables in three of the regressions are only borderline significant (t statistics between 1.8 and 1.9).

figures, there is some variation in the coefficient estimates across subsamples, but the earlier conclusions based on the full-sample estimates are qualitatively unchanged. In particular, excluding the observations from the late 1970s and early 1980s moderately reduces the estimated coefficients to about 20 basis points for the deficit-to-GDP ratio and 3 basis points for the debt-to-GDP ratio, but they remain significant at the 5% level.

4 Are the Results Consistent with Economic Theory?

A skeptical view of the evidence presented in the previous section would hold that the identification problems involved in these kinds of regressions are too severe to be ever completely overcome. One may therefore ask whether the empirical results can be reconciled with priors based on economic theory. One potential answer to this question, based on the neoclassical growth model, is sketched below; the argument is closely akin to the one developed in Elmendorf and Mankiw (1999).[11] Because in the neoclassical growth model the real interest rate is determined by the capital-output ratio, the discussion below focuses on the link between the stock of debt and the capital stock, and assesses the plausibility of the results for the debt-to-GDP ratio reported in the previous section. As mentioned above and discussed by Elmendorf and Mankiw (1999), however, whether it is deficits or debt that matter for the determination of interest rates depends on questions such as which model of consumer behavior one assumes. The analysis below therefore illustrates only one particular argument by which the empirical results can be related to economic theory.

Suppose that an increase in government debt reduces the private capital stock by a fraction c; that is, if D denotes the stock of government debt, and K the private capital stock, $\partial K/\partial D = -c$. The parameter c denotes the degree of crowding out, with the remaining fraction $1-c$ being the increase in private savings or capital inflows from abroad in response to the increase in the interest rate. Assuming factors of production earn their marginal product, the share of capital in income, s, is equal to the marginal product of capital times the capital-output ratio $k = K/Y$. Moreover, the marginal product is equal to the sum of the depreciation rate d of the private capital stock and the real interest rate r. Hence we can solve for r as $r = s/k - d$.

The effect of a one percentage point increase in the debt-to-GDP ratio on r can now

[11] A similar argument is used in Council of Economic Advisers (2003). See also Engen and Hubbard (2004).

be computed by calculating the partial derivative $\partial r/\partial D = \partial r/\partial k \cdot \partial k/\partial K \cdot (-c)$. Using a Cobb-Douglas production function $Y = K^s L^{1-s}$, we find that $k = K^{1-s}L^{-(1-s)}$, and therefore $\partial k/\partial K = (1-s)/Y$. Putting the pieces together, an increase $\Delta D = 0.01Y$ raises the interest rate by $(1-s)cs/k^2$ basis points.

The final step in obtaining numerical predictions of the interest rate effects is to choose values for c, s, and k. As an example, consider $s = 0.33$, consistent with a capital share in national income accounts data of about 1/3. For the parameter k, consider the BEA's estimate of private fixed assets at the end of 2001 ($22.2 trillion) divided by output in the nonfarm business sector in 2002 (approximately $8.4 trillion). This yields $k = 2.5$. The most difficult parameter to quantify is the degree of crowding out, c. Elmendorf and Mankiw (1999) survey a number of studies which show that, under assumptions for households' intertemporal elasticity of substitution consistent with household data, the increase in private savings in response to the change in interest rates is close to zero. Moreover, recent studies in the vein of Feldstein and Horioka (1980) suggest that roughly two-thirds of saving in developed countries is retained for domestic investment in the long run, implying that capital inflows from abroad offset about one-third of the increase in debt. Suppose, therefore, that $c = 0.6$. Then a one percentage point increase in the debt-to-GDP ratio raises the real interest rate by 2.1 basis points. This is only half of the effect reported in the regressions using the real interest rate as dependent variable, but only slightly less than the estimates reported in Tables 2 and 3 using the nominal interest rate as the dependent variable.

It should be noted, however, that the estimate of 2.1 basis points is conservative because it takes into consideration the endogenous response of output to the decline in the capital stock, but it omits the second-round effect that the debt-to-GDP ratio is effectively increasing by more than one percentage point. Moreover, as pointed out in the previous section, increases in projected *deficits* tend to be highly persistent, and hence a given increase in the 5-year-ahead projected debt-to-GDP ratio might be expected to be followed by larger increases in the debt-to-GDP ratio beyond five years into the future. If so, a percentage point increase in the debt-to-GDP ratio projected five years ahead should be associated with an increase in interest rates larger than the one implied by a percentage point increase in the *steady state* debt-to-GDP ratio predicted by the model.

