Working Paper Series
Congressional Budget Office
Washington, D.C.

The Effect of Government Debt on Interest Rates

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Working Paper 2019-01

March 2019

For helpful comments and suggestions, the authors thank Robert Arnold, Devrim Demirel, Wendy Edelberg, Michael Falkenheim, and John Kitchen (all of CBO) as well as William Gale. The authors thank Adam Staveski for research assistance and Christine Bogusz for editing. The authors also thank Thomas Laubach for sharing his data.

www.cbo.gov/publication/55018

Abstract

Under current law, the level of federal debt relative to gross domestic product (GDP) is projected to rise significantly over the next decade. The relationship between debt and interest rates plays a key role in the Congressional Budget Office's economic and budget projections (especially long-term projections) and for dynamic analyses of fiscal policy, where the sensitivity of interest rates with respect to changes in the level of debt is vitally important. In this analysis, we use a reduced-form regression to estimate the relationship between projected federal debt and expected long-term interest rates. Our results suggest that the average long-run effect of debt on interest rates ranges from about 2 to 3 basis points for each increase of 1 percentage point in debt as a percentage of GDP. We also use a dynamic stochastic general equilibrium model to illustrate how the response of interest rates to debt depends on the type of fiscal policy generating changes in the debt. In the context of that model, fiscal policies that bolster incentives for households and firms to invest in private capital or supply additional labor elicit a smaller interest rate response than the response suggested by the reduced-form estimates, which do not control for the nature of the fiscal policy change. Conversely, the results suggest that a fiscal policy that contains few or no incentives for households and firms to invest in additional private capital or supply additional labor elicits a larger interest rate response than that suggested by the reduced-form estimates.

Keywords: interest rates, fiscal policy, crowding out, government debt, government deficits

JEL Classification: E43, E60, E62, H60

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Introduction

The Congressional Budget Office projects that, under current law, federal debt held by the public as a share of gross domestic product (GDP) will increase from 77.8 percent at the end of fiscal year 2018 to 92.7 percent by the end of 2029.[1] The relationship between debt and interest rates plays a key role in the agency's economic and budget projections (especially long-term projections) and for dynamic analyses of fiscal policy, where the sensitivity of interest rates with respect to changes in the level of debt are vitally important.

This paper examines the long-run impact of rising federal debt and deficits on interest rates. According to economic theory, the macroeconomic effects of rising government debt primarily depend on how private investment activity responds to increased federal borrowing. If greater federal borrowing ultimately reduces—or crowds out—private investment below what it would have been without the additional borrowing, the stock of private capital would be lower in the long run. A lower private capital stock would push up the marginal product of capital, increasing the return on capital and the interest rate.

This paper uses a simple model with an aggregate production function to demonstrate a theoretical link between government debt, the crowding out of private capital, and interest rates and to provide a benchmark estimate of that effect. This paper then presents estimates of the average effect of projected debt and deficits on expected long-term interest rates using a reduced-form regression similar to that used by Gale and Orszag (2004), Engen and Hubbard (2004), and Laubach (2009). The empirical estimates measure the historical average relationship between interest rates and debt but do not control for the type of fiscal policy that generated the additional federal borrowing. For example, an increase in debt caused by an increase in government consumption would be expected to elicit a larger interest rate response than an increase in debt caused by a reduction in marginal tax rates on labor or capital. To illustrate how the interest rate response depends on the type of fiscal policy, we use CBO's medium-scale dynamic stochastic general equilibrium (DSGE) model, which resembles the model presented in Leeper and Yang (2008) and Traum and Yang (2015).

The reduced-form estimates of the effect of federal debt on interest rates range from about 2 to 3 basis points for each percentage-point increase in the projected debt-to-GDP ratio across various specifications. The reduced-form estimates measure the average effect of changes in the debt-to-GDP ratio on interest rates without controlling for the specific fiscal policy that generated the change in the ratio. The DSGE simulations, in contrast, take account of additional channels of influence on interest rates that are specific to the change in fiscal policy, such as changes in the marginal tax rates on labor and capital or lump-sum transfers. The DSGE

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[1] See Congressional Budget Office, *The Budget and Economic Outlook: 2019 to 2029 (*January 2019), www.cbo.gov/publication/54918.

simulations produce a range of estimates depending on the type of fiscal policy that generates a percentage-point increase in the projected debt-to-GDP ratio. Both types of estimates are useful in informing CBO's forecast of the effect of debt and deficits on interest rates in the long run.

Debt and Interest Rates in a Neoclassical Model of Production

The neoclassical production function can be used to demonstrate a theoretical link between debt and interest rates and provides a useful benchmark estimate of that relationship. In the context of a standard Cobb-Douglas production function, an increase in government debt leads to a reduction in private capital, which implies an increase in the marginal product of capital and, therefore, an increase in the real (inflation-adjusted) interest rate. The mathematical representation of that relationship is as follows:

$$\frac{\partial \mathrm{r}}{\partial \mathrm{D/Y}} = \frac{\alpha(1-\alpha)\mathrm{c}}{\mathrm{k}^2} \qquad (1)$$

where α is capital's share of income, r is the real interest rate, k is the ratio of capital to GDP, Y is GDP, and D is government debt.[2] The parameter c represents the degree of crowding out. If $c = 1$, then there is complete crowding out of private capital. If $c = 0$, which would be the case if there was Ricardian equivalence or if the flow of foreign capital was infinitely elastic, there is no crowding out of private capital from the government's issuance of additional debt.

Several previous studies have used that framework to quantify the effect of debt on interest rates (see Ball and Mankiw, 1995; Elmendorf and Mankiw, 1999; Engen and Hubbard, 2004; and Laubach, 2009). Most authors expect some degree of crowding out because higher government borrowing will probably be offset by some combination of increased domestic saving and increased lending from abroad (net inflows of foreign capital). Equation (1) implies that a percentage-point increase in the debt-to-GDP ratio would boost real interest rates by $[\alpha(1-\alpha)c/k^2]$ percentage points. Previous studies typically estimate that capital's share (α) is about one-third, the capital-to-GDP ratio (k) is between 2.5 and 3.2, and the crowding-out parameter c ranges from 0.5 to 0.8. Table 1 summarizes the findings of previous studies and presents a calculation based on 2017 data. Using that data, we estimated a capital-output ratio of 2.5 based on the Bureau of Economic Analysis's estimate of private fixed assets (excluding consumer durable goods but including owner-occupied housing) at the end of 2016 divided by aggregate income as measured by the gross value added by businesses, households, and

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[2] That equation describes the long-run relationship between changes in debt and changes in the real interest rate when the economy is at full employment with stable inflation. In the short run, the real interest rate might differ from its equilibrium because of temporary cyclical factors. See Appendix A for a derivation of the equation.

institutions in 2017.[3] The results from our estimate as well as previous studies range from 1.4 to 2.1 basis points of an effect on the real interest rate for each percentage-point change in the debt-to-GDP ratio.

Reduced-Form Estimates

This section of the paper presents empirical estimates of the relationship between federal debt (and deficits) and interest rates. An important challenge when estimating that relationship is separating the short-term, or cyclical, effects on interest rates from the longer-term effects on the marginal product of capital stemming from a reduced capital stock. Previous literature has addressed that challenge using one of two approaches. The first approach has been to adjust the deficit by removing the cyclical component and estimating the response of interest rates to changes in the structural, or full-employment, deficit.[4] A second approach has been to focus on the longer-term relationship between *expected* debt and *expected* interest rates.[5] That is the approach taken here and is similar to the approach used by Gale and Orszag (2004), Engen and Hubbard (2004), and Laubach (2009).[6] Focusing on the longer-term relationship between expected debt and expected interest rates lessens any business-cycle effects on interest rates that might have prevailed in the short run. For example, during a cyclical downturn, the response of interest rates to debt stemming from crowding out is confounded with movements in interest rates arising from changes in aggregate demand and the response of monetary policymakers. The method employed here attempts to exclude the effects of short-term cyclical movements in an effort to better isolate the crowding-out effect on interest rates in the long run.

