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Federal Government Debt and Interest Rates

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1. Introduction

The recent resurgence of federal government budget deficits has rekindled debates about the effects of government debt on interest rates. While the effects of government debt on the economy can operate through a number of different channels, many of the recent concerns about federal borrowing have focused on the potential interest rate effect. Higher interest rates caused by expanding government debt can reduce investment, inhibit interest-sensitive durable consumption expenditures, and decrease the value of assets held by households, thus indirectly dampening consumption expenditures through a wealth effect. The magnitude of these potential adverse consequences depends on the degree to which federal debt actually raises interest rates.

While analysis of the effects of government debt on interest rates has been ongoing for more than two decades, there is little empirical consensus about the magnitude of the effect, and the difference in views held on this issue can be quite stark. While some economists believe there is a significant, large positive effect of government debt on interest rates, others interpret the evidence as suggesting that there is no effect on interest rates. Both economic theory and empirical analysis of the relationship between debt and interest rates have proved inconclusive.

We review the state of the debate over the effects of government debt on interest rates and provide some additional perspectives not covered in other reviews. We also present some new empirical evidence on this relationship. The paper is organized as follows. In the second section, we discuss the potential theoretical effects of government debt on interest rates, and we provide what we think are some important guidelines for interpreting empirical analysis of this issue. In the third section, we look at some basic empirical facts about federal government debt and interest rates, review recent econometric analysis of the interaction of federal government debt and interest rates, and introduce some new analysis of this relationship. Finally, in the last section, we summarize our conclusions and briefly discuss the potential effects of government debt on the economy in general.

2. Theory: How Might Government Debt Affect Interest Rates?

A standard benchmark for understanding and calibrating the potential effect of changes in government debt on interest rates is a standard model based on an aggregate production function for the economy in which government debt replaces, or crowds out, productive physical capital.[1] In brief, this model has the interest rate (r) determined by the marginal product of capital (MPK), which would increase if capital (K) were decreased, or crowded out, by government debt (D). With a Cobb-Douglas production function:

$$Y = AK^{\alpha}L^{(1-\alpha)}$$

where L denotes labor units, A is the coefficient for multifactor productivity, and α is the coefficient on capital in the production function, then the total return to capital in the economy (MPK^*K) as a share of output (Y) equals α:

$$\alpha = (MPK \times K)/Y$$

This implies that the interest rate is determined by:

$$r = MPK = \alpha \times (Y/K) = \alpha \times A \times (L/K)^{1-\alpha}$$

If government debt completely crowds out capital, so that:

$$\partial K/\partial D = -1$$

then an exogenous increase in government debt (holding other factors constant) causes the interest rate to increase:

$$\partial r/\partial D = (\partial r/\partial K)(\partial K/\partial D) = \alpha(1-\alpha)(Y/K^2) > 0$$

because $0 < \alpha < 1$ and Y and K are positive.

In this theoretical framework, which is commonly used to describe the potential effects of government debt on interest rates, are several important implications for empirical analysis of those effects. First, the *level* of the interest rate is determined by the level of the capital stock and thus by the *level* of government debt. The *change* in the interest rate is affected by the government budget deficit, which is essentially equal to the *change* in government debt. Empirical estimates of the effect on interest rates tend to differ markedly depending on whether the deficit or debt is used (as we show later), and most empirical work uses a specification different from that implied by this economic model; that is, the deficit is regressed on the level of the interest rate.

A model that suggests that deficits affect the level of the interest rate is a Keynesian *IS-LM* framework where deficits increase the interest rate not only because debt may crowd out capital but also because deficits stimulate aggregate demand and raise output. However, an increase in interest rates in the short run from stimulus of aggregate demand is a quite different effect than an increase in long-run interest rates owing to government debt crowding out private capital. As discussed by Bernheim (1987), it is quite difficult (requiring numerous assumptions about various elasticities) to construct a natural Keynesian benchmark for quantifying the short-term stimulus from deficits and the long-term crowding out of capital in trying to parse out the effect of government deficits on interest rates.

Second, factors other than government debt can influence the determination of interest rates in credit markets. For example, in a growing economy, the monetary authority will purchase some government debt to expand the money supply and try to keep prices relatively constant.[2] Government debt held by the central bank does not crowd out private capital formation, but many empirical studies of federal government debt and interest rates ignore central bank purchases of government debt.

More difficult econometric problems are posed by the fact that other potentially important but endogenous factors are involved in the supply and demand of loanable funds in credit markets. In addition to public-sector debt, private-sector debt incurred to increase consumption also could potentially crowd out capital formation. Typically, measures of private-sector debt or borrowing are not included in empirical studies of government debt. In a variant of a neoclassical model of the economy that implies Ricardian equivalence, increases in government debt (holding government consumption outlays and marginal tax rates constant) are offset by increases in private saving, and thus the capital stock is not altered by government debt and the interest rate does not rise.[3] Private-sector saving is usually not included in empirical analyses of government debt and the interest rate. Also, in an economy that is part of a global capital market, increases in government debt can be offset by increases in foreign-sector lending. Many empirical analyses of government debt and interest rates do not account for foreign-sector lending and purchases of U.S. Treasury securities.

Finally, the interest rate is also affected by other general macroeconomic factors besides capital that influence output (Y); in the simple model here, that includes labor and multifactor productivity. Thus, there is usually some accounting for general macroeconomic factors that can affect the performance of the economy in empirical analyses of the effect of government debt on interest rates.

Certain assumptions—Ricardian equivalence or perfectly open international capital markets in which foreign saving flows in to finance domestic government borrowing—provide one benchmark for the potential effect of government debt on the interest rate. In these scenarios, government debt does not crowd out capital (i.e., $\partial K/\partial D = 0$) and thus has no effect on the interest rate. For the alternative crowding-out hypothesis (i.e., $-1 \leq \partial K/\partial D < 0$), the production-function framework presented above can provide a range of plausible calculations of the potential increase in interest rates from an increase in the government debt.

By taking logs of the interest rate equation above, differentiating, and noting that $dlnx$ is approximately equal to the percentage change ($\%\Delta$) in x yields:

$$\%\Delta r = \%\Delta Y - \%\Delta K = (\alpha - 1)(\%\Delta K) + (1 - \alpha)\%\Delta L$$

Because labor input is typically held constant (i.e., $\%\Delta L = 0$) in the debt-crowd-out experiment,

$$\%\Delta r = (\alpha - 1)(\%\Delta K)$$

For the purpose of calculating a benchmark, we assume that the capital share of output is $\alpha = \frac{1}{3}$, which is approximately equal to its historical value in the United States. National accounts data suggests that the marginal product of capital is about 10 percent. The value of U.S. private fixed assets (less consumer durables) is about $31 trillion.[4] Thus, an increase in government debt of 1% of gross domestic product (GDP)—equal to about $110 billion—would reduce the capital stock by 0.36 percent, assuming that there is no offset to the increase in federal debt from increased domestic saving or inflows of foreign saving

Table 1
Changes in federal government debt and interest rates: calculations from an economic model of crowding out

	Change in interest rates (basis points)		
Increase in federal debt (% of GDP)	No offset $\partial K/\partial D = -1$ (1)	20% offset $\partial K/\partial D = -0.8$ (2)	40% offset $\partial K/\partial D = -0.6$ (3)
(1) 1 percent	2.4	1.9	1.4
(2) 5 percent	11.8	9.5	7.1
(3) 10 percent	23.7	18.9	14.2
Eliminate federal debt			
(4) $4 trillion	−86	−69	−52

(i.e., $\partial K/\partial D = -1$). Multiplying this percentage decline by −0.67 (which is equal to $\alpha - 1$, where $\alpha = 0.33$) implies an increase in the marginal product of capital of 0.24 percent. The resulting increase in interest rates is 2.4 basis points, as shown in the first column of Table 1. Similarly, a government surplus of 1% of GDP would be expected to decrease interest rates 2.4 basis points.

If the increase in federal debt were larger—5% of GDP—then interest rates are calculated to rise by 11.8 basis points, as the second row of the first column in Table 1 shows. This effect could be the result of an increase in federal debt in a single year, or the result of a persistent increase in federal debt (i.e., a persistent deficit) of 1% of GDP per year over five years. An increase in the federal debt of 10% of GDP—again, the result of a one-time increase or the consequence of a persistent increase in federal debt of 1% of GDP per year over ten years—would increase interest rates by 23.7 basis points.[5]

Currently, total federal debt held by the public is about $4 trillion, or 12.9% of the $31 trillion private capital stock. Holding other factors constant, eliminating the federal debt (measured in this way) entirely and assuming it would increase the private capital stock on a one-for-one basis imply a decrease in interest rates of 86 basis points, as shown in the fourth row of the first column.

The calculations in the first column of Table 1 assume no offset from increased private saving or capital inflows from abroad, which is not consistent with the U.S. economic experience. As shown in the second column, if, for example, 20% of the increase in government debt is offset by these factors (i.e., $\partial K/\partial D = -0.8$), then a $110 billion (1% of GDP) increase in federal government debt would reduce the U.S.

capital stock by $88 billion, or about 0.28%. This implies an increase in the marginal product of capital of 0.19%, so the resulting increase in interest rates is about 1.9 basis points. An increase in federal debt of 5% of GDP—or a $550 billion increase in government debt—would increase the interest rate by 9.5 basis points. Alternatively, totally eliminating the federal debt is calculated to reduce interest rates by about 69 basis points. Assuming a larger but plausible offset to increases in federal debt from domestic and/or foreign saving of 40% (i.e., $\partial K/\partial D = -0.6$),[6] suggests that even an increase in federal debt equal to 10% of GDP would increase interest rates by only 14 basis points. Under this scenario, eliminating the federal debt would lower interest rates a little over 50 basis points.

These calculations provide a reasonable benchmark for evaluating the traditional crowding-out effect on interest rates of an exogenous increase in government debt, holding other factors constant. Given the size of deficits and surpluses seen in the United States, these effects are more subdued than one might think given some of the commentary on federal deficits and interests rates. However, because other factors that influence interest rates are not constant, changes in government debt are influenced by both exogenous and endogenous factors, and the likely interest rate effects of changes in federal government debt consistent with historical U.S. experience may be in the range of single-digit basis points, this poses a particular burden on empirical analysis to estimate these effects with less-than-perfect data and econometric techniques.

3. Empirical Evidence: Is There a Clear Answer?

Because economic theory is not conclusive in determining whether federal government debt raises interest rates, and if it does, by how much, this issue must ultimately be addressed by empirical analysis. However, model-based calculations of the potential effects of government debt on interest rates are instructive and provide some benchmarks to help assess empirical estimates of this relationship. Before turning to econometric analysis of the possible effects of federal government debt on interest rates in the United States, we first examine some basic empirical facts about government debt, interest rates, and other related factors in the U.S. economy. These facts illustrate some of the difficulties posed for econometric analysis.

3.1 *Some Basic Facts*

Over the past half-century, U.S. federal government debt held by the public as a percentage of GDP has fluctuated from a high of about 60% of GDP to a low of around 25% of GDP in the mid-1970s, as shown in Figure 1.[7] While federal debt climbed during the 1980s and early 1990s to almost 50% of GDP, it declined thereafter and still remains below 40% of GDP despite its recent upturn.

Federal borrowing, or the yearly change in federal debt, as a percentage of GDP has averaged about 2% over the past fifty years, and has fluctuated from peaks around 5% of GDP to the retirement of debt equal to about 3% of GDP in 2000, as shown in Figure 2.[8] Not surprisingly, federal borrowing tended to rise shortly after the recession episodes in 1974–1975, 1980–1981, 1990–1991, and 2001.

One of the primary concerns about federal debt is its potential to crowd out the formation of capital in the economy. Figure 3 shows federal government debt as a percentage of the U.S. private capital stock.[9] Federal government debt is currently equal to about 13% of the private capital stock, which provides an upper bound on the amount of capital that federal debt could have directly crowded out.

The federal government is not the only borrower in U.S. credit markets, and indeed it is not the largest. Figure 4 shows that federal

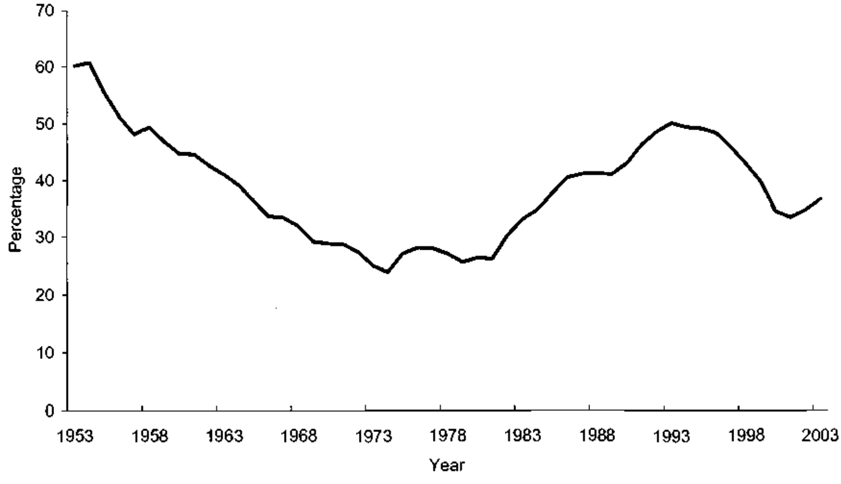

Figure 1
U.S. federal government debt held by the public as a percentage of GDP

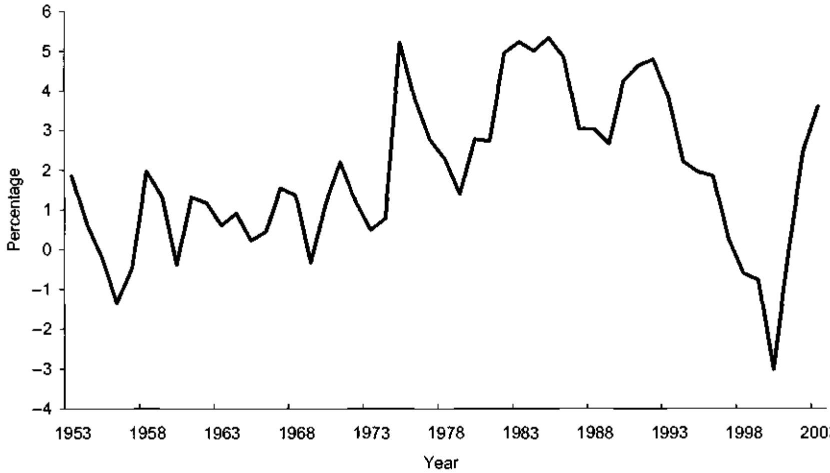

Figure 2
U.S. federal government borrowing as a percentage of GDP

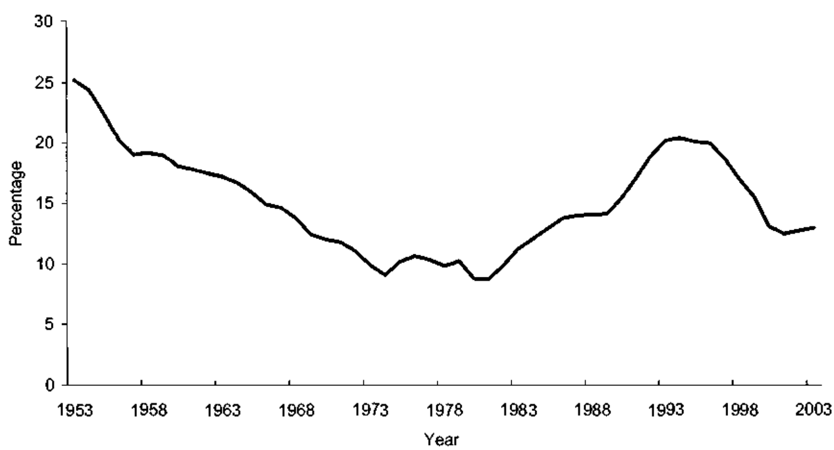

Figure 3
U.S. federal government debt held by the public as a percentage of U.S. private capital stock

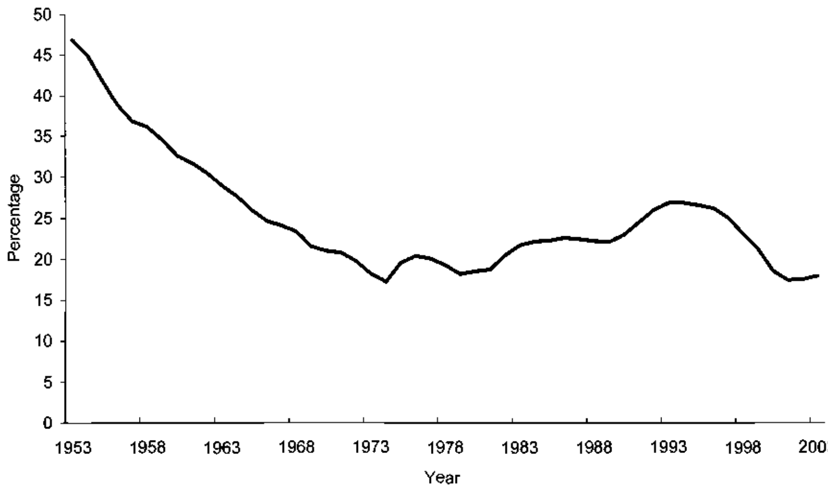

Figure 4
U.S. federal government debt held by the public as a percentage of total U.S. domestic nonfinancial debt

government debt as a share of total U.S. domestic (nonfinancial) debt has declined significantly since 1953, and it currently is less than 20% of total debt.[10] Figure 5 shows annual federal borrowing relative to total domestic U.S. borrowing. Federal government borrowing currently claims about one-fifth of the total funds loaned in U.S. credit markets. As global capital markets have become more integrated over time, the relevant size of the loanable funds market in which federal government debt interacts is much larger than the size of just the U.S. credit market, and thus these two figures overstate the relative size of federal debt and borrowing in the pool of available loanable funds. We return to this point below.

The debt incurred by the household, business, and state and local government sectors has been consistently larger than that incurred by the federal government over the past fifty years; it has also grown at a faster rate. Figure 6 shows U.S. domestic nonfederal (nonfinancial) debt as a percentage of GDP. Currently standing at approximately 160% of GDP, domestic nonfederal debt is about four times as large as federal government debt. Figure 7 presents annual nonfederal borrowing as a percentage of GDP; such borrowing has consistently been greater than federal borrowing over the past fifty years, except during the credit crunch of the early 1990s.

