Government Debt and Risk Premia

Yang Liu*

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Abstract

I document that government debt is related to risk premia in various asset markets: (i) the debt-to-GDP ratio positively predicts excess stock returns with out-of-sample R^2 up to 30% at a five-year horizon, outperforming many popular predictors; (ii) the debt-to-GDP ratio is positively correlated with credit risk premia in both corporate bond excess returns and yield spreads; (iii) higher debt-to-GDP ratio is associated with lower real risk-free rates, (iv) higher debt-to-GDP ratio corresponds to lower average expected returns on government debt; (v) debt-to-GDP ratio positively comoves with fiscal policy uncertainty. I rationalize these empirical findings in a general equilibrium model featuring recursive preferences, endogenous growth, distortionary taxation, and time-varying fiscal uncertainty. In the model, the tax risk premium is sizable and its time variation is driven by fiscal uncertainty. Furthermore, the model generates an endogenous relationship between the debt-to-GDP ratio and fiscal uncertainty. Fiscal uncertainty increases debt valuation through lower government discount rate. This mechanism is reinforced as higher debt conversely raises uncertainty in future fiscal consolidations. (JEL E62, G12, G17, H63)

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[*] Yang Liu (liuyang5@sas.upenn.edu) is at the Department of Economics, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104. I am immensely grateful to my advisors Amir Yaron, Enrique Mendoza, Frank Schorfheide, and Ivan Shaliastovich for their invaluable guidance and advice. I also thank Ravi Bansal, Ric Colacito, Hal Cole, Max Croce, João Gomes, Urban Jermann, Dirk Krueger, Nick Roussanov, Tom Sargent, Lukas Schmid, and seminar participants at Penn, Wharton, Philly Fed, and EconCon for helpful discussions. I thank George Hall for government debt data. All errors are my own.

1. Introduction

The government debt is of great importance to the economy, policymaking, and financial markets. This paper documents a set of new facts about the effects of government debt on asset prices in the United States. High debt-to-GDP ratios are related to high equity risk premia, high credit risk premia, low risk-free rates, low expected returns on government debt, and high fiscal policy uncertainty. I rationalize these facts in a general equilibrium model featuring a fiscal uncertainty channel that links government debt and asset prices.

The importance of government debt is manifested in equity, credit and treasury markets. First, high debt-to-GDP ratio corresponds to high equity premium. The debt-to-GDP ratio positively predicts excess stock returns at horizons from one quarter to five years. The ratio contains useful information beyond a large number of existing predictors, thus improving the predictive power. In a univariate predictive regression using debt-to-GDP ratio, the out-of-sample R^2 is 10% at an annual horizon and reaches 30% at a five-year horizon. In comparison, the out-of-sample R^2 of many popular predictors are marginally positive. A strategy that times the market using debt-to-GDP ratio can generate an excess return of 14.71% per annum with a Sharpe ratio of 0.66, while a buy and hold strategy of the market portfolio yields a Sharpe ratio of 0.3.

In credit markets, I observe a similar pattern that high debt-to-GDP ratios are related to high credit risk premia. One measure of credit risk premia is the expected excess return on corporate bonds. The debt-to-GDP ratio positively predicts excess returns on investment-grade and high-yield corporate bonds. The magnitude is close to the stock return predictability. Another measure of credit risk premium is a yield spread. I document that government debt raises the credit premium component of yield spreads.

The first two findings show that high debt-to-GDP ratio implies high cost of capital for firms. Regarding the cost of capital for government, however, high debt-to-GDP ratios are associated with low real risk-free rates and low expected returns on government debt. Both 1-month and 3-month real risk-free rates are negatively related to the debt-to-GDP ratio, controlling for expected growth and inflation. Furthermore, I examine the discount rate of the government. Since the government does not only issue short-term debt, the government discount rate or effective borrowing cost is the average return across terms to maturity on all the Treasury securities. In the default-free case, the government budget constraint implies that a high debt-to-GDP ratio can stem from three channels: (i) high expected future primary surplus to pay off the debt, (ii) high expected future growth to stabilize the ratio, and (iii) low expected future returns on government debt. The previous studies mainly focus on the first two channels. Here I document that the third discount rate channel is empirically important:[1] the debt-to-GDP ratio negatively predicts returns on government debt. I

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[1] This discount rate channel is addressed differently in several papers. Hall and Sargent (2011) show variations in realized returns affect the evolution of the debt-GDP ratio. Berndt et al. (2012) find that part of a fiscal spending shock

use a present value decomposition in a vector autoregression to quantify the relative contribution of these three components. The variation of expected returns accounts for 25% of the variation of the debt-to-GDP ratio.

Why does government debt have such significant effects on asset prices? Major existing channels of government debt such as liquidity, safety, and crowding out are silent or inconsistent with these facts. I propose a new channel—fiscal uncertainty—that can rationalize the empirical findings jointly. I propose a broad-based measure of fiscal policy uncertainty by utilizing 169 macro variables and estimating a dynamic factor model with stochastic volatility. In the data-rich environment, fiscal policy consists of 37 variables regarding various types of tax, spending and transfer. Fiscal uncertainty is measured as the common component of the conditional forecast error volatility of these fiscal policy instruments. Empirically, fiscal uncertainty fluctuates over time and positively comoves with the debt-to-GDP ratio with a correlation of 0.5. Therefore, government debt encodes the risks in fiscal policy that drive the variation of risk premia. I present direct evidence that fiscal uncertainty affects asset prices in equity, credit, and treasury markets in the same directions and has similar magnitudes as the debt-to-GDP ratio.

Within a general equilibrium model, I quantify the effects of government debt and fiscal uncertainty on asset prices. The key ingredients of the model include recursive preferences, endogenous growth through innovation, and fluctuations in the volatility of distortionary corporate income tax. Tax hikes depress innovation and economic growth so that persistent tax changes are a source of endogenous long-run risks. Stock prices drop with tax hikes because of the tax payment and the lower cash flow growth. For fear of the joint decrease of growth prospects and stock prices, agents demand a large equity premium for tax risks. This risk compensation is even larger when the "quantity" of risk increases in times of high fiscal uncertainty. Hence, time variation in equity premium is driven by fiscal uncertainty. In contrast, non-defaultable government bonds rally in times of high tax, because lower expected growth induces the agents to purchase safe bonds. Thus, government bonds hedge against tax risks for investors and have negative risk premia. In time of high fiscal uncertainty, the hedging motive drives down the government bond premium. Moreover, uncertainty increases the precautionary saving motive and lowers the risk-free rate.

The model generates a positive comovement between the debt-to-GDP ratio and fiscal uncertainty through two mechanisms. Uncertainty lowers both risk-free rate and bond risk premium and thus the expected return on government debt. The declining expected return leads to the rise of the bond price. Therefore, the debt-to-GDP ratio increases with uncertainty through the discount rate channel. Conversely, debt generates uncertainty in future fiscal policy. The government implements fiscal consolidations from time to time to reduce deficits and debt accumulation. The consolidation policy is uncertain and anticipated to be more active when debt is high. As a result,

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is financed with decreases in the discount rate.

high debt-to-GDP ratio brings more uncertainty in fiscal consolidations. The two mechanisms reinforce each other. In equilibrium, the debt-to-GDP ratio reveals fiscal uncertainty and has implications for asset prices that are consistent with the empirical findings. Calibrated to fiscal policy data, the model quantitatively explains many features of macroeconomics dynamics and asset markets such as equity premium and risk-free rate, as well as the novel facts regarding the government debt.

Relation to Literature. There is a long-lasting debate on the effects of government debt on interest rate (Elmendorf and Mankiw, 1999; Engen and Hubbard, 2005; Laubach, 2009). Few papers consider the importance of risk premia across different interest-bearing instruments. Distinguishing between real risk-free rate, return on equity, corporate bonds, and government debt, I show that high government debt is associated with high cost of capital for firms and low cost of capital for government. Krishnamurthy and Vissing-Jorgensen (2012) find that high government debt is related to lower spreads between assets with different liquidity and safety attributes.[2] My evidence of the effect of government debt on credit risk premia is complementary to their evidence of liquidity premia. I document differential effects that government debt enhances credit risk premia in corporate bond market and diminishes liquidity premia in money market. Croce et al. (2016) show that debt-to-GDP ratio predicts the spreads between innovation-sorted stock portfolios in the time series and cross section, while I focus on the aggregate asset markets. Greenwood and Vayanos (2014) document that the maturity structure of government debt affects nominal bond risk premia and term spreads.

I contribute to the voluminous literature of stock return predictability by analyzing debt-to-GDP ratio as a predictor. The results have little bias from the high persistence of the debt-to-GDP ratio (Campbell and Yogo, 2006; Stambaugh, 1999). The out-of-sample predictive power is compelling (Welch and Goyal, 2008). Debt-to-GDP ratio outperforms the popular predictors regarding out-of-sample mean squared error.[3]

A long theoretical literature links government debt to macroeconomic dynamics. Ricardian Equivalence states that government debt has no effect in a frictionless standard representative-agent model (Barro, 1974). However, in the presence of liquidity and safety needs, government debt plays a special role and has significant effects on macroeconomic quantities and asset prices (Bansal and Coleman, 1996; Krishnamurthy and Vissing-Jorgensen, 2012; Gorton and Ordonez, 2013; Drechsler et al., 2014; Greenwood et al., 2015). The impact of government debt is also large

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[2] Graham et al. (2014) document a similar negative relationship between debt-to-GDP ratio and Baa-Aaa spread. They also find that government debt has large impacts on corporate financing and investment policies.

[3] Some of the major predictors are the dividend-price ratio (Campbell and Shiller, 1988), book-to-market ratio (Kothari and Shanken, 1997), term spread (Fama and French, 1989), short rate (Hodrick, 1992; Ang and Bekaert, 2007), investment rate (Cochrane, 1991), the consumption-wealth ratio (Lettau and Ludvigson, 2001), output gap (Cooper and Priestley, 2009), and government investment rate (Belo and Yu, 2013).

in heterogeneous agent incomplete market models (Gomes et al., 2013). These theories are either silent on the new empirical findings or have counterfactual implications that high government debt is related to low equity premium and high risk-free rate. I contribute to the understanding of government debt by proposing a new fiscal policy uncertainty channel which operates through the government discount rate and also affects other risk premia. Because debt-to-GDP ratio encodes the variation of fiscal uncertainty, it explains risk premium variation, which complements the existing explanations of time-varying risk aversion (Campbell and Cochrane, 1999), time-varying consumption volatility (Bansal and Yaron, 2004), and time-varying risk of disasters (Wachter, 2013).

My analysis of fiscal uncertainty also relates to the recent literature examining the role of economic uncertainty both in the data and models (Bloom, 2009; Bansal et al., 2014; Jurado et al., 2015, among others). Pástor and Veronesi (2013) and Baker et al. (2015) study the asset pricing and macroeconomic impacts of general economic policy uncertainty. Fernández-Villaverde et al. (2015) and Born and Pfeifer (2014) show the importance of fiscal uncertainty on economic activities. I propose a new broad-based measure of fiscal policy uncertainty and illustrate its importance for asset prices.

More broadly, this article belongs to the growing literature studying asset prices in a production economy (Jermann, 1998; Croce, 2014). Similar to Kung and Schmid (2015) and Kung (2015), I endogenize the long run risks (Bansal and Yaron, 2004) in a expanding variety endogenous growth model (Romer, 1990).[4] The long run risks are purely driven by productivity shocks in Kung and Schmid (2015), whereas part of the long run risks rise from tax policy in my model. Croce et al. (2012) demonstrate a sizable tax risk premium in a model with capital structure choice where tax rate drives the technology growth exogenously.

The remainder of the paper is organized as follows. Section 2 documents the empirical findings. Section 3 lays out the model. Section 4 presents the economic mechanism and the quantitative implications of the model. Section 5 concludes.

2. Empirical Evidence

In this section, I document the new facts that high government debt-to-GDP ratio is related to high equity risk premium, high credit risk premium, low risk-free rate, low expected return on government debt, and high fiscal policy uncertainty.

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[4] Comin and Gertler (2006) study business cycle and long-run dynamics in a unified endogenous growth model.

2.1 Data Description

Government debt is defined as the market value of the federal government debt held by the public. The market value of government debt is constructed by summing up the market value of all the credit market instruments across maturities (Treasury bonds, Treasury botes, Treasury bills, TIPS, etc). Government debt data are from Dallas Fed, Flow of Funds and, George Hall (Hall and Sargent, 2011). Figure 1 demonstrates the time series plot of the debt-to-GDP ratio. The ratio doubled from 20% to 40% during the Great Depression and jumped to 100% around the second world war. It declined gradually in the peacetime expansion until the early 1970s. Congress increased its control on the government budget process after the Congressional Budget and Impoundment Control Act of 1974, leading to deficits and rising debt. In the 1980s, President Reagan's tax cuts and military buildup further increased the debt. The fiscal balance returned to a surplus in the term of President Clinton, due to tax increases, military spending decreases, and an economic boom. Finally, the Great Recession, combined with Bush tax cuts, caused expanding government expenditure and declining revenue. In 2014, the ratio reached its post-war peak. One crucial feature is that the debt-to-GDP ratio is driven mainly by military and political issues and fiscal policy reforms. While the debt-to-GDP ratio rises in NBER recessions, it does not tend to decline in normal times. In fact, the business cycle only accounts for a small proportion of its variance.

