Monetary Policy, Bond Returns and Debt Dynamics

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Abstract

Using the government's intertemporal budget constraint, we develop a framework for analyzing the dynamic response of the debt-to-GDP ratio, and its interest cost and primary deficit components, to the government's current fiscal position, and the role that conventional and unconventional monetary policy plays in shaping this response. We apply this framework to market values of U.S. fiscal balances between 1960 and 2012. We show that the unconventional monetary policy measures employed by the Federal Reserve since late 2008 led to a marginal increase in the Treasury's interest cost and hence the debt-to-GDP ratio. We develop a prediction model for future debt-to-GDP ratios and its components, and assess how the performance of the predictions changes when the monetary policy regime is and is not explicitly considered.

JEL Classifications: C5, E4, E6, G1, H6

Keywords: monetary policy, debt dynamics, bond returns, predictability

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1. Introduction

In response to the events associated with the recent financial crisis, the Federal Open Market Committee (FOMC) lowered the target federal funds rate to its effective zero lower bound by the end of 2008. With short-term nominal interest rates constrained by the zero lower bound (ZLB) since then, unconventional monetary policy strategies aimed at reducing longer-term interest rates were employed by the FOMC, such as forward guidance, large scale asset purchases and Operation Twist.[1]

Since 2008, a growing empirical literature has explored the effects of such unconventional monetary policy actions, with much of the focus on the years during the Great Recession and its aftermath, and on the question of whether purchases of large quantities of Treasury coupon securities by the Federal Reserve and various forms of forward guidance have altered the level of longer-term Treasury yields. Others have evaluated the effect of these policies on real economic activity and the borrowing costs that firms and households face.[2] Absent from this literature, however, is a quantitative analysis of the effect of these policies on the fiscal balances of the Treasury, especially its interest costs. This paper provides such an analysis for both the conventional monetary regime prior to 2008 and the unconventional monetary policy regime that followed.

Our analysis is based on the government's intertemporal budget constraint, which allows us to decompose the change in the ratio of market value of government debt to GDP into an interest cost and a primary deficit component. Using quarterly data from 1960 to 2012, we directly measure the Treasury's debt to GDP ratio and interest cost, which in turn allows us to quantify the primary deficit as dictated by the budget constraint.

To explore how monetary policy actions impact interest costs and, ultimately, debt to GDP ratios, we consider two different monetary policy regimes: The conventional monetary policy period from 1960 to 2008.III when the federal funds rate was 25 basis points or higher, and the unconventional monetary policy period from 2008.IV to 2012 when the federal funds rate was lower than 25 basis points.[3]

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[1] At its October 29, 2014 meeting, the FOMC officially ended its QE program.

[2] See Section 2 for a discussion of this literature and specific references.

[3] The timing of the conventional versus unconventional monetary policy matches the timing frequently used in the literature. See Gilchrist, Lopez-Salido, and Zakrajšek (2014) for a more detailed discussion about monetary policy regimes.

We show that during the conventional monetary policy regime, the debt-to-GDP ratio tended to increase or decrease by less that 0.6% per quarter. During the unconventional monetary policy regime, however, debt-to-GDP ratios increased dramatically, at an average rate of 3.68% per quarter. Even though this fast growth in debt to GDP was mostly driven by large primary deficits, our results indicate that interest costs, perhaps surprisingly, were sizable even though interest rates were at an unprecedented low. Indeed, average real holding returns on the government's portfolio of debt were 64 basis points per quarter, or 2.6% per year. Average nominal holding returns were 93 basis points per quarter, or 3.7% per year.

A closer look at nominal returns on government debt reveals that the flattening of the yield curve actively pursued by the FOMC during the unconventional monetary policy regime led on average to a marginal increase in nominal returns by 8 basis points per quarter. This translates into an average marginal increase in nominal interest costs by 0.17% of GDP per quarter, and is in stark contrast to the conventional monetary policy regime when changes in the slope of the yield curve tend to mitigate nominal interest costs.

Our findings suggest that any prediction model for future debt dynamics should incorporate information about the current monetary policy regime. When conditioning on the monetary policy regime, our prediction model explains 21% of the variation in the interest cost component of future debt to GDP growth and 35% of the variation in the primary deficit component. Without conditioning on the monetary policy regime, during the unconventional regime the average prediction error for nominal interest costs would be 0.6% of GDP, or $24 billion, higher per quarter. The mismeasurement of interest costs distorts debt to GDP forecasts as well: The average prediction error for debt to GDP would be $25 billion higher per quarter.

We conclude by comparing our debt to GDP forecasts to those made by the Congressional Budget Office (CBO). The CBO is the most widely cited source of fiscal forecasts. It reports, however, projections for the face rather than the market value of government debt. We document that our forecasting errors are comparable to those by the CBO, even though we face the added challenge of predicting capital gains and losses on outstanding government debt obligations.[4]

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[4] For a discussion of the correct measure of interest payments on government debt, see Hall and Sargent (2011).

2. Related Literature

Our work is related to several distinct, but complementary literatures: fiscal accounting and debt management, the effects of monetary and fiscal policies on interest rates, and forecasting of bond returns.

2.1 Fiscal accounting and debt management

Our analysis starts with a careful fiscal accounting of the components of the U.S. government's intertemporal budget constraint. The current U.S. government accounting system is largely based on cash accounting, and the disconnect between the fiscal concepts present in analytical models and the government's reports of these balances has been recognized by the macroeconomics literature for some time. One of the earlier papers on the issue, Boskin (1982), notes that the public sector income accounts, similar to private sector national accounts, either omit capital gains and losses or else have substantial problems in measuring them. Boskin (1982) emphasizes that swings in the change of the federal government's outstanding obligations are quite large in some periods and can dominate or at least equal the regular deficit figures. He cautions that using the reported measures in any econometric analyses of the impact of the government's budget deficit is not appropriate.

More recently, Missale (2012) suggests that debt management in practice focuses on interest expenditure based on cash accounting, as opposed to the market value of debt, because fiscal rules—such as the Stability and Growth Pact of the European Union or a budget balance rule—make the cash interest expenditure the key variable to be controlled by debt management. Bernaschi, Missale, and Vergni (2009) show that the focus on cash interest payments and deficits may bias debt managers' choices and favor suboptimal debt strategies. Their analysis points to the danger of evaluating debt management on the basis of reported national accounts figures.

Hall and Sargent (1997) provide an accounting scheme that is consistent with the government's budget constraint, uses market value of debt and incorporates the capital gains and losses based on the government's long-term obligations. In more recent work, Hall and Sargent (2011) document the contemporaneous contributions of nominal returns, inflation and GDP growth to changes in the U.S. debt-to-GDP ratio between World War II and 2008. We follow their procedure in constructing the market value of debt and holding returns on the entire government bond portfolio. We contribute to this literature by analyzing how unconventional monetary policy employed by the Federal Reserve between 2008.IV and 2012 affected the debt to GDP dynamics. Moreover, we use the insights gained from the contemporaneous decomposition of debt dynamics to build a prediction model suitable for assessing the potential impact of new monetary and fiscal policies on future fiscal balances.

2.2 Unconventional monetary policy and cost of borrowing

Our analysis of the Treasury interest cost also contributes to a growing empirical literature that evaluates the effects of unconventional policy measures on long-term yields. Much of this research focuses on the Great Recession and its aftermath, and on the question of whether purchases of large quantities of Treasury coupon securities by the Federal Reserve and various forms of forward guidance have altered the level of longer-term Treasury yields.[5] Employing a variety of approaches, Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Swanson (2011), Hamilton and Wu (2012), Christensen and Rudebusch (2012), D'Amico et al. (2012), Campbell et al. (2012), Wright (2012), D'Amico and King (2013), Li and Wei (2013), and Bauer and Rudebusch (2013) present compelling evidence that these unconventional policy measures have indeed significantly lowered longer-term Treasury yields.

A few other papers, such as Hanson and Stein (2012) and Nakamura and Steinsson (2013), analyze the effects of monetary policy on real and nominal Treasury yields over a period that includes both the conventional and unconventional policy regimes.[6] To the best of our knowledge, none of these papers actually compute the effect of unconventional monetary policy on the interest cost of public debt nor do they build a prediction model for debt dynamics. Our contribution is to fill this void in the literature and to help understand the distortions of unconventional monetary policy on not just yields, but the market value of debt and interest costs.

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[5] In a recent paper, Gilchrist, Lopez-Salido, and Zakrajšek (2014) study the short-term effects of monetary policy actions—both conventional and unconventional—not just on nominal and real Treasury yields, but also on the real borrowing costs faced by businesses and households.

[6] A closely related literature studies the effects of government debt and deficits on Treasury yields without explicitly computing interest costs and without making a distinction between monetary policy regimes. For example, see Tavares and Valkanov (2003), Laubach (2003) and Laubach (2009).

2.3 Predicting bond returns

Fama and Bliss (1987), Campbell and Shiller (1991) and Cochrane and Piazzesi (2005) argue that nominal returns can be predicted using a combination of forward rates. Ludvigson and Ng (2009) explore whether macroeconomic fundamentals contain information about bond returns not already embedded in bond market data. Although the macroeconomic fundamentals include a long list of variables, no direct fiscal measures—such as tax revenue or government spending—are included.[7]

The relationship between fiscal fundamentals and future interest rates or bond returns has been investigated by Dai and Philippon (2005). These authors introduce an empirical macro-finance model that combines a no-arbitrage affine term structure model with a set of structural restrictions to identify fiscal policy shocks, and trace the effects of these shocks on the prices of bonds of different maturities. Their results suggest that government deficits affect long-term interest rates. They also show that fiscal policy shocks account for up to 12% of the variance of forecast errors in bond yields. Our analysis does not involve VARs or identifying fiscal shocks, but it does involve identifying the best predictors of holding returns on the Treasury's portfolio of debt, including those tied to the government's fiscal adjustment process.