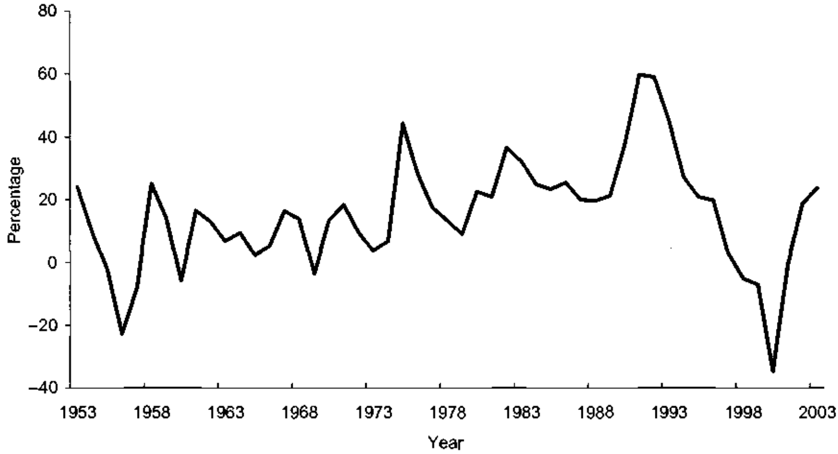

Figure 5
U.S. federal government borrowing as a percentage of total U.S. domestic nonfinancial borrowing

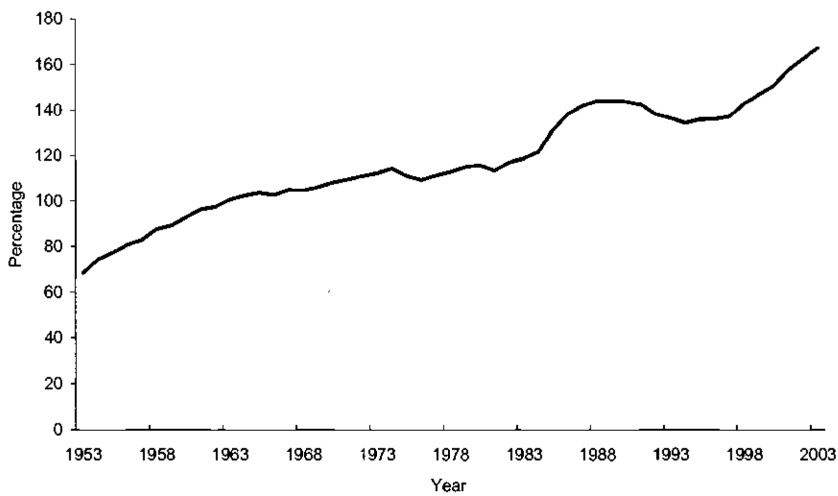

Figure 6
U.S. domestic nonfinancial, nonfederal debt as a percentage of GDP

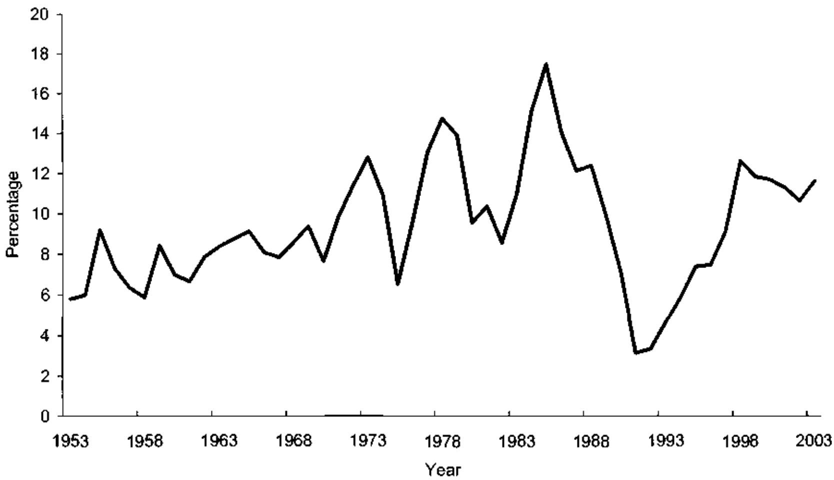

Figure 7
U.S. domestic nonfinancial, nonfederal borrowing as a percentage of GDP

Foreign saving is an ever-more important source of funds to U.S. credit markets, one that could also potentially influence the effect of federal government debt on interest rates. Indeed, foreign funds have been used increasingly to purchase U.S. federal government debt. As shown in Figure 8, while foreign holdings of U.S. Treasury securities were less than 5% of total outstanding federal debt just over 30 years ago, foreign purchases of Treasury securities have increased dramatically since then, and foreigners currently hold a little more than one-third of total federal debt.[11] Note that the recent surge in foreign holdings of U.S. Treasury securities is not unprecedented; both the early 1970s and the mid-1990s were periods when foreigners significantly increased their holdings of Treasury instruments.

Domestic private savers and foreign savers are not the only sectors that hold debt issued to the public by the federal government. As the U.S. monetary authority, the Federal Reserve also holds Treasury securities, using them to conduct monetary policy. The Federal Reserve currently holds about 15% of outstanding Treasury securities, up from around 10% about a decade ago, as Figure 9 shows. In a growing economy, the Federal Reserve must consistently acquire some Treasury securities in open-market operations to expand the money supply and prevent deflation, as we noted in the previous section. Treasury debt purchased by the Federal Reserve to increase the money supply may

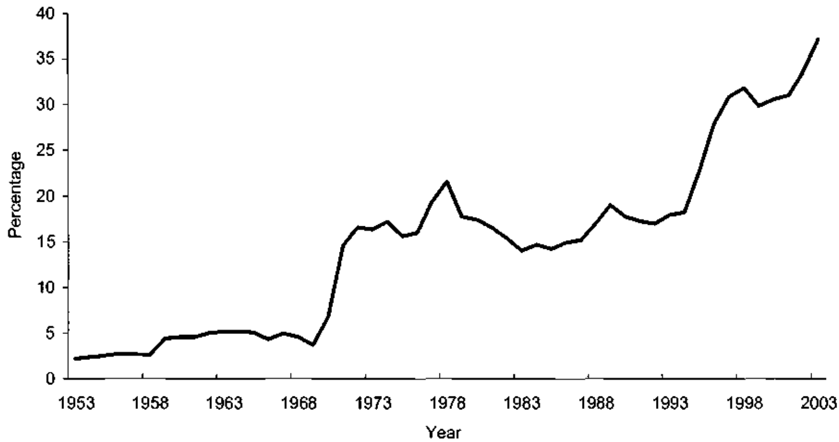

Figure 8
Foreign holdings of U.S. Treasury securities as a percentage of total U.S. Treasury securities outstanding

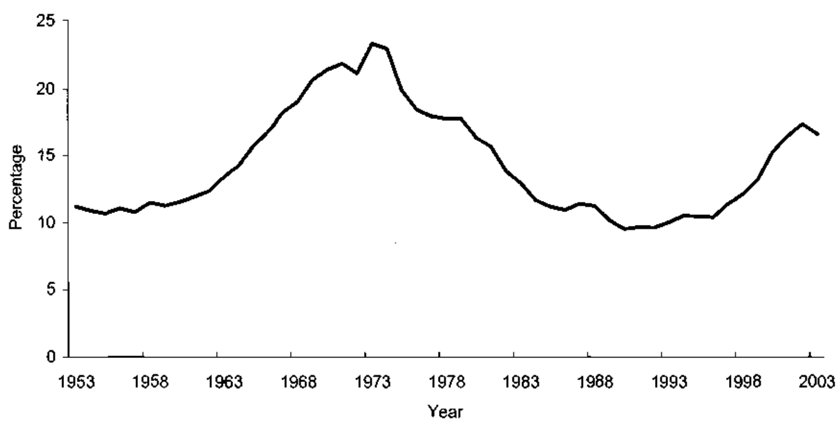

Figure 9
Federal Reserve holdings of U.S. Treasury securities as a percentage of total U.S. Treasury securities outstanding

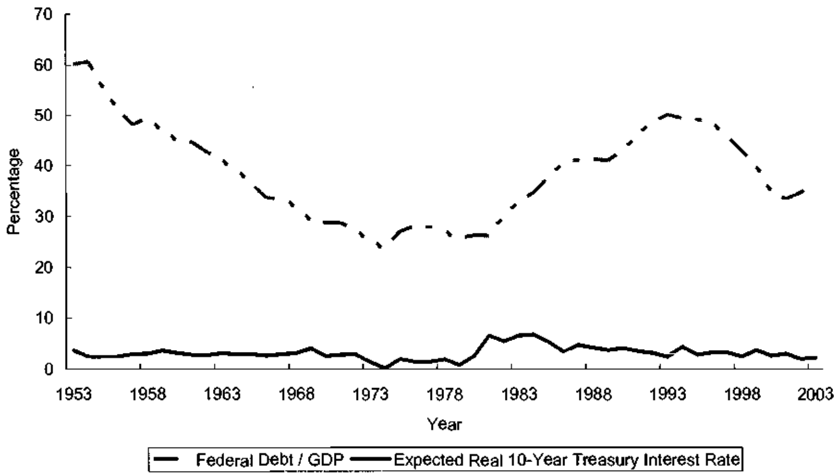

Figure 10
U.S. federal government debt held by the public as a percentage of GDP and real 10-year Treasury interest rate

not have the same effect of crowding out private capital formation as does federal debt purchased by the private sector.

Financing decisions of the federal government along with those of private-sector borrowers, state and local government borrowers, domestic and foreign savers, and the Federal Reserve all interact in the U.S. and international credit market to influence interest rates on U.S. Treasury debt and other debt. To get a sense of what effect U.S. federal government debt has had on interest rates, it is instructive to look at the historical evolution in federal debt (relative to GDP) compared to interest rates over the past fifty years. Figure 10 shows U.S. federal government debt held by the public as a percentage of GDP and a measure of the real interest rate on ten-year Treasury securities.[12] While federal debt relative to GDP has varied substantially, the real interest rate has been less variable and is currently equal to its average value over the past fifty years of about 3%. Indeed, the simple correlation between the stock of federal debt and this measure of the real interest rate over the entire period shown is only 0.15. Over the twenty-year period from the early 1950s to the early 1970s—when federal debt decreased by 50% relative to the size of the economy—the real interest rate remained relatively constant. The real interest rate did rise in the early 1980s, coincident with an increase in federal debt, but the real interest rate then declined and remained quite

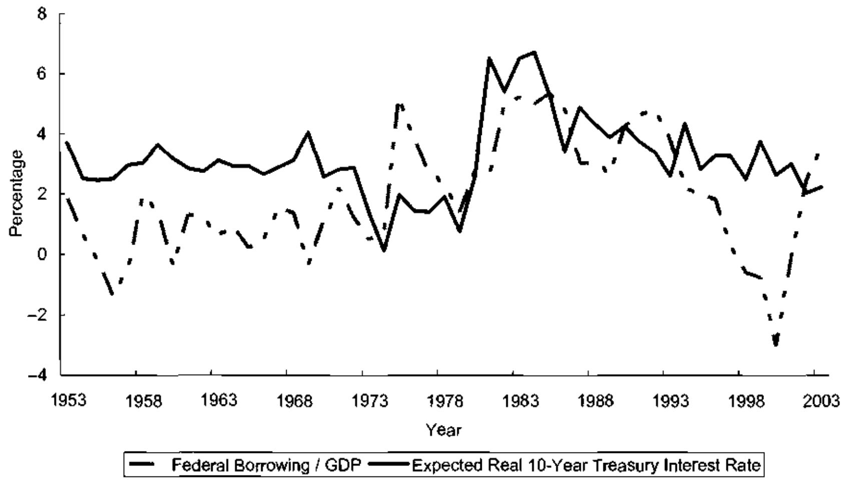

Figure 11
U.S. federal government borrowing as a percentage of GDP and real 10-year Treasury interest rate

steady even as federal debt continued to grow in the 1980s and early 1990s, and then fell in the late 1990s.

Figure 11 shows annual federal government borrowing as a percentage of GDP relative to the real rate on ten-year Treasury securities. Here, the correlation between federal government borrowing and the real interest rate is 0.39, higher than that between federal government debt and the real interest rate, but still modest. As we noted earlier, a simple economic model of crowding-out implies that federal government borrowing, which is equal to the change in federal government debt, is related to the change in the real interest rate rather than the level of the real interest rate, as shown in Figure 11. Figure 12 plots federal government borrowing (as a percentage of GDP) relative to the change in the real ten-year Treasury rate. The correlation between federal borrowing and the change in the real interest rate is 0.06, much smaller than the correlation between federal borrowing and the level of the real interest rate.

In addition to the concern that federal government debt might crowd out private capital formation by causing real interest rates to rise, federal government debt may also bring the temptation to monetize the debt, causing inflation. The presentation in Figure 13 of data for federal government debt (as a percentage of GDP) and both the expected

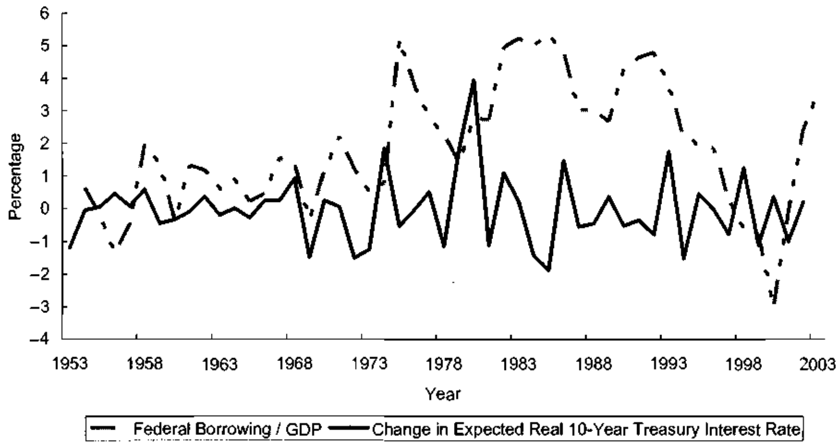

Figure 12
U.S. federal government borrowing as a percentage of GDP and the change in the real 10-year Treasury interest rate

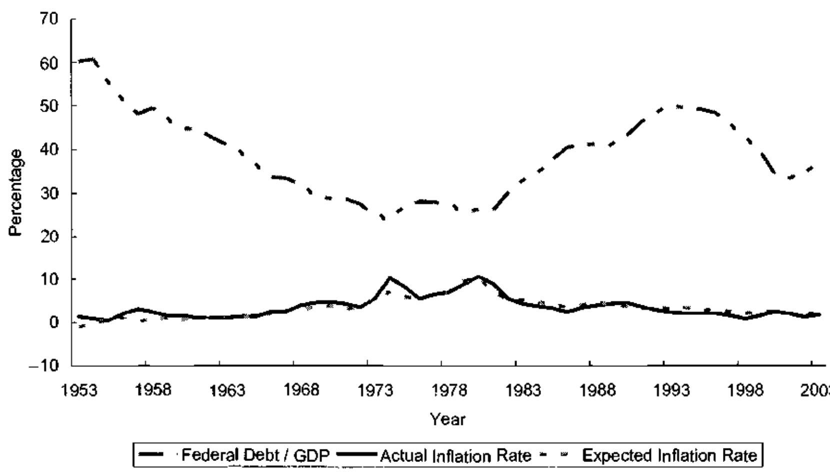

Figure 13
U.S. federal government debt held by the public as a percentage of GDP and the actual and expected inflation rate

inflation rate and the inflation rate shows that this concern has not been a problem in the United States over the past fifty years.[13] The correlation between federal government debt and the actual inflation rate is −0.71 over this period (and is similar for the expected inflation rate); inflation peaked when the federal debt relative to GDP was at its lowest points and declined as federal debt grew in the 1980s.

Returning to the potential effects of government debt on real interest rates, it is also useful to examine the difference in real interest rates between the United States and other major industrial economies. If international capital markets were not well integrated, then real interest rates might vary according to differences in government debt and borrowing patterns. Alternatively, if credit markets were integrated in the global economy, then real interest rates might be expected to be more similar across these different economies. Figure 14 presents real interest rates on ten-year government securities for the United States, Canada, France, Germany, Italy, Japan, and the United Kingdom since 1990.[14] Over this period real interest rates have generally declined, and currently there is much less dispersion in these real interest rates than there was in the early 1990s. Italy has the lowest real interest rate—just below 2%—while Germany has the highest at just under 4%. However, the current government financial positions of these countries are quite different. While Japan currently has a stock of government debt

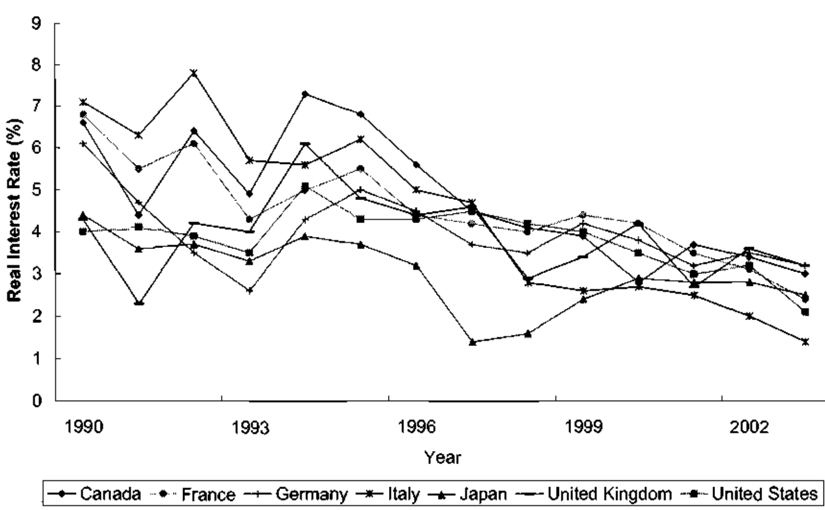

Figure 14
Real interest rates on 10-year government bonds for major advanced economies

of more than 70% of GDP, and an annual budget deficit of about 7% of its GDP, its real interest rate is almost the same as the United States and France, both of which have stocks of government debt and flow deficits (both relative to GDP) about half the size of those in Japan. Italy, currently with the lowest real interest rate, has a ratio of government debt to GDP of more than 90%, the highest in this group of economies. The United Kingdom currently has a deficit to GDP ratio of 1.5%, and Canada has a government surplus of almost 1%, but real interest rates in those countries are somewhat higher than in the United States. The similarity of real interest rates across these countries, despite having very different government borrowing needs, suggests that global credit markets are fairly integrated, so that the pool of loanable funds that any government may draw from substantially exceeds funds in the domestic credit market alone.

Several basic points summarize our assessment of these data on U.S. federal government debt and interest rates. First, the federal government is not the largest borrower in the U.S. domestic credit market, and the stock of outstanding federal debt has generally remained under 25% of total U.S. domestic debt for the past 30 years. Second, there is strong evidence that global credit markets have become increasingly integrated, so the relative role of U.S. federal government borrowing in the relevant international market for loanable funds is even smaller than in the domestic credit market. Third, the simple bivariate correlation between federal government debt and real interest rates in the United States has been quite weak over the past fifty years, so a strong positive relationship between federal government debt and real interest rates is not obvious. Of course, more rigorous econometric analysis of this relationship is necessary before a more definitive conclusion can be drawn.