5 Conclusions

This study has shown that statistically significant and economically plausible estimates of the effects of government deficits and debt on interest rates can be obtained by focusing on long-horizon forecasts of future deficits or debt, and future interest rates. The projections of deficits and debt published by the CBO and the OMB are arguably among the best publicly available forecasts for these variables. The effects of these projections manifest themselves at the longer end of the yield curve, as economic reasoning would predict. All else equal, the results of this study suggest that interest rates rise by about 25 to 30 basis points in response to a percentage point increase in the projected deficit-to-GDP ratio, and by about 4 to 5 basis points in response to a percentage point increase in the projected debt-to-GDP ratio.

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A The Data

The OMB data are taken from the annual releases of the administration's budget published in February, or slightly later in years in which a new administration took office. The months of CBO releases used in this study (releases omitted from the annual data set are marked by *) are 1/76, 12/76, 1/78, 1/79, 2/80, 7/81, 2/82, 2/83, 2/84, 2/85, 8/85*, 2/86, 8/86*, 1/87, 8/87*, 2/88, 8/88*, 1/89, 8/89*, 1/90, 7/90*, 1/91, 8/91*, 1/92, 8/92*, 1/93, 9/93*, 1/94, 8/94*, 1/95, 8/95*, 12/95*, 5/96, 1/97, 9/97*, 1/98, 8/98*, 1/99, 7/99*, 1/00, 7/00*, 1/01, 8/01*, 1/02, 8/02*, 1/03, 8/03*, 1/04. For the early years of the sample (1976-1982), constructing the series of both projected deficits and debt entails a choice because the CBO reported different projections of future deficits depending mainly on alternative assumptions regarding policy responses to the inflation-induced uptrend in tax receipts. To be consistent across the entire sample, I used the estimates based on the assumption of no policy change. The January 1991 projections are not the CBO baseline, but are based on the already legislated discretionary spending caps, which were the CBO's baseline for the remainder of the 1990s. The December 1995 projections are included despite the fact that they were based on a budget resolution already vetoed by the President. By contrast, the August 1996 update is omitted because of incomplete projections, given that the annual projections had only been published in May.

The series of inflation expectations, which is taken from the Federal Reserve Board's FRB/US model, consists of three different pieces. Until 1981:Q1, the series is an estimated step function based on the changepoint model developed in Kozicki and Tinsley (2001). From 1981:Q2 until 1991:Q2, the series is based on the Hoey survey of decision makers, which was conducted by Drexel-Burnham-Lambert, and later by Barclays De Zoete Wedd. Participants in this survey were polled for their expectation of CPI inflation ten years ahead. Finally, since 1991:Q3 the series is based on the Survey of Professional Forecasters conducted by the Federal Reserve Bank of Philadelphia, in which participants are asked

for their expectation of CPI inflation over the next ten years.[12] Overall, while the series is not ideal for our purposes, it should provide a good measure of inflation expectations over either of the horizons of the nominal yield series described above. The series is extrapolated to monthly frequency, and is sampled in the months corresponding to the yield data.

[12]Because in the FRB/US model this series is used to proxy for expectations of PCE deflator inflation rather than CPI inflation, the survey measures have been reduced by 55 basis points to account for the average difference between CPI and PCE inflation over this period.

Table 1: Projected Deficits and 5-Year-Ahead 10-Year Yields

Dep. Variable	Real Yield			Nominal Yield		
Source	CBO		OMB	CBO		OMB
Frequency	Semian.	Annual	Annual	Semian.	Annual	Annual
Sample	76:1-04:1	76-04	83-04	76:1-04:1	76-04	83-04
Exp. Inflation	–	–	–	1.18	1.22	1.24
				(9.95)	(6.84)	(11.63)
Proj. Deficit/GDP	.31	.29	.39	.27	.24	.33
	(10.89)	(11.87)	(3.92)	(6.37)	(5.46)	(3.04)
Trend Growth	1.09	1.05	.94	.78	.65	.70
	(3.73)	(3.16)	(2.09)	(2.88)	(1.70)	(1.89)
Eq. Premium	-.44	-.48	-.44	-.45	-.49	-.46
	(5.65)	(5.43)	(2.00)	(5.17)	(6.44)	(2.43)
R^2	.63	.68	.49	.92	.93	.91
S.E.	.65	.71	.71	.63	.68	.66
DW	1.12	2.03	1.78	1.14	2.06	2.33
N	48	29	22	48	29	22
Notes: Newey-West t statistics in parentheses.						