3. Debt Dynamics and Their Components

The dynamic period-by-period version of the government's budget constraint dictates a law of motion for government liabilities:

$$B_{t+1} = R_{t+1}B_t + D_{t+1}. \tag{1}$$

Here, B_{t+1} denotes the real market value of government debt outstanding at the end of period $t+1$, D_{t+1} denotes the federal government's real primary deficit for period $(t, t+1]$, and R_{t+1} denotes the gross real return paid on the government's bond portfolio between time t and $t+1$. According to the budget constraint, when the government enters into period $t+1$,

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[7] There is also a large literature that investigates possible contemporaneous linkages between macroeconomic variables and bond prices, such as Duffee (2002), Duffee (2011), Dai and Singleton (2002), Ang and Piazzesi (2003), Ang and Piazzesi (2003) and Piazzesi and Swanson (2008), amongst many others. These papers find empirical support for using observed macroeconomic variables in models of the term structure of interest rates.

it has liabilities of B_t. This initial debt is revalued at date $t+1$ market prices, therefore R_{t+1} represents the appreciation in the market value of B_t during the period $(t, t+1]$.

Scaling Equation (1) by real GDP for period $(t, t+1]$, Y_{t+1}, we obtain

$$\frac{B_{t+1}}{Y_{t+1}} = \frac{R_{t+1}}{Y_{t+1}/Y_t}\frac{B_t}{Y_t} + \frac{D_{t+1}}{Y_{t+1}}. \tag{2}$$

Using $\Gamma_{t+1} = Y_{t+1}/Y_t$ to denote the gross growth rate of real GDP between t and $t+1$, and $\widehat{B}_t = B_t/Y_t$ and $\widehat{D}_t = D_t/Y_t$, we can rewrite Equation (2) as

$$\widehat{B}_{t+1} = \frac{R_{t+1}}{\Gamma_{t+1}}\widehat{B}_t + \widehat{D}_{t+1}.$$

With $R_t = 1 + r_t$ and $\Gamma_t = 1 + \gamma_t$, we obtain $\widehat{B}_{t+1} \approx (1 + r_{t+1} - \gamma_{t+1})\,\widehat{B}_t + \widehat{D}_{t+1}$ or

$$\Delta\widehat{B}_{t+1} \approx (r_{t+1} - \gamma_{t+1})\,\widehat{B}_t + \widehat{D}_{t+1}. \tag{3}$$

Expressing real returns as nominal returns, r_{t+1}^{nom}, minus the rate of inflation, π_{t+1}, Equation (3) can be written as

$$\Delta\widehat{B}_{t+1} \approx (r_{t+1}^{nom} - \pi_{t+1} - \gamma_{t+1})\,\widehat{B}_t + \widehat{D}_{t+1}. \tag{4}$$

Equation (4) identifies the sources that lead to a change in the ratio of market value of debt to GDP. The first is the inflation and GDP adjusted interest cost, $r_{t+1}^{a}\widehat{B}_t$, where

$$r_{t+1}^{a} = r_{t+1}^{nom} - \pi_{t+1} - \gamma_{t+1} \tag{5}$$

is the inflation and GDP adjusted interest rate, and the second is the deficit-to-GDP ratio.

In what follows, we first document the times series behavior of the change in debt to GDP and its components in Equation (4) for the U.S. between 1960 and 2012. The market value of debt and interests costs are not readily available from national accounts or Treasury reports, so we construct our own measurements. Second, we use our constructed series to take a closer look at the government's interest cost and explore how this cost has been affected by the unconventional monetary policy measures employed between 2008.IV and 2012. Third, we build a prediction model of interest costs and primary deficits, and hence debt to GDP.

In the process, we demonstrate that the prediction error for future debt to GDP dynamics increases significantly if the current monetary policy regime is ignored.

4. Quantifying Debt Dynamics and Their Components

We now describe how debt dynamics, and each of their components in Equation (4), are measured. To compute the debt-to-GDP ratio, $\widehat{B}_t$, we divide our measurement of the nominal market value of government debt by nominal per-period GDP as reported in NIPA. We construct the nominal market value of government debt outstanding at the end of period t as

$$B_t^{nom} \;=\; \sum_{k=1}^{K} s_t^k P_t^{nom,k}, \tag{6}$$

where s_t^k denotes the notional amount due at time $t+k$ and $P_t^{nom,k}$ denotes the nominal price of a synthetic zero-coupon government bond with a notional amount of \$1 that matures at time $t+k$. At time t, we obtain s_t^k by unbundling all outstanding government debt into its principal and coupon payments, and then computing the notional amount due k periods later by accumulating across all bonds. To compute $P_t^{nom,k}$, we extract the nominal zero-coupon yield curve from Treasury bond price data.

Figure 1 displays our measure of debt dynamics, $\Delta\widehat{B}_{t+1}$, using quarterly data from 1960 to 2012. It reveals a wide range of changes in debt to GDP, from a low of -10.9% of GDP in the second quarter of 2000 (or -2.7% when GDP is annualized) to a high of 23.1% of GDP in the fourth quarter of 2008 (or 5.8% when GDP is annualized).

According to Equation (4), changes in the debt-to-GDP ratio are equal to inflation and GDP adjusted interest cost plus the deficit-to-GDP ratio. The adjusted interest cost consists of the nominal interest cost, $r_{t+1}^{nom}\widehat{B}_t$, an adjustment for inflation, $-\pi_{t+1}\widehat{B}_t$, and an adjustment for GDP growth, $-\gamma_{t+1}\widehat{B}_t$. Nominal holding returns on government debt, r_{t+1}^{nom}, are value weighted averages of the nominal holding returns on debt maturing at $t+k$, $r_{t+1}^{nom,k} = (P_{t+1}^{nom,k-1} - P_t^{nom,k})/P_t^{nom,k}$, across all maturities k:

$$r_{t+1}^{nom} \;=\; \sum_{k=1}^{K} w_t^{nom,k} r_{t+1}^{nom,k}, \tag{7}$$

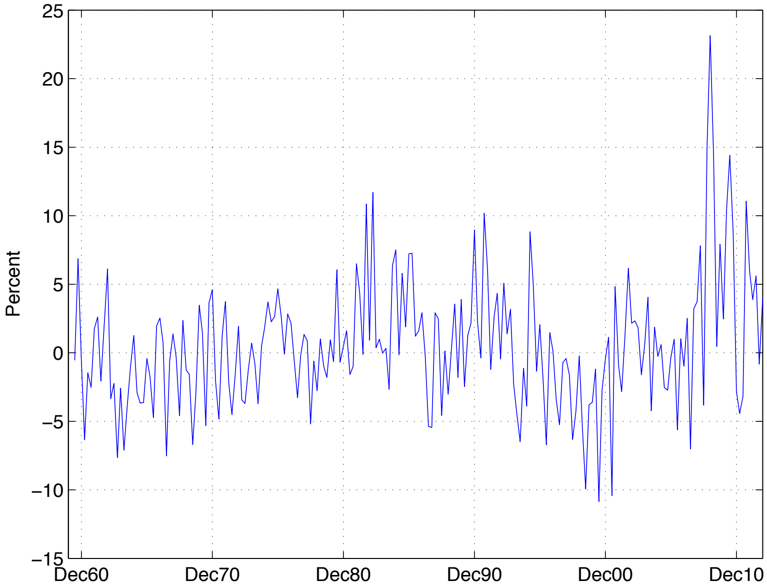

Figure 1: **Debt dynamics** This plot shows the quarterly time series of the quarterly change in the debt-to-GDP ratio, $\Delta \widehat{B}_{t+1}$. The sample period is 1960–2012.

where $w_t^{nom,k} = s_t^k P_t^{nom,k} / B_t^{nom}$ is the time-t weight for maturity k. We use the growth rate of CPI to measure inflation, and set γ to the real GDP growth rate.

Figure 2 shows the time series of the adjusted interest cost and its components. Much of the volatility in the adjusted interest cost stems from the nominal interest cost, especially since the early 1980s.

When computing deficit-to-GDP ratios, we measure primary deficits D_{t+1} as the difference between the market value of debt at the end of the period, B_{t+1}, and the beginning of the period debt revalued at end-of-period prices, $R_{t+1}B_t$, as dictated by Equation (1). Note that our primary deficit measure differs from that reported in NIPA. This is because primary deficits reported in NIPA are based on an interest cost calculation that fails to account for capital gains or losses on longer term debt obligations (see Hall and Sargent (2011)). While our primary deficit measure is consistent with the budget constraint (1), the primary deficit measure in NIPA is not.