The asset prices data are obtained from CRSP, Barclay and Fred. The average return on government debt is from George Hall. The stock return predictors are from Amit Goyal's website. The data on macroeconomic and fiscal variables are from NIPA and FRED-QD database (McCracken and Ng, 2016). The detailed explanations of the data are in the appendix.

2.2 Equity Premium

After studying the time series property of the debt-to-GDP ratio, I show that it strongly predicts future excess stock returns in sample and out of sample.

2.2.1 In-sample Tests

Table 1 reports the results from OLS regressions of future excess stock returns on log debt-to-GDP ratio. Excess stock return is the log market return subtracting the log risk-free rate. Long-horizon excess returns are the cumulative summation of the one-period excess returns. In the sample from 1926 to 2014, higher debt-to-GDP ratio forecasts higher stock returns in the future. The forecasting power becomes stronger at longer horizons as R^2 rises from 11% at the annual horizon to 38% at the five-year horizon. As in the previous findings, returns are more predictable at longer horizons, since the high-frequency noises are canceled out, and the slow-moving expected return is reflected more clearly in the data. The coefficients across all the horizons are statistically significant at 99%.

In Figure 2, I plot the 5-year ahead ex-post and expected excess return. The expected excess return is the fitted value of the predictive regressions. It is evident that higher debt-to-GDP ratio implies higher subsequent returns. The expected excess return rises from the 1930s to the 1950s, declines from the 1950s to the 1970s, and rises again from the 1970s to the 1990s and during the Great Recession.

Beyond the statistical significance, the economic impact of debt-to-GDP ratio on the expected excess return is substantial. A one percentage point increase in debt-to-GDP ratio indicates a 38 basis-point increase in expected excess return per annum.[5] Taking the Great Recession as an example, we observe a rapid increase in the debt-to-GDP ratio from 30% to 60%. This swing implies that the expected return is 11.4% higher than its pre-crisis level. It is acknowledged that excess return predictability is equivalent to time-varying equity premium in a standard rational pricing model.[6] Thus, the rise of debt-to-GDP ratio indicates that investors require a high premium to compensate equity risks. The classic equity premium puzzle emphasizes the difficulty in rationalizing the 6% average equity premium given the lower risk in the consumption profile. It is now more puzzling in that the equity premium is largely time-varying, from 2% in 2007 to 13% in 2014.

From an asset management point of view, this large time variation of expected return is valuable for investors. Consider a mean-variance investor who solves a static portfolio choice problem between aggregate stock and risk-free rate. As is shown in Campbell and Thompson (2008), observing the predictor increases the expected excess return by a factor of $(S^2+R^2)/((1-R^2)S^2)$, where S is the Sharpe ratio of the market return. In the sample 1926-2014, the equity premium is 6.03% and the Shape ratio is 0.3. A strategy that times the market using debt-to-GDP ratio can generate an excess return of 14.71% per annum and a Sharpe ratio of 0.66.[7]

Even though the debt-to-GDP ratio is acyclical in Figure 1, the denominator of GDP raises the concern that the ratio reflects the business cycle conditions. In economic downturns, low GDP raises the debt-to-GDP ratio and meanwhile the counter-cyclical expected return is high. To alleviate this concern, I show that the results are similar if a recession dummy and an interaction term are included in the regression. Excluding the dramatic increase of the ratio after the Great Recession from 2007 to 2014 doesn't alter the results. Moreover, the evident link between debt and wars leads to the conjecture that the forecasting power of the debt-to-GDP ratio is related to wars. I include a war-time dummy in the regression. The insignificance of the coefficients across horizons and time periods shows that the forecasting power remains in peacetime and wartime.

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[5] The debt-to-GDP ratio enters the regressions in log units. Given debt-to-GDP ratio has a mean of 0.40, a 1% increase is equivalent to a 0.40 percentage point increase of debt-to-GDP ratio.

[6] Equity premium is defined as the expected excess return of the stock market. If it can be predicted by some variable x, then in a simple regression case $E_t[r_{m,t+1}-r_{f,t}]=\beta_0+x_t'\beta$. As a result, equity premium comoves with the predictor x_t.

[7] The higher expected return is partially from taking on greater risk. The portfolio volatility increases by $1/(1-R^2)$ on average. Therefore, the portfolio Sharpe ratio increases by a factor of $(S^2+R^2)/S^2$.

Beyond the debt-to-GDP ratio, I have identified many other return predictors. Price-dividend ratio is arguably the most popular predictor that is both theoretically grounded and empirically successful. Controlling for price-dividend ratio, both the coefficients and significance of debt-to-GDP ratio are unchanged. As is seen in Figure 2, debt-to-GDP has distinct movements from the price-dividend ratio. Moreover, I consider a large set of alternative predictors: price-earning ratio (pe), dividend-earning ratio (de), stock return volatility (svar), book-to-market ratio (bm), net equity expansion (ntis), Treasury bill rate (tbl), long-term yield (lty), long-term return (ltr), term spread (tms), default yield spread (dfy), inflation (infl), investment-capital ratio (ik), consumption-wealth ratio (cay), GDP gap (gap), and government investment-capital ratio (gik). From the set of predictors, I extract the first three principal components that capture 98% of the variation. This parsimonious model is less subject to the concern of in-sample overfitting.[8] Conditioning on a large information set, the debt-to-GDP ratio still contributes to the prediction at a 99% significant level. The point estimates remain similar. The principal components do not drive out the explanatory power of debt-to-GDP ratio, suggesting that the ratio contains extra information.

To assess the stability of the results further, I run the same regressions on quarterly frequency post-war data. The results are reported in Table 2. Even at a short horizon of one quarter, the debt-to-GDP ratio significantly predicts excess return.[9] Moreover, the regression coefficients are highly significant and very close to the pre-war coefficients, and the R^2 are similar at the annual horizon and the five-year horizon. The significance is robust with several control variables that were mentioned before.

2.2.2 Out-of-sample Tests

The literature documents considerable in-sample predictability, but out-of-sample performance is usually unsatisfactory (Welch and Goyal, 2008). The poor out-of-sample predictive power raises the concern of data snooping. Debt-to-GDP ratio has strong out-of-sample predictive power. I use out-of-sample R^2 to evaluate the predictive accuracy.

$$R_{os}^2 = 1 - \frac{MSE_1}{MSE_0} \tag{1}$$

MSE_0 and MSE_1 are the mean square error using historical mean and the predictive model. In Table 3, the R_{os}^2 of univariate regression using debt-to-GDP ratio is 0.10 at the annual horizon and 0.29 at the five-year horizon, indicating that debt-to-GDP generates smaller MSE than the historical mean. The test for equal predictive accuracy (Clark and West 2007) shows that MSE_1 is statistically significantly smaller than MSE_0.

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[8] I explore each of the predictors in the out-of-sample tests.

[9] The predictability results hold at the one-month horizon as well.

Debt-to-GDP ratio outperforms many predictors regarding out-of-sample predictive power. I consider the set of predictors used in the in-sample tests. Debt-to-GDP ratio has the largest R^2_{os} among all the predictors. In fact, most predictors have negative R^2_{os}, showing that they are not better than the historical mean. Furthermore, including debt-to-GDP ratio in a bi-variate regression with existing predictors yields positive R^2_{os}. The p-values of the equal-predictability test show that debt-to-GDP ratio significantly improves the performance of available predictors. This test can also be interpreted as an encompassing test. Table 4 reports the results in the post-war sample. Several variables have better performance than the historical mean in this period, including price-dividend ratio, price-earning ratio, investment-capital ratio, consumption-wealth ratio, GDP gap, and government investment/capital ratio. The last two predictors are documented after the critic of Welch and Goyal (2008). Particularly, they are related to debt-to-GDP ratio. The result shows that debt-to-GDP still have the largest R^2_{os}. The improvement is significant at all horizons.

2.2.3 Robustness

The results are robust across many dimensions. First, I address the high persistence of the debt-to-GDP ratio. I use the efficient test by Campbell and Yogo (2006) that corrects for the endogeneity bias (Stambaugh, 1999) and provides an accurate approximation to the finite-sample distribution of test statistics under flexible degrees of persistence (stationary, local-to-unity, and unit root). The results confirm that the predictability is significant after considering the persistence of the predictor. Second, in the benchmark case, the government debt is defined as the market value of net debt held by the public. I consider other definitions and components of debt that have different economic interpretations (non-marketable debt, book value, intergovernmental holding, fed holding, foreign holding, etc). The results are similar to the benchmark case. Third, I verify the forecasting power using data from UK and Canada that have arguably little default risk and stationary debt-to-GDP ratios.

2.3 Credit Premium and Liquidity Premium

As shown in Section 2.2, debt-to-GDP ratio contains important information about risks in the equity market and *positively* predicts excess stock returns. Corporate bonds are another important asset class that reflect the risk premium for firms. Given the commonality of risk premia fluctuations, we expect to see similar results also in the credit market: the debt-to-GDP ratio (i) *positively* predicts excess returns on corporate bonds; (ii) *positively* relates to corporate bond yield spreads.

Excess returns and yield spreads between corporate and treasury bonds can capture the difference in several factors such as credit risk premium, liquidity premium, collateral premium, inflation premium, etc. A large literature argues that government debt plays a key role in liquidity (and safety) (Krishnamurthy and Vissing-Jorgensen, 2012). In this line of thought, investors value liquidity because of market frictions. Assets that provide liquidity attributes at different levels should have different premia. Time-varying liquidity premium depends on the outstanding amount of highly liquid assets such as government debt. Therefore, high government debt lubricates the economy and decreases the liquidity premium. These theories imply that the debt-to-GDP ratio (i) *negatively* predicts excess returns on equity;[10] (ii) *negatively* predicts excess returns on corporate bonds; (iii) *negatively* relates to corporate bond yield spreads. These implications of the liquidity channel are in sharp contrast to those of the risk channel.[11] Next, I test the two channels in the data.

In stock return predictability, I address the liquidity and safety channel of government debt by controlling yield spreads that account for the time-varying liquidity premium. These variables include spread between Moody's AAA bond and 30-year Treasury bond yield (ats) (Krishnamurthy and Vissing-Jorgensen, 2012) and spread between general collateral repo rate[12] and 3-month treasury bill (liqs) (Nagel, 2014). The results are in Table 2. The liquidity premium does not conceal the strong forecasting power of debt-to-GDP ratio. The sign is negative for ats, in contrast to the hypothesis that liquidity premium drives the excess return. Therefore, the time variation in equity premium cannot be explained only through the liquidity channel.

In bond return predictability, Table 5 shows that debt-to-GDP ratio positively predicts excess returns on corporate bonds, similar to the predictability of stock returns. In a one-year horizon, the coefficients are 0.09 and 0.12 for excess returns on investment-grade and high-yield bond portfolios, similar to the magnitude of coefficient of stock returns (0.15). Controlling for price-dividend ratio and market realized volatility does not weaken the effect of government debt. This predictability implies that debt-to-GDP ratio contains information about credit risk premium.

Next, I consider a broad range of yield spreads that measure credit risk premia. We expect to see a positive relationship between debt-to-GDP ratio and yield spread if government debt increases the credit risk premia. Gilchrist and Zakrajšek (2012) construct a spread index (GZ spread) from individual corporate bonds traded in the secondary market. They carefully match the duration and maturity between each corporate bond and treasury bond. Their bond also covers the entire maturity spectrum from 1 year to 30 years. In contrast, the standard Moody's seasoned bond yield focuses on bonds that have remaining maturities from 20 to 30 years and unknown duration. In Table 6, debt-to-GDP ratio is positively related to GZ spread. The result is significant at 99%

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[10] Bansal and Coleman (1996) and Krishnamurthy and Vissing-Jorgensen (2012) argue that part of the equity premium is liquidity premium. This liquidity premium channel can partially solve the equity premium puzzle.

[11] He and Xiong (2012) model that the interactions between liquidity and credit risk. Debt market illiquidity increases in not only liquidity premium but also credit risk. This mechanism amplifies the liquidity channel. The three implications have the same signs but larger magnitudes.

[12] The general collateral repo rate is available from 1991. As in Nagel (2014), I use the banker's acceptance rate before 1991.

confidence level, controlling for the realized volatility and term spread. Realized volatility partially measures the default probability. The term spread controls for the effect of any potential maturity mismatch in the yield spreads on the left-hand side. This relationship is not significant for the spreads between Moody's Aaa, Aa, A, Baa bond yield and 30-year treasury bond yield. Since both debt-to-GDP ratio and spreads are persistent, I specify the regression model in first difference to further explore the dynamic interactions. Both credit risk and liquidity risk channels have the same implications for regressions in levels and first differences. GZ spread and spreads from Moody's all show a positive and significant relationship, supporting the credit risk channel.