3.2 *Review of Previous Studies*

Several different surveys over the past twenty years have evaluated the empirical literature on the relationship between federal government debt and interest rates: Barth, Iden, and Russek (1984); Bernheim (1987, 1989); Barro (1989); Barth, Iden, Russek, and Wohar (1991); Seater (1993); Elmendorf and Mankiw (1999); and Gale and Orszag (2002, 2003), for example. Despite the volume of work, no universal consensus has emerged. For example, Barth, Iden, Russek, and Wohar (1991), referring also to their earlier review, write:

There was not then and there is not now a clear consensus on whether there is a statistically and economically significant relationship between government deficits and interest rates ... Since the available evidence on the effects of deficits is mixed, one cannot say with complete confidence that budget deficits raise interest rates and reduce saving and capital formation. But, equally important, one cannot say that they do not have these effects.

In their surveys of studies of Ricardian equivalence, Bernheim (1987, 1989) and Seater (1993) enumerate problems with tests of this hypothesis performed by examining the relationship between federal government debt and deficits with interest rates. Bernheim (1989) concludes that: "[I]t is easy to cite a large number of studies that support any conceivable position." However, in the end, Seater generally finds more overall support for the Ricardian equivalence hypothesis, which implies that federal government debt has no effect on interest rates, than does Bernheim, who argues that the Ricardian equivalence hypothesis should be rejected, which would make a positive relationship between federal government debt and interest rates more likely. Barro (1989) takes a similar position as Seater, concluding: "Overall, the empirical results on interest rates support the Ricardian view. Given these findings, it is remarkable that most macroeconomists remain confident that budget deficits raise interest rates."

In discussing empirical research on federal government debt and interest rates, Elmendorf and Mankiw (1999) state that "it is worth noting that this literature has typically supported the Ricardian view that budget deficits have no effect on interest rates." However, they go on to evaluate this evidence, writing: "Our view is that this literature, like the literature regarding the effect of fiscal policy on consumption, is ultimately not very informative. Examined carefully, the results are simply too hard to swallow...." Gale and Orszag (2002), in their survey of the economic effects of federal government debt, also acknowledge that "the evidence from the literature as a whole is mixed" but go on to conclude:

Closer examination of the literature, however, suggests the findings may not be as ambiguous as they initially appear. Indeed, studies that (properly) incorporate deficit expectations in addition to current deficits tend to find economically and statistically significant connections between anticipated deficits and current long-term interest rates.

Thus, while surveys of the empirical literature on federal government debt and interest rates note the wide range of results reported in different studies, interpretations and assessments of these mixed empirical results still differ. While we do not evaluate every empirical paper that has been written on the relationship between federal government debt and interest rates, we will offer an assessment of the existing literature, focusing primarily on more recent papers.

Many studies analyzing the effects of U.S. federal government debt or deficits on U.S. interest rates do not incorporate the potential effects of the fact that international financial markets are increasingly integrated. To account for this, Barro and Sala-i-Martin (1990) and Barro (1991) provide estimates of the effects that economic, fiscal, and monetary policy variables have on expected real world interest rates across ten major developed economies, including the United States. They use a structural approach where the world interest rate is determined by investment demand and desired saving. While they conclude that current government debt or deficits do not play an important role in the determination of real expected interest rates in these countries, their empirical analysis does not use expected future government deficits or debt.

Cohen and Garnier (1991) use forecasts of federal deficits for the United States provided by the Office of Management and Budget (OMB), and in additional analysis they also investigate the effects of forecasts of general government deficits made by the Organization for Economic Cooperation and Development (OECD) on interest rates across the G7 countries. Their analysis yields mixed results. For the United States, they generally do not find significant effects of the current deficit or expected deficits on interest rates, although they do find a significant statistical relationship between OMB deficit forecast *revisions* and interest rates in the United States. Their estimates imply that an upward revision in OMB's federal deficit forecast of one percentage point of GDP could increase real interest rates by about 80 to100 basis points. However, the theoretical calculations that we presented earlier raise the question of whether this result is economically plausible. In their analysis of the G7 countries, they find no evidence of a positive and significant relationship between home-country current debt or deficits and current interest rates, similar to Barro and Sala-i-Martin (1990) and Barro (1991), and they find that one-year-ahead forecasts of home-country government deficits by the OECD tend to have a significant *negative* effect on nominal short-term interest rates, in contrast to the prediction of the government deficit crowding-out hypothesis. However, one-year-ahead forecasts of other-country government deficits by the OECD tend to have a significant effect on home-country nominal short-term interest rates in the direction consistent with the government deficit crowding-out hypothesis, and also imply that credit markets across these countries are integrated.

Cebula and Koch (1989) explore the effect of the current U.S. federal government deficit, split into its cyclical and structural components, on both ten-year Treasury yields and corporate bond yields, while also controlling for foreign capital inflows. Their results imply that positive foreign capital inflows significantly lower both Treasury and corporate rates, consistent with integrated global credit markets, and significantly reduce the estimated effect of structural government deficits on interest rates. They find a statistically insignificant effect of the structural federal government deficit on Treasury yields but report a statistically significant effect of the structural federal government deficit on corporate bond yields, implying that the structural federal government deficit affects the yield spread between corporate and Treasury rates. It is not obvious why structural federal government deficits should affect the corporate-to-Treasury-yield spread. In contrast, Laubach (2003) reports that, based on regression analysis, he finds no evidence that yield spreads between corporate bonds and Treasuries, adjusted for cyclical variation, are systematically related to projected deficit-to-GDP ratios. Thus, the fact that Cebula and Koch (1989) are using current federal deficits in their analysis instead of expected federal deficits may be contributing to their result.[15]

Elmendorf (1993) analyzes the effect of expected federal government deficits on Treasury yields using a private-sector forecast of the federal government deficit from Data Resources, Inc. (DRI) instead of federal government deficit projections made by the OMB or the Congressional Budget Office (CBO). Presumably, the DRI deficit forecast incorporates expectations of fiscal policy changes that are not part of CBO and OMB projections and thus may be a more accurate reflection of financial market participants' expectations of future federal government deficits. Regression results show that the DRI forecasts of federal government deficits have significant and large (and statistically significant) positive effects on medium-term (three- or five-year) Treasury yields—an increase in the expected deficit of 1% of GDP is estimated to increase medium-term Treasury rates by more than 40 basis points—but have a smaller and statistically insignificant effect on a long-term (20-year) Treasury rate. If federal government borrowing is crowding out private capital formation, then one would expect to find a larger impact on long-term interest rates than on shorter-term interest rates.

Kitchen (2002) examines the effects of the CBO's current standardized federal government deficit measure—which adjusts the actual deficit for business-cycle effects and other (usually) one-time budget effects—on the spread between the three-month Treasury yield and longer-term Treasury rates, rather than the level of Treasury rates. In a parsimonious specification controlling only for inflation and the difference between actual GDP and the CBO's measure of potential GDP, he estimates that a 1% increase in the current standardized federal government deficit (relative to GDP) increases the spread between the ten-year Treasury rate and the three-month Treasury rate by 42 basis points. This estimate is much larger than the benchmark calculations from our simple economic framework presented above. Kitchen also uses a regression specification—effectively regressing the level of the interest rate on the federal deficit—that is not implied by the model. Also, because the estimates are based on *current* measures of interest rates and the federal deficit, it is not obvious whether the influence of other economic factors that might affect the interest rate, but are not included in his parsimonious regression specification, is affecting the estimate of the effect of federal deficits.

Laubach (2003) estimates the effect of five-year-ahead projections by the CBO of federal government debt or deficits on the five-year-ahead real ten-year Treasury yield. The purpose for using five-year-ahead interest rates and debt or deficit projections is to try to omit any effects of current economic conditions from measuring the effects of federal government deficits on the interest rate. He finds that a one-percentage-point (relative to GDP) increase in the measure of the expected federal government deficit increases the forward-looking ten-year Treasury rate by 28 basis points. However, when Laubach estimates an econometric specification that uses expected federal government debt instead of the deficit (which, in contrast to using a deficit measure, is a specification consistent with a standard economic model of crowding-out), he estimates that a one-percentage-point increase in the expected debt-GDP ratio increases the forward-looking ten-year Treasury rate by only five basis points—an estimate close to the benchmark calculations we presented previously. Thus, these results illustrate that whether an interest rate measure is regressed on the federal government deficit or on the federal government debt can yield markedly different implications for the magnitude of the associated interest rate effect.

Laubach suggests that the difference in these results can be reconciled by the fact that federal budget deficits tend to be serially correlated in historical U.S. data, and thus financial market participants may expect an increase in the federal government deficit to be persistent, and in turn there is a larger increase in interest rates.[16] However, federal government debt is also serially correlated in U.S. data. This is not surprising because federal government debt ($DEBT_t$) at the end of time period t is the sum of the federal budget deficit ($DEFICIT_t$) during time period t and federal government debt at the end of the prior period, $t - 1$:

$$DEBT_t = DEFICIT_t + DEBT_{t-1}$$

If financial market participants expect an increase in federal government deficits to be persistent, then they should also expect increases in federal government debt to be persistent, so it is not clear that this explanation reconciles the difference in the estimated interest rate effects when using federal deficits instead of federal debt. Indeed, current (end-of-period) debt contains information not only about the current deficit but also captures all information about previous government borrowing, and thus is a better measure to evaluate the effect of government borrowing on the *level* of the interest rate, as suggested in our theoretical discussion above. The *change* in government debt, or the deficit, would be expected to affect the *change* in the real interest rate, not necessarily the level of the interest rate, but that is not the econometric specification used by Laubach. We return to this point in our empirical work below.

Miller and Russek (1996) show that different econometric approaches can yield different conclusions about the effect of federal government deficits on interest rates. While their conventional estimates of reduced-form specifications indicate that increases in the current real per-capita deficit increases current nominal Treasury rates (although it is difficult to interpret the magnitude of this effect from their reported regression results), using vector autoregression (VAR) methods yields mixed results about this relationship.[17]

Evans and Marshall (2002) use a VAR framework to investigate the macroeconomic determinants of the variability in the nominal Treasury yield curve. They find that general macroeconomic shocks account for most of the variability in nominal Treasury yields, with fiscal policy shocks generally having mixed effects. Their measure of fiscal deficit shocks—derived from Blanchard and Perotti (2000)—does not significantly explain nominal Treasury yield variability. However, they do find that the measure of military buildup shocks suggested by Ramey and Shapiro (1998) tends to increase nominal Treasury rates.

Another approach to looking at the effects of federal government deficits on interest rates has been to focus on media-reported budget news. If news concerning federal government deficits occasionally leads to significant movements in bond market prices, then standard time-series techniques may have little power to identify these occasional, possibly nonlinear events. Previous economic research that has analyzed the effects of news announcements about federal government deficits on interest rates (Wachtel and Young, 1987; Thorbecke, 1993; Quigley and Porter-Hudak, 1994; Kitchen, 1996), have generally found only small or transitory effects. Elmendorf (1996) found that higher expected federal deficits and government spending tended to raise interest rates, but his methodology does not provide evidence of the magnitude of the effect.

Calomiris, Engen, Hassett, and Hubbard (2003) add to this analysis of the effects of federal budget news on interest rates in two ways. First, they estimated the extent to which monthly deviations of private-sector consensus forecasts of the federal government budget balance from actual monthly Treasury budget balance reports, along with deviations in consensus forecasts and actual reports on other macroeconomic variables, predict movements in interest rates. They found that stronger than expected reports on many macroeconomic factors (such as the employment situation, industrial production, and retail sales, for example) tended to increase interest rates, but actual deviations from expected monthly federal government budget deficits had no statistically significant effect on interest rates. Second, they collected historical data on large daily movements in interest rates and catalog the economic news that occurred on these days. Typically, the days with large interest rate movements are associated with general economic news rather than with federal budget news, and the movement in interest rates is consistent with what economic theory would suggest; that is, news that suggests more robust economic growth is associated with increases in interest rates. Both of these approaches yielded little evidence that unexpected news about the federal budget situation had significant effects on interest rates.

Evaluating the effects of government debt on interest rates is difficult given the lack of consensus on the appropriate underlying economic model of how federal debt or deficits and interest rates should interact. Variable definitions and other features of the data and econometric methodology vary across these studies, making comparisons difficult. As with most of the earlier reviews of the economic literature on federal debt, deficits, and interest rates, our view is that the existing evidence is quite mixed. Some studies find positive effects of federal deficits on interest rates; others do not. Even among the studies that do find a positive effect of deficits on interest rates, the magnitude of the effect on interest rates is still uncertain. However, looking systematically at the influence of different econometric specifications, different measures of federal government debt or deficits, different measures of the interest rate, and different econometric methodologies, the estimated effect of federal government debt on interest rates should provide some insight into this issue.

3.3 *Empirical Analysis of the Federal Debt and Interest Rates*

We now provide some new empirical evidence on the potential effects of federal government debt on interest rates. Consistent with most prior analysis, we initially examine this relationship by estimating a reduced-form equation:

$$i_t = \beta_0 + \beta_1 d_t + \Gamma Z + \varepsilon_t$$

where i_t is a measure of the interest rate (in time period t), d_t is a measure of federal government debt, and Z is a vector of other relevant variables that may influence interest rates. The effect of federal government debt on the interest rate is described by the estimate of the coefficient, β_1.

The specification of the interest rate variable, i, and the federal government debt variable, d, in the reduced-form equation can take different forms. As we noted earlier, the hypothesis that federal government debt might crowd out private capital formation and thus raise long-term real interest rates is typically based on a simple economic model as we presented above.[18] This model implies that:

1. The *level* of the real interest rate, i, is related to the *level*, or stock, of federal government debt, d, or

2. The *change* in the real interest rate, Δi, is related to the *change* in federal government debt, Δd, which is equal to federal government borrowing, or the deficit.

We estimate this reduced-form equation using both of these specifications for i and d. Although not consistent with the specifications for i

and d implied by an economic model of crowding-out, we also estimate this reduced-form equation using a third specification, in which:

3. The level of the real interest rate, i, is regressed on federal government borrowing (or the deficit), Δd.

A number of prior studies have used this third specification, and it is informative to compare the results from using this specification with those that employ the previous two specifications, even though it is not consistent with a simple crowding-out model. Economic theory suggests that it is the total *stock* of government debt that is the most relevant for explaining the *level* of the interest rate, not just the one-period change in government debt.

Another important issue for specifying i and d is whether these are *forward-looking*, or expected, measures of real interest rates and federal government debt, or whether they are *current* measures of these variables. Previous studies have varied in whether forward-looking or current measures of interest rates and federal government debt were used in their analysis. To compare how these different specifications for i and d affect estimates of the relationship between these two variables, we provide estimates for three different types of specifications. In particular, we estimate:

1. The effect of an expected, or projected, measure of federal government debt on a forward-looking measure of the real interest rate;
2. The effect of an expected, or projected, measure of federal government debt on a current measure of the real interest rate; and
3. The effect of a current measure of federal government debt on a current measure of the real interest rate.

A number of other economic variables should be included in the vector Z because they presumably also influence the determination of the real interest, i, and excluding them could bias the estimate of the coefficient β_1. As we noted in the earlier section discussing the potential theoretical effect of federal government debt on interest rates, it is important to account for general macroeconomic factors that can affect the performance of the economy. Accordingly, in the vector Z, we include the growth rate in real GDP, which is a variable usually included in these types of regressions.[19] The analysis by Barro and Sala-i-Martin (1990) and Barro (1991) finds that real oil prices are also an important exogenous macroeconomic variable that can affect real interest rates, so we include a measure of real oil prices in the vector Z.[20]

Laubach (2003) observes that in a Ramsey model of economic growth, where the preferences of a representative household are incorporated with a production function similar to the one we presented in Section 2 above, the real interest rate, r, is determined by:

$$r = \sigma g + \theta$$

where σ is the coefficient of relative risk aversion for the representative household in the model, g is the growth rate of technology, and θ is the rate of time preference for the representative household. He estimates that a measure of the equity premium—used as a proxy for risk aversion—is an important factor affecting real interest rates, so we include it in the vector Z.[21] If relative risk aversion declines, then households may be more willing to purchase equities than debt instruments, thereby leading to a rise in the interest rate.

Fiscal policies other than federal government debt may also affect real interest rates. Ramey and Shapiro (1998) and Evans and Marshall (2002) find that exogenous defense spending shocks—measured by Ramey and Shapiro as a dummy variable denoting the time period in which a significant military buildup begins—tend to increase interest rates.[22] This effect is consistent with the theoretical implication of an exogenous increase in government consumption in a neoclassical model even if the Ricardian equivalence hypothesis is operative.[23] Therefore, we include a variable to capture exogenous defense spending shocks in the vector Z.[24]

While conducting monetary policy, the Federal Reserve regularly purchases U.S. Treasury securities as the economy grows, which may reduce the impact of federal government debt on the real interest rate. Thus, we include a variable measuring the purchase of U.S. Treasury securities by the Federal Reserve, relative to GDP, in our specification of the regression equation.[25]

To summarize, in vector Z of the regression equation, we include the following variables:

1. The rate of growth in real GDP.
2. The real domestic crude oil price.
3. A measure of the equity premium (as a proxy for risk aversion).
4. A dummy variable for military buildups.
5. Federal Reserve purchases of U.S. Treasury securities.

We now turn to our empirical results.[26]

3.3.1 Forward-Looking Interest Rates and Federal Government Debt

The only previous study of which we are aware that analyzes the effect of forward-looking projections of federal government debt on a forward-looking measure of the real interest rate is Laubach (2003). The purpose for using these forward-looking measures is to attempt to omit any effects of current economic conditions and policies from the empirical estimate of the effect of federal government debt on interest rates.

Laubach constructs data from 1976 through 2003 on nominal ten-year Treasury rates expected to prevail five years ahead and then subtracts a series of inflation expectations taken from the Federal Reserve's econometric model of the United States. These data on real five-year-ahead ten-year Treasury yields are calculated to coincide with the CBO's five-year-ahead projections of federal government debt and deficits, relative to GDP, released in its annual *Economic and Budget Outlook*.[27] In this section, we use these measures of the forward-looking real interest rate and forward-looking federal government debt in our analysis. We also use the CBO's five-year ahead projection of real GDP growth rate. The other variables correspond to the time period just preceding the release of the CBO's annual report.