Figure 3 shows the time series of the primary deficit to GDP ratio. Consistent with the evidence in Figures 1 and 2, the deficit ratio is lowest in the second quarter of 2000 at -9.7% of GDP (or -2.4% for annualized GDP) and highest in the forth quarter of 2008 at 14.2% of

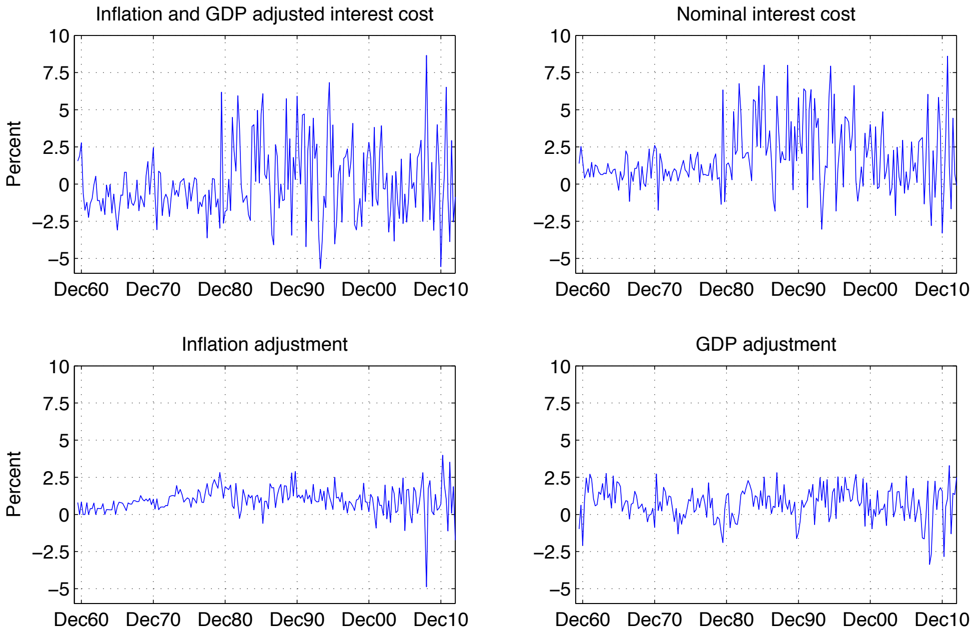

Figure 2: **Interest cost** The top left plot shows the quarterly time series of the quarterly inflation and GDP adjusted interest cost, $(r^{nom}_{t+1} - \pi_{t+1} - \gamma_{t+1})\,\widehat{B}_t$, and the top right plot shows the nominal interest cost, $r_{t+1}\widehat{B}_t$. The bottom two plots show the adjustment for inflation, $\pi_{t+1}\,\widehat{B}_t$, and the adjustment for GDP growth, $\gamma_{t+1}\,\widehat{B}_t$. The sample period is 1960–2012.

GDP (or 3.6% for annualized GDP).

The top panel of Table 1 reports the mean and standard deviation of each term in our debt dynamics equation (4). For our sample period from 1960 to 2012, we find an average quarterly increase in the debt-to-GDP ratio of 0.51% of GDP. Much of this increase stems from an average deficit-to-GDP ratio of 0.47%, with the remaining 0.04% increase due to adjusted interest costs. The bottom panel of the table reports a similar decomposition for the growth in debt-to-GDP ratios,

$$\frac{\Delta\widehat{B}_{t+1}}{\widehat{B}_t} \approx (r^{nom}_{t+1} - \pi_{t+1} - \gamma_{t+1}) + \frac{\widehat{D}_{t+1}}{\widehat{B}_t}. \tag{8}$$

We find that almost all of the average quarterly growth of 0.40% in the debt-to-GDP ratio is due to the average deficit-to-debt ratio of 0.44%. However, on average, adjusted returns help mitigate the effect of deficits: average adjusted returns are -0.06% per quarter, or -0.24% annually.

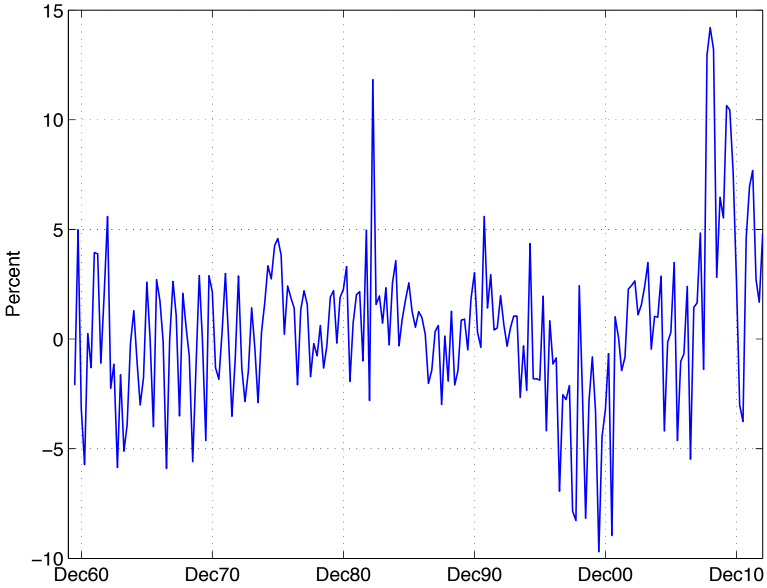

Figure 3: **Deficit to GDP** This plot shows the quarterly time series of the quarterly deficit-to-GDP ratio, $\widehat{D}_t$, as implied from Equation (1). The sample period is 1960–2012.

Table 1: **Summary statistics for debt dynamics and their components** This table reports the mean and standard deviation of debt dynamics and their components in Equations (4) and (8), in percent. We use quarterly observations for the sample period 1960–2012.

	1960–2012		1960–1981		1982–2008.III		2008.IV–2012	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
					Debt dynamics			
$\Delta\widehat{B}_{t+1}$	0.51	4.68	-0.51	3.23	0.47	4.60	5.97	7.35
$r^{nom}_{t+1}\,\widehat{B}_t$	1.73	2.19	0.98	1.09	2.36	2.47	1.63	3.29
$\pi_{t+1}\,\widehat{B}_t$	0.96	0.88	0.93	0.60	1.02	0.78	0.69	2.06
$\gamma_{t+1}\,\widehat{B}_t$	0.74	1.12	0.66	1.02	0.82	1.02	0.60	1.98
$\widehat{D}_{t+1}$	0.47	3.60	0.08	2.66	-0.04	3.40	5.61	4.97
					Growth rates			
$\Delta\widehat{B}_{t+1}/\widehat{B}_t$	0.40	4.25	-0.45	4.16	0.56	3.93	3.68	5.11
r^{nom}_{t+1}	1.57	1.84	1.33	1.63	1.88	1.95	0.93	1.89
π_{t+1}	0.98	0.93	1.35	0.99	0.79	0.66	0.29	1.31
γ_{t+1}	0.65	1.04	0.75	1.25	0.62	0.82	0.29	1.14
$\widehat{D}_{t+1}/\widehat{B}_t$	0.44	3.25	0.30	3.36	0.10	2.94	3.32	3.37

We investigate whether the decomposition of debt dynamics changes over time. To this end, we partition our sample period into subperiods characterized by their level of macroeconomic volatility. Figure 4 plots the time series of real GDP growth and reveals a low-volatility period—also known as the Great Moderation—starting in the early 1980s and lasting until the beginning of the Great Recession, and high-volatility periods prior to and following the Great Moderation. More precisely, our three sub periods are (i) the period prior to the Great Moderation, 1960-1981, (ii) the Great Moderation, 1982-2008.III, and (iii) the post moderation period, 2008.IV-2012. The standard deviation of real GDP growth in these three subperiods is 1.25%, 0.82% and 1.14%, respectively.

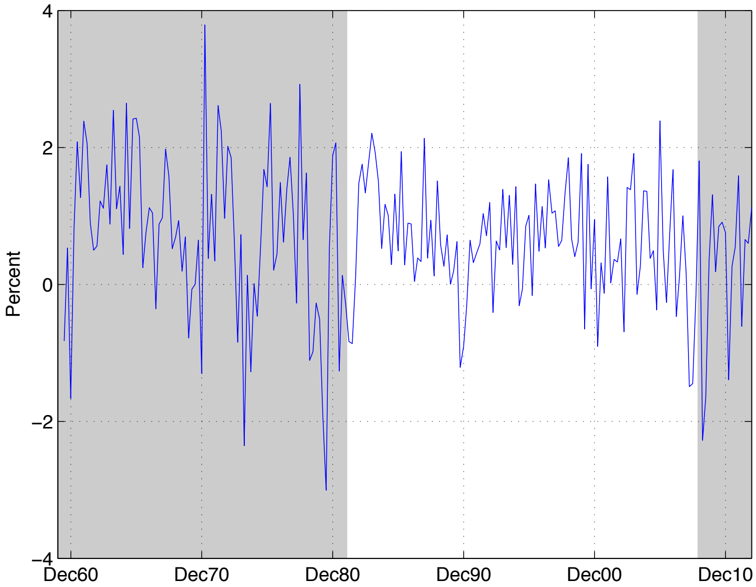

Figure 4: **GDP growth** The plot shows the quarterly time series of real GDP growth. The sample period is 1960–2012.

While one may argue about the precise end point of the Great Moderation, our partition of the sample period is convenient in the sense that the post moderation period coincides with the time period when short-term interest rates were at the zero lower bound and unconventional policy measures were employed by the FOMC. We therefore refer to the time spanned by the first two subperiods, 1960-2008.III, as the conventional monetary policy period, and to the period 2008.IV to 2012 as the unconventional monetary policy period.

The results displayed in the bottom panel of Table 1 show that during the conventional monetary policy regime, debt to GDP declined at an average rate of -0.45% per quarter during the pre-moderation period, and increased at an average rate of 0.56% per quarter during the Great Moderation period. While average adjusted returns were negative during the pre-moderation period at -0.77% per quarter, they were on average positive at 0.47% during the Great Moderation.

During the unconventional monetary policy regime, on the other hand, we observe a dramatic average growth in debt to GDP by 3.68% per quarter. Even though this steep increase in debt to GDP was largely driven by average deficit-to-debt ratios of 3.33%, adjusted returns were sizable and contributed an average of 0.35% to debt to GDP growth. This may perhaps be surprising, given that interest rates were at an unprecedented low during that period. Our findings in the bottom panel of Table 1 show that between 2008.IV and 2012, average real returns were 64 basis points per quarter, or 2.6% per year, and average nominal returns were 93 basis points per quarter, or 3.7% per year. In the next section, we take a closer look at interest costs to identify the sources of these returns.