We estimated the effect of expected federal debt on expected interest rates using the following reduced-form regression:

$$ {}_{t}i_{t+5}^{(10)} = \beta_0 + \beta_1 \, {}_{t}\pi_{t+5} + \beta_2 \, {}_{t}D_{t+5} + \beta_3 X_t + \varepsilon_t \qquad (2) $$

[3] These calculations typically relate the ending period capital stock in a given year (for example, 2016) to the production of output in the following year (2017).

[4] A large body of literature examines the contemporaneous relationship between deficits and interest rates. To account for the effects of the business cycle on interest rates, researchers typically measure the relationship between the cyclically adjusted (or full-employment) budget deficit and interest rates. See Kormendi (1983) and Kormendi and Meguire (1986, 1990, 1995) for discussions of that literature.

[5] Expected debt is usually measured as the Congressional Budget Office's or the Office of Management and Budget's projected debt, and expected interest rates are typically measured as the forward rates embodied in the yield curve at the time of the debt projection.

[6] An earlier study by Cohen and Garnier (1991) also estimated the relationship between deficit forecasts (by the Office of Management and Budget) and interest rates.

where ${}_{t}D_{t+5}$ is the projected five-year-ahead debt-to-GDP ratio published by CBO at time *t*.[7,8] For the expected interest rate ${}_{t}i_{t+5}^{(10)}$, we constructed the five-year-ahead 10-year rate from the yield curve observed at the end of the month in which the CBO report containing the projected debt-to-GDP ratio was published.[9, 10] The yield curve was generated from the parameters provided by Gürkaynak, Sack, and Wright (2007).[11] The regression residual is represented by ε_t.

The relationship that is captured by equation (2) is between the current-law expectations of federal fiscal policy (CBO's five-year-ahead projections of federal debt held by the public as a share of GDP) and the *nominal* interest rate. Economic theory suggests the relationship should be between the *real* interest rate and debt. To isolate the effect of changes in the debt-to-GDP ratio on the *real* interest rate, we included a measure of expected inflation, ${}_{t}\pi_{t+5}$, on the right-hand side of equation (2). Expected inflation is taken from the Federal Reserve's FR/BUS model and represents the expected 10-year annual average inflation in consumer prices as measured by the personal consumption expenditures (PCE) price index.[12]

The vector X_t contains additional control variables suggested by economic theory and used in previous studies. Following Laubach (2009), we included the dividend yield (div_yld_t) to control for the effect of the equity returns on interest rates. We also included trend real GDP growth (${}_{t}g_{t+5}$) to control for the effect of trend growth of real consumer spending as suggested by a

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7 Those data were taken from CBO's semiannual *Budget and Economic Outlook*, beginning with the January 1976 report and ending with the June 2017 report. Debt and deficits relative to GDP are measured on a fiscal year basis.

8 The measure of debt used in this analysis—debt held by the public—does not take account of the federal government's holdings of financial assets. Ideally, one would include the offsetting effects of such holdings in order to measure the full effect of government debt on interest rates. CBO's projections of "debt held by the public net of financial assets" were not reported on a regular basis before 2010 and are therefore not available for inclusion in this analysis.

9 That is the same measure used by Gale and Orszag (2004), Engen and Hubbard (2004), and Laubach (2009). Researchers used five-year-ahead projections because they generated the largest possible sample of observations. CBO produced five-year-ahead forecasts only for the years 1976–1991.

10 That is the standard market-based measure of expected interest rates used by other researchers. Nonetheless, it is important to note that forward rates have generally produced very poor forecasts of future interest rates over the past few decades (see Gamber, 2017).

11 The complete series of parameters used to construct daily Treasury yield curves from 1961 to the present can be found atwww.federalreserve.gov/pubs/feds/2006/200628/200628abs.html.

12 That is the variable PTR from the FRB/US database, which represents long-term expected inflation. Since the fourth quarter of 1991, that variable has been taken from the Survey of Professional Forecasters' long-term expected inflation measure. For further details on the construction of that series before then, see "FRB/US model packages," www.federalreserve.gov/econres/us-models-package.htm.

standard Ramsey growth model. The measure of trend growth used in the regressions below is the five-year-ahead forecast of real GDP growth as reported by CBO.

Baseline Results

We estimated our baseline specification of equation (2) over two samples. The first sample covers the period from January 1976 (the first CBO forecast) through August 2007, just before the onset of the 2007–2009 recession. The results using that sample are reported in the first three columns of Table 2. The main coefficient of interest, the coefficient on ${}_tD_{t+5}$, ranges from 0.021 to 0.029, which implies that a percentage-point increase in the projected debt-to-GDP ratio is associated with an increase of 2.1 to 2.9 basis points in the expected long-term real interest rate. Those estimates are similar to estimates presented in Gale and Orszag (2004), Engen and Hubbard (2004), and Laubach (2009).[13] The estimated coefficients on the dividend yield and trend growth are also similar to those found in other studies.[14] The estimated coefficient on expected inflation is larger than one, which is consistent with findings in the literature, and possibly reflects the extra compensation investors require for an increase in the inflation risk premium associated with increases in expected inflation.[15]

The second set of results, presented in Table 2, covers the sample of CBO's projections from January 1976 through June 2017. The full sample includes the 2007–2009 recession and the subsequent slow recovery, during which the expected debt-to-GDP and deficit-to-GDP ratios increased and, for several reasons, interest rates (and expected interest rates, see Figure 1) declined. Some of the reasons for the decline in interest rates—including the slowdown in trend growth, demographic shifts, and a global shortage of safe assets—predate the recession.[16] During and after the 2007–2009 recession, two factors in particular have probably played a role in pushing rates down. First, the extraordinary persistence in weak aggregate demand may confound the empirical results despite using expected debt and expected interest rates at a five-year horizon. Second, the Federal Reserve boosted its holdings of Treasury securities from a

[13] Our results are on the lower end of estimates reported in some cross-country studies. Brook (2003) reports a range of 1 to 6 basis points, whereas Kinoshita (2006) estimates a range of 4 to 5 basis points using panel data from 19 advanced economies.

[14] The estimates of the effect of trend growth on interest rates is negative (and statistically significant), which is counter to what is expected on the basis of economic theory. Previous authors (Engen and Hubbard, as well as Laubach) also reported negative signs on that coefficient, but their estimates were insignificantly different from zero.

[15] We also estimated the full set of regressions constraining the coefficient on expected inflation to equal 1, and the results were quantitatively similar to those reported in the text.

[16] See Rachel and Smith (2017) for a detailed description of the various factors pushing world real interest rates down since the mid-1980s.

little over 5 percent of GDP in late 2007 to roughly 14 percent by late 2014.[17] Previous authors (see, in particular, Bonis, Ihrig, and Wei, 2017) have identified significant negative effects of those purchases on long-term Treasury yields.[18] Another possible factor is foreign purchases of Treasury securities, which also rose significantly after 2007. Foreign official holdings of Treasury securities increased from about 11 percent of GDP at the end of 2007 to nearly 24 percent of GDP by early 2014.[19,20] Previous researchers have identified significant negative effects from foreign purchases of Treasury securities as well (see Warnock and Warnock, 2009; Kitchen and Chinn, 2011; and Wolcott, 2016).