In the first column of Table 2, we report coefficient estimates for regressions of the real five-year-ahead ten-year Treasury yield on the five-year projection of federal government debt along with the other variables. The results imply that a one-percentage-point (relative to GDP) increase in the CBO's five-year-ahead projection of federal government debt increases the real five-year-ahead ten-year Treasury yield by a little less than three basis points, and the estimate is statistically significantly different from zero.[28] This estimate is also consistent with the theoretical calculations presented in Table 1. The estimated coefficients on all of the other variables have the expected sign and are statistically significant from zero, except for the insignificant coefficient estimate on the projected real GDP growth rate.[29]

Coefficient estimates obtained by regressing the *change* in the real five-year-ahead ten-year Treasury yield on the CBO's five-year-ahead projection of the federal government deficit (relative to GDP) and the other variables are reported in the second column of Table 2. The results imply that a one-percentage-point (relative to GDP) increase in CBO's five-year-ahead projection of the federal government deficit increases the change in the real five-year-ahead ten-year Treasury yield

Table 2
Regression results for real five-year-ahead ten-year Treasury rate and CBO five-year-ahead federal debt or deficit projections (1976–2003)

	Dependent variable		
	(1) Level of Treasury rate	(2) Change in Treasury rate	(3) Level of Treasury rate
Federal debt/GDP	0.028 (0.011)*	—	—
Federal deficit/GDP	—	0.030 (0.053)	0.185 (0.066)*
Real GDP growth rate	−0.014 (0.284)	—	0.029 (0.279)
Change in real GDP growth rate	—	−0.851 (0.246)	—
Real oil price	0.059 (0.014)*	—	0.049 (0.021)*
Change in real oil price	—	0.028 (0.018)	—
Equity premium	−0.269 (0.134)*	—	−0.279 (0.105)*
Change in equity premium	—	−0.332 (0.164)*	—
Defense shock	1.398 (0.568)*	1.822 (0.210)*	1.087 (0.492)*
Federal Reserve Treasury holdings	−0.410 (0.197)*		
Federal Reserve Treasury purchases	—	−0.810 (0.570)	−0.521 (0.629)
Constant	4.136 (1.448)*	0.108 (0.231)	3.299 (0.501)*
Adjusted R-squared	0.69	0.32	0.69
DW statistic	2.52	2.90	2.39
N	28	28	28

Note: Newey-West standard errors in parentheses.
*Coefficient estimate significant at 10% level.

by about three basis points, but the estimate is not statistically significantly different from zero.

In the third column, the regression results suggest that a one-percentage-point (relative to GDP) increase in the CBO's five-year-ahead projection of the federal government deficit increases the real five-year-ahead ten-year Treasury yield by about 18 basis points, and the estimate is statistically significantly different from zero.[30] As we noted earlier, however, this specification is not consistent with one implied by an economic model of crowding out, so interpreting this result is difficult. The *stock* of federal debt is most relevant for determining the level of the interest rate, and the deficit, which represents only the most recent period's *change in the debt*, does not contain all relevant information—specifically, prior accumulated federal debt—contained in the measure of total federal debt. However, because the CBO's projections of federal deficits (as a percentage of GDP) are closely correlated with their projections of federal debt (as a percentage of GDP)—the correlation coefficient between these two series is 0.89 over the sample period—then the coefficient estimate on the smaller deficit component also picks up the effect of prior accumulated government debt, and the coefficient estimate is larger than when total government debt is used.

The results in Table 2 indicate that the estimated effect of projected federal government debt or deficits on a forward-looking measure of the real interest rate depends to a large degree on the specification. The estimates for the two specifications consistent with the analytical model of crowding out presented earlier imply that an increase in federal government debt of 1% of GDP raises the real interest rate by, at most, about three basis points.

3.3.2 Current Interest Rates and Expected Federal Government Debt

In this section, we employ a measure of the *current* real ten-year Treasury yield in our analysis while all of the other variables remain the same, as in the previous section. The nominal ten-year Treasury yields over the months that the CBO projections were released were then adjusted for expected inflation to construct the current real interest rates used in this section of our analysis.[31]

The first column of Table 3 reports the coefficient estimates when regressing the level of the real ten-year Treasury yield on the five-year-ahead projection of federal government debt (relative to GDP) made

Table 3
Regression results for current real ten-year Treasury rate and CBO five-year-ahead federal debt or deficit projections (1976–2003)

	Dependent variable		
	(1) Level of Treasury rate	(2) Change in Treasury rate	(3) Level of Treasury rate
Federal debt/GDP	0.033 (0.013)*	—	—
Federal deficit/GDP	—	0.034 (0.068)	0.236 (0.064)*
Real GDP growth rate	−0.373 (0.291)	—	−0.266 (0.347)
Change in real GDP growth rate	—	−0.607 (0.417)	—
Real oil price	0.091 (0.014)*	—	0.081 (0.024)*
Change in real oil price	—	0.064 (0.051)	—
Equity premium	−0.376 (0.134)*	—	−0.389 (0.145)*
Change in equity premium	—	−0.472 (0.189)*	—
Defense shock	0.440 (0.380)	0.665 (1.046)	0.047 (0.469)
Federal Reserve Treasury holdings	−0.668 (0.260)*		
Federal Reserve Treasury purchases	—	−0.485 (0.726)	−1.064 (0.587)*
Constant	5.058 (1.94)*	0.105 (0.260)	3.119 (0.634)*
Adjusted R-squared	0.86	0.42	0.86
DW statistic	1.68	2.90	1.68
N	28	28	28

Note: Newey-West standard errors in parentheses.
*Coefficient estimate significant at 10% level.

by the CBO, along with the other explanatory variables. The estimates imply that a one-percentage-point increase in the expected federal government debt-to-GDP ratio increases the current real ten-year Treasury yield by a little more than three basis points and is statistically significantly different from zero. This estimate is about one-half of one basis point larger than when the forward-looking real ten-year Treasury yield was used in the specification reported in the first column of Table 2.

The coefficient estimates for the specification regressing the change in the current real ten-year Treasury yield on the CBO's five-year-ahead projection of the federal government deficit (relative to GDP), along with the other variables, are reported in the second column of Table 3. Similar to the estimate in the first column, the estimated coefficient on the projected deficit variable implies that a one-percentage-point increase in the CBO's projection of the federal government deficit (relative to GDP) increases the current real ten-year Treasury yield by about three basis points, but here this estimate is not statistically significantly different from zero. In contrast, when instead the *level* of the current real ten-year Treasury yield is regressed on the CBO's projection of the federal government deficit, the estimated relationship suggests that increasing the expected federal deficit-to-GDP ratio by one percentage point causes the current real ten-year Treasury yield to increase by almost 24 basis points. While this estimate is statistically significant from zero, it is far larger than the benchmark calculations presented in Table 1, and it is also about five basis points larger than the corresponding estimate in Table 2, in which the forward-looking measure of the real ten-year yield was used. As discussed previously, however, this specification is not consistent with an economic model of crowding out. The coefficient estimate on the deficit is larger because it also incorporates the effect of prior accumulated federal government debt that is included in the total federal debt variable in the first column but is not included when using just the deficit measure in the third column.

The results in Table 3 indicate that the estimated effect of projected federal government debt or deficits on a current measure of the real interest rate is only a bit larger than those in which the forward-looking measure of the real interest rate was employed in estimating the results in Table 2. However, the forward-looking measure of the real interest rate may be a better measure for trying to separate the effect of current economic conditions on the interest rate and isolate the effect of expected federal government debt on real interest rates.

As before, the estimated results also depend to a great degree on the specification of the regression equation. The coefficient estimates derived using the two specifications of real interest rates consistent with an economic model of crowding out—the first two columns—imply that federal government debt may have a statistically significant effect on the level of real interest rates (or not, as shown in second column), but if so, the effect—about 3 basis points for an increase in the debt of 1% of GDP—is consistent with benchmark calculations presented earlier.

3.3.3 Current Interest Rates and Current Federal Government Debt
While using expected measures of interest rates and federal debt is a much more theoretically appealing approach to estimating the relationship between these variables, many previous studies have used only current measures of federal debt and interest rates. Thus, it is informative to estimate the effects of *current* federal debt on *current* real ten-year Treasury yields to compare the results to those of the prior sections.

To do so, we replace the data for the CBO's annual projections of federal government debt and deficits with data on current federal government debt and borrowing.[32] We also replace the CBO's projections for the rate of growth in real GDP with current real GDP growth rates. The current real ten-year Treasury yield measure reflects the prevailing rate at the end of each year and is constructed the same as in the prior section.[33] All of the other variables are the same as in the previous analysis.

As we show in the first column of Table 4, when using current federal government debt (relative to GDP) and a measure of the current real ten-year Treasury yield, the regression results imply that a one-percentage-point increase in the federal debt–GDP ratio is estimated to increase the real ten-year Treasury rate by a little less than five basis points, but the coefficient estimate is not statistically significantly different from zero.[34] The second column reports estimates for the regression equation where the change in the real ten-year Treasury yield is regressed on federal borrowing. The results imply that a one-percentage-point increase in federal government borrowing (relative to GDP) increases real ten-year Treasury rates by seven basis points, but again this estimate is not statistically significantly different from zero.

Alternatively, if the level of the real ten-year Treasury yield is regressed on this measure of federal government borrowing, the

Table 4
Regression results for current real ten-year Treasury rate and current federal debt or borrowing (1953–2003)

	Dependent variable		
	(1) Level of Treasury rate	(2) Change in Treasury rate	(3) Level of Treasury rate
Federal debt/GDP	0.047 (0.036)	—	—
Federal deficit/GDP	—	0.071 (0.066)	0.091 (0.107)
Real GDP growth rate	0.102 (0.049)*	—	0.112 (0.040)*
Change in real GDP growth rate	—	0.100 (0.035)*	—
Real oil price	0.101 (0.043)*	—	0.099 (0.039)*
Change in real oil price	—	0.115 (0.042)*	—
Equity premium	−0.224 (0.297)	—	−0.135 (0.286)
Change in equity premium	—	−0.091 (0.302)	—
Defense shock	−0.425 (0.349)	−0.195 (0.412)	−0.515 (0.321)
Federal Reserve Treasury holdings	−0.401 (0.525)		
Federal Reserve Treasury purchases	—	0.259 (0.544)	0.500 (0.496)
Constant	1.976 (4.407)	−0.263 (0.192)	1.017 (1.084)
AR(1)	0.521 (0.128)*		
Adjusted R-squared	0.60	0.21	0.59
DW statistic	2.02	2.56	2.13
N	50	50	50

Note: Newey-West standard errors in parentheses.
*Coefficient estimate significant at 10% level.

coefficient estimates shown in the third column imply that a one-percentage-point increase in the federal government borrowing–GDP ratio increases the real ten-year Treasury rate by about nine basis points, although this effect is not statistically significantly different from zero, as it is in the first two specifications. This estimate of the empirical relationship between federal government borrowing and the level of the real ten-year Treasury yield in Table 4 is markedly smaller than the corresponding estimates in Tables 2 and 3, which used forward-looking measures of federal government borrowing and the real interest rate. Unlike the strong positive correlation between the CBO's projected measures of federal debt and the deficit, there is not a positive correlation between actual federal debt and borrowing (both measured as a percentage of GDP); the correlation coefficient is −0.13 for these two series.

3.3.4 Vector Autoregressions

An alternative approach to the reduced-form equation estimation used in our analysis above is to estimate the relationship between federal government debt, or federal government borrowing, and the level of the real ten-year Treasury rate in a VAR framework. This methodology has been used in a number of empirical studies on the relationship between federal government debt and borrowing.

In estimating the VARs, we use the same data as those in the first and third columns of Tables 2 through 4; thus, we analyze the effect of a measure of the federal debt on the level of the interest rate and the effect of a measure of the federal deficit on the level of the interest rate. A useful way to analyze the results of the VAR estimates is to look at the impulse responses generated from these estimates. The corresponding impulse responses stemming from VAR estimates using projected federal government debt and the five-year ahead measure of the ten-year real Treasury rate are shown in Figure 15, and Figure 16 shows the impulse responses when the projected federal government deficits (instead of debt) is used in the VAR. The ordering of the variables used to generate these impulse responses is the same as the order of the charts in each figure: real oil prices, military buildup shocks, Treasury security holdings (or purchases) by the Federal Reserve, projected federal government debt (or deficits), the equity premium, and the projected real GDP growth rate. The charts of the impulse responses also include the plus or minus two standard-error (SE) bands, using Monte Carlo standard errors.

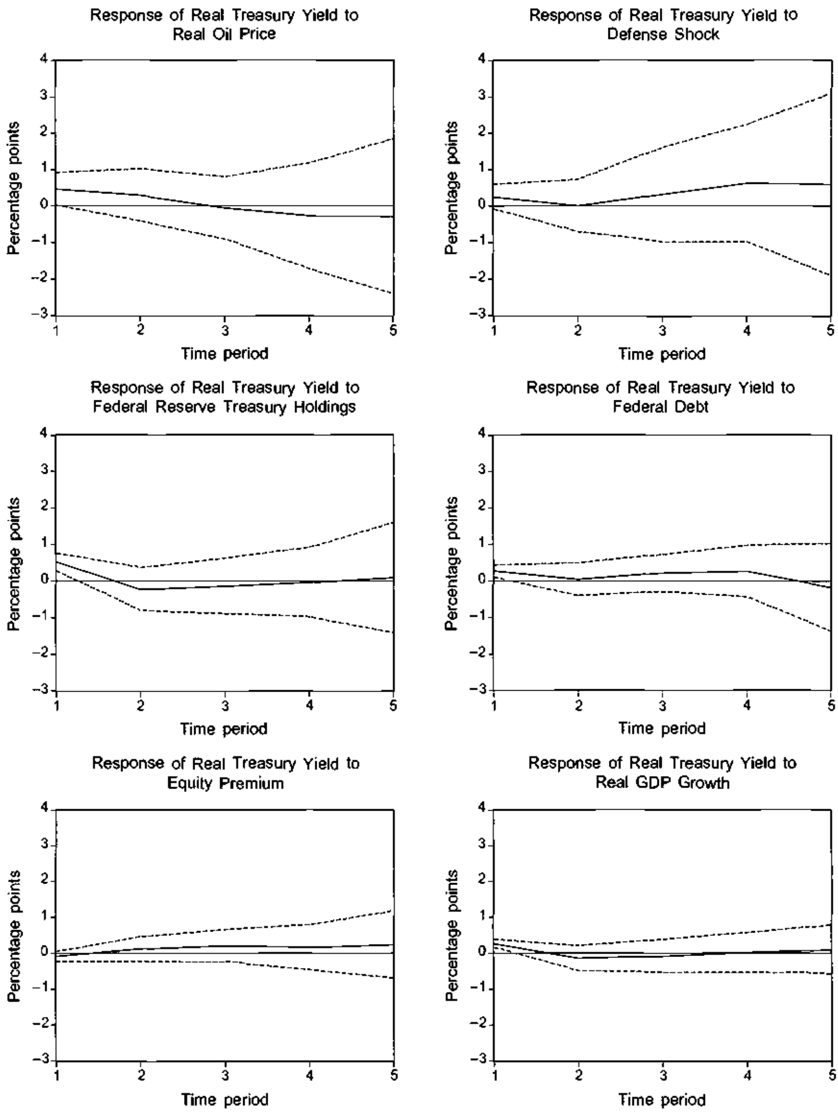

Figure 15
Effects of macroeconomic and projected debt variables on forward-looking real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations ± 2 SE)

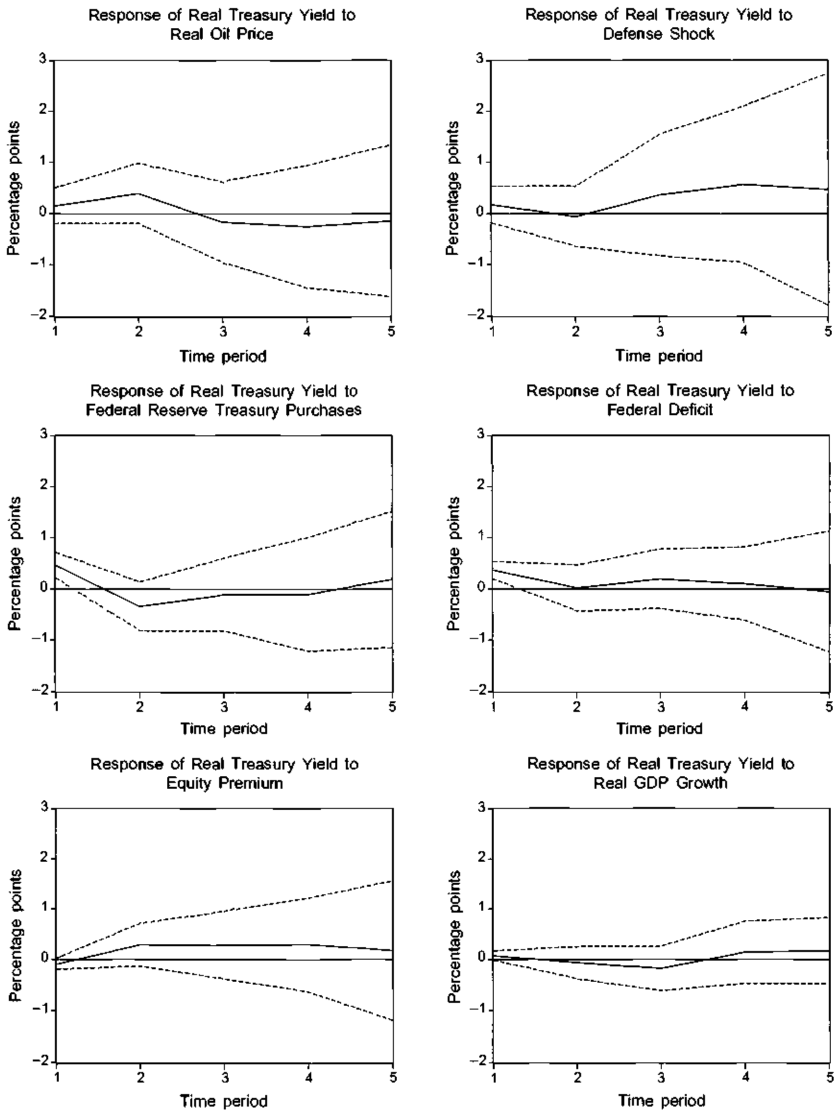

Figure 16
Effects of macroeconomic and projected deficit variables on forward-looking real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations ± 2 SE)

In Figure 15, the second chart from the top on the right side shows the response of the five-year-ahead real ten-year Treasury rate from a one standard deviation shock to projected federal government debt. The response of the forward-looking measure of the real interest rate to an increase in projected federal debt (relative to GDP) is positive and statistically significant in the first period. A one-standard-deviation shock in the projected federal debt–GDP ratio, which is equal to 16.3%, is estimated to increase the forward-looking real interest rate by 26.6 basis points. Thus, this estimate implies that an increase in federal debt equal to 1% of GDP causes the real interest rate to increase by about $1\frac{1}{2}$ basis point, which is somewhat smaller than the corresponding estimate from the reduced form regression results in Table 2 but is still consistent with the theoretical calculations presented in Table 1. As shown in the corresponding variance decomposition presented in Table 5, only 10% of the variation in the forward-looking measure of the real interest rate is due to the innovation in projected federal debt.