In a longer sample from 1919 to 2008, Krishnamurthy and Vissing-Jorgensen (2012) find that Aaa-Treasury spread is negatively related to the debt-to-GDP ratio in a level regression. As seen in Table 6, the result is not significant in the sample of 1973-2014 when GZ spread is available. One reason could be sub-sample stability. Another possible reason is that credit risk premium and liquidity premium offset each other. In fact, different yield spreads capture the two sources of premium with different weights. On one hand, Longstaff et al. (2005) document that the majority of long-term bond spreads are due to credit risks. On the other hand, some spreads in money market capture mostly liquidity premium and a priori have few default risks. These include spreads between general collateral repo rate, certificate of deposits rate, AA commercial paper rate, federal funds rate and T-bill rate (Drechsler et al., 2014; Nagel, 2014). Therefore, we could roughly categorize yield spreads into two groups: credit spreads (GZ, Aaa-Treasury, Aa-Treasury, A-Treasury, Baa-Treasury) are mainly in corporate bond market and liquidity spreads (Repo-Bill, CD-Bill, Paper-Bill, FFR-Bill) are in money market. These two categories are not only economically motivated but also empirically grounded. After a factor analysis, I find that each group of spreads has a single factor structure. The first principal component of the spreads within each group explains more than 80% of the variations. However, the two common factors have a low correlation of 0.15. The factor analysis shows that the time-varying liquidity premium and credit premium are different phenomena.

I verify the liquidity channel in the group of liquidity spreads in Table 6. Higher debt-to-GDP ratio is associated with lower spreads that have more weight on liquidity premium. The results are significant both in the level and first difference specifications.

I further study the dynamics relationship between debt-to-GDP ratio and yield spreads by analyzing the impulse response functions and variance decomposition in a vector autoregression framework. I identify debt-to-GDP shocks that are non-discretionary and not related to business cycle and market volatility. Similar to the regression results, positive debt-to-GDP shocks raise credit spreads in corporate bond market but decrease liquidity spreads in money market. Furthermore, the effect of government debt is quantitatively important. Specifically, the debt-to-GDP ratio shocks explain 9% of the one-year forecast error variance of GZ spread, 7% of the Aaa-Treasury spread, 15% of the Baa-Aaa spread and around 20% of yield spreads in money market. I leave the details of the analysis to the appendix.

Therefore, empirical evidence suggests that both channels of credit and liquidity risk are present. High debt-to-GDP ratio is associated with high credit risk premia and low liquidity risk premia. Debt-to-GDP ratio increases yield spreads that mainly capture credit risk and decreases yield spreads that mainly capture liquidity risk.

2.4 Real risk-free rate

Government debt could have impacts on the interest rate. This is a long-standing empirical question with little consensus in the literature. In contrast to major previous work, I focus on the short-term real rate. This choice avoids two issues that: (i) the long-term inflation expectation is hard to measure, and (ii) long-term inflation premium is quantitatively important (Ang et al., 2008). To measure the short-term inflation expectation, I use the four-quarter moving average of past inflation and Livingston survey. These two measures are acknowledged to have superior out-of-sample forecasting power. The real risk-free rate is the nominal risk-free rate subtracting the inflation expectation. To control for expected growth, expected inflation, and time-varying risk aversion, I include in the regression the current and lagged consumption growth and inflation and price-dividend ratio. Table 7 shows that debt-to-GDP ratio is significantly negatively related to real risk-free rate. The results hold for both pre-war and post-war samples.

2.5 Return on Government Debt

After studying the short-term real risk-free rate, I explore the effect of government debt on its aggregate return. The return is defined as the average return across terms to maturity on all the Treasury securities.[13] This return measures the effective borrowing cost or discount rate of the government. Unless the government only issues one-period debt, the return differs from the risk-free rate. In the government budget constraint, the evolution of government debt B_t depends on the government receipts T_{t+1}, total outlay net of interest G_{t+1}, and the holding period return on government debt $R_{b,t+1}$.

$$B_{t+1} + T_{t+1} - G_{t+1} = B_t R_{b,t+1} \tag{2}$$

Similar to Campbell and Shiller (1988), dividing Equation (2) by GDP, log-linearizing, iterating

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[13] Define $Q_t^{(n)}$ the price and $b_t^{(n)}$ the amount of n-period discount bond. A coupon bond can be effectively decomposed into discount bonds. The holding period return $R_{b,t}^{(n)} = Q_t^{(n-1)}/Q_{t-1}^{(n)}$. The total market value of debt $B_t = \Sigma_n Q_t^{(n)} b_t^{(n)}$ is the summation of all the outstanding debt. The return on government bond is the average return weighted by the bond value $R_{b,t} = \Sigma_n \frac{Q_{t-1}^{(n)} b_{t-1}^{(n)}}{B_{t-1}} R_{b,t}^{(n-1)}$.

forward, and taking expectation, we obtain the following present value decomposition.

$$by_t \approx E_t[\underbrace{\Sigma_{j=0}\kappa_1^j(\kappa_2\tau y_{t+j} - \kappa_3 gy_{t+j})}_{surplus} + \underbrace{\Sigma_{j=0}\kappa_1^j\Delta y_{t+j}}_{real\ growth} - \underbrace{\Sigma_{j=0}\kappa_1^j r_{b,t+j}}_{discount\ rate}] + \kappa_0 \tag{3}$$

where κ are some constants.[14] The terminal term converges to zero under the assumption of no default. This condition has a intuitive interpretation. A high debt-to-GDP ratio is rationalized by three channels: (i) high expected future primary surplus to pay off the debt, (ii) high expected future growth to stabilize the ratio, and (iii) low discount rates. The early studies mainly focus on the surplus channel. I find that the often-neglected discount rate channel is empirically important. In predictive regressions in Panel A of Table 8, higher debt-to-GDP ratio predicts lower return on government debt from 1 year to 20 years. Moreover, a variance decomposition illustrates the importance of discount rate channel. Take the covariance between Equation (3) and by_t on both sides, the variance of debt-to-GDP ratio can be attributed to the three sources.

$$\begin{aligned} var(by_t) =& cov(E_t[\Sigma_{j=0}\kappa_1^j(\kappa_2\tau y_{t+j} - \kappa_3 gy_{t+j})],\ by_t) + cov(E_t[\Sigma_{j=0}\kappa_1^j\Delta y_{t+j}],\ by_t) \\ & - cov(E_t[\Sigma_{j=0}\kappa_1^j r_{b,t+j}],\ by_t) \end{aligned}$$

I estimate a vector autoregression model with five variables $[by_t,\ gy_t,\ \tau y_t,\ \Delta y_t,\ r_{b,t}]'$ to decompose the variance. Panel B of Table 8 shows that higher debt-to-GDP ratio precedes higher surplus, higher growth, and lower return. The variance of debt-to-GDP ratio corresponds to variations of all three sources. The discount rate channel accounts for 0.25 of the total variance. The importance is close to the growth channel and half of the surplus channel.[15]

2.6 Fiscal Uncertainty

Why does government debt have such significant effects on asset prices? I propose a new channel–fiscal uncertainty–that can rationalize the facts jointly. In this section, I establish the evidence that government debt and fiscal uncertainty positively comove with each other. Furthermore, fiscal

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[14] Define $by_t = log(B_t/Y_t)$, $\tau y_t = log(T_t/Y_t)$, $gy_t = log(G_t/Y_t)$. Dividing Equation (2) by GDP and log-linearizing,

$$\kappa_0 + \kappa_1 by_{t+1} + \kappa_2\tau y_{t+1} - \kappa_3 gy_{t+1} = by_t + r_{b,t+1} - \Delta y_{t+1}$$

where $\kappa_1 = \frac{B}{B+T-G}$, $\kappa_2 = \frac{T}{B+T-G}$, $\kappa_3 = \frac{G}{B+T-G}$.

Interating forward,

$$by_t = \Sigma_{j=0}\kappa_1^j(\kappa_2\tau y_{t+j} - \kappa_3 gy_{t+j}) + \Sigma_{j=0}\kappa_1^j\Delta y_{t+j} - \Sigma_{j=0}\kappa_1^j r_{b,t+j} + \kappa_0 + lim_{j\to\infty}\kappa_1^j by_{t+j}$$

The term $lim_{j\to\infty}\kappa_1^j by_{t+j} = 0$ because of the no-Ponzi condition and the assumption of no default.

[15] Cochrane (2011) documents that the importance of the discount rate channel is pervasive in a variety of asset markets.

uncertainty drives asset prices in equity, credit, and treasury markets.

Throughout history, there exist many periods when people had little consensus about future fiscal policy. In Congress and the White House, policymakers had heated debates on issues such as military expenditures, tax reforms, entitlement, debt limit, and consolidations. In other periods, fiscal policy was relatively stable, and households and firms reacted accordingly with more confidence. Fiscal policy uncertainty measures how precisely the agents can predict future fiscal policy.

One signal of large fiscal uncertainty is debt-ceiling crises. After 1939, Congress use an aggregate debt limit to restrict federal borrowing. If the debt limit binds, the government and Congress have to negotiate reforms on expenditure and tax in short period to avoid the cost of government shut down. These negotiations lead to large fiscal policy uncertainty. It is generally believed that the debt limit does not impose constraints on deficits or surpluses after 1939 (Hall and Sargent, 2015). However, there are a few exceptions. The first debt-ceiling crises is in 1953. The request of the Eisenhower administration to increase the limit was initially declined. After three temporary increases in 1954, 1955, and 1956, the limit reverted to its 1953 level. Another famous case is the government shutdown in 1995–1996. Recently, we have witnessed the fiscal cliff and multiple debt-ceiling crises. In every crisis, Congress was reluctant to increase the limit unless some balanced-budget amendments were added. The fiscal turmoil raised deep concerns about fiscal policy. Evidently, these crises took place when the government was highly indebted. When the debt-to-GDP ratio is low, the government has more room for its budget with few concerns of a binding debt limit. Therefore, debt-to-GDP ratio determines the probability of a debt-ceiling crisis and encodes fiscal policy uncertainty.

More formally, it is ideal to have some empirical measures of unobserved fiscal uncertainty to examine its effects. I propose a new measure of fiscal uncertainty that utilizes the dynamic factor model in a data-rich environment. This method follows Jurado et al. (2015), who measure macroeconomic and financial uncertainty. Formally, the h-period ahead uncertainty $U_i(h)$ of a variable $y_{i,t}$ is defined as its conditional volatility.

$$U_i(h) = \sqrt{E_t[(y_{j,t+h} - E_t[y_{j,t+h}])^2]} \tag{4}$$

One main challenge is to correctly compute the conditional mean by including all the variables in the information set. Especially, since the government announces many of policy changes before implementation, accounting for such expected news as forecasting error will lead to a biased uncertainty measure. I collect 169 macroeconomics variables and fit them into a factor model (Equation 5-6) to capture the conditional mean dynamics of each variable. These variables are related to national income, industrial production, employment, inventories, orders and sales, prices, earning and productivity, and money and credit. Details of the data set are in the appendix. To filter out the conditional volatility, I specify the model with stochastic volatility (Equation 7) in both factor shocks ($\sigma^F_{j,t}$) and idiosyncratic shocks ($\sigma^y_{j,t}$) . I estimated the model by the Markov Chain Monte Carlo method.

$$y_{j,t+1} = \phi^y_j(L)y_{j,t} + \gamma^F_j(L)F_t + \sigma^y_{j,t}\varepsilon^y_{j,t+1} \tag{5}$$

$$F_{j,t+1} = \Phi^F F_{j,t} + \sigma^F_{j,t}v^F_{j,t+1} \tag{6}$$

$$log(\sigma^i_{j,t+1}) = \alpha^i_j + \beta^i_j log(\sigma^i_{j,t}) + \sigma^i_j\eta^i_{t+1},\ \eta^i_{j,t+1} \sim N(0,1),\ i = \{y,F\} \tag{7}$$

Another challenge is to determine what variables reveal the uncertainty on fiscal policy. The policy-making process is not separate in fiscal instruments. Therefore, I consider fiscal policy uncertainty as the first principal component of the uncertainty of 37 variables related to fiscal policies, ranging from different taxes to government consumption and investment.

The second measure of fiscal uncertainty is the Economic Policy Uncertainty Index (EPU) in Baker et al. (2015). These indices combine the newspaper coverage of policy-related economic uncertainty, the number of federal tax code provisions set to expire in future years, and disagreement among economic forecasters. The indices begin in year 1985 and span 11 specific policies such as monetary policy, fiscal policy, and health care policy.