Table 2: The Role of Forward Rates: Deficits

Source & Sample	CBO, 1976-2004			
Dep. Variable	10-Year Yield	Spread	5-Y-Ahead 5-Year Yield	5-Y-Ahead 10-Year Yield
Exp. Inflation	1.70	–	1.25	1.22
	(9.04)		(7.33)	(6.84)
Proj. Deficit/GDP	.10	.20	.20	.24
	(1.97)	(2.56)	(2.89)	(5.46)
Trend Growth	.62	-1.08	.64	.65
	(1.20)	(1.14)	(1.61)	(1.70)
Eq. Premium	-.80	.31	-.58	-.49
	(7.43)	(1.23)	(5.19)	(6.44)
R^2	.94	.24	.90	.93
S.E.	.74	1.71	.78	.68
DW	1.43	.66	1.45	2.06
Notes: Newey-West t statistics in parentheses.				

Table 3: Primary Deficits, Outlays, and Revenues

Source & Sample	CBO, 1976-2003		
Fiscal Variable	Primary Deficit	Outlays and Revenues	Pr. Outlays and Revenues
Exp. Inflation	1.27	1.27	1.30
	(8.34)	(7.39)	(8.73)
Proj. Deficit/GDP	.33	–	–
	(5.64)		
Outlays/GDP	–	.18	.25
		(2.22)	(2.46)
Revenues/GDP	–	-.35	-.39
		(5.97)	(6.21)
Trend Growth	.52	.60	.50
	(1.49)	(1.65)	(1.52)
Eq. Premium	-.50	-.49	-.50
	(6.25)	(5.38)	(5.43)
R^2	.93	.93	.93
S.E.	.67	.67	.67
DW	2.00	2.32	2.22
Notes: Newey-West t statistics in parentheses.			

Table 4: Projected Debt and 5-Year-Ahead 10-Year Yields

Dep. Variable	Real Yield			Nominal Yield		
Source	CBO		OMB	CBO		OMB
Frequency	Semian.	Annual	Annual	Semian.	Annual	Annual
Sample	76:1-04:1	76-04	83-04	76:1-04:1	76-04	83-04
Exp. Inflation	–	–	–	1.29	1.33	1.25
				(9.58)	(6.56)	(11.43)
Proj. Debt/GDP	.056	.056	.054	.044	.041	.043
	(5.65)	(5.29)	(2.90)	(4.22)	(3.41)	(2.51)
Trend Growth	1.55	1.53	1.46	.95	.80	1.10
	(3.54)	(3.09)	(2.27)	(2.23)	(1.34)	(2.03)
Eq. Premium	-.48	-.55	-.39	-.49	-.55	-.42
	(4.26)	(5.07)	(1.79)	(4.01)	(5.73)	(2.27)
R^2	.47	.53	.42	.90	.90	.90
S.E.	.77	.86	.75	.71	.78	.70
DW	.95	2.05	1.85	1.01	2.03	2.30
Notes: Newey-West t statistics in parentheses.						

Table 5: The Role of Forward Rates: Debt

Source & Sample	CBO, 1976-2004			
Dep. Variable	10-Year Yield	Spread	5-Y-Ahead 5-Year Yield	5-Y-Ahead 10-Year Yield
Exp. Inflation	1.76	–	1.33	1.33
	(9.47)		(7.49)	(6.56)
Proj. Debt/GDP	.011	.057	.038	.041
	(.95)	(2.76)	(2.80)	(3.41)
Trend Growth	.57	-.43	.85	.80
	(.88)	(.48)	(1.52)	(1.34)
Eq. Premium	-.82	.24	-.64	-.55
	(6.38)	(.92)	(5.07)	(5.73)
R^2	.93	.29	.89	.90
S.E.	.76	1.65	.82	.78
DW	1.47	.58	1.56	2.03
Notes: Newey-West t statistics in parentheses.				