5. Interest Cost

Using our definition of the market value of debt in Equation (6) and the nominal holding returns on the debt in Equation (7), the nominal interest cost on publicly held debt as a fraction of GDP, IC_{t+1}, can be written as:

$$\begin{aligned} IC_{t+1} &= r^{nom}_{t+1}\widehat{B}^{nom}_t \\ &= \sum_{k=1}^{K} \widehat{s}^k_t (P^{nom,k-1}_{t+1} - P^{nom,k}_t), \end{aligned} \tag{9}$$

where $\widehat{s}^k_t$ is s^k_t divided by nominal GDP in period t.

Equation (9) can be decomposed into three components:

$$\begin{aligned} IC_{t+1} &= \underbrace{\sum_{k=1}^{K} \widehat{s}^k_t (P^{nom,k-1}_t - P^{nom,k}_t)}_{IC^a_{t+1}\text{: Fixed yield curve component}} + \underbrace{\sum_{k=1}^{K} \widehat{s}^k_t (\widetilde{P}^{nom,k-1}_{t+1} - P^{nom,k-1}_t)}_{IC^b_{t+1}\text{: Parallel shift effect}} \\ &\quad + \underbrace{\sum_{k=1}^{K} \widehat{s}^k_t (P^{nom,k-1}_{t+1} - \widetilde{P}^{nom,k-1}_{t+1})}_{IC^c_{t+1}\text{: Tilt effect}}, \end{aligned} \tag{10}$$

where $\widetilde{P}^{nom,k-1}_{t+1}$ is the nominal value at time $t+1$ of a zero-coupon bond with maturity $t+k$, if all nominal yields were to be adjusted by the change in the 1-year yield between t and $t+1$. The first component on the right-hand side of Equation (10), IC^a_{t+1}, is the nominal interest cost that would apply if yields would remain unchanged between time t and $t+1$. We refer to this as the fixed yield curve component. The second component, IC^b_{t+1}, is the added interest cost due to a parallel shift in the yield curve by the change in the short-term yield. We refer to this component as the parallel shift effect on interest costs. The third component, IC^c_{t+1}, is the added interest cost due to a change in the slope of the term structure. It corrects for the over- or undershooting of long-term yields associated with the parallel shift of the yield curve. We refer to this component as the tilt effect.

Table 2 reports summary statistics for the decomposition of interest costs in Equation (10). During our sample period, the average interest cost is 1.73% of GDP. Of this average interest cost, the fixed yield curve component is 1.58% of GDP and the parallel shift effect accounts for 0.18% of GDP. The tilt effect tends to reduce the interest cost by 0.03% of GDP. A similar decomposition pattern—meaning that the fixed yield curve component and parallel shift effect exceed the average interest cost and that the tilt effect helps reduce this cost—is observed during the conventional monetary policy period. However, between 2008.IV and 2012 when unconventional monetary policy is in place, the tilt effect reinforces the shift effect and increases average interest costs by 0.17% of GDP. Even more strikingly, when compared to the Great Moderation years, the tilt effect accounts for an additional 0.25% of GDP of interest costs per quarter during the unconventional monetary policy period.

We further explore the role of the tilt effect during the unconventional monetary policy years using a variance-covariance decomposition:

$$var(IC_{t+1}) \quad = \quad cov(IC_{t+1}, IC^a_{t+1}) + cov(IC_{t+1}, IC^b_{t+1}) + cov(IC_{t+1}, IC^c_{t+1}). \qquad (11)$$

The top panel of Table 3 reports the covariance terms on the right-hand side of Equation (11), as a fraction of the variation in interest cost. These fractions are computed as the β coefficients in the regressions

$$IC^x_{t+1} \quad = \quad \alpha^x + \beta^x \, IC_{t+1} + \varepsilon^x_{t+1}, \qquad (12)$$

Table 2: **Decomposition of nominal interest costs** This table reports the mean and standard deviation of each component of Equation (10), in percent. We use quarterly observations for the sample period 1960–2012.

	1960–2012		1960–1981		1982–2008.III		2008.IV–2012	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
				Interest cost				
	1.73	2.19	0.98	1.09	2.36	2.47	1.63	3.29
(a)	1.58	0.74	1.14	0.33	2.05	0.74	0.90	0.21
(b)	0.18	2.47	-0.15	1.51	0.39	3.10	0.55	1.81
(c)	-0.03	1.22	-0.01	0.61	-0.08	1.39	0.17	2.12
				Nominal returns				
	1.57	1.84	1.33	1.63	1.88	1.95	0.93	1.89
(a)	1.49	0.67	1.54	0.63	1.60	0.63	0.49	0.14
(b)	0.14	2.26	-0.18	2.21	0.37	2.41	0.36	1.13
(c)	-0.05	1.00	-0.03	0.89	-0.10	1.08	0.08	1.13

for $x \in \{a, b, c\}$.

Table 3: **Variance decomposition of nominal interest costs and returns** This table reports the β coefficient estimates in Equation (12). T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly observations for the sample period 1960–2012.

	1960–2012		1960–1981		1982–2008.III		2008.IV–2012	
				Interest cost				
(a)	0.16	(6.43)	0.12	(2.99)	0.13	(4.69)	0.03	(4.19)
(b)	0.93	(11.20)	1.30	(11.48)	1.09	(13.43)	0.43	(3.55)
(c)	-0.09	(-1.05)	-0.42	(-4.44)	-0.22	(-2.90)	0.54	(4.37)
				Nominal returns				
(a)	0.17	(5.77)	0.17	(3.89)	0.16	(4.86)	0.04	(3.90)
(b)	1.07	(12.22)	1.25	(9.62)	1.07	(13.80)	0.49	(4.19)
(c)	-0.23	(-3.13)	-0.43	(-4.22)	-0.23	(-3.40)	0.47	(3.88)

For the full sample, almost all variation in interest costs corresponds to variation in the shift effect, that is, the variation in the adjustment of short-term yields. An increase in interest costs by 10 basis points is associated with an increase in the shift effect by more than 9 basis points. The shift effect is the dominant component for both the pre-moderation and Great Moderation subperiods, when conventional monetary policy is in place, and it is dampened by a significant tilt effect. During the unconventional monetary policy period, however, the shift effect is no longer the dominant component as only 43% of the variation in interest costs corresponds to variation in this effect. At the same time, more than half of the variation in interest costs corresponds to variation in the tilt effect, which now significantly reinforces the shift effect as a consequence of the unconventional monetary policy measures aimed at moving longer-term interest rates. Figure 5 provides further evidence of the importance of the tilt effect since 2008.IV.

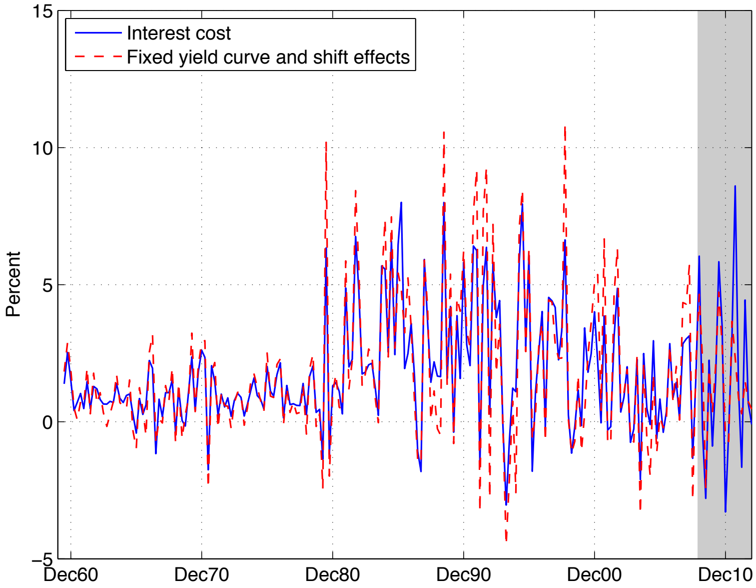

Figure 5: **Interest cost components** This plot shows the quarterly time series of quarterly nominal interest costs, and the sum of the fixed yield curve and shift effects. The sample period is 1960–2012.

To quantify the components of nominal holding returns rather than interest costs, we divide Equation (12) by debt to GDP and obtain

$$
\begin{aligned}
r^{nom}_{t+1} \quad = \quad & \underbrace{\sum_{k=1}^{K} w^k_t \, \frac{P^{nom,k-1}_t - P^{nom,k}_t}{P^{nom,k}_t}}_{r^{nom,a}_{t+1}\text{: Fixed yield curve component}} + \underbrace{\sum_{k=1}^{K} w^k_t \, \frac{\widetilde{P}^{nom,k-1}_{t+1} - P^{nom,k-1}_t)}{P^{nom,k}_t}}_{r^{nom,b}_{t+1}\text{: Parallel shift effect}} \\
& + \underbrace{\sum_{k=1}^{K} w^k_t \, \frac{P^{nom,k-1}_{t+1} - \widetilde{P}^{nom,k-1}_{t+1})}{P^{nom,k}_t}}_{r^{nom,c}_{t+1}\text{: Tilt effect}} .
\end{aligned}
$$

The bottom panel of Table 2 shows that the tilt effect increases nominal returns on government debt by an average of 8 basis points per quarter during the unconventional monetary policy period. In contrast, the tilt effect reduces average returns by 3 to 10 basis points during the earlier periods. Table 3 reveals that during the unconventional monetary policy regime, nearly half of the variation in nominal returns corresponds to variation in the tilt effect, whereas in earlier periods variation in the tilt effect has an offsetting effect.