Taking the two measures of fiscal uncertainty, I study whether they are related to the debt-to-GDP ratio. Figure 3 reports that when the debt-to-GDP ratio is high, the fiscal uncertainty is high. In Table 9, the correlation is 0.5 between 3-year fiscal uncertainty and the debt-to-GDP ratio. Furthermore, fiscal uncertainty is distinct from a broad measure of macroeconomic uncertainty. The macro uncertainty is the common component of the 132 variables excluding fiscal-related variables, similar to the measure in Jurado et al. (2015). The correlation between macro uncertainty and the debt-to-GDP ratio is less than 0.1. In a more recent sample from 1985 to 2014, the debt-to-GDP ratio is still positively related to the fiscal uncertainty measures but not to macro uncertainty. The results are the same as the uncertainty measures from the very different narrative approach. The correlation between debt-to-GDP ratio and fiscal uncertainty in EPU indices is 0.36. This positive relationship is observed in a variety of fiscal-related policies, such as taxes, government spending, health care, and entitlement. On the contrary, debt-to-GDP ratio not is related to the non-fiscal policies, such as monetary, national security, and trade policy. Therefore, the results robustly show that debt-to-GDP largely captures the fiscal uncertainty.

If this risk channel exists, the fiscal uncertainty should have a direct impact on asset prices. In Table 10, I demonstrate that fiscal uncertainty affects the asset price in the same way as the debt-to-GDP ratio. Fiscal uncertainty positively predicts excess returns on stocks and corporate bonds. The R^2 is around 25% at the five-year horizon. This amount of predictability is large given the difficulty of measuring uncertainty. Fiscal uncertainty is positively related to GZ spread and negatively related to real risk-free rate and return on government debt. The results hold in both the broad-based measure and the EPU measure.

In sum, the evidence shows that high debt-to-GDP ratio is related to high equity risk premium, high credit risk premium, low risk-free rate, and low expected return on government debt. Furthermore, debt-to-GDP ratio positively reflects fiscal policy uncertainty. Fiscal uncertainty also has direct effects on the asset prices consistent with the effects of debt-to-GDP ratio.

3. Model

In this section, I propose a general equilibrium model to understand why fiscal uncertainty affects risk premia and why the debt-to-GDP ratio is positively correlated with fiscal uncertainty.Building on a standard expanding variety endogenous growth model (Romer, 1990), I study the implications of recursive preferences as in (Kung and Schmid, 2015). Besides, I augment the model with fiscal policy. The model quantifies the importance of the fiscal uncertainty channel and matches the novel facts.

3.1 Preference

The discrete-time economy is populated by measure one of representative agent with Epstein-Zin recursive preferences. These preferences break the link between relative risk aversion (γ) and intertemporal elasticity of substitution (IES) (ψ) in CRRA preferences. δ is the time discount factor. $\theta \equiv \frac{1-\gamma}{1-/\psi}$. Agents maximize the utility function

$$U_t = [(1-\delta)C_t^{\frac{1-\gamma}{\theta}} + \delta(E_t[U_{t+1}^{1-\gamma}])^{\frac{1}{\theta}}]^{\frac{\theta}{1-\gamma}} \tag{8}$$

subject to the budget constraint,

$$C_t + P_t s_t + B_t = (P_t + D_t)s_{t-1} + B_{t-1}R_{b,t} + w_t L_t(1-\tau_{l,t}) \tag{9}$$

where P_t and D_t are the stock price and dividend. $R_{b,t}$ is the return on government debt. The households supply labor inelastically and receive wage bill subject to income tax. As shown in Epstein and Zin (1989), the stochastic discount factor is given by,

$$M_{t+1} = \beta(\frac{C_{t+1}}{C_t})^{-\frac{1}{\psi}}(\frac{U_{t+1}^{1-\gamma}}{E_t[U_{t+1}^{1-\gamma}]})^{\frac{\psi-\gamma}{1-\gamma}} \tag{10}$$

The agents' marginal utility depends not only on the current consumption but also the continuation utility.

3.2 Final good producer

Final goods are produced using capital K_t, labor L_t, and intermediate inputs $X_{i,t}$, according to the following production function.

$$Y_t \;=\; ({K_t}^{\alpha}(A_tL_t)^{1-\alpha})^{1-\xi}\left[(\int_0^{N_t} X_{i,t}^{\nu}di)^{\frac{1}{\nu}}\right]^{\xi}$$

where N_t is the number of varieties that the final good producer purchases from the intermediate good producers. ν affects the substitution between different inputs. A_t is the exogenous technology process and follows AR(1) process.

$$log(A_{t+1}) = (1-\rho)log(A) + \rho log(A_t) + \sigma_a\varepsilon_{t+1} \tag{11}$$

The firm owns capital and makes investment decisions subject to investment adjustment cost.

$$K_{t+1} = (1-\delta)K_t + \Phi(\frac{I_t}{K_t})K_t \tag{12}$$

The corporate income tax is levied on the profit net cost of labor and inputs at rate $\tau_{c,t}$. The free cash flow equals the net profit subtracting investment.

$$D_t = (1-\tau_{c,t})\left[Y_t - w_tL_t - \int_0^{N_t} P_{i,t}X_{i,t}di\right] - I_t \tag{13}$$

The firm maximizes equity value.

$$V_t(K_t) = max_{I_t,K_{t+1},L_t,X_{i,t}} D_t + E_t[M_{t+1}V_{t+1}(K_{t+1})] \tag{14}$$

3.3 Intermediate good producer

Intermediate good producers use a specific patent to build one unit of intermediate good using one unit of the final good. Thanks to the patent, they have monopoly power and set the price of the intermediate good to maximize profits. They face a downward-sloping demand curve implied by the cost minimization of the final goods producer. The optimality conditions are standard and omitted. In equilibrium, the profits depend on the demand elasticity

$$\Pi_{i,t} = (\frac{1}{\nu} - 1)X_{i,t}$$

These firms also have to pay the corporate income tax. Each patent has finite expected lifespan determined by the depreciation rate ϕ. The value of the intermediate firm equals its discounted profit.

$$V_{i,t}^{I} = (1-\tau_{c,t})\Pi_{i,t} + (1-\phi)E_t[M_{t+1}V_{i,t+1}^{I}] \tag{15}$$

3.4 Innovation

Agents use final goods to conduct R&D. $S_{i,t}$ is the R&D expenditure. The stock of intangible capital or patents is accumulated through R&D and evolves as follows:

$$N_{t+1} = S_{i,t} + (1-\phi)N_t \tag{16}$$

Free entry to innovation pins down the optimality condition of R&D. One unit of R&D expenditure yields one unit of intermediate firm that has value $V_{i,t}$.

$$E_t[M_{t+1}V_{i,t+1}^{I}] = 1 \tag{17}$$

3.5 The government

The government levies tax, arranges spending, and borrows from the households. In this positive analysis, I do not model the policymaking behavior. Instead, tax revenue and government spending are assumed exogenously to match the observed data. Both spending and tax follow AR(1) processes.

$$log(\frac{G_{t+1}}{Y_{t+1}}) \equiv gy_{t+1} = \mu_{gy}(1-\rho_g) + \rho_g gy_t + \sigma_{g,0}\sigma_{\tau,t}u_{g,t+1} \tag{18}$$

$$\tau_{c,t+1} = \mu_{\tau c}(1-\rho_\tau) + \rho_\tau \tau_{c,t} + \sigma_{\tau,0}\sigma_{\tau,t}u_{\tau,t+1} + u_{c,t+1} \tag{19}$$

I introduce the time-varying volatility of the tax and spending shock $\sigma_{\tau,t}$, modeled as an AR(1) process (Fernández-Villaverde et al., 2015).

$$log(\sigma_{\tau,t+1}) = \nu_\tau log(\sigma_{\tau,t}) + \sigma_{\tau,w}w_{\tau,t+1} \tag{20}$$

A positive volatility shock $w_{\tau,t+1}$ leads to a higher conditional volatility of tax rate and fiscal uncertainty.

The second source of fiscal uncertainty comes from the fiscal consolidation shock.

$$u_{c,t+1} = \frac{B_t}{Y_t}\phi_{\tau,t+1}, \; \phi_{\tau,t+1} \sim N(\bar{\phi}_\tau, \sigma_{\phi\tau}^2) \tag{21}$$

In response to high debt-to-GDP ratio, the government tends to increase tax ($\bar{\phi}_\tau > 0$). D'Erasmo et al. (2016) systematically document that primary balance responds to the outstanding debt. However, when and how the government will consolidate is uncertain. On one hand, this uncertainty comes from the policymaking processes. Song et al. (2012) build a political economy model to endogenize the debt policy in respond to the fundamentals. On the other hand, the uncertainty is associated with the stochastic tax base in the business cycle. To pay off a certain amount of debt, the government has to set a high tax rate under a lower tax base ($corr(\phi_{\tau,t+1},\ \varepsilon_{t+1}) < 0$). This is the mechanism in the literature of tax smoothing and recent work of Croce et al. (2016). This specification is similar to that used in the fiscal consolidation literature. For example, Bi et al. (2013) assume that probability of a fiscal consolidation is rising in the debt-to-GDP ratio. In their specification, $u_{c,t+1}$ is zero if the debt is lower than a random threshold and positive for four quarters if debt exceeds the threshold.

Since there is no distortion on labor, the labor tax rate is set to be fixed. Given the tax rates, the total tax receipts equal the tax revenue from three sources of income.

$$T_t = \tau_{c,t}\left[Y_t - w_tL_t - \int_0^{N_t} P_{i,t}X_{i,t}di\right] + \tau_{c,t}\int_0^{N_t}(\frac{1}{\nu}-1)X_{i,t}di + \tau_{l,t}w_tL_t \tag{22}$$

The government can issue a full menu of default-free zero-coupon debt across maturities. Define $Q_t^{(n)}$ the price and $b_t^{(n)}$ the amount of n-period discount bond. The total market value of debt $B_t = \Sigma_n Q_t^{(n)} b_t^{(n)}$ is the summation of all the outstanding debt. For tractability, the government actively manages the maturity structure to achieve a fixed geometrically-decaying maturity. $b_t^{(n)} = \phi_b^{n-1} b_t$. $\phi_b < 1$ determines the maturity structure. The quantity of debt depends on a single factor b_t. The government financing policy is specified as exogenous. Each period, it issues $b_t^{(n)}$ amount of bonds given the market price.

$$b_{t+1} = \rho b_t + u_{b,t+1} \tag{23}$$

The law of motion of debt is,

$$B_t = B_{t-1}R_{b,t} + G_t - T_t + Tr_t \tag{24}$$

where $R_{b,t} = \frac{\Sigma_n Q_{t-1}^{(n)} b_{t-1}^{(n)} R_t^{(n-1)}}{B_{t-1}}$ is the total return on government debt including matured principal and capital gains. Tr_t is the lump-sum transfer that guarantees the holding of the government budget constraint at each period, since spending, tax, and financing policy are exogenous.[16]

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[16] If the government debt is state contingent, the return will adjust to guarantee the holding of the budget constraint. This is not the case in the current structure of long-term debt.

4. Model Implications

4.1 Equilibrium Growth

In equilibrium, the output has the familiar Cobb-Douglas form.

$$Y_t = K_t^{\alpha} (Z_t L_t)^{1-\alpha} \tag{25}$$

TFP Z_t is driven not only by the exogenous force A_t but also the intangible capital stock N_t,

$$Z_t = (\xi \nu)^{\frac{\xi}{(1-\xi)(1-\alpha)}} A_t N_t \tag{26}$$

The insight of the endogenous growth beyond standard exogenous growth model is that the economic growth is determined in part by the growth of the intangible capital, which in turn is determined by the discounted profit of intermediate good producers. Expecting larger profits, innovators exert more effort in R&D, which results in more innovation and faster economic growth.

$$\frac{N_{t+1}}{N_t} = (1-\phi) + E_t \left[\Sigma_{i=1}^{\infty} (1-\phi)^{i-1} M_{t,t+i} (1-\tau_{c,t+i}) \Pi_{t+i}\right]^{\frac{\eta}{1-\eta}} \tag{27}$$

It is apparent that fiscal policy plays a role in the innovation process. Part of the profits are taken by the government in the form of corporate income tax. Figure 4 plots the impulse response functions to a one-standard-deviation positive tax shock $u_{\tau,t}$. A tax hike reduces future monopoly profits and innovation incentive, leading to lower intangible capital value V_t and innovation growth Δn_t. This slowdown of innovation transforms into lower consumption growth Δc_t. The increase of consumption on impact is due to the reduction in investment.[17] Through this tax mechanism, the model features an endogenous persistent and predictable component in the growth rate as in the long-run risks model (Bansal and Yaron, 2004). The negative growth effect of distortionary taxation is well-documented in the endogenous growth literature. Gemmell et al. (2011) find strong empirical support for this mechanism. Djankov et al. (2010) further document the adverse effect of the corporate tax on aggregate investment and entrepreneurial activity.