To account for some of the factors pushing interest rates down since 2007, we estimated equation (1) using two additional control variables: the stock of Treasury securities currently held by the Federal Reserve (Fed) and foreign official holdings of Treasury securities (foreign). Both are measured as a percentage of GDP. The last six columns of Table 2 report the full sample estimates with those additional control variables (see columns 7 through 9) and without them (see columns 4 through 6). The estimated coefficients on those two variables are correctly signed and statistically significant. Including them results in estimated coefficients on the expected debt-to-GDP ratio that are similar in size to the results presented in Table 1 using the sample ending in 2007.

Taking account of Federal Reserve and foreign holdings of Treasury securities, we found that a percentage-point increase in the expected debt-to-GDP ratio is associated with an increase of 1.9 to 2.4 basis points in the expected long-term real interest rate over the full sample (1976 through 2017). Those estimates are in line with the simple production function calculations presented above. Moreover, given these reduced-form estimates, the capital-to-GDP ratio, and the capital income share, a simple back-of-the-envelope calculation using equation (1) suggests that the degree of crowding out ($\partial K / \partial D = -c$) of the long-run capital stock ranges between 0.5 and 0.7.[21] When Federal Reserve and foreign holdings of Treasury securities are excluded as short-

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[17] That proportion declined slightly, to around 13 percent by the end of 2017. That calculation is based only on the Federal Reserve's holdings of Treasury securities. It excludes the Federal Reserve's holdings of mortgage-backed securities and agency debt.

[18] Bonis, Ihrig, and Wei (2017) estimate that the cumulative effect of the Federal Reserve's various quantitative easing programs reduced the term premium on long-term Treasury securities by about 100 basis points.

[19] That calculation is based on the value of Treasury securities held by foreign official institutions from the "Financial Accounts of the United States" produced by the Federal Reserve.

[20] That ratio declined slightly to just over 20 percent by mid-2017.

[21] That range is at the high end of the estimates presented in an earlier CBO analysis. Based on a review of the literature, that analysis concluded that for each dollar's increase in the federal deficit, the effect on investment ranged from a decrease of 15 cents to a decrease of 50 cents, with a central estimate of a decrease of 33 cents. See Huntley (2014) for a discussion of those estimates.

run controls (see columns 3 through 6 of Table 2), the coefficients on the debt-to-GDP ratio are of the wrong sign and statistically insignificant or marginally significant.

Debt or Deficits?

There is much debate in the literature about whether to measure the response of interest rates to debt or deficits. Much of the early empirical work focused on measuring the response of interest rates to cyclically adjusted deficits. In most macroeconomic models that assume some type of nominal rigidity, such as price or wage stickiness, increased federal borrowing competes with the private sector for the flow of saving (both domestic and foreign), thus crowding out investment in private capital and pushing up interest rates. That flow effect, accumulated over several years, implies a lower capital-to-GDP ratio and higher interest rates in the long run. In other words, the two approaches are connected, and one should be able to relate the two approaches based on the expected persistence of federal deficits. To investigate that connection, we reestimated equation (2), replacing the projected debt-to-GDP ratio (${}_tD_{t+5}$) with the projected deficit-to-GDP ratio (${}_td_{t+5}$). The projected deficit-to-GDP ratio is taken from CBO's semiannual *Budget and Economic Outlook*. The results are presented in Table 3.

The estimated coefficients on the deficit-to-GDP ratio in the first sample (before the 2007–2009 recession) range from 0.15 to 0.19, which implies that a percentage-point increase in the projected deficit-to-GDP ratio is associated with an increase of 15 to 19 basis points in the expected long-term real interest rate. Those estimates are similar in magnitude to those reported by Engen and Hubbard (2004) and Laubach (2009) and slightly smaller than those presented in Gale and Orszag (2004), all of whom used slightly shorter sample periods. Extending the sample beyond 2007 results in coefficient estimates on the deficit-to-GDP ratio in all three specifications that are negative and insignificant (see the middle three columns of Table 3). Including controls for Federal Reserve and foreign holdings of Treasury securities restores the estimates to their prerecession values (see the last three columns of Table 3).

Given the relationship between deficits and the stock of debt, it is not surprising that the coefficient on a percentage-point change in projected deficits as a share of GDP is larger than the coefficient on a percentage-point change in projected debt. Assuming that deficits exhibit some degree of persistence, a change in the deficit-to-GDP ratio today implies, through the summation of future deficits, a change in the debt-to-GDP ratio in the future. Moreover, the greater the persistence of deficits, the larger the expected change in future debt over some finite time horizon. In the extreme, if a change in the deficit-to-GDP ratio is perceived to be permanent, a percentage-point increase in the deficit relative to GDP will lead to a long-run increase in the debt-to-GDP ratio of $(1 + g)/g$ percentage points, where g is the growth rate of nominal GDP. If $g = 0.06$, roughly the average annual growth rate of U.S. nominal GDP over the 1976–2017 period, the response of interest rates to a permanent percentage-point increase in the deficit-to-GDP ratio should be about 18 times larger than the response from a percentage-point increase in the debt-to-GDP ratio. The ratio of the coefficients on deficits to the coefficients on debt reported in Tables 2 and 3 ranges from 7.5 to 8, which suggests that market participants perceive changes in deficits to be highly persistent but not permanent.

Short-Term Rates

Most previous studies have focused on the effect of federal debt and deficits on long-term interest rates. Another important issue, however, is how changes in debt and deficits affect short-term rates or, equivalently, the slope of the yield curve. To investigate that question, we estimated two variations on equation (2). The first replaces ${}_{t}i_{t+5}^{(10)}$ with ${}_{t}i_{t+5}^{(3mo)}$— the five-year-ahead 3-month rate extracted from the yield curve. The second variation replaces ${}_{t}i_{t+5}^{(10)}$ with the slope of the yield curve as measured by the difference between the five-year-ahead 10-year and 3-month rates: $\left({}_{t}i_{t+5}^{(10)} - {}_{t}i_{t+5}^{(3mo)}\right)$.

Tables 4 and 5 show the results for the five-year-ahead 3-month rate, ${}_{t}i_{t+5}^{(3mo)}$, which are quite similar to the estimates using the 10-year rate. Changes in the debt-to-GDP ratio are associated with a change of roughly 2 basis points in short-term interest rates. Changes in the deficit-to-GDP ratio are associated with a change of 10 to 20 basis points in short-term rates.

Tables 6 and 7 show the results for the slope of the yield curve, $\left({}_{t}i_{t+5}^{(10)} - {}_{t}i_{t+5}^{(3mo)}\right)$. There is some evidence of a slight steepening (half a basis point) in the pre-2007 sample, but that effect disappears in the full sample when the Federal Reserve and foreign holdings of Treasury securities are included in the regression. The results are similar for the deficit regressions shown in Table 7. The slight steepening of the yield curve observed in the pre-2007 sample disappears when the full sample is used.

The results for the response of short-term rates and the yield curve to changes in debt and deficits suggest that changes in debt (or deficits) are associated with shifts, as opposed to rotations, in the yield curve. An alternative way to view that result is that changes in debt (or deficits) affect the long-run neutral rate of interest (commonly referred to as r^*) rather than the spread between short-term and long-term interest rates.

Alternative Specifications

To test the robustness of the reduced-form estimates presented in the previous section, we considered three alternative specifications.