6. Forecasting Debt Dynamics

While a contemporaneous decomposition of debt dynamics offers important insights into the sources of debt-to-GDP growth, a prediction model is needed to assess the potential impact of new fiscal and monetary policies on future changes in debt to GDP and its interest cost and primary deficit components. Equations (6) and (9) state that we can predict debt to GDP growth as the sum of predicted adjusted returns and predicted primary deficit-to-debt ratios.

6.1 Forecasting adjusted bond returns

To predict adjusted returns, we build a state vector that includes variables known to predict nominal returns, inflation and real GDP growth. Fama and Bliss (1987), Campbell and Shiller (1991) and Cochrane and Piazzesi (2005) argue that nominal returns can be predicted using a combination of forward rates. Figure 6 displays the maturity structure of U.S. government debt during our sample period. The value weighted maturity fluctuates between 1 and 4 years, indicating that outstanding government liabilities tend to be short- and medium-term liabilities. We therefore estimate the predictive regression

$$r_{t+1}^{nom} \quad = \quad a + b_1 \, f_t^1 + b_3 \, f_t^3 + b_5 \, f_t^5 + \epsilon_{t+1}, \tag{13}$$

where f_t^n is the n-year forward rate at time t, that is, the log forward rate for loans between time $t+n-1$ and $t+n$.

Table 4 reports that for the conventional monetary policy regime, the prediction R^2 for the model in Equation (13) is 23.5%. The estimated linear combination of forward rates that best predicts bond returns exhibits the tent shape described in Cochrane and Piazzesi (2005). Table 5 reveals that for the conventional monetary policy regime, the predictive power of the 1-, 3- and 5-year forward rates for bond returns is largely due to their predictive power for the fixed yield curve component of returns. This is intuitive since together the 1-, 3- and 5-year forward rates offer a close description of the short- and medium-term portion of the

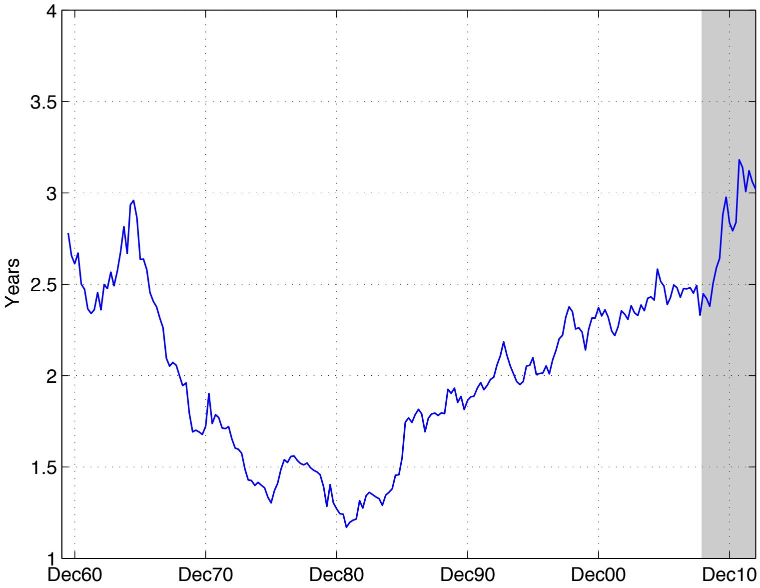

Figure 6: **Maturity structure of publicly held debt** This plot shows the market value weighted maturity (in years) of publicly held debt. The sample period is 1960–2012. The shaded area identifies the unconventional monetary policy regime where the federal funds rate is less than 25 basis points.

yield curve and hence, in light of Figure 6, of the fixed yield curve component. In contrast, the forward rates have little to no predictive power for the parallel shift and tilt effects.

Table 4 also reveals that during the conventional monetary policy regime, the 3-year forward rate alone explains almost as much of the variation in future bond returns as the 1-, 3- and 5-year forward rates combined. This, however, is no longer the case during the unconventional monetary policy regime. Between 2008.IV and 2012, the 3-year forward rate alone explains only 6.4% of the variation in future bond returns. Controlling for f^1 in addition to f^3 raises the prediction R^2 dramatically, from 6.4% to 52.1%. This steep increase in R^2 is consistent with combinations of short- and medium-term forward rates offering a more reliable prediction of future rates during the unconventional monetary police years when the FOMC was committed to lowering interest rates across maturities. Further evidence of the lower level of uncertainty regarding future rates changes between 2008.IV to 2012 is provided in Table 2, which reports a relatively low volatility for the parallel shift component during that time.

Table 4: **Predicting nominal bond returns** The table shows the results for regression (13). T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly returns and quarterly observations for the sample period 1960–2012. "Conventional monetary policy" refers to the subperiod where the federal funds rate is 25 basis points or higher.

	Conventional monetary policy						
constant	-0.001	-0.007	-0.006	-0.007	-0.005	-0.006	-0.006
	(-0.387)	(-2.157)	(-1.694)	(-2.091)	(-1.425)	(-1.638)	(-1.753)
f^1	0.292			-0.007	0.151		-0.045
	(5.587)			(-0.045)	(1.654)		(-0.262)
f^3		0.343		0.350		0.507	0.572
		(6.955)		(2.259)		(3.276)	(1.824)
f^5			0.327		0.181	-0.174	-0.196
			(5.624)		(1.663)	(-1.020)	(-0.956)
R^2	0.198	0.230	0.200	0.230	0.213	0.234	0.235
adj R^2	0.194	0.226	0.196	0.222	0.205	0.226	0.222
	Unconventional monetary policy						
constant	0.014	-0.002	-0.008	0.009	-0.003	-0.013	0.025
	(1.813)	(-0.374)	(-1.209)	(1.715)	(-0.421)	(-1.220)	(2.920)
f^1	-2.189			-13.032	-8.331		-16.603
	(-0.933)			(-4.801)	(-4.063)		(-6.184)
f^3		0.542		2.528		-1.226	5.235
		(1.688)		(5.909)		(-0.584)	(2.657)
f^5			0.449		1.162	1.243	-1.521
			(2.444)		(4.864)	(0.935)	(-1.323)
R^2	0.037	0.064	0.097	0.521	0.392	0.123	0.574
adj R^2	-0.032	-0.003	0.032	0.447	0.298	-0.012	0.467

Table 5: **Predicting nominal bond return components** The table shows the adjusted R^2 for regression (13) with r_{t+1}^{nom} replaced by $r_{t+1}^{nom,a}$, $r_{t+1}^{nom,b}$ or $r_{t+1}^{nom,c}$. We use quarterly returns and quarterly observations for the sample period 1960–2012. "Conventional monetary policy" refers to the subperiod where the federal funds rate is 25 basis points or higher.

	Conv mon policy			Unconv mon policy		
	$r^{nom,a}$	$r^{nom,b}$	$r^{nom,c}$	$r^{nom,a}$	$r^{nom,b}$	$r^{nom,c}$
f^1	0.941	0.021	0.024	0.402	-0.058	0.005
f^3	0.966	0.021	0.009	0.910	0.038	-0.071
f^5	0.899	0.012	0.002	0.929	0.054	-0.067
f^1, f^3	0.989	0.017	0.032	0.943	0.423	0.080
f^1, f^5	0.987	0.016	0.037	0.924	0.229	0.051
f^3, f^5	0.966	0.026	0.019	0.937	-0.018	-0.092
f^1, f^3, f^5	0.992	0.021	0.032	0.944	0.522	0.008

We take these findings into account when building a prediction model for adjusted returns,

$$r_{t+1}^{a} = \alpha_r + X_t\,\beta_r' + \varepsilon_{r,t+1}. \tag{14}$$

To predict the nominal return component of r^a, we include a dummy variable 1_{ZLB} in the state vector X that equals one during the unconventional monetary policy regime when the federal funds rate is less than 25 basis points, and zero otherwise. We control for 1-, 3- and 5-year forward rates, as well as their interaction with 1_{ZLB}.

To predict future inflation we also control for past inflation, and to predict future GDP growth we add a leading variable, in particular housing starts, to the state vector.[8] As for fiscal variables, the empirical literature testing the effects of deficits, debt, government spending and tax revenue on bond returns is divided on which quantities are most relevant.[9] We therefore use the government's budget constraint to identify relevant fiscal factors. Equation (8) states that growth in debt to GDP is equal to adjusted returns plus the deficit-to-debt ratio. Since current deficits have predictive power for future deficits they may impact future bond prices. Hence we include GB_t and TB_t in X_t, where GB_t is the ratio between government expenditures as reported in NIPA for period $(t-1,t]$ and time-$(t-1)$ debt, and TB_t is a similar ratio of government receipts as reported in NIPA and beginning-of-period debt.[10] In summary, the state vector X is specified as

$$X \quad = \quad (1_{ZLB}, f^1, f^3, f^5, f^1 1_{ZLB}, f^3 1_{ZLB}, f^5 1_{ZLB}, \pi, \text{houst}, GB, TB), \tag{15}$$

Table 6 reports the prediction results for adjusted returns in the last column and its three components—nominal returns, inflation and GDP growth. Variation in the state vector explains 28% of the variation in quarterly nominal returns, 43% of the variation in quarterly

---

[8] While past inflation is measured as past quarterly inflation, housing starts are measured as year-on-year growth. We experimented with other leading variables, but found that the combination of housing starts and the Treasury yield level, slope and curvature, as captured by $\{f^1, f^3, f^5\}$, provided the most powerful results.

[9] See for example, Laubach (2003), Laubach (2009), Tavares and Valkanov (2003) and Dai and Philippon (2005).