4.2 Asset Prices

Stocks and bonds are priced by the agents in the model. The risk premium on an asset is related to the covariance between its return $R_{i,t+1}$ and stochastic discount factor M_{t+1}. The risk premium is the sum of risk premia of all the shocks. In the beta representation, the premium of each shock depends on the price of risk λ, risk exposure β, and the quantity of risk. Focusing on the tax risk

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[17] The aggregate output doesn't change given the fixed labor supply.

premium,

$$E_t[R_{i,t+1} - R_{f,t}] = \frac{Cov_t[M_{t+1}, R_{i,t+1}]}{E_t[M_{t+1}]} \approx \underbrace{\lambda_\tau \beta_{\tau,i} Var_t(\tau_{c,t+1})}_{tax\ risk\ premium} + other\ premia \tag{28}$$

High marginal utility after tax hikes is a standard property in macroeconomic models. In Figure 4, the stochastic discount factor increases after the positive tax shock. The negative price of risk λ_τ does not rely on endogenous growth or the Epstein-Zin preferences. Related to the risk premium puzzle, the key issue is to have a large price of risk in the model to match asset price facts. In our economy, the agents have Epstein-Zin preferences so that they are sensitive to the persistent shifts in growth rate. Furthermore, tax rates are also highly persistent. As a result, tax variation is a large source of risk for investors and is manifested in asset prices. The price of risk is negative and sizable.

Upon tax hikes, stock prices fall as in Figure 4, because of two reasons: (i) higher tax payment, and (ii) lower cash flow growth in the future.[18] Thus, stocks have negative tax risk exposure $\beta_{\tau,m} < 0$. Because stocks perform poorly in bad times of high tax, investors require positive excess returns on average. Thus, tax risk premium is positive and large. When fiscal uncertainty increases and "quantity" of risk is larger, investors require higher compensation for this risk and equity premium increases. Hence, time variation in equity premium is driven by the fiscal uncertainty.

The implication is different for government bonds. Facing high tax and low expected growth, agents have high marginal rate of substitution. Meanwhile, bond yield decreases with growth rate and the government bonds rally, so that government debt is a hedge against tax risks for investors and has a negative risk premium. $\beta_{\tau,b} > 0$. In time of high fiscal uncertainty, the high hedging motive drives down the bond risk premium. Furthermore, risk-free rate is affect by uncertainty through "flight to safety" channel. When uncertainty is high, agents have a precautionary saving motive that lowers the risk-free rate.

4.3 Debt-to-GDP ratio and Fiscal Uncertainty

After analyzing the determination of risk premium and how it is affected by fiscal uncertainty, I relate fiscal uncertainty to debt-to-GDP ratio. From Equation (3), the debt-to-GDP ratio varies from the variation of expected future primary surplus, growth, and discount. The importance of the discount rate channel has been documented in the empirical section.

In the model, the positive comovement between the debt-to-GDP ratio and the fiscal uncertainty is generated endogenously through two channels. As is stated in the last subsection, fiscal

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[18] As documented in Sialm (2009), stock valuation declines with tax burden. For tractability, I neglect distribution tax and put all the taxes on corporate profits. One interpretation of this tax is the sum of both corporate tax and income tax in the real world.

uncertainty decreases both risk-free rate and risk premium on debt. In total, fiscal uncertainty reduces the expected return on debt and raises debt valuation through the discount rate channel. An exogenous fiscal uncertainty shock will raise the fiscal uncertainty and debt-to-GDP ratio.

The second channel is due to the uncertain fiscal consolidations. The several reasons for uncertain fiscal consolidation have been discussed in Section 3.5. Having this feature, the conditional volatility of the tax rate comes from regular tax shocks and consolidation shocks. The second term is an increasing function of the debt-to-GDP ratio.

$$var_t(\tau_{c,t+1}) = \sigma^2_{\tau,0}\sigma^2_{\tau,t} + (\frac{B_t}{Y_t})^2\sigma^2_{\phi\tau} \tag{29}$$

The two channels reinforce each other. A volatility shock increases the fiscal uncertainty, which is manifested in bond prices and changes debt-to-GDP ratio. The rise of debt-to-GDP ratio raises the uncertainty of fiscal consolidations, back to the first channel. Consequently, debt-to-GDP ratio positively reflected the fiscal uncertainty.

4.4 Calibration

The uncertainty channel qualitatively explains the facts. Next, the model is calibrated to evaluate the quantitative importance. I report the benchmark calibration in Table 11. The model is calibrated in quarterly frequency. Panel A refers to the preference and technology parameters. In line with the estimated value in Schorfheide et al. (2014), the risk aversion is set to 10 and the intertemporal elasticity of substitution is 2 so that agents have preferences for early resolution of uncertainty. The time discount factor is chosen to match the real risk-free rate. The calibration values of the technology parameters are in line with the class of endogenous growth models (Kung and Schmid, 2015). Capital share is set to 0.33 and the intermediate inputs share is 0.5. Through the balanced growth path, these parameters imply a markup of 1.6, consistent with the evidence in micro data. The depreciation of physical capital is 0.025. The depreciation of R&D capital is 0.075, matching the recent estimate in Li and Hall (2016). The capital adjustment cost function $\Phi(\frac{I}{K}) = [\frac{a_{1,k}}{1-1/\xi_k}(\frac{I}{K})^{1-1/\xi_k} + a_{2,k}]$. ξ_k is the same as Kung and Schmid (2015), and $a_{1,k}$, $a_{2,k}$ is set such that $\Phi = I/K$ and $\Phi' = 0$ at the steady state. The mean of the productivity is chosen to match the mean of the growth. The persistent and volatility of productivity shocks are set to match the consumption volatility. This is less persistent and volatile than the productivity in Kung and Schmid (2015), since a crucial source of endogenous long-run risk is taxation that is not in their model.

The lower panel includes parameters of fiscal processes. Most of the values are from direct data estimates. Federal corporate income tax is 36% on average. Tax rate has a persistence of 0.99, in the confidence interval [0.91, 0.99] of the effective tax rate. The statutory tax rate in the data tends to be more persistent. The calibration is conservative in that the volatility of tax rate is set to be 0.03, less than half of the volatility of the data counterpart. The persistence of the fiscal volatility follows the persistence of the broad-based fiscal uncertainty measure. The volatility of the volatility shock is in the estimated range of Fernández-Villaverde et al. (2015). Labor tax is set to be 10% to match the total tax receipt over GDP. Spending-to-GDP ratio has a mean of 0.17. Spending includes federal and state and local government and excludes transfers. For simplicity, state and local government has no debt and levy lump sum transfer to cover their spending needs. The average maturity is set to be 7 years, consistent with Greenwood and Vayanos (2014). The volatility and persistence of bond quantity inherit the persistence of debt-to-GDP ratio.

In the benchmark case, I focus on the effect of the tax volatility shock. Therefore, all the parameters about fiscal consolidation and government spending shock are set to be zero in panel C. In the extended model, I set the mean and volatility of the fiscal consolidation to be 0.001 and 0.006, in line with the estimated value in Fernández-Villaverde et al. (2015). The consolidation shock is negatively correlated with the productivity shock. The correlation is 0.5 so that half of the consolidations are attributed to tax base concerns. To allow for the effect of government spending shock, I choose the volatility and persistence of the spending process as in the data.

4.5 Quantitative Results

I solve the model by third-order pertrubation to account for the effects of time-varying volatility. A pruning method is applied to ensure the stablity of sample paths (Andreasen et al., 2013). Table 12 shows the unconditional moments of the key financial variables. The reported model moments are the mean, 5% and 95% quantile of the short-sample simulation. The moments implied by the model are largely consistent with the data. The mean (standard deviation) of consumption growth is 1.80% (2.70%) in the data and 1.80% (2.62%) in the model. The output growth is less volatile than the data mainly because the model abstracts away from the labor supply margin that allows immediate adjustment of output. In the model, the stock return is measured as the total return on tangible and intangible capital and levered by a factor of 2. The model generates a large equity premium (5.19%). The model undershoots the volatility of excess return as the production economy does not generate volatile enough endogenous cash flow. In the model, the log price-dividend ratio has a very similar mean (3.63) and volatility (0.43) as the data. Furthermore, the model matches the small and stable risk-free rates. In the data, the return on government return is larger and more volatile than the risk-free rate. It is commonly acknowledged that long-term bonds compensate for expected inflation and also inflation premium. Ang et al. (2008) show that the inflation premium for a five-year bond is 1.14% on average. Since the real model is silent on the inflation premium, I add this premium on the model-implied return. Model-implied government debt return has similar mean and volatility as the data. Finally, the debt-to-GDP ratio has a mean of 0.52 and volatility of 0.08, similar to the data. Even though I only consider the corporate income tax, the overall tax-to-GDP ratio is close to the data. This guarantees that the model does not imply a counterfactual high and volatility tax burden on the economy as a whole.

I evaluate the effect of debt-to-GDP ratio in the model in Table 13. In a univariate predictive regression, the benchmark model matches the stock return predictability in the data. The positive coefficients, ranging from 0.03 in 1 quarter to 0.65 in five years, closely matches the coefficients in the data. The 90% interval of R^2 of the model covers the data estimates. Because of the short sample, the distribution of the R^2 is variable. Moreover, the model generates observed evidence that debt-to-GDP ratio is negatively related to real risk-free rate and bond return. Both the coefficient and the R^2 are similar to the data counterparts. Especially, the long-run bond return regression implies that higher debt-to-GDP ratio predicts lower discount rate on debt. In other words, the expected return variation contributes to the debt-to-GDP variation to a large extent. This verifies the importance of the discount rate channel. Next, I investigate the impact on stock return itself instead of excess return. The model implies comparable magnitude to the data. Thus, the model successfully matches not only the extent of excess return predictability but also the amount of predictability of stock return and risk-free rate separately.

Finally, I directly test the implications of fiscal uncertainty in the data and the model in Panel B. The model implies a positive correlation of 0.43 between debt-to-GDP ratio and fiscal uncertainty. The fiscal uncertainty is measured as the conditional volatility of the tax rate $var_t(\tau_{c,t+1})$. This shows that the discount rate channel itself will endogenize a positive comovement of debt-to-GDP ratio and fiscal uncertainty. Consistent with Equation (28), fiscal uncertainty increases the equity premium, and decreases the risk-free rate and bond returns. The magnitude of the channel is close to both the broad-based measure and the measure in Economic Policy Uncertainty Index.

The benchmark model only has the exogenous fiscal volatility channel. In Table 14, I entertain the other potential channel: fiscal consolidations. The parameters of the fiscal consolidations are set as in Table 11. First, introducing the uncertain fiscal consolidations will magnify the importance of the fiscal uncertainty. Debt-to-GDP ratio has stronger impacts on stock return, risk-free rate, and government bond return in terms of both coefficients and R^2. The five-year R^2 goes up from 14% to 18%. Second, I shut down the stochastic volatility ($\sigma_{\tau,w} = 0$). With only fiscal consolidations, the model does a good job in matching the effect of debt-to-GDP ratio. The R^2 on stock returns are two-third of the ones with only stochastic volatility. The magnitude of risk-free rates and government bond returns are close to the data. However, this channel implies a perfect correlation between debt-to-GDP ratio and fiscal uncertainty. By construction, the only reason fiscal uncertainty fluctuates is that the strength of fiscal consolidations is related to debt-to-GDP ratio. Third, the model abstracts away from both stochastic volatility and fiscal consolidations. In this case, the risk premium is fixed and the predictability in the model is tiny. The positive R^2

are from small sample bias since R^2 is restricted to be non-negative. There is no movement in fiscal uncertainty and no relationship between uncertainty and debt. Finally, I introduce government spending shock. This shock does not change the asset pricing implications and has a small quantitative impact in the third decimal place.

One implication of the model is the large and persistent effect of tax on the growth rate. The size of this effect is both model dependent and empirically controversial. Gemmell et al. (2011) is the recent contribution to this question and they argue for the existence of significant effects. They document that 1% increase of Tax-to-GDP ratio reduces GDP by 5.8% in 10 years in the US and 3.2% in OECD countries. I also find a negative significant impact of tax rate on 10-year output growth. In Table 15, the impact is 3.7%, consistent with their estimates. The model matches the impact of the tax. The predictive R^2 in the data (model) are 0.13 (0.17) at the annual horizon and 0.21 (0.22) at the 10-year horizon. The point estimates of coefficients in the data are within the 90% set of the model. This result holds in consumption and TFP growth, too. Hence, the calibration does not exaggerate this endogenous long-run risk channel.

As a result, the model quantitatively matches macroeconomics and asset prices moments. More importantly, the model replicates the relationship between debt-to-GDP ratio, various asset prices and fiscal uncertainty.