Figure 16 shows the impulse responses from the VAR estimates when the projected federal government deficit (relative to GDP) is used instead of federal government debt. An increase in the projected federal government deficit is estimated here to have a positive effect on the five-year-ahead measure of the real ten-year Treasury yield and is statistically significantly different from zero in the first period. A one standard deviation shock in the projected federal deficit–GDP ratio, which is equal to 3%, is estimated to increase the forward-looking real interest rate by 36.6 basis points. Thus, this estimate implies that an increase in the federal deficit equal to 1% of GDP causes the real interest rate to increase by about 12 basis points, which is somewhat smaller than the corresponding estimate from the reduced-form regression results in Table 2. As shown in the corresponding variance decomposition presented in Table 6, about 28 percent of the variation in the forward-looking measure of the real interest rate is due to the innovation in projected federal deficit. However, this specification is not consistent with our analytical model of crowding out, and the estimated effect is much larger than the benchmark calculations presented in Table 1. The estimated effect of the projected deficit is also larger than the effect of the projected federal debt, as in the reduced-form regression estimates in Table 2, but as explained above, this is because the projected deficit variable is strongly correlated with the projected debt variable, and the deficit variable does not include the relevant information on prior accumulated federal debt.

Table 5
Variance decomposition of five-year-ahead, ten-year Treasury rate (Corresponds to impulse responses in Figure 15)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury holdings	Projected federal debt	Equity premium	Projected real GDP growth	Forward-looking real Treasury yield
1	4.50	30.26	8.27	36.82	10.05	1.39	9.65	3.56
		(16.28)	(10.13)	(12.60)	(6.09)	(1.67)	(4.16)	(1.24)
2	6.29	33.78	6.62	35.73	8.23	2.32	10.29	3.02
		(16.22)	(9.52)	(12.95)	(5.70)	(5.20)	(5.25)	(1.41)
3	6.88	27.45	14.04	30.73	10.81	5.12	8.99	2.87
		(14.29)	(17.39)	(12.22)	(6.91)	(5.15)	(4.53)	(2.06)
4	7.60	23.22	32.01	20.53	11.14	4.91	5.97	2.21
		(15.33)	(16.17)	(12.13)	(5.91)	(4.48)	(4.29)	(1.71)
5	8.41	21.58	40.13	15.83	9.86	6.12	4.80	1.68
		(13.77)	(17.43)	(12.84)	(6.40)	(4.61)	(4.42)	(1.47)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury holdings, projected federal debt, equity premium, projected real GDP growth, forward-looking real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

Table 6
Variance decomposition of five-year-ahead, ten-year Treasury rate (Corresponds to impulse responses in Figure 16)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury purchases	Projected federal deficit	Equity premium	Projected real GDP growth	Forward-looking real Treasury yield
1	3.88	4.79	6.11	45.68	28.35	1.92	1.04	12.10
		(8.77)	(8.29)	(14.05)	(10.09)	(2.20)	(1.85)	(4.74)
2	7.04	21.32	3.92	39.76	16.01	10.98	1.18	6.82
		(13.70)	(8.13)	(10.23)	(6.91)	(9.70)	(3.24)	(3.12)
3	7.77	17.95	13.98	29.91	14.71	14.67	3.63	5.14
		(12.79)	(14.57)	(9.84)	(7.73)	(8.30)	(3.56)	(3.15)
4	8.27	16.22	29.02	21.39	10.77	15.30	3.67	3.63
		(12.30)	(17.78)	(9.35)	(6.76)	(8.53)	(2.79)	(2.70)
5	8.91	14.51	35.21	19.29	9.07	14.21	4.51	3.20
		(12.40)	(17.08)	(8.11)	(8.79)	(7.94)	(3.86)	(2.83)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury purchases, projected federal deficit, equity premium, projected real GDP growth, forward-looking real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

Figures 17 and 18 show the impulse responses of the current real ten-year Treasury rate to innovations in the projected measures of federal debt and deficits along with our other explanatory variables. The second chart from the top on the right side of Figure 17 shows the impulse response of the current real ten-year Treasury rate from a one standard deviation shock to projected federal government debt. The projected federal debt is estimated to have a positive and statistically significant effect on the current real interest rate. A one standard deviation shock in the projected federal debt–GDP ratio (equal to 16.3%) is estimated to increase the current real interest rate by 40 basis points. Thus, this estimate implies that an increase in federal debt equal to 1% of GDP causes the current real interest rate to increase by about $2\frac{1}{2}$ basis points. This estimate is somewhat smaller than the corresponding estimate from the reduced form regression results in Table 3, but it is still consistent with the theoretical calculations presented in Table 1. As shown in the corresponding variance decomposition presented in Table 7, about 37% of the variation in the current real interest rate is due to the innovation in projected federal debt.

As shown in Figure 18 and Table 8, the effect of the projected federal deficit on the current real interest rate is positive but not statistically significantly different from zero, in contrast to both the results in Figure 16, when the forward-looking measure of the real interest rate was used, and the corresponding estimate from the reduced-form regression results in Table 3. Figure 19 and Table 9, and Figure 20 and Table 10, also show that innovations in the current federal debt, or current federal borrowing, have effects on the current real interest rate that are not statistically significantly different from zero. These results are similar to the corresponding estimates shown in Table 4 for our reduced-form regression analysis.

In general, our analysis of the effect of federal government debt on the real interest rate using VAR analysis is fairly similar to the results we find from our reduced-form regression estimates. Projected measures of the federal debt tend to have a statistically significant, positive effect on forward-looking or current real interest rates; an increase in the projected federal debt equal to 1% of GDP is estimated to increase the real interest rate by about two to three basis points. However, current measures of the federal debt do not have a statistically significant effect on current real interest rates.

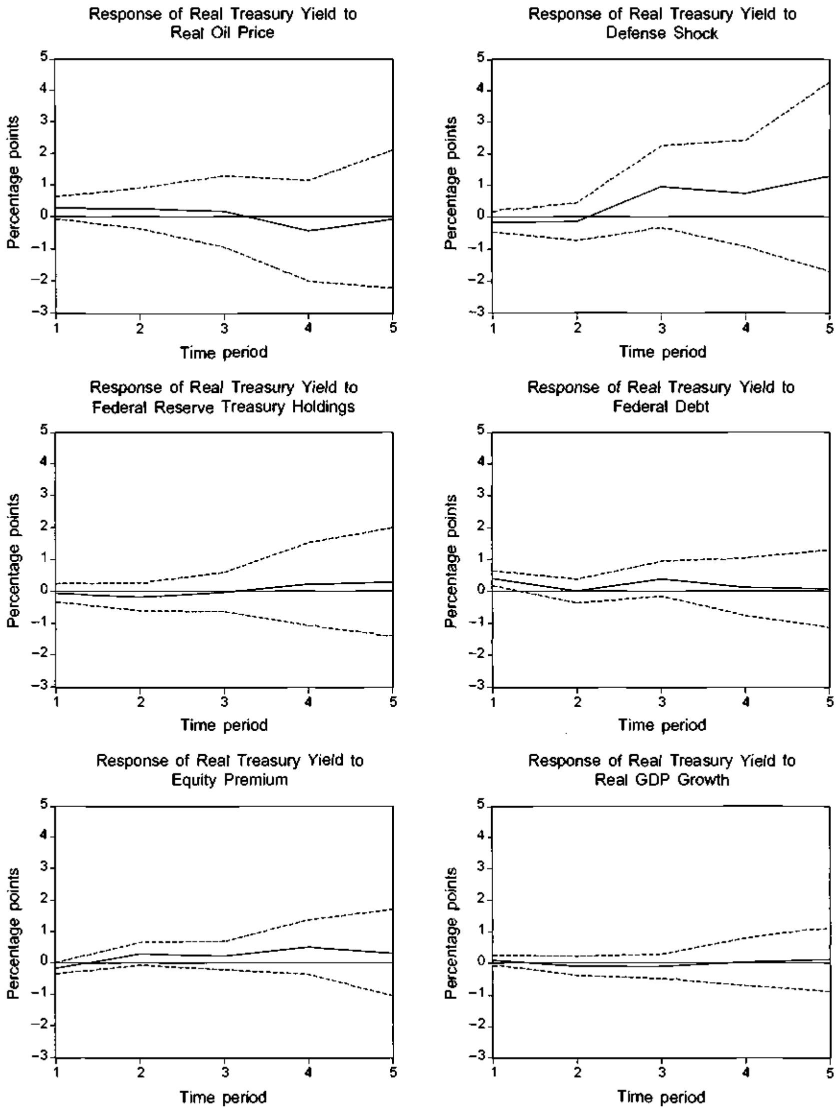

Figure 17

Effects of macroeconomic and projected debt variables on current real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations ± 2 SE)

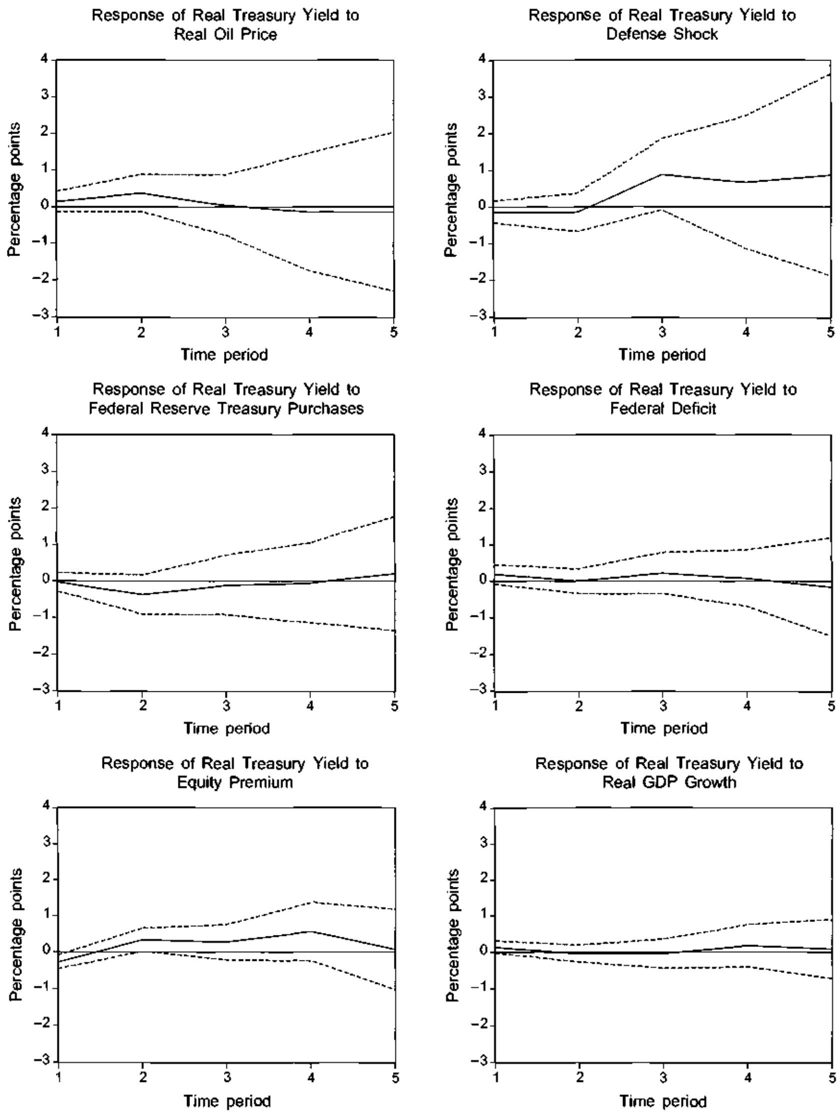

Figure 18
Effects of macroeconomic and projected deficit variables on current real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations $\pm$ 2 SE)

Table 7
Variance decomposition of current ten-year Treasury rate (Corresponds to impulse responses in Figure 17)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury holdings	Projected federal debt	Equity premium	Projected real GDP growth	Current real Treasury yield
1	5.12	16.84	5.67	0.65	37.42	7.09	1.91	30.41
		(13.88)	(7.98)	(5.39)	(13.96)	(7.63)	(3.29)	(10.28)
2	6.44	21.01	7.02	4.91	24.25	17.08	2.93	22.78
		(15.97)	(9.09)	(8.29)	(9.60)	(9.87)	(3.81)	(7.90)
3	6.94	9.10	52.38	1.81	16.84	9.07	1.78	9.02
		(16.54)	(19.78)	(6.64)	(8.12)	(5.77)	(3.55)	(4.74)
4	8.22	12.44	51.65	2.73	11.20	14.34	1.15	6.50
		(15.49)	(17.04)	(6.06)	(7.59)	(8.71)	(3.61)	(3.77)
5	9.48	7.54	64.47	3.40	6.80	10.53	0.92	6.34
		(13.49)	(16.53)	(5.53)	(6.74)	(7.03)	(3.86)	(4.78)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury holdings, projected federal debt, equity premium, projected real GDP growth, current real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

Table 8
Variance decomposition of current ten-year Treasury rate (Corresponds to impulse responses in Figure 18)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury purchases	Projected federal deficit	Equity premium	Projected real GDP growth	Current real Treasury yield
1	4.30	5.80	7.29	0.34	10.26	24.80	5.29	46.21
		(10.18)	(8.22)	(4.69)	(8.45)	(11.53)	(5.69)	(10.96)
2	7.11	20.56	6.40	20.19	4.31	24.55	2.54	21.45
		(17.06)	(7.52)	(12.98)	(6.25)	(10.04)	(3.40)	(6.19)
3	8.00	9.35	49.35	9.98	4.51	15.37	1.34	10.10
		(14.16)	(19.53)	(9.32)	(5.68)	(7.67)	(3.24)	(3.87)
4	8.33	7.27	50.87	6.90	3.26	22.84	2.03	6.83
		(11.94)	(17.68)	(10.14)	(5.51)	(9.76)	(3.57)	(3.77)
5	8.92	5.99	59.25	6.19	3.26	16.84	1.68	6.79
		(12.05)	(15.99)	(9.99)	(7.92)	(7.07)	(3.02)	(3.39)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury purchases, projected federal deficit, equity premium, projected real GDP growth, current real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

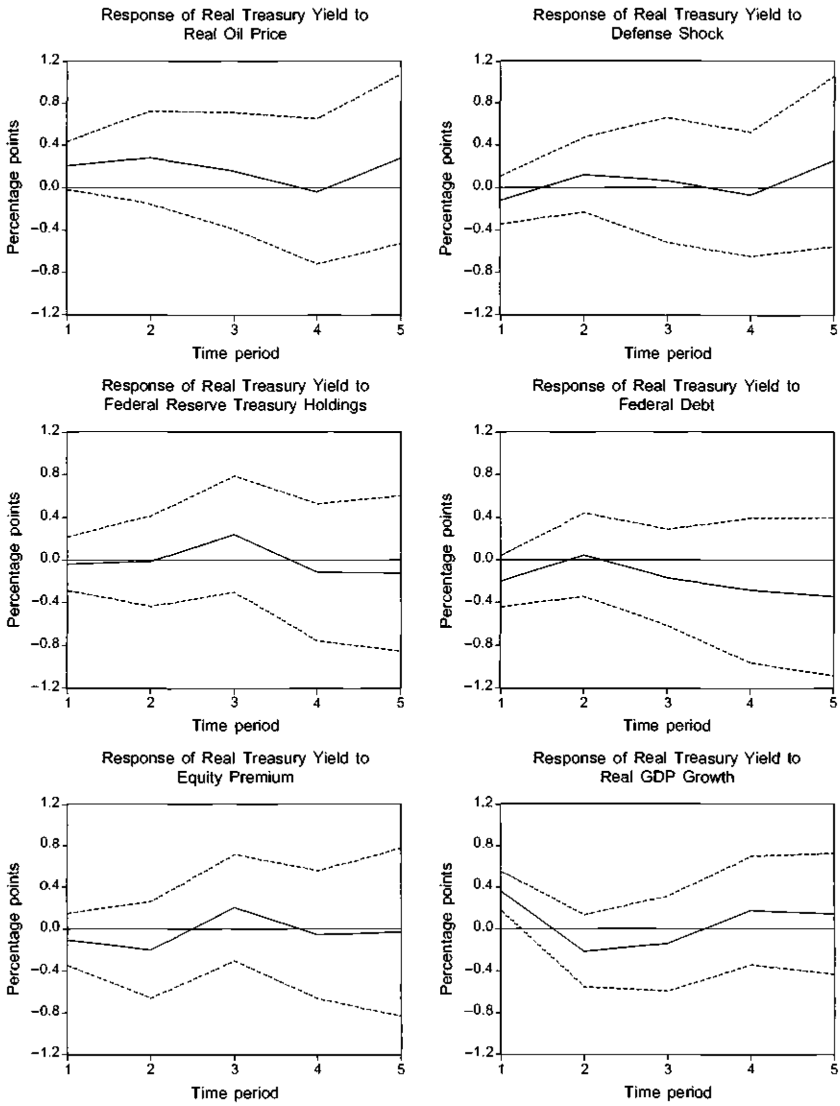

Figure 19
Effects of macroeconomic and current debt variables on current real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations ± 2 SE)

Table 9
Variance decomposition of current ten-year Treasury rate (Corresponds to impulse responses in Figure 19)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury holdings	Federal debt	Equity premium	Real GDP growth	Current real Treasury yield
1	4.23	7.15	2.41	0.25	6.86	1.78	22.09	59.46
		(6.31)	(5.06)	(2.86)	(6.77)	(3.38)	(8.97)	(11.45)
2	5.42	15.57	3.65	0.22	5.45	6.49	22.48	46.14
		(9.37)	(6.83)	(5.41)	(5.97)	(7.38)	(9.03)	(10.54)
3	6.54	15.25	3.44	6.12	7.39	9.71	20.44	37.66
		(10.19)	(5.76)	(8.93)	(6.68)	(8.27)	(7.87)	(9.73)
4	7.39	13.10	3.33	6.42	13.60	8.53	20.14	34.87
		(10.33)	(6.76)	(8.63)	(8.01)	(8.11)	(7.14)	(7.93)
5	8.10	15.49	6.91	6.18	19.09	6.78	17.23	28.33
		(9.79)	(8.92)	(7.84)	(8.46)	(8.13)	(7.00)	(6.50)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury holdings, federal debt, equity premium, real GDP growth, current real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