[10] See NIPA Table 3.2, Federal Government Current Receipts and Expenditures, seasonally adjusted and measured in billions of dollars. Government expenditures include current expenditures (Line 41), gross government investment (Line 42), and capital transfer payments (Line 43). We subtract consumption of fixed capital (Line 45) and debt interest payments (Line 29) from current expenditures. Government receipts are total receipts (Line 37 of NIPA Table 3.2)—which include current tax receipts, contributions for social insurance, income receipts on other assets and current transfer receipts—plus seignorage revenue. We compute seignorage revenue at time t as $(M_t - M_{t-1})/CPI_t$, where M_t is the monetary base at time t and CPI_t is the price level defined by the consumer price index at t. Seignorage revenue therefore includes the "inflation tax", the resources generated from adjusting the real value of the existing monetary base, and the real value of revenues from a change in the monetary base. The monetary base data are the St. Louis Adjusted Monetary Base (AMBSL) series, seasonally adjusted and measured in billions of dollars.

inflation and 30% of the variation in quarterly GDP growth. The resulting R^2 for adjusted returns is 21%.

Table 6: **Forecasting adjusted bond returns** The table shows the regressions results for Equation (14). The state vector X is specified as in Equation (15). T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly observations for the sample period 1960–2012.

	r^{nom}	π	γ	r^a
constant	0.002	-0.005	0.015	-0.008
	(0.315)	(-1.842)	(4.884)	(-1.058)
1_{ZLB}	0.026	-0.007	-0.004	0.037
	(2.386)	(-0.947)	(-0.495)	(2.698)
f^1	-0.030	0.253	-0.048	-0.235
	(-0.122)	(3.644)	(-0.432)	(-0.759)
f^3	0.510	-0.366	0.228	0.648
	(1.468)	(-3.155)	(1.292)	(1.384)
f^5	-0.155	0.206	-0.252	-0.108
	(-0.793)	(2.498)	(-2.358)	(-0.416)
$f^1 \times 1_{ZLB}$	-17.376	3.131	-5.076	-15.431
	(-5.654)	(1.348)	(-2.310)	(-3.946)
$f^3 \times 1_{ZLB}$	4.414	-1.399	1.993	3.819
	(2.067)	(-1.257)	(2.023)	(1.446)
$f^5 \times 1_{ZLB}$	-1.181	0.768	-0.743	-1.207
	(-1.035)	(1.294)	(-1.497)	(-0.866)
π	0.173	0.073	0.045	0.055
	(1.202)	(0.849)	(0.551)	(0.301)
houst	-0.010	0.000	0.019	-0.029
	(-1.954)	(0.017)	(6.991)	(-3.767)
TB	-0.088	0.077	-0.152	-0.014
	(-1.033)	(1.826)	(-3.513)	(-0.116)
GB	0.045	-0.029	0.136	-0.062
	(0.593)	(-0.714)	(3.326)	(-0.555)
R^2	0.279	0.426	0.302	0.210
adj R^2	0.239	0.394	0.263	0.166

For nominal returns, the ZLB dummy and its interaction terms with 1-year and 3-year forward rates are significant at the 5% confidence interval level. Our results suggest that explicitly accounting for the monetary policy regime is important for predicting nominal returns and, by extension, adjusted returns. For inflation, the three forward rates–f^1, f^3 and f^5—are the only significant variables. The Treasury yield curve predicts one quarter ahead inflation, without a significant additional contribution from past inflation or housing starts. For GDP growth, housing starts and the fiscal factors are the most significant predictor variables.

6.2 *Forecasting deficit-to-debt ratios*

Table 7 documents that our state vector X also has predictive power for future deficit-to-debt ratios:

$$\frac{\widehat{D}_{t+1}}{\widehat{B}_t} \;=\; \alpha_d + X_t\,\beta_d' + \varepsilon_{d,t+1}. \tag{16}$$

Indeed, variation in X_t explains 35% of the variation in $DB_{t+1} = \widehat{D}_{t+1}/\widehat{B}_t$. Not surprisingly, much of the predictive power comes from the fiscal variables GB_t and TB_t.

Table 7: **Forecasting deficit-to-debt ratios** The table shows the regressions results for Equation (16), using DB as a short-cut for defict-to-debt ratios. The state vector X is specified as in Equation (15). T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly observations for the sample period 1960–2012.

	GB	TB	DB^{res}	DB
constant	0.006	0.019	0.000	-0.013
	(2.350)	(3.654)	(-0.008)	(-1.428)
1_{ZLB}	-0.008	-0.026	-0.002	0.016
	(-1.321)	(-1.921)	(-0.110)	(0.738)
f^1	0.038	0.402	0.562	0.199
	(0.549)	(3.393)	(2.838)	(1.041)
f^3	0.056	-0.257	-0.418	-0.105
	(0.492)	(-1.401)	(-1.151)	(-0.312)
f^5	-0.185	-0.251	-0.025	0.041
	(-2.294)	(-1.846)	(-0.083)	(0.144)
$f^1 \times 1_{ZLB}$	0.464	1.712	-8.420	-9.669
	(0.326)	(0.397)	(-1.293)	(-1.631)
$f^3 \times 1_{ZLB}$	-0.175	-0.655	2.300	2.780
	(-0.225)	(-0.251)	(0.729)	(0.657)
$f^5 \times 1_{ZLB}$	0.315	0.623	-0.770	-1.077
	(0.721)	(0.449)	(-0.485)	(-0.454)
π	0.316	0.415	-0.780	-0.879
	(4.247)	(2.475)	(-3.218)	(-2.932)
houst	0.003	0.014	-0.011	-0.022
	(1.088)	(3.029)	(-1.000)	(-1.873)
TB	0.179	0.896	-0.223	-0.941
	(4.195)	(10.331)	(-1.295)	(-5.861)
GB	0.806	0.039	0.281	1.049
	(20.347)	(0.557)	(1.728)	(6.929)
R^2	0.988	0.980	0.099	0.350
adj R^2	0.987	0.978	0.049	0.314

We decompose the deficit-to-debt ratio into a NIPA-based expenditure to debt ratio, a

NIPA-based receipt-to-debt ratio, and a residual component:

$$DB_{t+1} \quad = \quad GB_{t+1} - TB_{t+1} + DB^{res}_{t+1}. \tag{17}$$

The residual component, DB^{res}, is defined as the difference between our measured deficit-to-debt ratio, DB, and the one calculated from NIPA data, $GB - TB$. It may deviate from zero because primary deficits reported in NIPA are based on an interest cost calculation that fails to account for capital gains or losses on longer term debt obligations, as pointed out by Hall and Sargent (2011).

Figure 7 plots our measured deficit-to-debt ratio against the NIPA reported one in the left panel, and their difference in the right panel. On average across the whole sample, the residual component amounts to 0.47% of debt, with a standard deviation of 2.8%. Much of the volatility of the residual component is observed during the pre-moderation period.

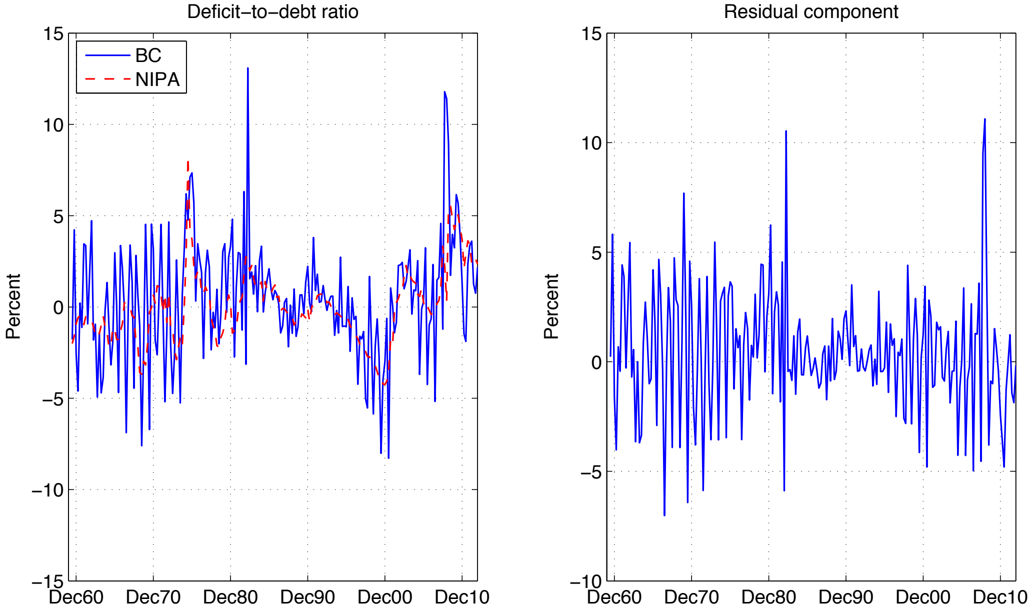

Figure 7: **Deficit-to-debt ratios** The left panel shows the deficit to debt ratio, as implied by the budget constraint (solid) and as reported by NIPA (dashed line). The right panel shows the difference of the two deficit to debt measures, DB^{res}. The sample period is 1960–2012.

The first two columns of Table 7 report the results from the prediction regressions (16), with defict to debt replaced by GB or TB. They show that one quarter ahead GB and TB can be predicted almost perfectly by their past. The third column reports the prediction regression results for the residual deficit to debt component. We find that DB^{res} is difficult to predict. Only past inflation and the 1-year forward rate are significant, and the R^2 is less than 10%.

6.3 Forecasting debt-to-GDP growth

We combine our results from Tables 6 and 7 to predict debt-to-GDP growth. Figure 8 shows the time series of realized and predicted debt-to-GDP growth. It reveals that our prediction model captures the overall trend in debt-to-GDP growth well, but that our predictions generate less volatility than that observed for quarterly growth rates.