5. Conclusion

This paper documents a set of novel facts that government debt is related to risk premia in various asset markets. First, the debt-to-GDP ratio positively predicts excess stock returns. The forecasting power is compelling, and it outperforms many popular predictors. Second, higher debt-to-GDP ratio is correlated with higher credit risk premia in both corporate bond excess returns and yield spreads. Third, higher debt-to-GDP ratio is associated with lower real risk-free rate. Fourth, higher debt-to-GDP ratio predicts lower average returns on government debt. Expected return variation contributes to a sizable amount of the volatility of the debt-to-GDP ratio. Fifth, debt-to-GDP ratio positively comoves with fiscal policy uncertainty. Fiscal uncertainty also has direct effects on the asset prices consistent with the effect of debt-to-GDP ratio.

I rationalize these empirical findings in a general equilibrium model featuring recursive preferences, endogenous growth, and time-varying fiscal uncertainty. In the model, the tax risk premium is sizable and its time variation is driven by fiscal uncertainty. Furthermore, the model endogenize a positive relationship between the debt-to-GDP ratio and fiscal uncertainty: fiscal uncertainty increases debt valuation through discount rate channel whereas higher debt conversely raises uncertainty because of future fiscal consolidations. Through this channel, the government debt has asset pricing implications consistent with the facts. However, major existing channels of government debt such as liquidity, safety, and crowding out are silent or inconsistent with these facts. The empirical findings and theory shed new light on how government debt is related to the cost of capital for firms and the government.

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Figure 1: Debt-to-GDP Ratio

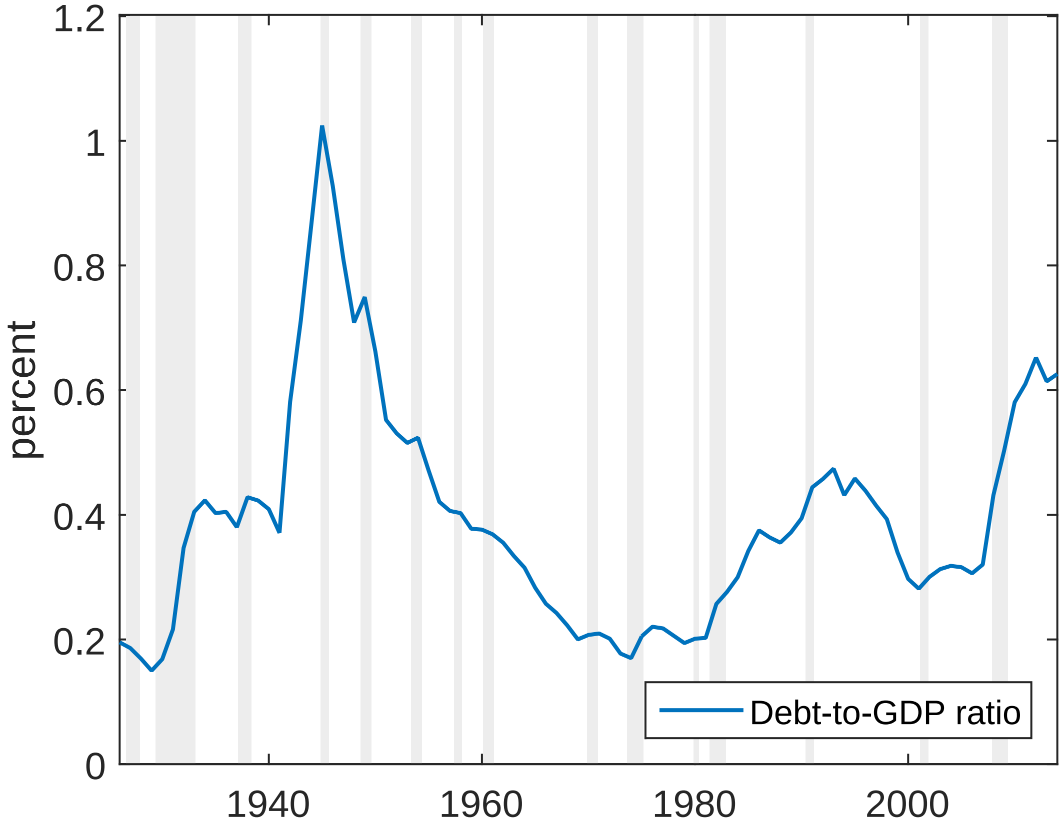

Figure 2: Debt-to-GDP Ratios and Expect Return

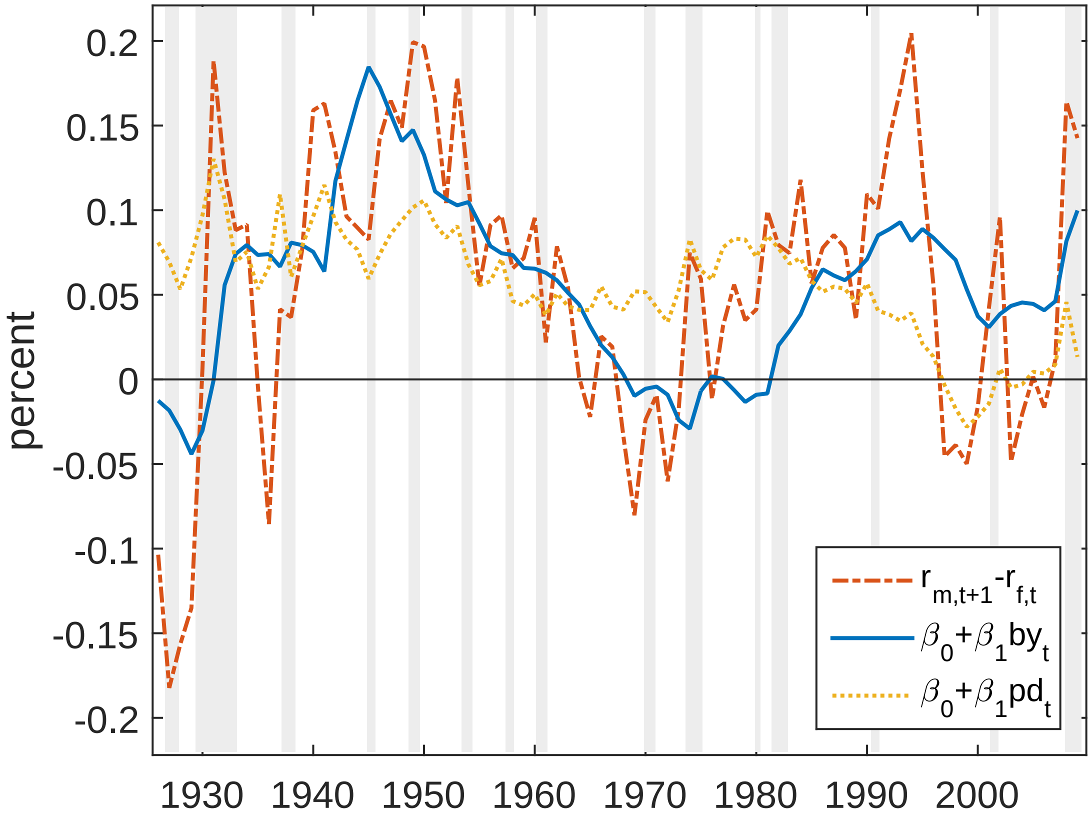

Figure 3: Debt-to-GDP Ratio and Fiscal Uncertainty

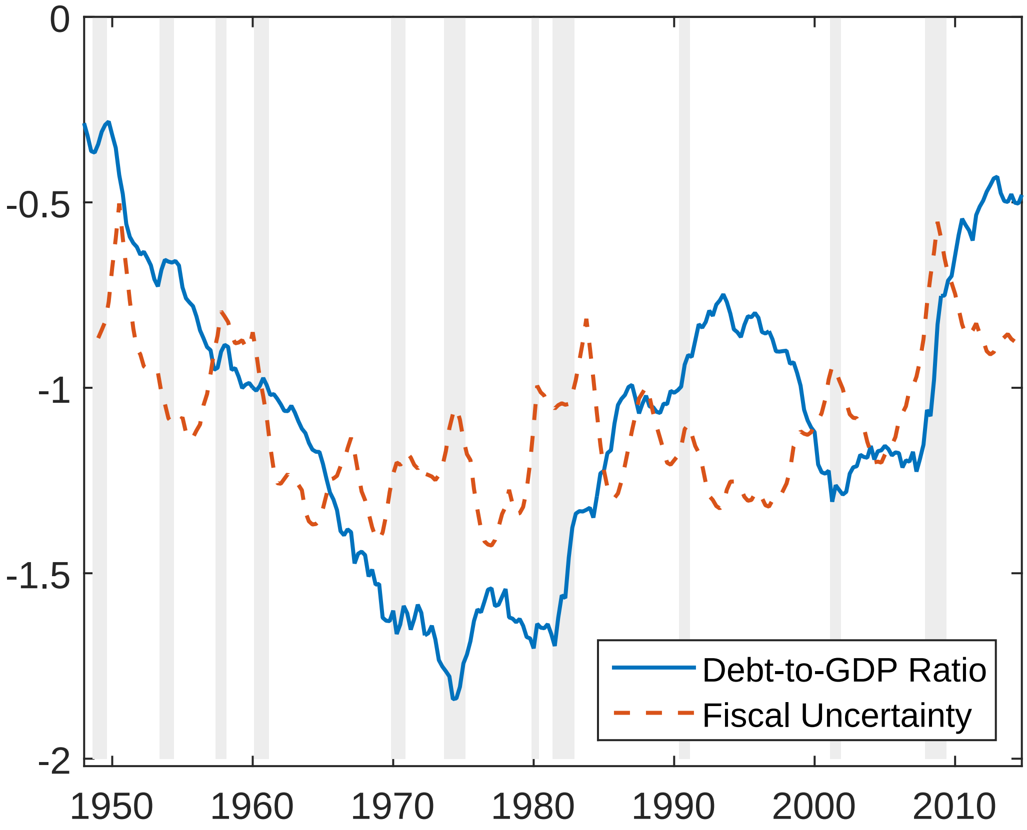

Figure 4: Impulse Response Functions to a 1 s.d. Tax Shock

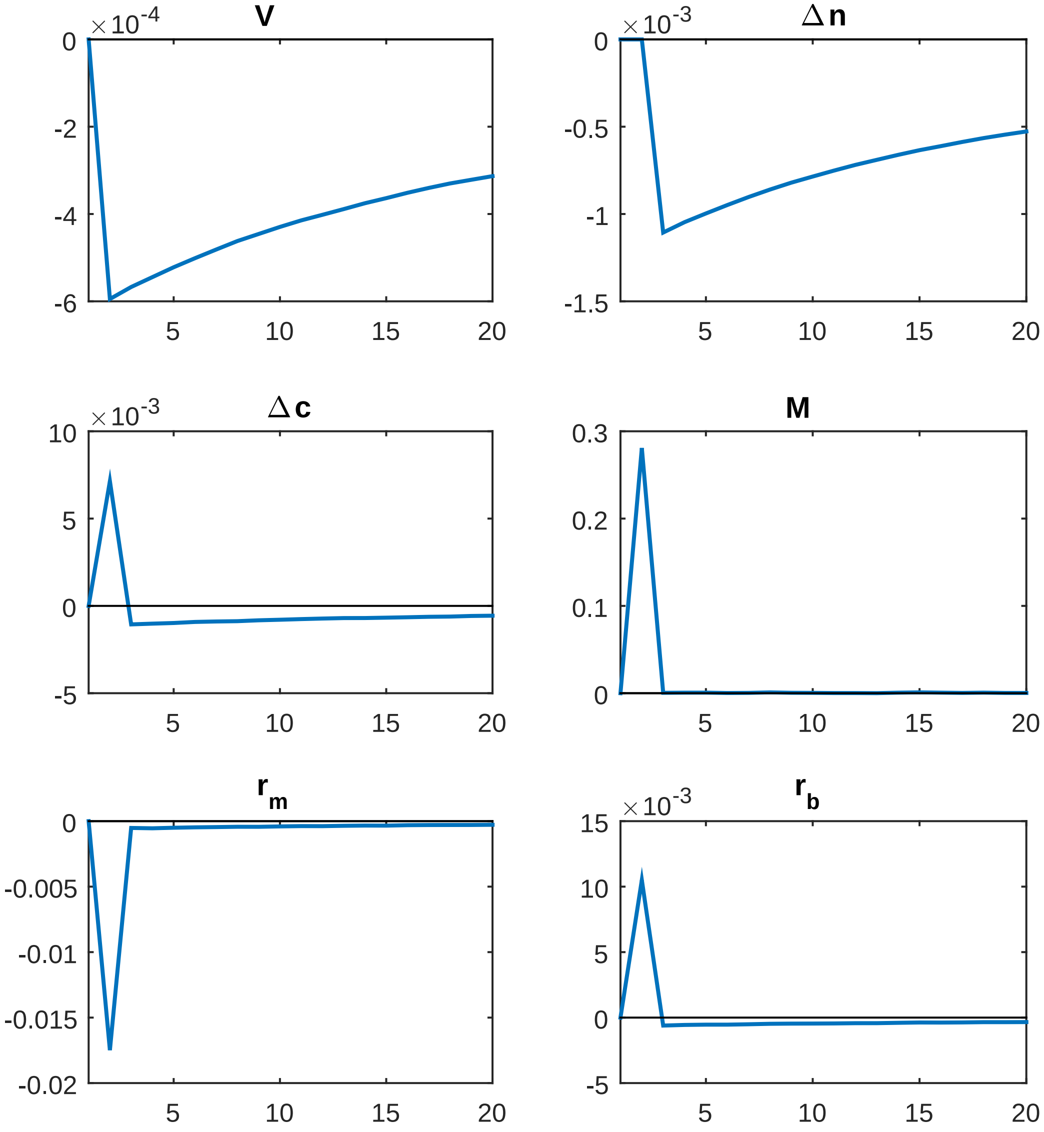

Table 1: Predictability of Excess Stock Returns

The table reports estimates from OLS regressions of future excess stock returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{m,t+i} - r_{f,t+i-1}) = \beta_0 + by_t\beta_1 + x_t\beta + u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. *by* is the log debt-to-GDP ratio. D_r equals 1 when US is in recession reported by NBER. D_w equals 1 when US is in war time. *pd* is the price-dividend ratio. *PC* are the first three principal components of a set of predictors including price-dividend ratio, price-earning ratio, dividend-earning ratio, stock return volatility, book-to-market ratio, net equity expansion, treasury bill rate, long-term yield, long-term return, term spread, default yield spread and inflation. *h* is the predictive horizon. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample is from 1926 to 2014.