The first alternative includes a measure of the GDP gap (GAP_t) to test the effect of current business-cycle conditions on the expected interest rate.[22] Our rationale for using expected debt and expected interest rates in the reduced-form estimation was to minimize the effects of

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[22] The GDP gap is the real-time measure from the Federal Reserve through 1997 and from CBO thereafter.

temporary cyclical influences on interest rates. The proxy for expected interest rates—the forward rate extracted from the yield curve—probably contains a term premium in addition to expected future interest rates. If that term premium is influenced by cyclical movements in the economy, then there is some risk that the use of forward rates does not adequately eliminate the cyclical movements in interest rates. The first three columns of Table 8 report the regression results including the GDP gap. The coefficient on the GDP gap is insignificantly different from zero in the first two regressions, and the coefficient on the debt-to-GDP ratio is comparable to the estimates presented in the previous section. When the trend growth rate of GDP (${}_{t}g_{t+5}$) is added to the regression (column 3), the coefficient on the debt-to-GDP ratio falls by half and is no longer significant. That result is consistent with the pattern observed in the previous estimates. That is, when trend growth is added to the specification, it enters with the theoretically incorrect sign and tends to reduce the magnitude of, and in some specifications eliminate, the statistical significance of the coefficient on the fiscal variable (either debt to GDP or deficit to GDP).[23]

The second alternative specification we considered was to test whether the source of the change in deficits matters for the interest rate response. Fiscal policies generating changes in revenues might have different effects on interest rates than policies that generate changes in primary outlays. To test that hypothesis, we used measures of expected revenues and expected primary outlays in the regression. Both are measured relative to GDP, and the difference between those two measures is, therefore, the primary deficit relative to GDP. The point estimates (shown in columns 4 through 6 of Table 8) suggest that an increase in the primary deficit generated by a decrease in revenues would have a larger effect on interest rates than an increase in the primary deficit generated by an increase in primary outlays. However, because those coefficients are imprecisely estimated, it is not possible to reject the hypothesis that they are of equal and opposite signs. The estimated coefficients measure the average effects over various changes in fiscal policy and do not take account of additional channels of influence on interest rates that are specific to particular changes in policy, such as changes in the marginal tax rates on labor and capital or lump-sum transfers. To properly account for those additional channels of influence, a structural model, such as an overlapping generations (OLG) model or a dynamic stochastic general equilibrium model, would be required.

Finally, we investigated whether the effect of debt or deficits on interest rates has diminished over time by conducting a standard breakpoint test.[24] The tests for both the debt and deficit regressions indicated breaks in the estimated coefficients in 1987 (with statistical tests placing

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[23] That finding is similar to the findings of Laubach (2009), who posited that CBO's five-year-ahead trend growth projection might be a poor proxy for households' expectation of future consumption growth.

[24] See Andrews (1993).

the breaks in August 1987 in the semiannual data). The last two columns of Table 8 show the results of estimating the regressions using only data and including August 1987.[25] The coefficient on expected debt is 0.016, which is slightly lower than the 0.024 estimated using the full sample (not shown in the table). That result suggests that the response of interest rates to debt has diminished since 1987, but the difference is small and imprecisely estimated. The coefficient on expected deficits, however, declined dramatically, from 0.18 using the full sample to 0.07 using the sample from August 1987 through June 2017, suggesting that the effect of deficits on interest rates may have diminished since the sample break.

Interest Rate Effects in a DSGE Model

Because the reduced-form estimates presented above measure the average effect of debt or deficits on interest rates across various changes in fiscal policy, they are only useful as part of a larger analysis that takes account of other effects of the policies generating the change in debt, including those that could offset some of the effects of debt on interest rates. For example, a rise in debt that is caused by a reduction in distortionary taxes on capital might lead to an increase in capital investment that partly offsets some of the initial crowding out and therefore results in a smaller increase in long-term interest rates. Combining the reduced-form effects with the estimated offset from higher investment would provide a researcher with an (admittedly crude) approximation of the effects generated by a richer class of models, such as OLG or DSGE models.

Previous authors have shown that the effects of debt on interest rates depend critically on the types of policies that generate the change in debt. For example, Traum and Yang (2015) use a DSGE model to demonstrate that the interest rate effect of an increase in debt resulting from a decrease in taxes on capital investment will probably have a different effect on the after-tax marginal product of capital (and therefore interest rates) than an increase in debt resulting from higher transfer payments. They report reduced-form regressions based on data generated from their model showing that the magnitude, and even the sign, of the response of interest rates to debt can vary greatly depending on the fiscal policy generating the additional debt. Those findings imply that the reduced-form regressions are not well-suited to measuring the combined response of interest rates to changes in debt and policies that produce those changes.

To illustrate how the interest rate response fundamentally depends on the type of fiscal policy that generates the additional debt, we simulated the effect of increased debt on interest rates using CBO's medium-scale DSGE model.[26] We conducted two experiments: The first assumes

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[25] The pre-August 1987 sample of 14 observations is too small to provide meaningful results.

[26] There is no strict definition of "medium-scale" DSGE models; however, that label is typically applied to models that incorporate financial and labor market frictions but, unlike "large-scale" models, maintain the assumption of a single sector. See Appendix B for a brief description of CBO's DSGE model.

that the increase in debt is the result of an increase in government consumption spending. The second assumes that the increase in debt is the result of a reduction in distortionary taxes on both labor income and capital income. In each experiment, the debt-to-GDP ratio increases by 1 percentage point by the fifth year.

In the first experiment, an increase in government consumption financed by government borrowing crowds out private investment and pushes up the interest rate. That experiment captures the effect of an increase in debt when there are limited or no offsetting incentive effects arising from an increase in the labor supply or additional capital investment. For an increase of 1 percentage point in the debt-to-GDP ratio five years ahead, the real interest rate rises by about 3 basis points.

In the second experiment, the increase in debt is the result of reductions in both distortionary taxes on labor and distortionary taxes on capital income.[27] As a result, capital investment rises because the reduction in tax rates on capital income boosts the return from investing in private capital. In addition, the supply of labor increases, boosting the productivity of capital (that is, output per unit of capital) and, therefore, investment in private capital. Thus, the crowding out caused by the increased borrowing to finance the tax cut is partially offset by the higher investment stemming from increased productivity of capital. Higher investment arising from both effects partly offsets the crowding-out effects of higher government debt. Not surprisingly, the effect on interest rates is lower than in the first experiment. For an increase of 1 percentage point in the debt-to-GDP ratio in the fifth year, the real interest rate rises by about one basis point.[28]

The two DSGE experiments presented here illustrate the incentive effects that different fiscal policies might elicit. The size of the response of interest rates to debt in the DSGE experiments is sensitive to how the model is calibrated, as well as the type, timing, and size of the fiscal instruments used to ensure the debt path is sustainable. Thus, the results from the DSGE experiments are not directly comparable to the results from the reduced-form regression. The regressions measure the effect of debt on interest rates averaged over various policies generating the changes in projected debt over history. The DSGE experiments explicitly account for

[27] To generate a percentage-point increase in the debt-to-GDP ratio five years ahead, we reduced the marginal effective tax rate on both labor and capital income by 2.6 percent in that experiment.

[28] Our results are broadly consistent with those of Gale and Orszag (2005), who showed that a reduction in taxes that generates an increase in the budget deficit leads to an increase in the user cost of capital and, therefore, higher interest rates. In our DSGE experiments involving a tax-cut-driven increase in debt, we find an initial decline in the user cost of capital (because of a boost in savings from lower taxes on capital income) and an increase of about 0.3 percent in the long term (because of higher deficits).

differences in policies; as a result, the estimated effect of debt on interest rates is conditional on those differences. Those analyses suggest that if a fiscal policy improves the incentives to invest in private capital or supply additional labor, the effect on interest rates would probably be lower than the empirical estimates because a higher supply of capital or labor would offset some of the initial crowding out caused by higher government borrowing. Conversely, a fiscal policy that contains few or no incentives to invest in additional private capital or supply additional labor would most likely cause the interest rate response to be higher than the empirical estimates suggest.