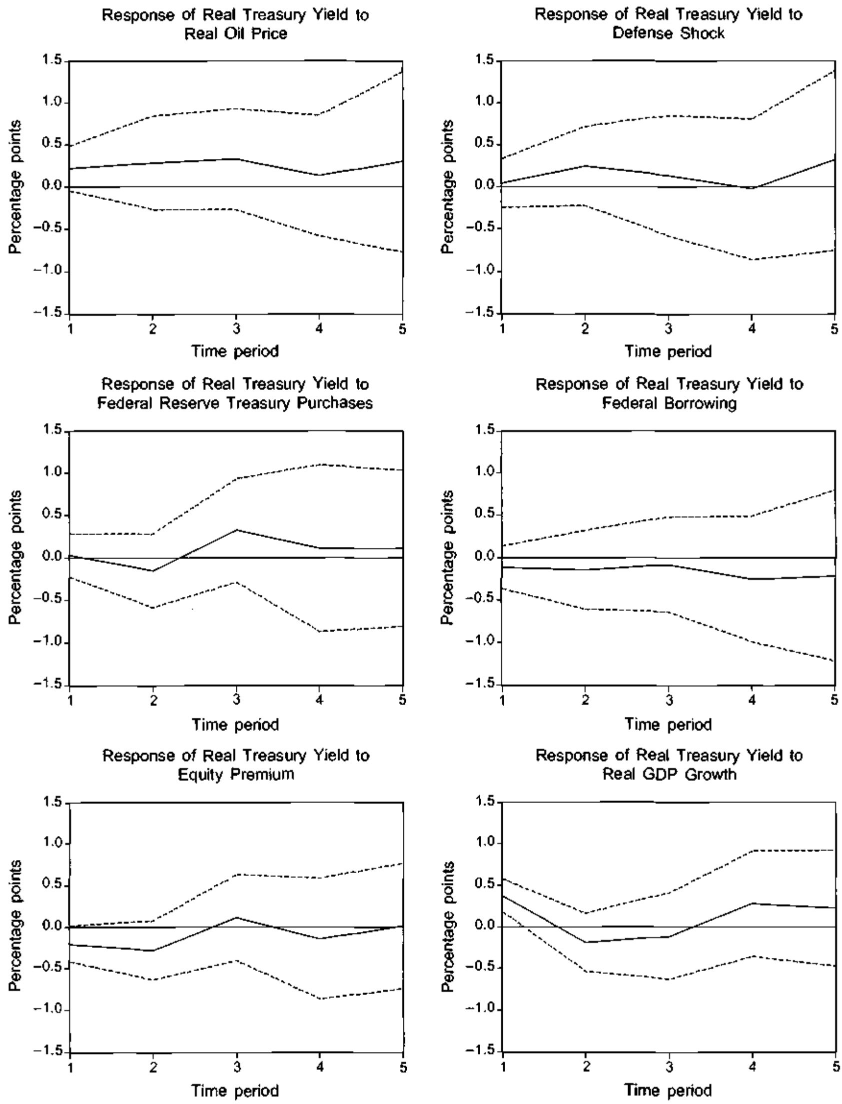

Figure 20
Effects of macroeconomic and current deficit variables on current real Treasury rate, VAR analysis (Response to Cholesky One S.D. Innovations ± 2 SE)

Table 10
Variance decomposition of current ten-year Treasury rate (Corresponds to impulse responses in Figure 20)

Period	S.E.	Oil price	Defense shock	Federal Reserve Treasury purchases	Federal borrowing	Equity premium	Real GDP growth	Current real Treasury yield
1	4.72	7.17	0.25	0.12	2.07	6.70	22.07	61.62
		(7.85)	(3.39)	(3.71)	(3.68)	(7.05)	(8.69)	(9.88)
2	6.19	12.99	6.32	2.60	3.63	13.04	18.56	42.86
		(11.01)	(7.94)	(6.52)	(6.43)	(9.31)	(6.87)	(9.35)
3	6.99	18.71	6.27	10.46	3.43	11.25	15.69	34.20
		(12.79)	(9.39)	(8.00)	(6.46)	(7.06)	(6.07)	(7.79)
4	7.47	16.51	5.22	9.41	7.17	10.73	18.05	32.91
		(11.29)	(8.63)	(9.13)	(7.70)	(6.40)	(6.16)	(7.16)
5	7.82	18.65	9.94	8.52	8.52	8.91	17.70	27.76
		(11.13)	(11.15)	(8.25)	(7.50)	(6.39)	(6.91)	(6.37)

Cholesky ordering: oil price, defense shock, Federal Reserve Treasury purchases, federal borrowing, equity premium, real GDP growth, current real Treasury yield.
Standard errors: Monte Carlo (100 repetitions).

4. Conclusion

As we noted at the outset, the recent reemergence of U.S. federal government budget deficits has focused attention on an old question: Does government debt affect interest rates? Despite a substantial body of empirical analysis, the answer based on the past two decades of research is mixed. While some studies suggest a small increase in the real interest rate when federal debt increases, others estimate large effects, and some studies find no statistically significant interest rate effect. Comparing results across studies is complicated by differences in economic models, definitions of government debt and interest rates, econometric approaches, sources of data, and rhetoric.

Using a standard set of data and a simple economic framework, we reconsider and add to empirical evidence on the effect of federal government debt and interest rates. We begin by deriving analytically the effect of government debt on the real interest rate and conclude that an increase in government debt equivalent to 1% of GDP would likely increase the real interest rate by about two to three basis points. While some existing studies estimate effects in this range, others find larger effects. In almost all cases, larger estimates come from specifications relating federal deficits (as opposed to debt) and the level interest rates (as opposed to changes in interest rates).

We present our own empirical analysis in two parts. First, we examine a variety of conventional reduced-form specifications linking interest rates and government debt and other variables. In particular, we provide estimates for three types of specifications to permit comparisons among different approaches taken in previous research; we estimate the effect of (1) an expected, or projected, measure of federal government debt on a forward-looking measure of the real interest rate; (2) an expected, or projected, measure of federal government debt on a current measure of the real interest rate; and (3) a current measure of federal government debt on a current measure of the real interest rate. Most of the statistically significant estimated effects are consistent with the prediction of our economic model calculations. Second, we provide evidence using vector autoregression analysis. In general, these results are similar to those found in our reduced-form econometric analysis and are consistent with the analytical calculations.

Taken together, the bulk of our empirical results suggest that an increase in federal government debt equivalent to 1% of GDP, all else being equal, is likely to increase the long-term real rate of interest by about three basis points, while some estimates are not statistically significantly different from zero. By presenting a range of results with the same data, we illustrate the dependence of estimation on specification and definition differences.

This paper is deliberately narrow in its scope; our focus, as the paper's title suggests, is only on the interest rate effects of government debt. The effect of debt and deficits on interest rates has been the focus of much of the recent and previous policy discussions concerning the effects of government borrowing on investment and economic activity. However, we do believe that other effects of federal debt and deficits on economic factors other than interest rates are important topics for analysis. We have not investigated the degree to which federal borrowing might be offset by private domestic saving or inflows of foreign saving or both. These factors interact with federal borrowing in ways that may have similar effects on interest rates but different effects on the overall economy.[35]

Our findings should not be construed as implying that deficits don't matter. Substantially larger, persistent, and unsustainable levels of government debt can eventually put increasing strains on the available domestic and foreign sources of loanable funds, and they can represent a large transfer of wealth to finance current generations' consumption from future generations, which much eventually pay down federal debt to a sustainable level. Holding the path of noninterest government outlays constant, deficits represent higher future tax burdens to cover both these outlays plus interest expenses associated with the debt, which have adverse consequences for economic growth. In the United States at the present time, unfunded implicit obligations associated with the Social Security and Medicare programs are particularly of concern.[36]

Notes

An earlier draft of this paper was prepared for presentation at the NBER Macroeconomics Annual Conference in Cambridge, MA, April 2–3, 2004. We thank Bill Gale, Mark Gertler, Kevin Hassett, Thomas Laubach, Jonathan Parker, Ken Rogoff, Matthew Shapiro, and NBER conference participants for helpful comments, and Anne Moore for providing excellent research assistance with this paper.

1. See Ball and Mankiw (1995), Elmendorf and Mankiw (1999), and Council of Economic Advisers (2003).

2. See McCallum (1984) for more discussion of this issue.

3. See Bernheim (1987), Barro (1989), and Seater (1993) for discussions of the Ricardian equivalence hypothesis.

4. We calculate the private capital stock using data in the Federal Reserve's flow of funds accounts on the fixed assets of the household, business, farm (excluding farmland, which is not included in the accounts), and nonprofit sectors of the economy. This measure does not include stocks of consumer durables or business inventories. This measure understates the size of the total capital stock in the United States that could potentially be affected by federal government debt since it does not include the capital of state and local governments, and thus somewhat overstates the potential percentage change in interest rates from federal government debt crowding out capital formation in other sectors of the economy.

5. *Expectations* of future government borrowing are not part of the simple framework presented here. But it is probably a reasonable benchmark to assume that the expected crowding-out effect on current interest rates from expected future federal borrowing is similar in magnitude to the calculations presented here; i.e., if borrowing is expected to be higher by 1 percent of GDP in each of the next ten years, then the current real interest rate may be expected to be about 24 basis points higher. However, Cohen and Follette (2003) have shown that budget deficit forecasts beyond one year are typically very poor, primarily owing to the difficulty in forecasting federal tax receipts. See also Congressional Budget Office (2004) for a discussion about the difficulty of forecasting federal budget deficits.

6. This is a measure of the degree of offset to federal government borrowing that is consistent with a discussion in Council of Economic Advisers (1994), for example.

7. Data on federal government debt held by the public are from the Federal Reserve's flow of fund accounts, and includes federal debt held by the Federal Reserve. This measure of federal government debt does not, of course, include the implicit unfunded liabilities associated with the Social Security and Medicare programs. Data for GDP are from the national income and product accounts produced by the Bureau of Economic Analysis.

8. Federal borrowing here is the net issuance of new federal debt, as measured by the Federal Reserve's flow of funds accounts, and thus is not exactly equal to the federal unified federal budget deficit, though it is closely correlated with it. However, it is a measure that captures better the potential effects of federal borrowing in credit markets.

9. This measure of the U.S. private capital stock is constructed with data from the Federal Reserve's flow of fund accounts, as we described in footnote 4.

10. We constructed data for U.S. domestic (nonfinancial) debt and borrowing used in Figures 4 through 7 from the Federal Reserve's flow of funds accounts.

11. Data on U.S. Treasury security holdings shown in Figures 9 and 10 are from the Federal Reserve's flow of funds accounts.

12. Data on nominal ten-year Treasury yields are from the Federal Reserve. The real interest rate is computed by subtracting the average expected inflation rate for the consumer price index (CPI) from the Livingston Survey compiled by the Federal Reserve Bank in Philadelphia.

13. The expected inflation rate is the same measure from the Livingston Survey used to construct the real interest rate in the previous charts. The actual rate of inflation is

measured by the growth rate in the price index for personal consumption expenditures in the national income and product accounts.

14. These measures of the real interest rate are constructed using data from the Organization for Economic Cooperation and Development (OECD) for nominal ten-year government bond yields and the actual rate of growth in the price index for personal consumption expenditures in each country's national income accounts. To our knowledge, measures of expected inflation for each country are not readily available.

15. In a subsequent paper by Cebula and Koch (1994), again investigating the effects of current federal government deficits and capital inflows on corporate yields, they do not separate the deficit into its structural and cyclical components and do not report results of the effects of deficits and capital inflows on Treasury yields. Given the results of their 1989 analysis, these are significant omissions, so it is not clear how to interpret their findings of a positive effect of government deficits on corporate yields in their 1994 paper.

16. In related research, Auerbach (2003) and Bohn (1998) note that U.S. fiscal policy appears responsive to fiscal conditions so that spending is reduced and/or taxes are raised when federal debt and deficits increase.

17. In related analysis, Miller and Russek (1991) use Granger-causality tests to assess the relationship between federal government deficits and long-term Treasury rates. They find bidirectional causality between current real per-capita federal government deficits (or current real per-capita federal debt) and long-term interest rates. Again, however, it is difficult to interpret the magnitude of the effect on interest rates from their results.

18. We focus on the effect of federal government debt on a measure of the real, long-term interest rate because that is the measure of the interest rate most likely to be affected by federal government debt if it is crowded out by private capital formation. Accordingly, we use a measure of the ten-year Treasury yield, adjusted for expected inflation, for our analysis.

19. Data for the growth rate of real GDP are available in the national income and product accounts produced by the Bureau of Economic Analysis (BEA).

20. Data for inflation-adjusted domestic crude oil prices in the United States are obtained from the Department of Energy. Barro and Sala-i-Martin (1990) and Barro (1991) find that an increase in the real price of oil tends to increase the real interest rate presumably because the resulting decline in investment demand is dominated by the fall in desired saving.

21. As in Laubach (2003), we calculate the equity premium as dividend income from the national income and product accounts, as a percentage of the market value of corporate equities held by households in the Federal Reserve's flow of fund accounts, plus the trend growth rate in real GDP, minus the real ten-year Treasury yield.

22. See Cohen and Follette (2003) and Eichenbaum and Fisher (2004) for more discussion about exogenous defense spending shocks.

23. See, for example, Bernheim (1987), Barro (1989), and Seater (1993). Baxter and King (1993) show that in a neoclassical model, however, the interest rate may increase only in the short run but be unchanged in the long run.

24. The time periods denoted in this dummy variable as significant military buildups include the beginning of the Vietnam war buildup in 1965 and the Carter–Reagan military buildup beginning in 1980, as in Ramey and Shapiro (1998), and we add the beginning of

the military buildup for the war in Afghanistan and Iraq in 2002, as in Eichenbaum and Fisher (2004).

25. This variable is constructed using data on Federal Reserve purchases of U.S. Treasury securities from the Federal Reserve's flow of funds accounts expressed as a ratio to GDP from the national income and product accounts.

26. We do not include additional variables to capture other demands on loanable funds (such as private-sector debt) and sources of loanable funds (such as domestic and foreign saving) because of significant potential endogenity problems.

27. We thank Thomas Laubach for making these data on forward-looking real interest rates available to us; see Laubach (2003) for more details on the calculation of these data. The data do not go back earlier than 1976 because the CBO has been in existence only since the mid-1970s.

28. If we estimate the more parsimonious regression specification of Laubach (2003)—which includes only the projected federal debt, projected real GDP growth, and the equity premium—then the results imply that a one-percentage-point (relative to GDP) increase in the CBO's five-year-ahead projection of the federal debt increases the real five-year-ahead ten-year Treasury yield by a bit more than five basis points, which replicates his estimate. This estimate is more than two basis points larger than when the larger set of other explanatory variables is used, as in the first column of Table 2, suggesting that part of Laubach's estimated effect of projected debt reflected inadequate control for other current macroeconomic factors that determine the real interest rate. Thus, the operating assumption that using forward-looking measures of federal government debt and interest rates omits any effects of current economic conditions and policies from the empirical estimate appears to be invalid.

29. If the oil price, defense shock, and Federal Reserve Treasury holding variables are not included, as in Laubach, then the coefficient on the projected real GDP growth rate variable is estimated with the expected sign (positive) and is statistically significant from zero.

30. If the set of independent variables includes only the projected federal deficit, projected real GDP growth, and the equity premium, as in Laubach (2003), then the regression results imply that a one-percentage-point (relative to GDP) increase in the CBO's five-year-ahead projection of federal deficit increases the real five-year-ahead ten-year Treasury yield by 28 basis points, which replicates his estimate. This estimate is almost ten basis points larger than when the larger set of other explanatory variables is used in the third column of Table 2.

31. We obtained data for the nominal ten-year Treasury from the Federal Reserve Board, and the data for average inflation expectations from the Livingston Survey maintained by the Federal Reserve Bank of Philadelphia.

32. These data are from the Federal Reserve Board's flow of funds accounts. Because the time period of the data is not limited by the availability of the CBO projections, we extend the data back to 1953.

33. The timing is adjusted slightly so that it reflects the prevailing interest rate at the end of the year (December) rather than the month when the CBO projections are released (which is typically in the following month of January).

34. Preliminary estimates of this equation revealed the presence of serially correlated errors, so the regression results reported here are for estimates with an AR(1) corrected specification of the residuals.

35. Recent federal income tax reductions have also rekindled interest in the impact of deficits on consumption. Shapiro and Slemrod (2003) and Johnson, Parker, and Souleles (2004) investigate the impact of deficit-increasing tax reductions on household consumption.

36. See Congressional Budget Office (2003) and Gokhale and Smetters (2003), for example, for recent discussions of the potentially large unfunded obligations associated with these entitlement programs.

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Comment

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1. Introduction

This article addresses a timely question of significant import for today's policymakers: What is the effect of government debt on interest rates? The article measures how much larger real interest rates have been when the federal government has run large deficits or had a large debt.

The received wisdom on this topic is given by the following quote from the 2003 Economic Report of the President:

> [T]he marginal product of capital rises by 0.67 percent when the capital stock falls by 1.0 percent ... one dollar of debt reduces the capital stock by about 60 cents.... A conservative rule of thumb based on this relationship is that interest rates rise by about 3 basis points for every additional $200 billion in government debt (Council of Economic Advisers, 2003, pp. 57–58).

R. Glen Hubbard was of course the chair of the Council of Economic Advisers when this report was written. And the rule of thumb in this quote is a useful guide for policymakers because it makes the point that government debt can raise interest rates and reduce private investment and economic growth. Thus, the benefits of any policy that increases debt should be weighed against these costs.

As the paper describes, the received wisdom comes in part from the analysis of a Cobb-Douglas production function in which output (Y) is produced from capital (K) and labor (N) with capital share of about a third, denoted α. Cost minimization by firms implies that:

$$r = \frac{\partial}{\partial K} F(K/N) = A\alpha k^{\alpha - 1} \tag{1}$$

where A is the level of technology and k is the capital labor ratio. The authors take the net return on private capital to be 10%.[1] Differentiating both sides of equation (1) with respect to the level of government debt (D), the change in the real interest rate for a change in debt is:

$$\frac{dr}{dD} = \left(\frac{\partial K}{\partial D}\frac{\partial}{\partial K} + \frac{\partial N}{\partial D}\frac{\partial}{\partial N}\right)\frac{\partial}{\partial K}F(K/N)$$

If $dN = 0$, multiplying both sides by Y gives:

$$\frac{dr}{dD/Y} = A\alpha(\alpha-1)k^{\alpha-2}y\frac{\partial K}{\partial D} = (\alpha-1)r\frac{y}{k}\frac{\partial K}{\partial D} \simeq -2.2\left(\frac{\partial K}{\partial D}\right)\%$$

So if we assume, as above, that $\partial K/\partial D = -0.6$, then a 1% change in the debt to GDP ratio leads to a 0.013% change in the real interest rate. This is small relative to the volatility of the real interest rate. For a change in debt of $4 trillion, or 40% of Y, which is both about the current level of federal debt and about how much the Congressional Budget Office's forecast of debt 10 years in the future has increased from January 2001 to the present, the real interest rate is predicted to change by just over 0.5%.

From this exercise, the authors take three points: if debt crowds out capital, it raises the real interest rate; the level of debt determines the level of the real interest rate; and the magnitude of the effect is small.