h	*by*	(*t*-stat)	$D_r \times by$	(*t*-stat)	$D_w \times by$	(*t*-stat)	*pd*	(*t*-stat)	excl. 07-14	*PC*	R^2
1Y	0.15	(2.92)									0.11
	0.16	(3.35)	-0.02	(-0.10)							0.11
	0.18	(2.70)			-0.09	(-0.73)					0.12
	0.14	(2.61)							Y		0.10
	0.15	(2.87)					-0.07	(-1.54)			0.13
	0.15	(2.98)								Y	0.15
3Y	0.41	(3.41)									0.27
	0.51	(3.95)	-0.35	(-2.60)							0.31
	0.52	(3.40)			-0.30	(-1.30)					0.30
	0.40	(3.11)							Y		0.26
	0.40	(3.09)					-0.20	(-2.60)			0.34
	0.41	(3.31)								Y	0.35
5Y	0.60	(4.46)									0.38
	0.68	(5.16)	-0.28	(-1.51)							0.41
	0.66	(3.85)			-0.20	(-0.71)					0.39
	0.57	(4.27)							Y		0.38
	0.57	(3.90)					-0.32	(-4.28)			0.50
	0.58	(4.08)								Y	0.49

Table 2: Predictability of Excess Stock Returns

The table reports estimates from OLS regressions of future excess stock returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{m,t+i} - r_{f,t+i-1}) = \beta_0 + by_t\beta_1 + x_t\beta + u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. *by* is the log debt-to-GDP ratio. D_r equals 1 when US is in recession reported by NBER. *pd* is the price-dividend ratio. *PC* are the first three principal components of a set of predictors including price-dividend ratio, price-earning ratio, dividend-earning ratio, stock return volatility, book-to-market ratio, net equity expansion, treasury bill rate, long-term yield, long-term return, term spread, default yield spread, inflation, investment-capital ratio, consumption-wealth ratio, GDP gap and government investment-capital ratio. *liqs* is the spread between general collateral repo and 3-month T-bill rate. *ats* is the spread between Moody's AAA bond and 30-year Treasury bond yield. *h* is the predictive horizon. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample is from 1947:I to 2014:IV.

h	by	(t-stat)	$D_r \times by$	(t-stat)	pd	(t-stat)	PC	$liqs$	(t-stat)	ats	(t-stat)	R^2
1Q	0.04	(3.26)										0.04
	0.04	(4.11)	-0.01	(-0.26)								0.04
	0.04	(3.30)			-0.02	(-2.30)						0.06
	0.06	(3.94)					Y					0.08
	0.04	(2.99)						0.70	(0.35)	0.38	(0.30)	0.03
1Y	0.15	(3.78)										0.12
	0.17	(4.38)	-0.03	(-0.49)								0.17
	0.15	(3.75)			-0.10	(-2.79)						0.20
	0.21	(4.45)					Y					0.22
	0.17	(4.03)						4.60	(1.25)	-0.44	(-0.13)	0.12
3Y	0.41	(6.59)										0.33
	0.46	(6.74)	-0.14	(-1.65)								0.40
	0.40	(5.94)			-0.26	(-3.22)						0.49
	0.50	(6.14)					Y					0.48
	0.35	(4.98)						6.74	(1.49)	-13.87	(-2.30)	0.37
5Y	0.61	(5.11)										0.42
	0.67	(5.76)	-0.18	(-1.74)								0.49
	0.56	(5.92)			-0.40	(-6.20)						0.66
	0.61	(4.71)					Y					0.59
	0.57	(4.80)						12.14	(2.06)	-12.10	(-1.80)	0.44

Table 3: Out-of-sample Test

The table reports in-sample and out-of-sample R^2 from OLS regressions of future excess stock returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{m,t+i}-r_{f,t+i-1})=\beta_0+by_t\beta_1+x_t'\beta+u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. *by* is the log debt-to-GDP ratio. The other regressors are as follows: price-dividend ratio (pd), price-earning ratio (pe), dividend-earning ratio (de), stock return volatility (svar), book-to-market ratio (bm), net equity expoansion (ntis), treasury bill rate (tbl), long-term yield (lty), long-term return (ltr), term spread (tms), default yield spread (dfy) and inflation (infl). The first column shows the regressor. The out-of-sample period starts in 20 periods from the beginning of the sample. R^2_{OS} is from univariate regressions and $R^2_{OS,by}$ is from bi-variate regression with debt-to-GDP ratio and a regressor. Column "p" shows p value of testing hypothesis $H_0: MSE_1 > MSE_0$ against $H_1: MSE_1 < MSE_0$. In the row of "by", MSE_0 is the mean squared error from historical mean. MSE_1 is the mean squared error from predictive model with by. In other rows, MSE_0 is the mean squared error from a predictor. MSE_1 is the mean squared error from predictive model with the predictor and by. The sample is from 1926 to 2014.

	R^2_{OS}	$R^2_{OS,by}$	p	R^2_{OS}	$R^2_{OS,by}$	p	R^2_{OS}	$R^2_{OS,by}$	p
		1Y			3Y			5Y	
by	0.10		0.00	0.29		0.00	0.29		0.00
pd	0.00	0.10	0.00	-0.27	-0.08	0.00	-0.32	-0.14	0.00
dy	-0.16	-0.02	0.00	-0.73	-0.38	0.00	-0.25	0.20	0.00
pe	0.00	0.10	0.00	-0.05	0.30	0.00	-0.16	0.36	0.00
de	-0.04	0.07	0.01	-0.20	0.10	0.00	-0.12	0.03	0.01
$svar$	-0.05	0.07	0.00	-0.09	0.22	0.00	-0.20	0.06	0.00
bm	-0.07	0.11	0.00	-0.55	0.06	0.00	-0.56	0.21	0.00
$ntis$	-0.10	0.02	0.00	-0.27	0.11	0.00	-0.25	0.23	0.00
tbl	-0.04	0.04	0.00	-0.52	0.12	0.00	-1.00	0.06	0.00
lty	-0.06	0.01	0.00	-0.28	0.27	0.00	-1.24	0.35	0.00
ltr	-0.07	0.06	0.00	-0.05	0.27	0.00	-0.16	0.21	0.00
tms	-0.01	0.07	0.00	-0.35	0.02	0.00	-0.31	0.12	0.00
dfy	-0.01	0.10	0.00	-0.16	0.10	0.00	-0.19	0.10	0.00
$infl$	-0.07	0.06	0.01	-0.07	0.25	0.00	-0.11	0.20	0.00

Table 4: Out-of-sample Test

The table reports in-sample and out-of-sample R^2 from OLS regressions of future excess stock returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{m,t+i} - r_{f,t+i-1}) = \beta_0 + by_t\beta_1 + x_t'\beta + u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. *by* is the log debt-to-GDP ratio. The other regressors are as follows: price-dividend ratio (pd), price-earning ratio (pe), dividend-earning ratio (de), stock return volatility (svar), book-to-market ratio (bm), net equity expoansion (ntis), treasury bill rate (tbl), long-term yield (lty), long-term return (ltr), term spread (tms), default yield spread (dfy), inflation (infl), investment-capital ratio (ik), consumption-wealth ratio (cay), GDP gap (gap), government investment-capital ratio (gik). The first column shows the regressor. The out-of-sample period starts in 20 periods from the beginning of the sample. R^2_{OS} is from univariate regressions and $R^2_{OS,by}$ is from bi-variate regression with debt-to-GDP ratio and a regressor. Column "p" shows p value of testing hypothesis $H_0: MSE_1 > MSE_0$ against $H_1: MSE_1 < MSE_0$. In the row of "by", MSE_0 is the mean squared error from historical mean. MSE_1 is the mean squared error from predictive model with by. In other rows, MSE_0 is the mean squared error from a predictor. MSE_1 is the mean squared error from predictive model with the predictor and by. The sample is from 1947:I to 2014:IV.

	R^2_{OS}	$R^2_{OS,by}$	p	R^2_{OS}	$R^2_{OS,by}$	p	R^2_{OS}	$R^2_{OS,by}$	p	R^2_{OS}	$R^2_{OS,by}$	p
		1Q			1Y			3Y			5Y	
by	0.02		0.02	0.06		0.02	0.27		0.00	0.34		0.01
pd	-0.01	0.01	0.02	-0.05	-0.01	0.01	0.01	0.32	0.00	0.10	0.55	0.00
dy	0.00	0.02	0.01	-0.02	0.03	0.01	0.01	0.30	0.00	0.11	0.55	0.00
pe	-0.01	0.00	0.04	-0.07	0.00	0.00	-0.08	0.31	0.00	-0.12	0.43	0.01
de	-0.02	0.00	0.01	-0.06	-0.01	0.02	-0.13	0.11	0.00	-0.12	0.22	0.01
svar	-0.01	0.01	0.02	-0.05	0.02	0.00	-0.16	0.23	0.00	-0.23	0.27	0.01
bm	-0.02	0.01	0.02	-0.07	0.05	0.00	-0.27	0.24	0.00	-0.49	0.48	0.02
ntis	-0.03	0.00	0.02	-0.07	-0.01	0.01	-0.18	0.18	0.00	-0.31	0.28	0.01
tbl	-0.01	0.00	0.02	-0.05	-0.07	0.08	-0.31	0.05	0.03	-0.79	0.29	0.04
lty	-0.02	-0.02	0.05	-0.14	-0.11	0.00	-0.45	0.18	0.01	-1.24	0.22	0.04
ltr	-0.02	0.01	0.02	-0.01	0.07	0.00	-0.09	0.26	0.00	-0.14	0.35	0.01
tms	-0.02	0.00	0.02	-0.07	-0.10	0.16	-0.10	0.24	0.00	-0.31	0.34	0.01
dfy	-0.02	0.00	0.01	-0.06	0.00	0.00	-0.28	0.03	0.00	-0.46	0.41	0.00
infl	0.00	0.01	0.03	0.02	0.05	0.02	-0.05	0.26	0.00	-0.17	0.36	0.01
ik	0.02	0.02	0.22	0.05	0.05	0.09	0.15	0.26	0.01	0.07	0.40	0.02
cay	0.00	-0.01	0.05	0.03	-0.02	0.06	0.09	0.20	0.01	0.15	0.28	0.04
gap	0.02	0.04	0.01	0.02	0.10	0.00	0.04	0.36	0.00	0.00	0.46	0.00
gik	-0.01	0.01	0.01	-0.02	-0.01	0.06	0.03	0.26	0.00	-0.05	0.30	0.00

Table 5: Predictability of Corporate Bond Excess Return

The table reports estimates from OLS regressions of future excess corporate bond returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{corp,t+i} - r_{f,t+i-1}) = \beta_0 + \beta_1 by_t + \beta_2 pd_t + \beta_3 svar_t + u_{t+h}$$

Excess corporate bond return is the log Barclay's corporate bond portfolio return r_{corp} subtracting the log risk free rate r_f. Longer horizon excess returns are the cumulative summation of the one-period excess returns. by_t is the log debt-to-GDP ratio. by is the log debt to GDP ratio. pd is the log price-dividend ratio. $svar$ is the stock return realized volatility. h is the predictive horizon. The corporate bond portfolio is indicated in the name of the panel. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample is from 1973:I to 2014:IV for investment-grade bond and from 1983:I to 2014:IV for high-yield bond.