Interest Rate Effects When Debt Is High and Rising

For the historical period from which the data for this study were drawn, the current-law projection of five-year-ahead debt relative to GDP ranged from 7 percent (July 1981) to 83 percent (June 2017). Despite that large range, the response of interest rates to debt appears not to depend on the size of the projected debt relative to GDP.[29] However, under current law, the debt-to-GDP ratio is projected to rise to 93 percent by 2029. If that ratio continues to climb, it is possible that, at some point, historical experience will provide little guidance about the response of interest rates. That response could be dramatically larger than the estimates presented here.

There are two possible scenarios under which the response of interest rates to increasing levels of debt could differ significantly from the empirical estimates presented in this analysis. In both scenarios, an increase in the ratio of debt to GDP causes investors to lose confidence in the real value of the principal and interest payments on Treasury securities. That loss in confidence leads to higher interest rates as investors demand greater compensation for possible future losses.

In the first scenario, a rising level of debt relative to GDP could increase the likelihood that, at some point, the government might have to increase the money supply to finance its expenditures. Such increases could boost inflation, which would reduce the real value of principal and interest payments to existing bondholders. Once investors begin to worry that this might happen, they will demand a greater inflation risk premium to compensate for the increased risk, and interest rates might rise much more dramatically in response to an increase in the debt-to-GDP ratio than the reduced-form estimates suggest.[30]

In the second scenario, investors become concerned about an outright default, in which the government fails to pay the interest or principal on outstanding debt. Because the U.S. dollar is a

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[29] We investigated that question by ordering the data in equation (2) by size of projected debt-to-GDP ratio rather than time and by testing for structural breaks in the estimated coefficient on the debt-to-GDP ratio. We found no evidence of a structural break (in other words, we failed to reject the null hypothesis of no break).

[30] That is essentially the "unpleasant monetarist arithmetic" argument presented by Sargent and Wallace (1981) and more recently by Woodford (2001).

reserve currency and the United States borrows from abroad in dollars, the risk of that occurring is quite small. However, with the debt-to-GDP ratio projected to rise to unprecedented levels, it is increasingly likely that at some point investors will become concerned about the risk of default.[31] Once investors begin to believe that such a possibility is more likely, they will demand a default risk premium, and interest rates might rise much more in response to an increase in the debt-to-GDP ratio than the estimates presented here suggest.

No one can accurately predict whether or when investors might lose confidence in the government's ability to make principal or interest payments on its debt or when their expectations of inflation might be affected. Such a loss in confidence could lead to a fiscal crisis—a situation in which investors would become unwilling to finance the government's borrowing unless they were compensated with continually increasing interest rates. Whether that could occur in the United States, and how it would unfold if it did occur, are highly uncertain. In particular, the debt-to-GDP ratio has no identifiable tipping point to indicate that a crisis is likely or imminent.[32] Nonetheless, a large and rising federal debt would almost certainly heighten the risk of a fiscal crisis.[33] Those concerns could perpetuate a cycle: Higher interest rates would increase concerns over repayment, which would continue to raise interest rates even further. Even in the absence of a full-blown crisis, such risks would lead to higher rates and borrowing costs for the U.S. government and the private sector.

Conclusion

This paper presents evidence on the relationship between federal debt and interest rates. The reduced-form-regression results showed that expected interest rates have responded positively to expected current-law debt and deficits, relative to GDP. In the baseline specification, for each percentage-point increase in the ratio of projected debt to GDP, expected interest rates have increased by 2 to 3 basis points. Those estimates are in line with a simple calculation using a neoclassical production function. However, those average effects do not control for the type of fiscal policy that generated the change in federal debt. The simulations of a medium-scale DSGE model demonstrated that the response of interest rates to federal debt can vary significantly depending on the fiscal policy generating the change in debt. If a fiscal policy improves the incentives to invest in private capital or supply additional labor, the effect on interest rates would

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[31] See Congressional Budget Office, *The 2018 Long-Term Budget Outlook* (June 2018), www.cbo.gov/publication/53919.

[32] The debt-to-GDP ratio that is associated with a crisis varies considerably over time and across countries. It appears to depend on a number of factors, including whether a country borrows primarily in its own currency and whether financial market participants perceive the path of deficits to be sustainable (see Reinhart and Rogoff, 2009).

[33] For more information, see Congressional Budget Office, *Federal Debt and the Risk of a Fiscal Crisis* (July 2010), www.cbo.gov/publication/21625. That report points out, for example, that during past fiscal crises, Argentina, Greece, and Ireland were forced to make difficult choices in the face of sharp increases in interest rates on government debt.

probably be lower than the empirical estimates because a higher supply of capital or labor would offset some of the initial crowding out caused by higher government borrowing. Conversely, a fiscal policy that contains few or no incentives to invest in additional private capital or supply additional labor would probably cause the interest rate response to be higher than empirical estimates suggest.

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Appendix A: Details of the Production Function Calculation

This appendix presents the details of the calculation of the effect of debt on interest rates based on the Cobb-Douglas production function, which takes the following form:

$$Y = K^{\alpha}L^{1-\alpha}$$

where

Y = aggregate real output,

K = stock of capital,

L = labor input, and

α = share of income paid to capital.

In the neoclassical growth model, if factors are paid their marginal product (MP), then

$$\alpha = MP_k k, \text{ where } k = \frac{K}{Y} = K^{1-\alpha}L^{-(1-\alpha)} \qquad \text{(A1)}$$

Additionally, the marginal product of capital can be written as:

$$MP_k = r + \delta \qquad \text{(A2)}$$

where δ is the depreciation rate, and r is the real interest rate.

Combining equations (A1) and (A2) yields the following:

$$r = \frac{\alpha}{k} - \delta = \frac{\alpha}{K^{1-\alpha}L^{-(1-\alpha)}} - \delta \qquad \text{(A3)}$$

The effect of an increase in government debt on interest rates is represented by the derivative:

$$\frac{\partial r}{\partial D} = \frac{\partial r}{\partial K}\frac{\partial K}{\partial D}$$

The first term on the right-hand side of that derivative is found by differentiating (A3) with respect to K:

$$\frac{\partial r}{\partial K} = \frac{\alpha(\alpha - 1)}{k^2 Y}$$

The final step in this calculation ($\partial K/\partial D = -c$) requires an assumption about the degree to which an increase in government debt crowds out private capital. As explained in the main text, if government debt completely crowds out capital (that is, if private saving does not respond to increased government debt), then $\partial K/\partial D = -1$. More generally, if we assume a unit increase in government debt (D) reduces the private capital stock by a fraction $0 \leq c \leq 1$, then the impact of government debt on the real interest rate is:

$$\frac{\partial r}{\partial D} = \frac{\alpha(1-\alpha)c}{k^2 Y} \geq 0 \qquad \text{(A4)}$$

The effect of a change in the ratio of debt to gross domestic product on the real interest rate is therefore:

$$\frac{\partial r}{\partial D/Y} = \frac{\alpha(1-\alpha)cY}{k^2 Y} = \frac{\alpha(1-\alpha)c}{k^2}$$

Appendix B: CBO's DSGE Model

In the Congressional Budget Office's view, changes in fiscal policies affect the economy in the short term primarily by altering overall demand for goods and services and in the long term by adjusting national saving, productivity, and households' and firms' incentives to work, save, and invest. CBO examines those effects by using evidence about the effects of past fiscal policy changes and by using results from a suite of macroeconomic models. One model that the agency uses occasionally to analyze both short- and long-term macroeconomic effects and other specific aspects of fiscal policy changes is a dynamic stochastic general equilibrium (DSGE) model.