All the empirical findings of the paper are consistent with Figures 11 and 12. There is a small but significant correlation between debt and real interest rates. And there is a larger and significant relationship between deficits and real interest rates. The former finding is consistent with a slightly larger effect than implied by the above rule of thumb. The regressions suggest that a 1% increase in D/Y is associated with a 0.03 percentage point increase in r. The latter—the larger relationship between deficits and interest rates—supports, informally at least, a significant short-term Keynensian effect of deficits: deficits increase the demand for goods and raise interest rates.

According to my reading of the literature and this paper, these findings are robust and correct. To reverse them would require cruel and unusual treatment of the data. The balance of my discussion therefore focusses on interpretation.

I make two points. First, we are less concerned with the effect of debt on interest rates than the effect on capital or other measures of future well-being. The curvature of the production function, which the authors use to argue that the interest rate effect should be small, also implies that there are large effects of debt on capital for only small interest rate movements. Second, the effect of debt on interest rates is determined by the structure of the economy and by the tax and spending policies pursued in response to debt. In terms of understanding the causal effect of tax and spending policies on the capital stock and interest rates, at best the deficit and debt are noisy regressors. At worst, they are concepts without economic content.

2. Do We Care About the Effect on Interest Rates?

Only indirectly. We care directly about the effect of debt on real variables and outcomes, which can be large even when the effect on interest rates is small.

In extreme, there can be no effect of debt on real rates, and yet debt might significantly depress economic activity. Thus, small interest rate effects do not imply small welfare costs of debt.

For example, the capital–labor ratio determines wages as well as the return to capital according to $w = f(k) - rf'(k)$. If a policy that increases debt also lowers labor supply or the accumulation of human capital, then the policy can have no effect on real rates and yet decrease output. As another example, if production has features of learning by doing or if there are human capital spillovers, so that the aggregate production function has the AK structure, then policy choices that increase debt and decrease capital will not change the interest rate even though they may have detrimental effects on output and economic growth. Finally, the United States is a reasonably open economy, and so capital inflows offset government debt. In extreme, a policy that increases debt can have no effect on the interest rate or the capital stock but can significantly reduce the future income of households.

Even assuming away movements in labor, taking as given the Cobb-Douglas production function, and assuming no capital inflows, the curvature of the production function, which the authors use to argue that the interest rate effect should be small, also implies that there are large effects of debt on capital and output for only small interest rate movements. Above, I calculated what the rule of thumb implies about the effect of the current federal debt on interest rates. We can also calculate the effect on output. The production function implies that we can write:

$$\frac{dY}{dD} = \frac{\partial}{\partial K}F(K/N)\frac{\partial K}{\partial D} = r\frac{\partial K}{\partial D}$$

The current debt is roughly $4 trillion, which is roughly $13,000 per person. For $\partial K/\partial D = -0.60$, output declines by about $1,000/year/person given marginal product of capital of 10%.

Finally, the same point can be made in reverse: policies that lead to large debt can be quite beneficial, regardless of their effect on the real interest rate. It is possible that some policies that raise the debt also have benefits that outweighed the costs of the debt. While more debt is bad because it requires lower spending on public goods and services or higher levels of distortionary taxation, there can be benefits from the tax cuts or spending increases that caused the increase in debt. And the benefits of a policy can outweigh the costs of raising debt. Depending on your politics, think Head Start, defense spending, or investment tax credits. What matters in each case is not the effect on interest rates, but the benefits and costs—inclusive of debt—that the policy causes.

3. Do We Care About the Effect of Debt?

We certainly care about the impact of any policy, as just noted. But the definition of debt is arbitrary. I make this point first in the context of measurement, using the example of the liabilities of the Social Security system. Then I argue that economic theory is not even clear about what debt is.[2]

Consider the U.S. Social Security and Medicare System (SSMS). Households pay into the system and are promised in return a pension and health insurance when they retire. The government could set aside contributions and use them to fund the future benefits of the contributors. But it has not and does not, so that current benefits are paid from current contributions.[3] Thus, the government has a commitment to pay resources to future retirees and does not have the assets to cover these future liabilities.

Compare these promises made by the SSMS to government debt. Debt is a commitment by the government to pay resources to bondholders, and the government does not have the assets to cover these future liabilities. Thus, the liabilities of the SSMS are just like debt, with the one exception that the government does not count these liabilities as debt.

Is this a purely academic point? Not at all. The implicit liabilities in the SSMS are larger than the current federal debt. And Figure 1 shows that at current benefit rates, the SSMS annual benefits are expected to increase dramatically. If the tax system remains stable, SSMS expenses

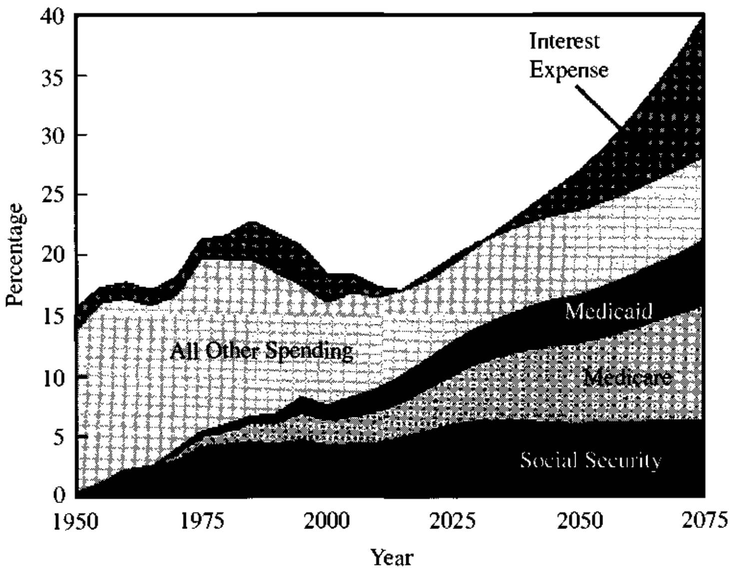

Figure 1
Federal outlays by type; as a percentage of GDP
Source: Congressional Budget Office (2002).

and interest on the official debt would exceed total federal government revenues in fifty years (Figures 1 and 2). Including SSMS liabilities in debt measures would not only increase the official debt but would make it vary quite differently. The official debt is a political construction, not an economic concept, and it can be radically changed by a change of definition. This issue presents a significant problem for empirical work based on the official measure of debt.

Further, this issue—that the definition of debt is arbitrary—really means that to measure the effect of a policy on interest rates correctly requires a model of the future path of distortions and benefits of any policy. This requires many more assumptions about the structure of the economy than we can confidently make—making the case that historical correlations as studied by this paper are useful. But the main ingredients at least are clear, and the parameter that the paper estimates is an amalgam of these ingredients.

The correlation between debt and interest rates is determined by whether debt changes due to changes in government spending, lump-sum taxation, or distortionary taxation. As a basic example, consider deterministic variation in government defense purchases in a Ricardian

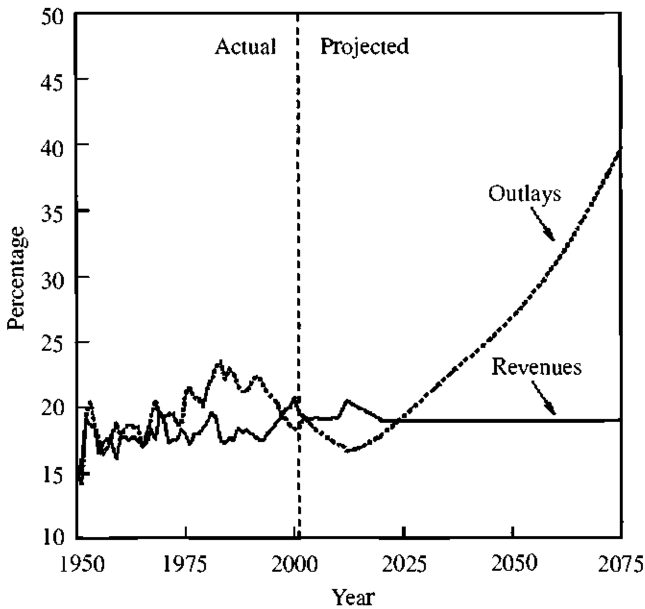

Figure 2
Federal revenues and outlays as a percentage of GDP
Source: Congressional Budget Office (2002).

economy with a fixed level of taxation. When government spending is high, deficits are high and the debt level rises, and there is high demand for goods today relative to goods tomorrow so that the real interest rate is high. But the debt is completely irrelevant for the capital stock and the prevailing interest rate. If instead debt were being raised and lowered by fluctuations in lump-sum taxes with a constant level of government spending, we would observe no correlation between interest rates and debt (ceteris paribus) because the interest rate would be constant (at least on the balanced growth path).

More generally how is debt reduced? Bohn (1991) shows that historically just under two-thirds of the U.S. debt has been eliminated by reductions in government spending (as a share of gross domestic product [GDP]) instead of increases in taxes. Thus, interest rates are raised by high debt because government spending is expected to be lower in the future and because taxes are expected to be higher.

Finally, the correlation between debt and interest rates depends on how distortionary taxes are. Other things being equal, the presence of less distortionary taxes makes fluctuations in debt less likely to affect the return on capital. An extreme example is the opportunity—readily available right now in the United States—to default on the debt. On the other hand, if all taxes were extremely distortionary, then debt could crowd out capital more than one for one if high debt meant that taxes had to be raised.

4. Conclusion: What Is Debt?

Consider a variant of the neoclassical model due to McGrattan and Prescott (2001), in which a price-taking representative household maximizes the present discounted value of utility from consumption (C) and leisure (l):

$$Max \sum_t \beta^t U(C_t, l_t)$$

subject to an intertemporal budget constraint:

$$\sum_t R_{0,t}\{C_t + V_t(s_{t+1} - s_t)\} = \sum_t R_{0,t}\{(1 - \tau_{div})d_t s_t + (1 - \tau_{per})(w_t N_t + INT_t) + T_t\}$$

where β is the discount factor, $R_{0,t}$ is the gross real interest rate—the price of output at time t relative to time 0, V_t is the value of a share of the capital stock, s_t is the number of shares the household owns, τ_{div} is the tax rate on dividends, d_t is the dividends per share, τ_{per} is the personal income tax rate, w_t is the wage rate, INT_t is interest on government debt, and T_t are lump-sum transfers from the government to the household. We assume that $U(C_t, l_t)$ is of the King-Plosser-Rebelo class of utility functions so that permanent changes in after-tax wages have no impact on labor supply (N).

Firms maximize the present discounted value of dividends, where dividends are the profits of the firm after corporate taxes:

$$d_t = (1 - \tau_{corp})\{f(K_t, N_t) - w_t N_t - \delta K_t\} - K_{t+1} + K_t$$

where τ_{corp} is the corporate tax rate; we assume that capital depreciates at rate δ. Finally, markets clear:

$$l_t + N_t = 1$$

$$C_t + (K_{t+1} - (1 - \delta)K_t) + G_t = F(K_t, N_t)$$

Let the economy start in steady state with fixed tax rates and debt $= 0$, such that the intertemporal budget constraint of the government is met. And, as in the United States, let the consumption share of output be greater than the labor share, so that net payments from firms to households are positive.

Consider a shock that raises debt (or consider two otherwise identical economies with different initial levels of debt). Does debt raise interest rates and crowd out capital? Not necessarily. The following three policies to balance the budget at $t = 0$ do not affect the time path of $\{Y, C, K\}$:

1. A permanent increase in τ_{div}
2. A permanent cut in transfers
3. A one-time cut in entitlements: eliminate payments to bondholders

Under scenarios 1 and 2, the debt remains high for some time and is slowly reduced. Under scenario 3, the debt is eliminated at time zero (this policy can also be called seigniorage). Thus, among these policies, neither the debt shock nor the level of debt has any effect on the real outcomes of the economy.[4]

These claims follow almost directly from the following three equilibrium conditions (see also Bradford, 1981):

$$R_{t,t+1}^{-1} = \frac{V_{t+1} + (1 - \tau_{div})d_{t+1}}{V_t}$$

$$R_{t,t+1}^{-1} = (1 - \tau_{corp})(F_1(K_t, N_t) - \delta) + 1$$

$$R_{t,t+1}^{-1} = \beta \frac{u_{1,t+1}}{u_{1,t}}$$

The third pins down $R_{t,t+1}^{-1}$ as a function of the discount rate. The second gives the capital–labor ratio as a function of τ_{corp} and $R_{t,t+1}^{-1}$. And the first gives the value of the capital stock as a function of $R_{t,t+1}^{-1}$ and d_t, which in turn is given by the fixed steady-state level of N, τ_{corp} and the already pinned down capital–labor ratio.

When are interest rates affected? The second equilibrium condition shows that debt would lead to an increase in the interest rate if households expected an increase in τ_{corp} to balance the budget. The interest rate—the rate of return to capital—is reduced by the corporate tax rate. In steady state, the capital stock is lower the higher τ_{corp}.

So what is debt? Debt is only a plan to take money from some people and give it to some people, sometimes even the same people. And the plan can be abandoned. There is nothing in tastes or technology that requires debt in the present to have any impact on the economy. But the interesting point for economic theory is that it seems to.

Notes

1. In this discussion, all percentages are given at annual rates and all interest rates are real.

2. Kotlikoff (2002) presents the general argument in the context of an overlapping generations model.

3. There is a modest surplus in the current Social Security trust fund, it is held in Treasury bonds.

4. It is also the case here that permanent changes in τ_{pers} are nondistortionary. But if we modeled human capital accumulation, then taxes on labor income would be capital taxes and so would be distortionary.

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Comment

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Are cookies fattening? For every 2,850 calories one eats in excess of the steady-state caloric requirement for maintaining weight, one gains a pound. Suppose a cookie has 100 calories. So eating a cookie, all other things being equal, leads to a weight gain of 0.035 pound, a positive but small effect on weight. The 0.035 is the marginal effect of a cookie on weight. Engen and Hubbard's aim in this paper is to estimate a similar parameter, the marginal effect of federal debt on long-term interest rates. They survey the evidence and present new empirical estimates and theoretical calculations. Based on their analysis, they conclude, according to their preferred metric, that increasing the ratio of federal debt to GDP by 1 percentage point will increase long-term real interest rates by 0.035 percentage point, or 3.5 basis points. Hence, they characterize their results as showing that the marginal effect of federal debt on long-term interest rates is small but positive.

There is little to quarrel with in this estimate. It is in line with results found in a recent, careful study by Thomas Laubach (2003) of the Federal Reserve Board. Nonetheless, the paper does not tell the full story about the impact of federal debt on the interest rates and the economy in general. The main message of the paper is that changes in the federal debt have statistically significant but very small effects on real interest rates and, by extension, to the real economy. Though the authors are careful not to say so explicitly, the implication is that the public and policymakers should not be unduly concerned about the recent and projected increases in federal debt since 2001. Notwithstanding qualifications inserted in the paper, by focusing on the marginal effect of increasing debt, they leave the impression that the effects of federal debt are so small that the recent and persistent fiscal imbalances—from the tax cuts in each of the last three years, the slowdown in economic growth, the increase in military spending after 9/11, and the general abandonment of fiscal restraint in the rest of the budget (e.g., the agriculture bill of 2001 and the Medicare prescription drug bill)—are of no concern, at least insofar as they might affect borrowing costs and therefore investment. Likewise, the paper could be read to imply that the substantial progress made in reducing deficits and debt during the 1990s was of little consequence for economic performance.

What does the positive but small effect identified by Engen and Hubbard imply in practice about the effect of federal borrowing on interest rates? To answer this question, I return to my question, "Are cookies fattening?" As I already noted, if I eat a cookie, I gain 0.035 pound. That is only a very small fraction of my body weight, so I might conclude that cookies are not fattening. Yet eating one cookie is not really the issue if I am trying to watch my weight. My experience with cookies suggests that the right question is, What if I eat a cookie a day for a year in addition to my normal caloric intake? In that case, I will gain 365 times 0.035 pounds per day, which equals 12.8 pounds in a year. If I do this for 10 years.... Well, let's not go there. Based on these considerations, I would say that cookies are fattening.

Federal deficits have a similar implication for the federal debt as eating cookies does for weigh gain. They are persistent, so nibbles tend to cumulate. Consider the increase in the debt/GDP ratio in the 1980s. It rose from roughly one-quarter to one-half of GDP, an increase of 25 percentage points. As Benjamin Friedman notes, using the preferred estimate of Engen and Hubbard, this would increase long-term real interest rates by 25 times 3.5 basis points, which equals 87.5 basis points. Such an increase in interest rates will have major implications for the accumulation of capital and housing, for financial markets, and for the cost of financing the federal debt. With current policy, we appear to be repeating the experiment of the 1980s, that is, cutting taxes, increasing defense spending, and not restraining nondefense spending. The authors' estimates thus imply that current policy will lead to a noticeable, sustained increase in real interest rates.

Engen and Hubbard's estimates for the effect of borrowing on interest rates are very close to those found in several recent papers that carefully study the relationship between interest rates and federal borrowing. In particular, estimates by Thomas Laubach (2003) of the Federal Reserve Board point to only slightly higher marginal effects of debt on real long-term interest rates. Laubach finds large effects on interest rates of a percentage point increase in the *deficit*/GDP ratio, results that Engen and Hubbard confirm in their regressions. Engen and Hubbard downplay these larger point estimates, however, for the deficit. Yet as the authors hint in their discussion of the evidence, the big coefficient on the deficit is not inconsistent with the smaller coefficient on the debt. Deficits are persistent, so a current deficit implies increases for the debt in the medium run. Taking into account the persistence of the deficit and the difference in units, the estimates based on deficits and debt tell similar stories.

So the estimates presented by Engen and Hubbard are in line with those found in the literature. Why then do the Fed and the Brookings Institution agree that the recent shift in fiscal policy pushed long-term rates up by 50 to 100 basis points (see Gale and Potter, 2002), which is surely a substantial number that has noticeable real effects? As Gale and Orszag (2003) observe, this magnitude of increase in borrowing costs more relative to the offsets in the reductions in marginal rates in the 2001 bill in the cost of capital. What accounts for the difference in interpretation of the evidence is Engen and Hubbard's focus on percentage point movements in the debt/GDP ratio and inferred moves in the capital/GDP ratio, both of which are very misleading. I will show you this by taking the ingredients of Engen and Hubbard's analysis and embedding it in the Solow growth model, which for this application is a good approximation to what one would find with a dynamic general equilibrium (DGE) model. Using the Solow model will link the analysis to the national saving and investment rates, which are a better way to understand and quantify the economics rather than debt per se.