Table 6: The Role of Trend Growth and the Equity Premium

Source & Sample	CBO, 1976-2004					
	OLS				IV	
Exp. Inflation	1.16	1.29	1.18	1.33	1.22	1.34
	(8.39)	(8.11)	(4.95)	(5.53)	(7.15)	(6.65)
Proj. Deficit/GDP	.26	–	.25	–	.24	–
	(3.68)		(2.91)		(5.42)	
Proj. Debt/GDP	–	.039	–	.035	–	.041
		(2.60)		(1.80)		(3.03)
Trend Growth	–	–	-.08	-.17	.66	.92
			(.14)	(.24)	(1.30)	(1.15)
Eq. Premium	–	–	–	–	-.49	-.61
					(3.69)	(3.00)
R^2	.87	.83	.87	.83	.93	.90
S.E.	.87	.98	.88	1.00	.69	.80
DW	1.33	1.23	1.33	1.21	2.02	2.08
Notes: Newey-West t statistics in parentheses.						

Figure 1: Actual and Projected Deficits as Percent of GDP

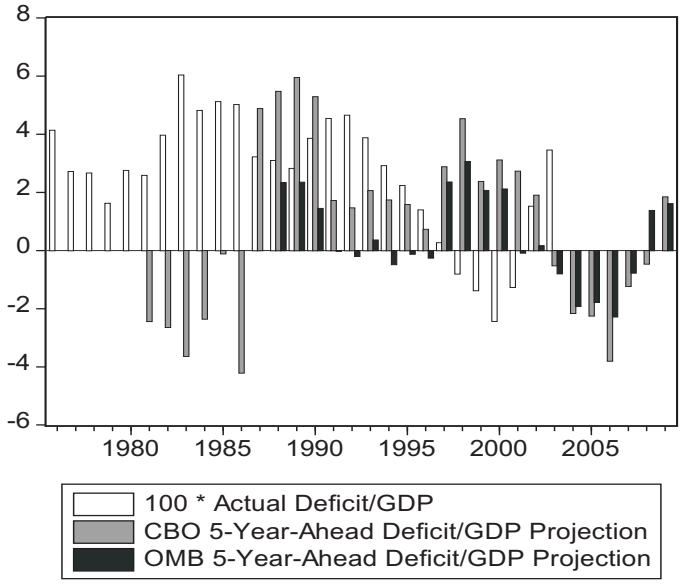

Figure 2: Actual and Projected Debt as Percent of GDP

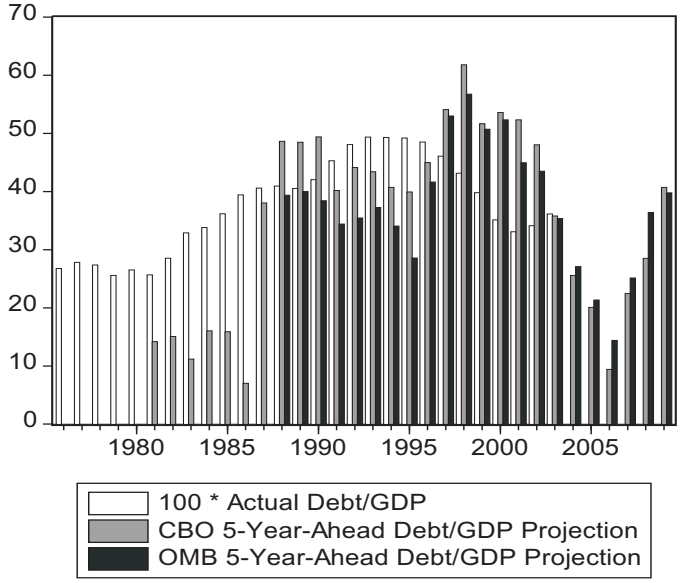

Figure 3: Interest Rates and Inflation Expectations

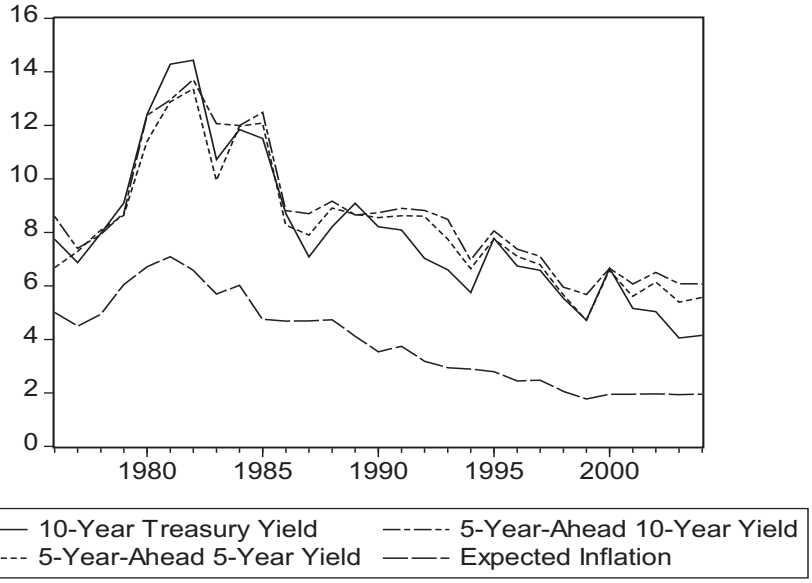

Figure 4: Projected GDP Growth and Equity Premium

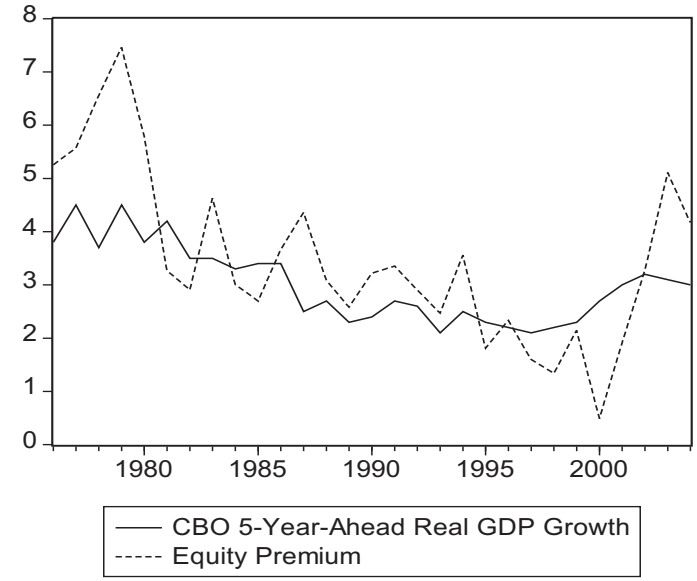

Figure 5: Coefficient Stability: Deficit-to-GDP Ratio

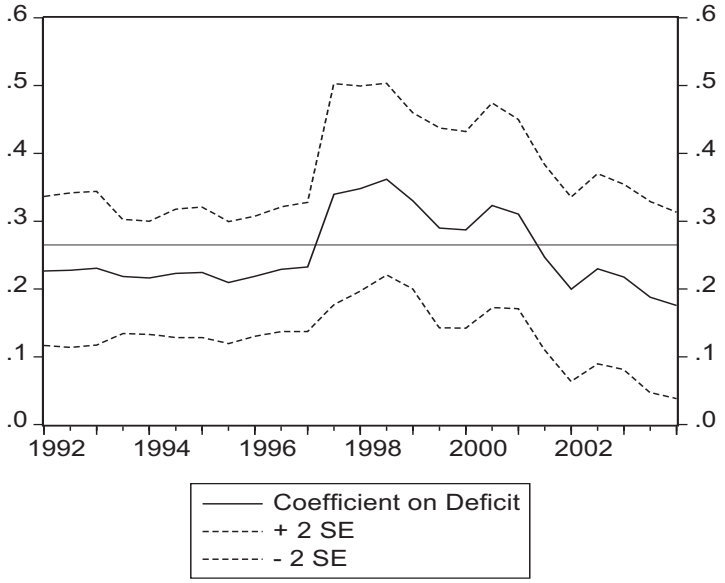

Figure 6: Coefficient Stability: Debt-to-GDP Ratio