CBO's DSGE model includes households and firms that are forward-looking in their behavior and a government that conducts fiscal and monetary policy. Those agents interact with each other and with the rest of the world in domestic and international goods and capital markets, responding to prices—such as wages, the rates of return on saving, and the real exchange rate—that are themselves determined by the interactions of those agents.

Households

Households make consumption, saving, and work decisions to maximize their lifetime well-being. The DSGE model has two types of households: savers and nonsavers. Savers have access to domestic and international capital markets; they invest in productive capital but incur investment adjustment costs that increase with the amount of newly accumulated capital. Those households can also save by purchasing domestic and foreign financial assets. Nonsavers do not have access to financial markets and consume all of their disposable income in each period of the model.

Both types of households consume a composite consumption bundle that is made up of domestic and imported components, and each component has a variety of differentiated goods. Investments in productive capital by savers also comprise a bundle of domestic and imported components but with potentially different shares for each component.

Households face uncertainty about future economic outcomes and government policies and form their expectations rationally—that is, they do not systematically over- or underpredict the probabilities of particular events or future economic and policy outcomes. The explicit treatment of households' beliefs is useful for examining how expectations influence the effects of fiscal policy on the economy. For example, the model provides a useful framework to quantify how much the effects of anticipated changes in tax rates, government purchases, or transfer payments differ from the effects of unanticipated changes.

Each household is a supplier of differentiated labor services. Households set their nominal wages, but wages adjust slowly in response to changes in economic conditions and government policies because wage adjustments are costly. In the model, wage-adjustment costs represent the labor market frictions that give rise to nominal wage stickiness.

The combination of nominal wage stickiness, investment adjustment costs, and the presence of different household types (with different saving behavior) helps generate plausible movements in economic variables, especially in response to fiscal policy changes. For example, investment adjustment costs cause crowding out to occur gradually, resulting in empirically plausible changes in output in the short term in response to debt-financed changes in government purchases. In addition, wage stickiness and the presence of nonsavers help generate reasonable changes in output and employment in response to changes in transfer payments.

Firms

Each differentiated product included in households' consumption and investment bundles is produced by a forward-looking firm. Firms rent capital and buy labor services from households. They set the prices on differentiated goods to maximize the sum of current and discounted future profits. However, prices change slowly (just as nominal wages do) in response to changes in economic conditions and government policies because firms incur costs when they adjust their prices. That feature generates nominal price rigidity in the model. Along with nominal wage stickiness, price rigidity helps induce empirically plausible effects on economic variables from changes in fiscal and monetary policy.

Fiscal and Monetary Policy

The model features a rich fiscal policy setting that includes government consumption, public investment, distortionary taxes, and transfer payments to households. The government levies taxes on labor and capital income as well as consumption to finance a stream of transfer payments and expenditures on public investment and noninvestment purchases. In the short run, revenues and spending are independent of each other, and the government may run a balanced budget, a surplus, or a deficit depending on revenues and spending in a given year. In the long run, the government adjusts purchases, the tax rates, and transfer payments to stabilize the ratio of debt to gross domestic product.

Monetary policy is implemented through a Taylor-type interest rate rule. The monetary authority adjusts the short-term interest rate in response to changes in inflation, the output gap (defined as the percentage difference between actual and trend output), and past values of the interest rate.

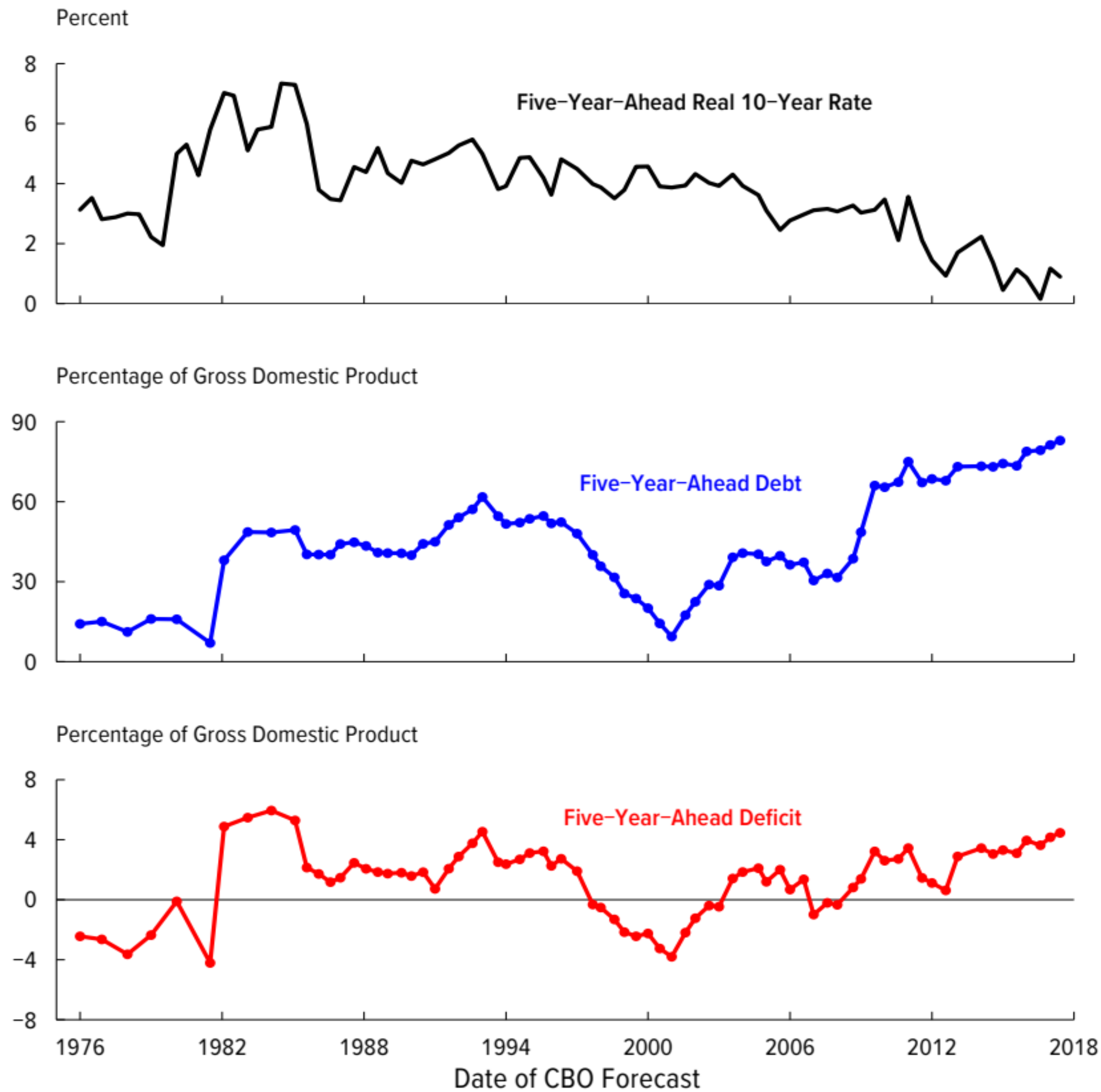
Rest of the World

The domestic economy interacts with the rest of the world in goods markets through imports and exports and in capital markets through purchases and sales of international financial assets.

Because foreign goods are a part of domestic consumption and investment bundles, a certain fraction of total expenditures in each period is spent on imports. That fraction increases (or decreases) as the real exchange rate appreciates (or depreciates) or as foreign goods become cheaper (or more expensive) relative to domestically produced goods. The economy's trade balance, defined as the nominal value of exports minus that of imports, equals net capital outflows minus net investment income from the rest of the world on a period-by-period basis (thereby satisfying a balance-of-payments relationship).