In implementing these calculations, I will embrace the details of Engen and Hubbard's analysis. I agree with them that modeling the saving rate is a good way to summarize the effects on capital accumulation of changes in government saving, even if the changes in national saving are not identical to the changes in government saving. That is, a 1% increase in the federal deficit might reduce national saving by less than 1% because of foreign capital flows or Ricardian increases in private saving. The current paper does not have anything new to say about these effects. To approximate them, consider, a 2 percentage point drop in national saving, which may arise, for example, from a 4 percentage point drop in federal saving that is partially offset by an increase in private saving. The purpose of using the Solow model is to get the stock-flow identities right and to calculate the dynamic general equilibrium effects of the change in the capital stock from the change in saving.

Let me start by considering steady-state changes in the saving rate. The Solow model is so familiar that I will not rehearse its equations for you. Let me tell you, however, what parameter values I use. The growth rate ($n + g$) is 4% per year, the rate of depreciation (δ) is 4% per year, the investment rate (s) is 20% of income, and the capital share (α) is 0.33. These parameters are totally conventional. The warranted growth rate of 4%, 1% for labor force, and 3% for technology is in line with most estimates. The depreciation rate of 4% matches Bureau of Economic Analysis (BEA) aggregates for the total net capital stock. (Like Engen and Hubbard, this capital stock and depreciation rate includes residential and nonresidential structures as well as business equipment.) The investment rate is a little high, but call me an optimist. These parameters loosely replicate U.S. aggregates. That is, they generate a capital/output ratio of 2.5 and a gross marginal product of capital of 13.2%. The capital/output ratio in the data is 2.7. The MPK of 13.2 is in line with estimates of the pretax gross return to capital.[1]

Now let's run several policy experiments through the Solow model. Consider economies where the steady-state saving rate (taken equal to the investment rate) was lower by 1, 2, or 4 percentage points. Table 1 shows the steady-state effects of these changes in the saving rate. Such permanent reductions of the saving rate have very large effects on the steady-state marginal product of capital (these are percentage points, not basis points) and on the capital stock itself. For a 1% permanent cut in the saving rate, the marginal product would increase 70 basis points and the capital stock would fall 7.4%. Because of diminishing marginal product of capital, the effects of larger drops in saving are more than proportional. These effects are very large and would correspond to significant decreases in consumption per capita on a permanent basis, though there would be increases in consumption along the transition path. In thinking about the prospect of fiscal deficits for the

Table 1
Steady-state effect of changing savings on MPK: Solow model

Change in savings rate (fraction)	Change in MPK (percentage points)	Change in K (percent)
−0.01	0.7	−7.4
−0.02	1.5	−14.6
−0.04	3.3	−28.4

Table 2
Steady-state effect of changing savings on MPK: Solow model

Change in savings rate (fraction)	Change in MPK (percentage points)	Change in K (percent)
−0.00036	0.024	−0.27
−0.00134	0.090	−1.0
−0.00200	0.135	−1.5

distant future, these calculations give an estimate of the permanent effects.

Why are Engen and Hubbard less concerned? First, their static, partial equilibrium calculation significantly understates the steady-state effects. Second, the perturbations they consider lead to only very small changes in national saving in a steady-state analysis. Let me illustrate these points by asking what change in saving in steady state would generate results that Engen and Hubbard highlight. First, what change in saving would generate the steady-state change in MPK of 2.4 basis points that they feature in their discussion? This calculation is shown in Table 2. To get this change, the saving rate would have to fall by 36/100,000. First, this is a very small change in the saving rate. Second, note that the capital stock does not fall by nearly 1%. To get the capital stock to fall by 1%, the drop in the saving rate must be larger, 136/100,000, but still very small. Finally, to get the capital/output ratio to fall by 1%, the saving rate has to fall by 2/1,000. This is the experiment that Engen and Hubbard have in mind in column 1 of Table 1. Note two points. First, again this drop in the capital stock is generated by a very small decline in saving. Second, dynamic general equilibrium effects of this drop leading to a 1% drop in the K/Y ratio lead to a 13.5 basis point increase in the MPK, not a 2.4 increase.

Now the steady-state calculations of the Solow model likely overstate the effect of fiscal deficits because they are based on permanent changes in national saving and investment. Also, they refer to effects long in the future that may have little relevance even for current long-term interest rates. I will address both these points later in this discussion by considering the dynamic response to a realistic path of deficits in the Solow model. Nonetheless, these calculations are the right theoretical benchmark for starting the discussion of persistent federal dissaving and tell a much different story from that of the authors' static calculations.

Before returning to the dynamic general equilibrium impact of a realistic path for deficits, let me raise some additional issues about the paper. There are other factors, hard to control for in regressions that affect the relationship between debt or deficits and interest rates. One of the most important ones is monetary policy. Much *Macroeconomics Annual* ink has been spilled in the past and will continue to be spilled in the future about how monetary policy affects the real interest rate. But it is pretty clear that when the Fed changes nominal short rates, the real short rate moves almost one for one. And these changes in the short rates have a surprisingly strong impact on longer-term rates. Hence, whether the Fed is accommodating a fiscal expansion or leaning against it will have a significant effect on the interest rate/deficit linkage. The Fed will behave differently given different circumstances, so this effect is not systematic. For example, in 1993, we had tightening fiscal policy and accommodative monetary policy. In 2003, we had loosening fiscal policy and accommodative monetary policy. Perhaps these effects could be controlled for in the regressions by including a variable that indicated the deviation of the federal funds rate from its long-term target. Doing so would be hard, however, because it is hard to imagine a variable that is more endogenous. Nonetheless, the point that the stance of monetary policy has an important impact on the real rate and that monetary policy and fiscal policy are not unrelated should not be lost.

The long-term stance of monetary policy is also important for fiscal policy and its link to the real interest rate. Around the world, it is fairly clear the central banks have new and firm commitments to low inflation. For fiscal policy, this means that there is little prospect for inflating away accumulated debt in the future. This places an added constraint on fiscal authorities such that, if we are to stay out of scary regions predicted by the fiscal theory of the price level, the fiscal balance must be achieved in the future by raising taxes or lowering spending.

This point about monetary policy disciplining fiscal policy leads to a more general point about deficits: they might be persistent, but they are not permanent. Though the debt/GDP ratio in the United States has some important low-frequency swings, it has stayed under control because we have been willing to pay off the debt we have accumulated by fighting wars and have corrected previous fiscal imbalances. For example, a combination of higher tax rates and stronger-then-expected economic growth during the Clinton administration brought the debt/

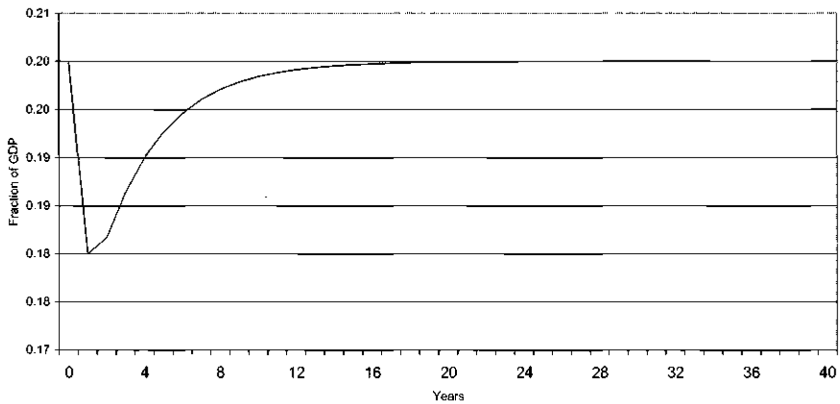

Figure 1
Dynamics of a shock to savings

GDP ratio down (see figures in the paper). It has started to rise again since 2001, but if previous experience repeats itself, some future administration will tackle the fiscal imbalances that we see currently. At some point, presumably when the economy is stronger, political attention will shift to the deficit, as it did in the mid-1980s to 1990s.

Or maybe not. If it becomes clear that the nation does not have the will to pay its bills over the long haul, interest rates are likely to rise sharply. With the looming liabilities associated with the aging of the population, it is an open question how this will play out. But for now, financial markets are telling us that they do expect the fiscal problems to be addressed.

The data bear out the point that the deficits are persistent but not permanent. Using quarterly data, I estimated a simple AR(4) model of the deficit/GDP ratio. Figure 1 presents the dynamic response to a 0.02 of GDP drop in federal saving. (Controlling for the cycle does not affect the picture much.) This shows persistent deficits, but deficits that correct themselves over a decade or so. (These estimates perhaps somewhat understate the persistence of deficits because I have not corrected the AR coefficients for the downward bias. The largest quarterly autoregressive root is 0.93.) Hence, the time series evidence is consistent with a view that deficits, though persistent, are not permanent. What if we run this path through the Solow model? I think it corresponds well to what might be expected from the current fiscal imbalances. The impulse is a drop in saving of 0.02 of GDP. This is less than half the

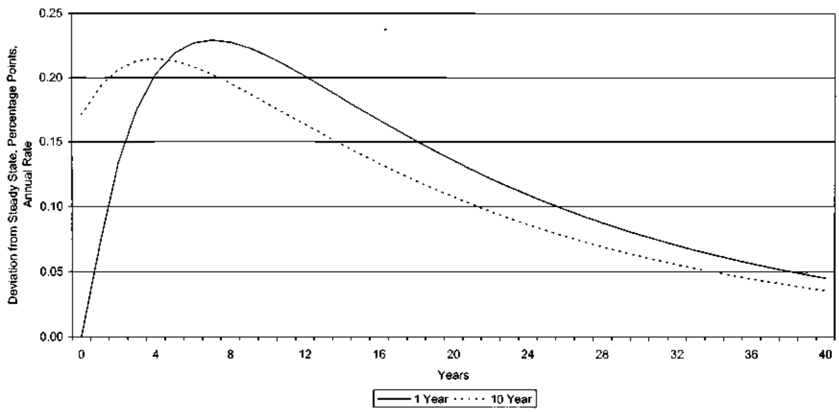

Figure 2
Response of MPK to shock to savings, Solow model

size of current deficits, so it allows for some private response to damp the effect of the deficit on national saving.

Figure 2 shows the MPK implications for this dynamic change in the saving rate in Figure 1. The solid line is the one-period MPK. The dashed line is the 10-year forward average—a simple way to approximate the 10-year interest rate that is featured in the paper. These calculations show that the 10-year rate increases by about 17 basis points on impact. The capital stock is maximally affected in year 8; the 10-year rate peaks somewhat earlier at about an increase of 22 basis points.

Note how much smaller these effects are than a permanent reduction in the saving rate shown in Table 2. That deficits typically self-correct substantially damps their effect. Yet I view the simulation in Figure 2 as somewhat conservative. It assumes that fiscal discipline will be restored at the historical rate. Given that there is no prospect in the near run for cutting spending, especially with growing national security concerns, and little willingness either to pay for our increased defense, increased drug benefits, or future liability to retirees, a more realistic path of deficits would show higher interest rates.

Finally, I want to conclude by saying that the tight focus on the link between interest rates and federal saving of this paper misses the larger picture. First, even if there were no interest rate effects (e.g., because foreigners elastically supplied saving to finance our deficit), these loans will have to be repaid. We are simply borrowing from the future. Engen and Hubbard know this point well. That they do not make it, however, testifies to the very narrow focus of this paper and its very narrow implications for the economic effects of debt.

Second, calculations based on the Cobb-Douglas production function and disembodied technology, such as those presented in the paper and I have mirrored, probably understate the cost of squeezing current investment. If there are growth rate effects of capital accumulation, or technology is embodied in new capital, the cost of deferring investment could be very much higher than in standard estimates.

Note

1. The empirical analysis of the paper concerns the Treasury bond rate, which is riskless except for inflation risk. The theoretical model of the paper and this comment concerns the return to capital, which earns a substantial risk premium. An implicit assumption of the paper is that changes in the capital/output ratio in the range considered do not affect the risk premium, so that changes in marginal product of capital map one-for-one into the interest rate.

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Discussion

In response to the discussants' comments, R. Glenn Hubbard emphasized that the paper he and Engen wrote was not about the effects on interest rates or on the economy, and that it was never their intention for anybody to infer that a small effect on interest rates was a small effect on the economy. In his intervention, Engen also said that the paper was only about government debt and interest rates, and he acknowledged that there might be other important economic effects but that they were not the topic of this work. He remarked that Jonathan Parker's comment on national income, consumption, and wealth was very interesting and that they would consider using them, but that it was not the subject they were trying to address in their paper. Hubbard then said, and Engen later agreed, that the relation of government spending versus taxation was very important and that one would expect that in almost any model an increase in government spending would raise the real interest rate. However, in a period when military shocks dominate fiscal positions, government spending would give little information about deficit shock. He quoted a work by Evans and Marshall in which they made the argument that tax shocks or deficit shocks did not appear to have much impact; the impact was coming from military spending. Hubbard also acknowledged that the point about incentive effects was very important because some tax changes had stronger incentive effects than others.

Eric M. Engen addressed the issue raised by both discussants that when there are savings inflows, interest may not change at that time but it will have to be paid some time in the future. Engen pointed out that while that was true and was normally regarded as a bad outcome, people often missed the fact that players in the economy, policymakers, and society itself had decided to make an intertemporal tradeoff. They enjoyed higher levels of consumption today for lower levels of income later.

Engen went on to say that he and Hubbard wanted to work more on identifying the expectations of the market and economic agents about what policymakers were going to do in the future. This was complicated, however, starting with the decision about which indicators to use and how to build those expectations into a simple reduced form of regression or some kind of vector autoregression (VAR) framework.

Several of the participants raised the issue of the proportion of government debt that was in the hands of foreigners. Graciela Kaminsky was impressed by the increase from basically zero to about 35% of the debt. She believed this was a reflection of the differences between globalization in the 1950s and globalization in the 1990s and could explain significantly the structural stability on the regressions that were estimated in the paper. Kaminsky also said that it might be interesting to look at the different effects in the earlier and later parts of the sample on the current account and whether deficits were likely to be financed by the rest of the world. The authors responded to this issue that although it would be interesting to determine this and they actually tried it, their sample size was too small and only spanned from 1976 to 2003. Engen added that precisely because of sample-size issues, they had added foreign purchases of Treasuries as one of their macro variables to try to control for the differences over time in the longer regressions. He also pointed out that most of the integration has taken place in a short period of time and that led to small-sample-size issues.

On the other hand, Robert Gordon did not consider there to be a break in the post–World War II period. According to him, the deficit–gross domestic product (GDP) ratio consistently decreased up until the early 1980s, only to rise during the Reagan–Bush period (which for him runs from 1982 to 2000) and then decline again. Gordon was also concerned about whether foreigners would finance the U.S. debt forever. He pointed out the fact that every year the United States had net international liabilities equal to 25% of GDP, and yet it had negative net investment income in the current account. According to Gordon, this responded to the fact that foreigners invested in low-yield government debt. Stephen Cecchetti also commented on the large proportion of debt owned by foreigners but warned about the fact that this only reflected official holdings and that private holdings might not be as easy to identify. He said that if a private brokerage firm such as Merrill Lynch were to be holding U.S. Treasuries for a foreign investor, this would appear as domestic holdings.

Kenneth Rogoff and Cecchetti both commented on the variations in debt and deficits across countries, and the similarities in interest rates. Rogoff believed that the similarities in interest rates responded to highly integrated global capital markets, and the fact that this accounted for only one-quarter of global GDP led to the expectation of a small interest rate effect. On the other hand, Cecchetti did not believe that interest rates were similar at all despite the relatively high correlation in the sample. He cited differences of between 2 and 4 percentage points, which he considered quite large on a medium-term interest rate. Engen responded that this is true if one looked at the most-current rates, but that if one looked at different countries and their fiscal positions, it would become evident that some of the countries with the worst fiscal positions, like Japan, were at the low end of that range and some of the better ones were at the high end. One had to look beyond real interest rates and see that some of the discrepancy did not seem to correlate with their fiscal positions.

Rogoff and Benjamin Friedman commented on the issue of whether the effects of interest rates are small or large. Rogoff agreed with the discussants that there seemed to be a legacy of the Barro debt neutrality regressions in which interest rates were small and therefore it did not really matter that much. However, the calibrations in the paper showed that this was wrong and that in fact one could get fairly large welfare effects from small interest rate effects. He recommended that the authors could say that their calibration showed that even though deficits could be catastrophic, this would not come up in interest rates, instead of simply stating in the paper they were not claiming deficits were bad. Friedman was concerned with the definition of a small effect and a large one. The authors, he said, presented their base case as a 1% increase in the debt ratio, and that did not seem to be a lot. However, he cited the example of the Reagan–Bush Sr. period, in which the debt–GDP ratio was raised by 20 to 25%, and if one were to multiply this by 3.5 basis points, one would obtain an increase of between 70 and 80 basis points, which was very large for U.S. real interest rates. This would be an example of why it could not really be said that the paper was purely about real interest rates and not about the effect of the capital stock because *small* and *large* were relative terms. If one were to look at the effect on the capital stock, and the analysis was grounded in a production function with little curvature, small changes in rates would become large. He recommended eliminating the adjectives *small* and *large* to add credibility to the paper. Engen responded to this issue by saying that they presented the result as one percentage point in the debt–GDP ratio for purposes of comparability with other studies that present it in the same way.

Friedman also considered it odd that the regressors in Tables 2, 3, and 4 included the flow of removal of securities from the market by either foreigners or the domestic central bank as purchases and did not include the flow of the Treasury's putting new securities in the market. Engen responded that they had tried to simplify so they would have less changes and that two of the specifications were changes in debt, so classifying them as purchases was appropriate. If they had been classified as holdings, the estimated effect of federal debt on the interest rate would remain unchanged. However, he acknowledged the need for greater consistency. Hubbard added that he agreed that it was silly to hide behind interest rates and that the point of the discussion should be future tax burdens.

Valerie Ramey questioned the reference to the neoclassical model in the paper because it departed significantly from what she believed the neoclassical model to be. She said that what mattered were government purchases, not how they were financed, even if they were financed with distortionary taxes. There should not be a permanent effect in real interest rates even with a permanent increase in government purchases. When government purchases increase, there is a negative wealth effect that leads to a decrease in leisure, which in turn leads to an increase in the marginal product of capital and higher interest rates in the short run and an increase in capital stock that responds to an increase in government spending. Eventually, interest rates would go back to their steady state. She then said that work carried out by Matthew Shapiro and herself supported this with empirical evidence, and she recommended a more developed model in which transition dynamics were included in addition to the steady state.

Fumio Hayashi wanted to know if the authors were drawing from the Investment-Saving/Liquidity of Money (IS/LM) model used for the Congressional Budget Office (CBO) forecasts, which assumed the effect of deficits on interest rates in their regression of interest rates on the CBO forecasts of debts and deficits. Eric Engen responded that the CBO makes projections of debt and deficit, but the forward-looking interest rates were different. They were a constructed five-year-ahead measure of the ten-year Treasury rates. He explained that the CBO did not use that forecast for interest rates and that the problem might arise if the markets were really taking the CBO projections of debt and deficit seriously, in which case those projections might be determining interest rates.