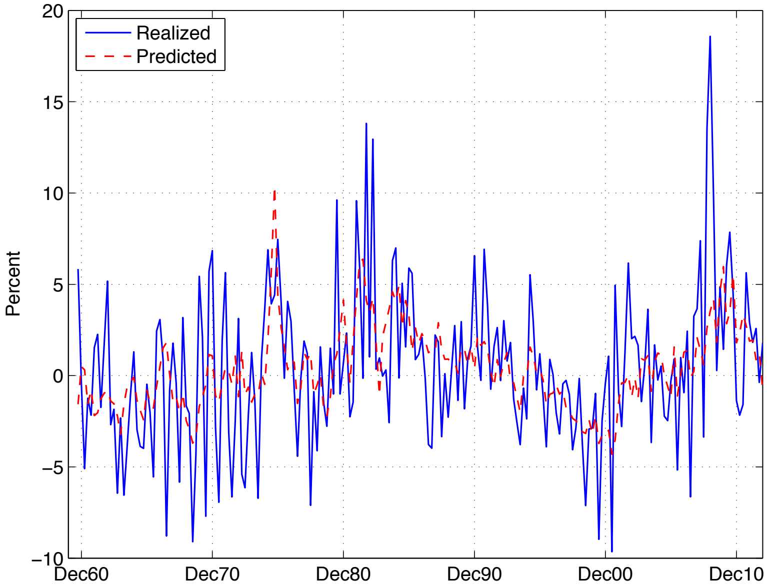

Figure 8: **Realized and predicted debt-to-GDP growth** This plot shows the realized and predicted debt-to-GDP growth. Predicted debt-to-GDP growth is computed using the results in Tables 6 and 7. The sample period is 1960–2012.

Figure 9 shows the time series of realized and predicted debt-to-GDP ratios. We predict the temporal pattern of one quarter ahead debt to GDP rather well, with a tracking error of about 3.9% of quarterly GDP, or less than 1% of annualized GDP.

Our findings in Table 6 show that the the current monetary policy regime is an important predictor of future bond returns. At the same time, Table 7 reveals that the ZLB dummy and interaction terms play less of a role when predicting future deficit-to-debt ratios. Combined, our results suggest that any prediction model for future debt-to-GDP growth should

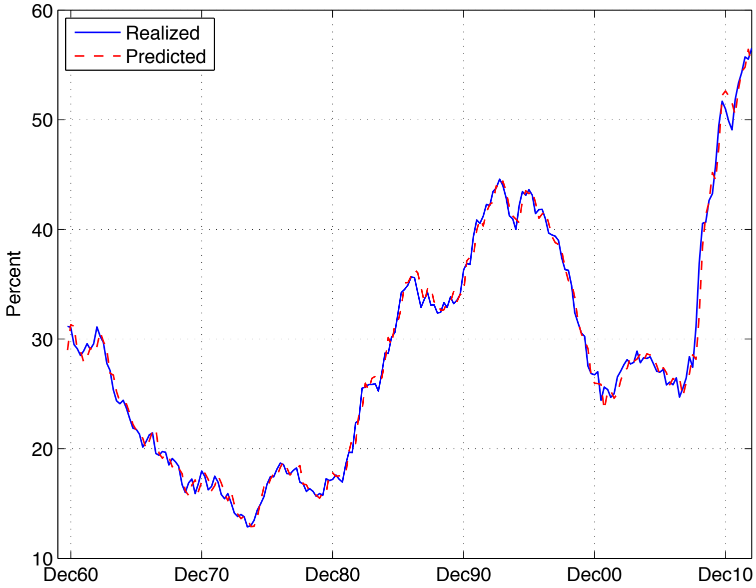

Figure 9: **Realized and predicted debt-to-GDP ratios** This plot shows the realized and predicted debt-to-GDP ratios. Predicted debt-to-GDP ratios are computed using the results in Tables 6 and 7. For the purpose of this plot, we quarterly GDP is annualized. The sample period is 1960–2012.

incorporate information about the current monetary policy regime, because the monetary policy regime impacts debt to GDP through interest costs. We further support this claim by quantifying the increase in average prediction errors when the ZLB dummy and its interactions terms are removed from the state vector in Equation (15). The results are reported in Table 8 and show that without conditioning on the monetary policy regime, during the unconventional regime the average prediction error for nominal interest costs would be 0.6% of GDP, or $24 billion, higher per quarter. The mismeasurement of interest costs distorts debt to GDP forecasts as well: The average prediction error for debt to GDP would be $25 billion higher per quarter.

7. A Comparison to CBO Debt-to-GDP Forecasts

In this section, we compare our debt-to-GDP forecasts to those made by the CBO. The CBO is the most widely cited source of fiscal forecasts. It reports, however, projections for the face rather than the market value of government debt. Figure 10 shows the time series of our and the CBO's measure of debt to GDP. Clearly, market values of debt are smaller than

Table 8: **Prediction errors** The table shows the results for regression (15). T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly returns and quarterly observations for the sample period 1960–2012. "Conventional monetary policy" refers to the subperiod where the federal funds rate is 25 basis points or higher.

	Conventional monetary policy		Unconventional monetary policy	
	ZLB dummies	No ZLB dummies	ZLB dummies	No ZLB dummies
	Percent of GDP			
$\widehat{B}_{t+1}$	2.7	2.7	5.1	5.8
$r^{nom}_{t+1}\,\widehat{B}_t$	1.3	1.3	1.6	2.2
$\pi_{t+1}\,\widehat{B}_t$	0.5	0.5	1.1	1.2
$\gamma_{t+1}\,\widehat{B}_t$	0.7	0.7	1.2	1.5
$\widehat{D}_{t+1}$	2.0	2.0	2.9	3.0
	In billion USD			
B_{t+1}	36.4	36.5	187.3	212.5
$r^{nom}_{t+1}\,B_t$	19.8	19.9	58.3	82.5
$\pi_{t+1}\,B_t$	8.1	7.9	42.2	43.5
$\gamma_{t+1}\,B_t$	9.8	9.6	44.3	56.3
D_{t+1}	21.1	21.8	105.7	111.1

face values, but importantly, they are also more volatile and therefore harder to predict.

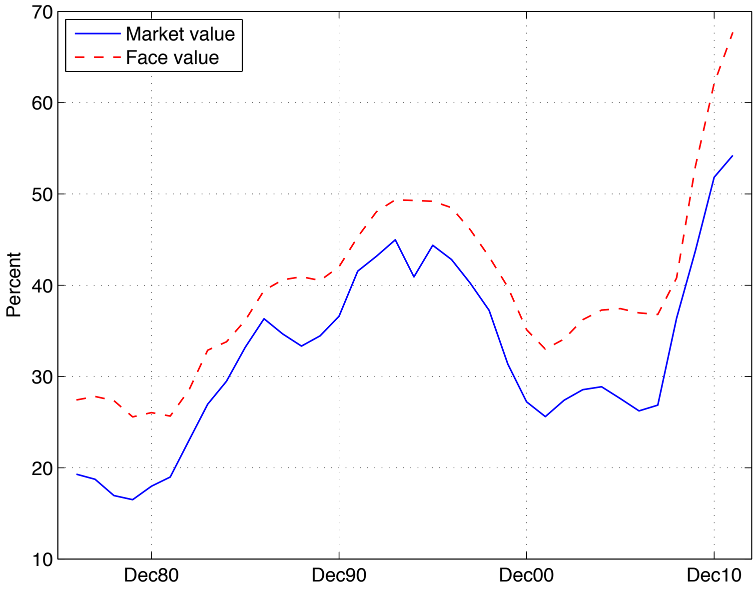

Figure 10: **Debt to GDP ratios using face and market value of debt** This plot shows the annual time series of debt-to-GDP ratios based on the market value of debt (solid line) and the face value of debt as reported by the CBO (dashed line). The sample period is 1976–2012.

To align ourselves with the CBO's timing, we re-interpret the period length in the budget constraint (1) as one year rather than one quarter, and obtain estimates for annual debt-to-GDP growth, adjusted returns and deficit-to-debt ratios. We re-estimate our prediction models in Equations (14) and (16) using quarterly data on annual adjusted returns and deficit-to-debt ratios. The state vector X in Equation (15) remains the same except that inflation, GB and TB are now expressed as annual rather than quarterly rates.[11] The results are summarized in Table 9.

Table 9: **Forecasting annual adjusted bond returns and deficit-to-debt ratios** The table shows the regressions results for Equations (14) and (16), using quarterly data for annual adjusted returns and deficit-to-debt ratios. The state vector X is specified as in Equation (15), except that inflation, GB and TB are measured on an annual rather than quarterly basis. T-statistics are calculated using Newey-West standard errors with 4 lags and reported in parentheses. We use quarterly observations for the sample period 1960–2012.