Foreign output, prices, and the return on foreign financial assets all have exogenous components in addition to components that change with domestic economic variables. Foreign output and prices potentially respond to domestic demand for foreign goods, and the return on foreign financial assets changes with the net foreign asset holdings of domestic households.

Figure 1. Expected 10-Year Rates, Debt, and Deficits



Sources: Congressional Budget Office; authors' calculations.

The five-year-ahead real 10-year Treasury rate is calculated as the difference between the five-year-ahead 10-year rate and the long-run average inflation rate in consumer prices (as measured by the personal consumption expenditure price index taken from the Federal Reserve's FRB/US model). The five-year-ahead debt and deficits (as a percentage of gross domestic product) are taken from CBO's annual projections through 1984 and semiannual projections thereafter.

Tables

Table 1.
Interest Rate Effect of Debt: Cobb-Douglas–Based Estimates

			With No Offsets From Saving or Capital Inflows	Crowding-Out Parameter	With Offsets
	Capital's Share	K/Y	$\frac{\partial r}{\partial D/Y}$	c	$\frac{\partial r}{\partial D/Y}$
Ball and Mankiw (1995)	0.3	2.5	0.034	0.5	0.017
Elmendorf and Mankiw (1999)[a]	0.32	3.2	0.021	--	--
Engen and Hubbard (2004)[b]	0.33	3.0	0.024	0.6-0.8	0.014-0.019
Laubach (2009)	0.33	2.5	0.035	0.6	0.021
Authors' Estimates	0.33	2.5	0.035	0.6	0.021

Sources: Cited studies; authors' calculations.

a. Elmendorf and Mankiw report a capital output ratio of "a little over three."
b. Engen and Hubbard do not report the capital output ratio used in their calculation. The ratio of 3 reported here is derived from their reported capital's share of output of 0.33 and $\partial r / \partial D = 0.024$ using equation (1).

Table 2.
Interest Rate Effect of Expected Debt: Reduced-Form Estimates
Dependent Variable: $_t i_{t+5}^{(10)}$

DEBT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$_t\pi_{t+5}$	1.31**	1.47**	1.49**	1.45**	1.77**	1.76**	1.11**	1.31**	1.34**
	(0.13)	(0.38)	(0.42)	(0.15)	(0.34)	(0.40)	(0.14)	(0.32)	(0.35)
$_tD_{t+5}$	0.027*	0.029*	0.021	-0.022	-0.019	-0.026†	0.022*	0.024*	0.019†
	(0.013)	(0.013)	(0.014)	(0.014)	(0.015)	(0.015)	(0.010)	(0.010)	(0.010)
div_yld_t	--	-0.21	-0.18	--	-0.42	-0.31	--	-0.25	-0.23
	--	(0.49)	(0.53)	--	(0.52)	(0.59)	--	(0.39)	(0.41)
$_tg_{t+5}$	--	--	-0.15*	--	--	-0.29**	--	--	-0.12*
	--	--	(0.06)	--	--	(0.08)	--	--	(0.05)
Fed_t	--	--	--	--	--	--	-0.24**	-0.25**	-0.25**
	--	--	--	--	--	--	(0.05)	(0.06)	(0.06)
$Foreign_t$	--	--	--	--	--	--	-0.11**	-0.10**	-0.09**
	--	--	--	--	--	--	(0.02)	(0.02)	(0.02)
Adjusted R^2	0.84	0.84	0.84	0.79	0.79	0.81	0.90	0.90	0.91
S.E. of Regression	0.87	0.87	0.85	1.17	1.17	1.11	0.79	0.79	0.78
Durbin-Watson	0.85	0.90	0.89	0.52	0.58	0.63	1.07	1.12	1.11

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 3.
Interest Rate Effect of Expected Deficits: Reduced-Form Estimates
Dependent Variable: $_{t}i_{t+5}^{(10)}$

DEFICIT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$_{t}\pi_{t+5}$	1.23**	1.41**	1.45**	1.56**	2.13**	2.14**	1.06**	1.30**	1.33**
	(0.12)	(0.34)	(0.38)	(0.16)	(0.38)	(0.41)	(0.13)	(0.31)	(0.33)
$_{t}d_{t+5}$	0.18*	0.19**	0.15*	0.00	0.05	-0.00	0.17**	0.18**	0.15**
	(0.07)	(0.07)	(0.07)	(0.12)	(0.10)	(0.10)	(0.06)	(0.06)	(0.06)
div_yld_t	--	-0.23	-0.21	--	-0.80	-0.72	--	-0.29	-0.28
	--	(0.43)	(0.47)	--	(0.48)	(0.52)	--	(0.34)	(0.36)
$_{t}g_{t+5}$	--	--	-0.14*	--	--	-0.20**	--	--	-0.09*
	--	--	(0.06)	--	--	(0.06)	--	--	(0.04)
Fed_t	--	--	--	--	--	--	-0.22**	-0.23**	-0.23**
	--	--	--	--	--	--	(0.05)	(0.05)	(0.05)
$Foreign_t$	--	--	--	--	--	--	-0.09**	-0.08**	-0.08**
	--	--	--	--	--	--	(0.02)	(0.02)	(0.02)
Adjusted R^2	0.85	0.85	0.86	0.76	0.78	0.78	0.91	0.91	0.91
S.E. of Regression	0.84	0.84	0.82	1.24	1.21	1.19	0.76	0.75	0.75
Durbin-Watson	0.85	0.90	0.89	0.43	0.54	0.54	1.07	1.13	1.12

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 4.
Interest Rate Effect of Expected Debt: Reduced-Form Estimates
Dependent Variable: ${}_{t}\mathbf{i}_{t+5}^{(3mo)}$

DEBT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
${}_{t}\pi_{t+5}$	1.41**	1.55**	1.57**	1.57**	1.94**	1.92**	1.17**	1.30**	1.34**
	(0.13)	(0.43)	(0.46)	(0.16)	(0.36)	(0.42)	(0.14)	(0.36)	(0.38)
${}_{t}D_{t+5}$	0.022	0.024	0.016	-0.028*	-0.023	-0.032*	0.020†	0.021†	0.015
	(0.014)	(0.014)	(0.015)	(0.013)	(0.014)	(0.014)	(0.011)	(0.011)	(0.011)
div_yld_{t}	--	-0.18	-0.15	--	-0.48	-0.36	--	-0.16	-0.14
	--	(0.53)	(0.57)	--	(0.52)	(0.60)	--	(0.42)	(0.44)
${}_{t}g_{t+5}$	--	--	-0.14*	--	--	-0.32*	--	--	-0.13*
	--	--	(0.07)	--	--	(0.12)	--	--	(0.05)
Fed_{t}	--	--	--	--	--	--	-0.15**	-0.16*	-0.15*
	--	--	--	--	--	--	(0.05)	(0.06)	(0.06)
Foreign_{t}	--	--	--	--	--	--	-0.16**	-0.16**	-0.14**
	--	--	--	--	--	--	(0.03)	(0.03)	(0.03)
Adjusted R^2	0.83	0.83	0.84	0.80	0.80	0.83	0.91	0.91	0.91
S.E. of Regression	0.94	0.95	0.93	1.24	1.23	1.16	0.83	0.83	0.82
Durbin-Watson	0.84	0.86	0.87	0.54	0.57	0.67	1.09	1.10	1.12

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 5.
Interest Rate Effect of Expected Deficits: Reduced-Form Estimates
Dependent Variable: $_t i_{t+5}^{(3mo)}$