	r^{nom}	π	γ	r^a	GB	TB	DB^{res}	DB
constant	-0.008	0.008	0.032	-0.047	0.066	0.154	-0.008	-0.097
	(-0.747)	(0.684)	(4.013)	(-2.483)	(2.510)	(4.100)	(-0.282)	(-2.258)
1_{ZLB}	0.031	-0.011	-0.010	0.052	0.056	-0.044	-0.093	0.006
	(0.793)	(-0.328)	(-0.301)	(1.413)	(0.754)	(-0.445)	(-0.991)	(0.044)
f^1	-0.655	0.924	-0.128	-1.451	0.460	3.544	0.182	-2.902
	(-1.993)	(3.538)	(-0.449)	(-2.854)	(1.111)	(4.828)	(0.493)	(-3.746)
f^3	2.373	-1.303	0.596	3.080	-0.007	-2.393	0.112	2.498
	(5.363)	(-2.960)	(1.714)	(4.230)	(-0.010)	(-1.858)	(0.132)	(1.790)
f^5	-0.549	0.436	-0.428	-0.556	-1.724	-2.191	-0.188	0.279
	(-2.101)	(1.594)	(-1.904)	(-1.196)	(-2.284)	(-2.079)	(-0.256)	(0.255)
$f^1 \times 1_{ZLB}$	-18.171	6.394	-14.615	-9.950	-48.552	-52.200	0.746	4.393
	(-1.957)	(1.073)	(-2.337)	(-1.002)	(-3.237)	(-2.485)	(0.054)	(0.213)
$f^3 \times 1_{ZLB}$	-1.269	0.389	1.488	-3.146	8.002	10.372	-0.001	-2.370
	(-0.239)	(0.220)	(0.473)	(-0.821)	(1.235)	(0.981)	(0.000)	(-0.268)
$f^5 \times 1_{ZLB}$	2.381	-0.432	0.141	2.672	-0.432	-0.034	1.148	0.750
	(0.749)	(-0.338)	(0.071)	(1.159)	(-0.109)	(-0.005)	(0.275)	(0.122)
π	-0.152	0.515	-0.378	-0.289	0.732	0.478	0.595	0.849
	(-0.860)	(3.122)	(-2.512)	(-1.040)	(1.753)	(0.966)	(2.727)	(1.765)
houst	-0.040	0.018	0.037	-0.096	-0.082	0.038	-0.042	-0.162
	(-2.967)	(1.451)	(3.594)	(-3.837)	(-3.036)	(0.944)	(-1.151)	(-2.791)
TB	0.007	0.007	-0.058	0.058	0.829	1.232	0.000	-0.403
	(0.129)	(0.157)	(-1.678)	(0.614)	(5.396)	(9.549)	(0.003)	(-2.443)
GB	-0.023	0.012	0.071	-0.107	0.160	-0.337	0.017	0.513
	(-0.456)	(0.321)	(2.267)	(-1.200)	(0.989)	(-2.814)	(0.162)	(3.218)
R^2	0.677	0.644	0.528	0.550	0.968	0.954	0.385	0.534
adj R^2	0.658	0.624	0.501	0.524	0.966	0.951	0.350	0.507

Our regression R^2s improve drastically when moving from a quarterly to an annual fore-

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[11] Remember that housing starts have been defined as a year-on-year rate.

casting horizon, mainly because annual returns and deficit-to-debt ratios are less volatile than their quarterly counterparts. Our prediction model explains 55% of the variation in one year ahead annual adjusted returns and 53% of the variation in next year's deficit-to-debt ratios. For adjusted returns, interaction terms with the ZLB dummy remain significant.

We use our results from Table 9 to predict annual debt-to-GDP growth. Figure 11 shows the time series of realized and predicted annual debt-to-GDP growth. It reveals that our prediction model captures a large fraction of the movements in annual debt-to-GDP growth. Figure 12 shows the time series of realized and predicted debt-to-GDP ratios. We still predict the temporal pattern of one year ahead debt to GDP rather well, with a tracking error of about 2.1% of annual GDP.

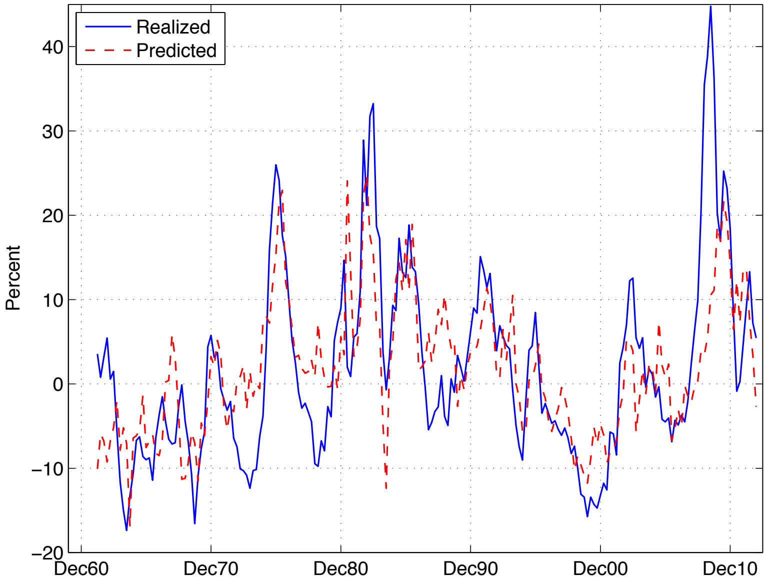

Figure 11: **Realized and predicted annual debt-to-GDP growth** This plot shows the realized and predicted annual debt-to-GDP growth. Predicted debt-to-GDP growth is computed using the results in Table 9. The sample period is 1960–2012.

To compare the forecasting accuracy of our model to that of the CBO, for each year between 1976 and 2012, we estimate predictive regressions that use only historical data to compute a one year ahead forecast of debt to GDP. The time series of realized and forecasted annual debt-to-GDP ratios is plotted in the left panel of Figure 13. We find that our forecasting errors are comparable to those by the CBO, which are shown in the right

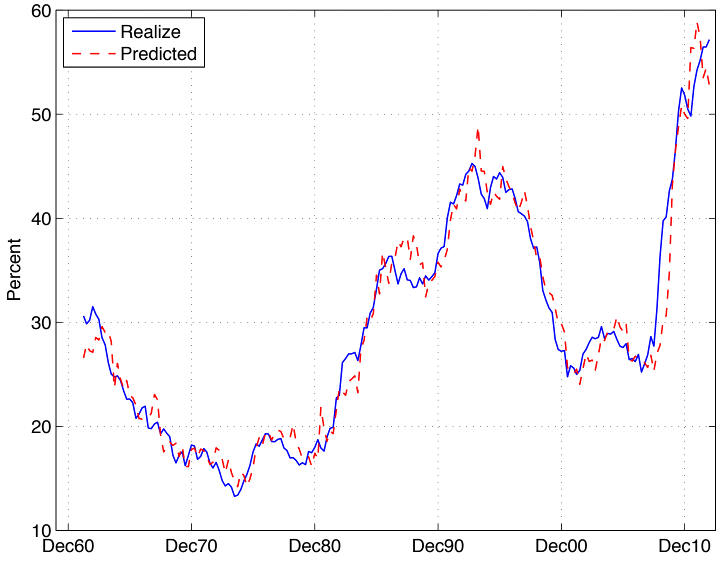

Figure 12: **Realized and predicted annual debt-to-GDP ratio** This plot shows the realized and predicted annual debt-to-GDP ratios. Predicted debt-to-GDP ratios are computed using the results in Table 9. The sample period is 1960–2012.

panel of the figure, even though we face the added challenge of predicting capital gains and losses on outstanding government debt obligations.

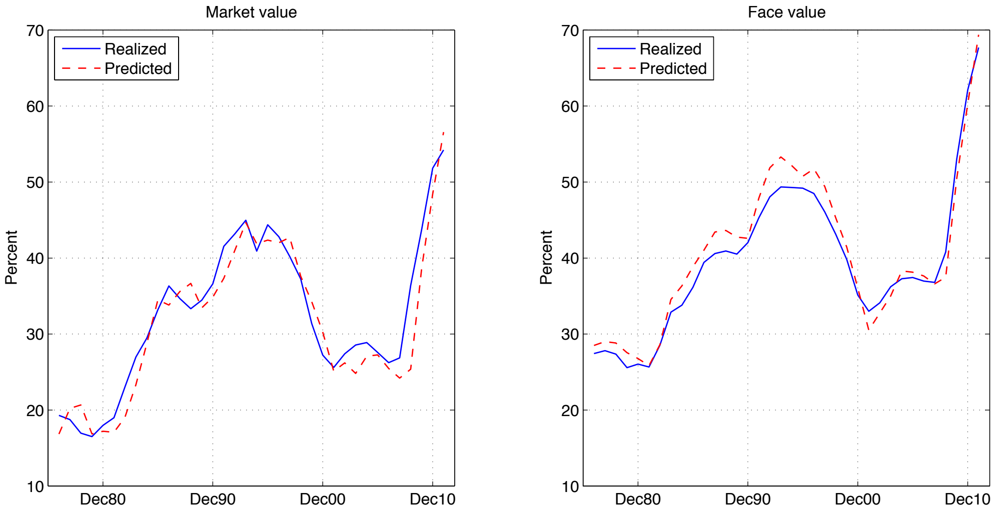

Figure 13: **Realized annual debt-to-GDP ratios and their forecasts** The left panel shows the realized debt to GDP ratio using market value of debt and its forecast based on a rolling estimation of Equations (14) and (16), using quarterly data for annual adjusted returns and deficit-to-debt ratios. The right panel shows the equivalent CBO data. The sample period is 1976–2012.

8. Conclusion

Beginning in late 2008, as a response to the financial events that triggered the Great Recession, the Federal Reserve embarked on monetary policy actions regarded as unconventional and controversial. In addition to a dramatic increase in the monetary base, the Federal Reserve started buying long-term assets, private and public, in an effort to reduce long-term interest rates in the economy. Analyzing the effects of this recent monetary policy has become a fertile ground for research, as future policy design rests on fully understanding the distortions and benefits associated with these unconventional policies on bond markets, private borrowing costs and the real economy.

We contribute to this growing literature by quantifying the effect of these unprecedented policies on the government's fiscal balances, specifically on its interest costs and future debt obligations. We provide a decomposition of the government's fiscal balances between 1960 and 2012, and show that the unconventional policies aimed at reducing longer term yields actually adversely affected fiscal balances, through the impact they had on interest costs. We then offer a prediction model for debt dynamics, and show that conditioning on the monetary policy regime employed significantly improves the performance of our interest cost and debt-to-GDP forecasts. Our findings suggest that any prediction model for future debt dynamics should incorporate information about the current monetary policy regime to provide more accurate projections for future fiscal and monetary policies.

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