DEFICIT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$_t\pi_{t+5}$	1.35**	1.50**	1.54**	1.70**	2.35**	2.36**	1.13**	1.29**	1.33**
	(0.13)	(0.39)	(0.42)	(0.17)	(0.43)	(0.45)	(0.13)	(0.35)	(0.37)
$_t d_{t+5}$	0.15†	0.15*	0.12	-0.03	0.02	-0.03	0.16*	0.16*	0.13*
	(0.08)	(0.08)	(0.08)	(0.12)	(0.10)	(0.10)	(0.07)	(0.06)	(0.07)
div_yld_t	--	-0.19	-0.17	--	-0.89†	-0.80	--	-0.21	-0.19
	--	(0.48)	(0.52)	--	(0.52)	(0.56)	--	(0.38)	(0.40)
$_t g_{t+5}$	--	--	-0.13†	--	--	-0.23*	--	--	-0.11*
	--	--	(0.07)	--	--	(0.11)	--	--	(0.05)
Fed_t	--	--	--	--	--	--	-0.13**	-0.14**	-0.14**
	--	--	--	--	--	--	(0.05)	(0.05)	(0.05)
$Foreign_t$	--	--	--	--	--	--	-0.15**	-0.14**	-0.13**
	--	--	--	--	--	--	(0.02)	(0.03)	(0.03)
Adjusted R^2	0.84	0.84	0.84	0.77	0.78	0.79	0.92	0.92	0.92
S.E. of Regression	0.93	0.93	0.92	1.34	1.30	1.27	0.80	0.80	0.80
Durbin-Watson	0.84	0.86	0.87	0.44	0.53	0.54	1.13	1.14	1.15

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 6.
Interest Rate Effect of Expected Debt: Reduced-Form Estimates
Dependent Variable: $_{t}i_{t+5}^{(10)} - {}_{t}i_{t+5}^{(3mo)}$

DEBT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$_{t}\pi_{t+5}$	-0.10**	-0.08	-0.08	-0.12**	-0.16†	-0.16†	-0.06	0.01	0.00
	(0.04)	(0.08)	(0.08)	(0.04)	(0.09)	(0.09)	(0.04)	(0.09)	(0.09)
$_{t}D_{t+5}$	0.005†	0.005†	0.005	0.005	0.005	0.006	0.002	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.004)	0.004	(0.005)	(0.003)	0.003	(0.003)
div_yld_{t}	--	-0.03	-0.02	--	0.06	0.04	--	-0.09	-0.09
	--	(0.10)	(0.10)	--	(0.11)	(0.11)	--	(0.09)	(0.09)
$_{t}g_{t+5}$	--	--	-0.01	--	--	0.04	--	--	0.01
	--	--	(0.02)	--	--	(0.05)	--	--	(0.03)
Fed_{t}	--	--	--	--	--	--	-0.09*	-0.09*	-0.09*
	--	--	--	--	--	--	(0.04)	(0.04)	(0.04)
$Foreign_{t}$	--	--	--	--	--	--	0.05**	0.06**	0.05**
	--	--	--	--	--	--	(0.02)	(0.02)	(0.02)
Adjusted R^2	0.21	0.19	0.18	0.24	0.23	0.23	0.39	0.38	0.38
S.E. of Regression	0.32	0.32	0.32	0.39	0.39	0.39	0.35	0.35	0.35
Durbin-Watson	1.19	1.20	1.20	0.76	0.74	0.79	0.93	0.99	1.01

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 7.
Interest Rate Effect of Expected Deficits: Reduced-Form Estimates
Dependent Variable: $_{t}i_{t+5}^{(10)} - {}_{t}i_{t+5}^{(3mo)}$

DEFICIT	1976:1-2007:08 *55 Observations*			1976:1-2017:06 *74 Observations*			1976:1-2017:06 *74 Observations*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$_{t}\pi_{t+5}$	-0.12**	-0.09	-0.09	-0.15**	-0.21*	-0.21*	-0.07	0.01	0.00
	(0.03)	(0.08)	(0.08)	(0.04)	(0.11)	(0.10)	(0.04)	(0.09)	(0.09)
$_{t}d_{t+5}$	0.04*	0.04*	0.04*	0.03	0.02	0.03	0.01	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	0.02	(0.02)
div_yld_t	--	-0.03	-0.03	--	0.09	0.08	--	-0.09	-0.09
	--	(0.09)	(0.09)	--	(0.12)	(0.11)	--	(0.08)	(0.08)
$_{t}g_{t+5}$	--	--	-0.00	--	--	0.04	--	--	0.02
	--	--	(0.02)	--	--	(0.05)	--	--	(0.03)
Fed_t	--	--	--	--	--	--	-0.09*	-0.09*	-0.09*
	--	--	--	--	--	--	(0.04)	(0.04)	(0.04)
$Foreign_t$	--	--	--	--	--	--	0.05**	0.06**	0.06**
	--	--	--	--	--	--	(0.02)	(0.02)	(0.02)
Adjusted R^2	0.23	0.22	0.20	0.22	0.21	0.21	0.39	0.38	0.38
S.E. of Regression	0.31	0.31	0.32	0.40	0.40	0.40	0.35	0.35	0.35
Durbin-Watson	1.17	1.19	1.18	0.73	0.70	0.73	0.91	0.97	0.99

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.

Table 8.
Alternative Specifications
Dependent Variable: $_{t}i^{(10)}_{t+5}$

	1976:1-2017:06 *74 Observations*						1987:8-2017:06 *60 Observations*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$_{t}\pi_{t+5}$	1.07**	1.29**	1.30**	1.04**	1.30**	1.34**	1.22**	1.22**
	(0.15)	(0.33)	(0.37)	(0.13)	(0.30)	(0.34)	(0.19)	(0. 22)
$_{t}D_{t+5}$	0.022*	0.024*	0.01	--	--	--	0.016*	--
	(0.011)	(0.010)	(0.01)	--	--	--	(0.008)	--
$_{t}d_{t+5}$	--	--	--	--	--	--	--	0.08**
	--	--	--	--	--	--	--	(0.05)
$_{t}Rev_{t+5}$	--	--	--	-0.12	-0.11	-0.04	--	--
	--	--	--	(0.12)	(0.10)	(0.09)	--	--
$_{t}Outlays_{t+5}$	--	--	--	0.18*	0.21**	0.19*	--	--
	--	--	--	(0.08)	(0.07)	(0.08)	--	--
div_yld_{t}	--	-0.28	-0.36	--	-0.35	-0.35	-0.21	-0.15
	--	(0.37)	(0.44)	--	(0.35)	(0.39)	(0.23)	(0.26)
$_{t}g_{t+5}$	--	--	-0.28**	--	--	-0.12**	--	--
	--	--	(0.08)	--	--	(0.05)	--	--
Fed_{t}	-0.23**	-0.24**	-0.21**	-0.21**	-0.22**	-0.21**	-0.22**	-0.19**
	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
$Foreign_{t}$	-0.12**	-0.11**	-0.11**	-0.10**	-0.09**	-0.09**	-0.10	-0.09**
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
GAP_{t}	-0.02	-0.03	-0.12**	--	--	--	--	--
	(0.05)	(0.05)	(0.04)	--	--	--	--	--
Adjusted R^2	0.90	0.90	0.91	0.91	0.91	0.91	0.91	0.91
S.E. of Regression	0.79	0.79	0.75	0.77	0.77	0.76	0.56	0.57
Durbin-Watson	1.07	1.14	1.29	1.09	1.17	1.16	1.35	1.27

Source: Authors' estimates.

Newey-West standard errors are reported in parentheses below the coefficient estimates. The asterisks indicate statistical significance corresponding to the null hypothesis that the estimated coefficient is zero: ** denotes significance at the 0.01 level; * denotes significance at the 0.05 level; † denotes significance at the 0.10 level.