h	by	(t-stat)	pd	(t-stat)	$svar$	(t-stat)	R^2
			Investment Grade				
1q	0.03	(3.08)	-0.01	(-1.72)	0.01	(2.06)	0.06
1y	0.09	(2.73)	-0.04	(-1.42)	0.02	(2.62)	0.13
2y	0.12	(2.29)	-0.04	(-0.91)	0.06	(3.85)	0.20
			High Yield				
1q	0.04	(3.16)	-0.03	(-2.36)	0.01	(1.40)	0.10
1y	0.12	(2.59)	-0.11	(-2.75)	0.04	(1.80)	0.24
2y	0.13	(1.55)	-0.18	(-2.07)	0.07	(2.03)	0.28

Table 6: Yield Spreads and Debt-to-GDP ratio

The table reports estimates from OLS regressions of yield spreads on log debt-to-GDP ratio and other control variables.

$$spread_t = \beta_0 + \beta_1 by_t + \beta_3 svar_t + \beta_3 tms_t + u_t$$

$$\Delta spread_t = \beta_0 + \beta_1 \Delta by_t + \beta_3 \Delta svar_t + \beta_3 \Delta tms_t + u_t$$

The spreads include: Gilchrist and Zakrajŝek (2012) spread index (GZ spread), the spreads between Moody's Aaa, Aa, A, Baa bond yield and 30-year treasury bond yield, the spread between general collateral repo rate (Repo), Certificate of Deposits rate (CD) , AA commercial paper (Paper) rate, federal funds rate (FFR) and treasury bill rate. *by* is the log debt-to-GDP ratio. *svar* is the stock return realized volatility. *tms* is the spread between 10-year treasury bond and 3-month T-bill. Panel A shows the regression in level and Panel B shows the regression in first difference. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors.

h	by	(t-stat)	R^2	by	(t-stat)	$svar$	(t-stat)	tms	(t-stat)	R^2
					A. Level					
GZ spread	0.83	(1.80)	0.10	0.72	(3.92)	0.85	(3.59)	7.97	(1.14)	0.59
Aaa-Treasury	0.16	(1.25)	0.03	0.24	(1.75)	0.28	(5.72)	-3.73	(-1.26)	0.41
Aa-Treasury	-0.03	(-0.15)	0.00	-0.02	(-0.09)	0.34	(5.44)	-0.35	(-0.10)	0.39
A-Treasury	-0.21	(-0.70)	0.02	-0.25	(-1.02)	0.40	(4.99)	3.41	(0.69)	0.35
Baa-Treasury	-0.19	(-0.52)	0.01	-0.28	(-1.02)	0.52	(3.90)	6.04	(1.04)	0.38
Baa-Aaa	-0.36	(-1.22)	0.08	-0.52	(-2.17)	0.23	(2.14)	9.79	(2.17)	0.29
Repo-Bill	-0.83	(-3.84)	0.31	-0.59	(-3.04)	0.10	(1.44)	-13.80	(-3.29)	0.42
CD-Bill	-0.87	(-3.69)	0.18	-0.81	(-3.11)	0.29	(2.98)	-2.52	(-0.35)	0.28
Paper-Bill	-1.10	(-3.78)	0.29	-0.71	(-2.73)	0.09	(1.47)	-22.45	(-3.59)	0.43
FFR-Bill	-0.79	(-3.86)	0.26	-0.59	(-3.11)	0.11	(1.62)	-11.24	(-2.55)	0.35
					B. First Difference					
GZ spread	3.00	(1.73)	0.06	2.18	(1.51)	0.32	(2.81)	-5.77	(-2.22)	0.33
Aaa-Treasury	1.55	(2.56)	0.04	1.15	(2.18)	0.18	(5.37)	-10.83	(-3.31)	0.35
Aa-Treasury	2.06	(2.82)	0.06	1.60	(2.26)	0.20	(4.75)	-9.06	(-2.25)	0.33
A-Treasury	2.56	(2.56)	0.07	2.00	(2.09)	0.23	(4.27)	-7.83	(-2.16)	0.30
Baa-Treasury	3.65	(2.58)	0.09	2.98	(2.18)	0.27	(3.65)	-7.90	(-1.45)	0.28
Baa-Aaa	2.10	(2.20)	0.08	1.83	(1.90)	0.10	(1.75)	2.91	(1.11)	0.14
Repo-Bill	-3.43	(-2.85)	0.07	-3.71	(-2.92)	0.13	(2.21)	-9.31	(-1.02)	0.15
CD-Bill	1.21	(0.52)	0.00	0.10	(0.05)	0.31	(4.01)	35.23	(2.19)	0.20
Paper-Bill	-1.58	(-1.13)	0.01	-1.50	(-0.80)	0.02	(0.17)	-17.72	(-1.18)	0.08
FFR-Bill	-3.43	(-2.55)	0.06	-3.75	(-2.69)	0.14	(1.77)	-6.86	(-0.74)	0.12

Table 7: Risk-free Rate and Debt-to-GDP Ratio

The table reports estimates from OLS regressions of real risk-free rate on log debt-to-GDP ratio and other control variables.

$$r_{f,t} = \beta_0 + \beta_1 by_t + \beta_2 \Delta c_t + \beta_3 \Delta c_{t-1} + \beta_4 \pi_t + \beta_5 \pi_{t-1} + \beta_6 pd_t + u_t$$

The real risk-free rate is the nominal risk-free rate minus the four-quarter moving average of past inflation. The first column shows 3-month and 1-month real risk-free rate. "r_f, survey" calculate the real risk-free rate using Livingston survey on inflation. by is log debt-to-GDP ratio. Δc is consumption growth. π is inflation. pd is price-dividend ratio. "r_f, survey" is observed bi-annually. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors.

Period		by_t	Δc_t	Δc_{t-1}	π_t	π_{t-1}	pd_t	R^2
1947:I–2014:IV	r_f, 3M	-0.03	0.39	0.32	-0.76	-0.86	0.00	0.33
		(-2.94)	(2.29)	(1.37)	(-2.56)	(-2.86)	(-0.32)	
	r_f, 1M	-0.03	0.42	0.32	-0.78	-0.88	0.00	0.35
		(-3.09)	(2.60)	(1.45)	(-2.74)	(-3.14)	(-0.21)	
	r_f, survey	-0.02	0.02	0.00	-0.22	-0.78	-0.01	0.24
		(-2.45)	(0.07)	(-0.01)	(-0.99)	(-2.12)	(-1.17)	
1926–2014	r_f, 3M	-0.05	0.01	-0.09	-0.79	0.19	0.00	0.71
		(-4.97)	(0.12)	(-0.71)	(-8.09)	(1.69)	(0.21)	

Table 8: Government Debt Return and Debt-to-GDP Ratio

Panel A reports estimates from OLS regressions of government debt return on log debt-to-GDP ratio.

$$\Sigma_{i=1}^{h} r_{b,t+i} = \beta_0 + \beta_1 by_t + u_{+h}$$

The government debt return r_b is the log average return across terms to maturity on all the government debt outstanding subtracting the realized inflation. Longer horizon returns are the cumulative summation of the one-period return. by is log debt-to-GDP ratio. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample is from 1929 to 2014.

Panel B reports the variance decomposition. Surplus is $E_t[\Sigma_{j=0}\kappa_1^j(\kappa_2 \tau y_{t+j} - \kappa_3 g y_{t+j})]$. Growth is $E_t[\Sigma_{j=0}\kappa_1^j \Delta y_{t+j}]$. Return is $E_t[\Sigma_{j=0}\kappa_1^j r_{b,t+j}]$. The conditional expectation is computed from a first order vector autoregression model with five variables $[by_t,\ gy_t,\ \tau y_t,\ \Delta y_t,\ r_{b,t}]'$.

A. Predictive Regression

h	by_t	(t-stat)	R^2
1Y	-0.04	(-2.29)	0.09
5Y	-0.14	(-1.74)	0.15
10Y	-0.24	(-2.00)	0.17
20Y	-0.44	(-3.59)	0.28

B. Variance Decomposition

	surplus	growth	discount rate
$cov(by_t, E_t[.])/var(by_t)$	0.49	0.30	-0.25

Table 9: Fiscal Uncertainty and Debt-to-GDP Ratio

This table reports the correlation between log debt-to-GDP ratio and measures of uncertainty. Panel A shows the broad-based measure of fiscal and macro uncertainty. Panel B shows the Economic Policy Uncertainty Index from Baker et al. (2015).

	$corr(by, uncertainty)$	
	1947:I–2014:IV	1985:I:2014:IV
A. Broad-based Uncertainty Measure		
1Y Fiscal Uncertainty	0.28	0.21
3Y Fiscal Uncertainty	0.50	0.29
5Y Fiscal Uncertainty	0.54	0.29
1Y Macro Uncertainty	0.06	0.15
3Y Macro Uncertainty	0.06	0.06
5Y Macro Uncertainty	0.06	-0.26
B. Economic Policy Uncertainty		
Economic Policy Uncertainty		0.26
Monetary policy		-0.18
Fiscal Policy		0.36
Taxes		0.33
Government spending		0.37
Health care		0.58
National security		-0.14
Entitlement programs		0.45
Regulation		0.51
Financial Regulation		0.27
Trade policy		-0.01
Sovereign debt, currency crises		0.31

Table 10: Fiscal Uncertainty and Asset Prices

Panel A reports estimates from OLS regressions of asset prices on log debt-to-GDP ratio.

$$r_t = \beta_0 + \beta_1 Uncertainty_t + u_t$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. by is the log debt-to-GDP ratio. Excess corporate bond return is the log Barclay's corporate investment-grade bond portfolio return r_{corp} subtracting the log risk free rate r_f. GZ spread is the credit spread in Gilchrist and Zakrajŝek (2012). The real risk free rate r_f is the nominal risk free rate minus the four-month moving average of past inflation. The government debt return r_b is the log average return across terms to maturity on all the government debt outstanding subtracting the realized inflation. Uncertainty is measured as the broad-based 3-year fiscal uncertainty or the fiscal policy uncertainty in Economic Policy Uncertainty Index from Baker et al. (2015).

	Broad-based	(*t*-stat)	R^2	EPU	(*t*-stat)	R^2
$r_{m,t+1} - r_{f,t}$, 1Y	0.021	(1.26)	0.02	0.048	(2.39)	0.08
$r_{m,t+1} - r_{f,t}$, 3Y	0.073	(2.14)	0.07	0.153	(2.99)	0.25
$r_{m,t+1} - r_{f,t}$, 5Y	0.168	(2.93)	0.21	0.188	(4.79)	0.24
$r_{corp,t+1} - r_{f,t}$, 1Y	0.025	(2.43)	0.07	0.018	(2.42)	0.09
GZ spread	0.007	(2.51)	0.43	0.003	(1.10)	0.06
$r_{f,t}$	-0.002	(-1.54)	0.09	-0.002	(-2.19)	0.10
$r_{b,t+1}$	-0.002	(-0.41)	0.00	-0.012	(-1.99)	0.09

Table 11: Calibration

The table reports the calibration of the model. Panel A contains the preferences and technology paraemters. Panel B contains fiscal policy parameters. Panel C contains parameters in fiscal consolidation and government spending policies.

Description	Parameter	Value
A. Preferences and Technology		
Subject discount factor	β	0.994
Intertemporal elasticity of substitution	ψ	2
Relative risk aversion	γ	10
Capital share	α	0.33
Intermediate inputs share	ξ	0.50
Depreciation rate of R&D capital	ϕ	0.075
Depreciation rate of capital	δ	0.025
Investment adjustment cost	ξ_k	0.80
Exogenous productivity shock volatility	σ_a	0.008
Exogenous productivity persistence	ρ	0.97
B. Fiscal Policy		
Corporatetax rate mean	$\mu_{\tau c}$	0.36
Corporate tax rate shock volatility	$\sigma_{\tau.0}/\sqrt{1-\rho_\tau}$	0.03
Corporate tax rate persistence	ρ_τ	0.99
Fiscal uncertainty shock volatility	$\sigma_{\tau,w}$	0.7
Fiscal uncertainty persistence	ν_τ	0.995
G-Y ratio mean	μ_{gy}	0.17
Labor tax rate mean	$\mu_{\tau l}$	0.10
Long-term debt maturity	ϕ_b	0.99
Bond quantity persistence	ρ_b	0.99
Bond quantity volatility	σ_b	0.01
C. Fiscal Consolidation and Government Spending Policy		
Fiscal consolidation	$\bar{\phi}_\tau$	0.001
Fiscal consolidation volatility	$\sigma^2_{\phi\tau}$	0.006
Fiscal consolidation cyclicality	$corr(\phi_{\tau,t+1},\varepsilon_{t+1})$	-0.5
G-Y ratio shock volatility	$\sigma_{g,0}/\sqrt{1-\rho_g}$	0.01
G-Y ratio persistence	ρ_g	0.99

Table 12: Macroeconomic Dynamics and Asset Prices

The table reports the macroeconomic and asset price moments in the data and the model. The reported model moments are the mean, 5% and 95% quantile of short-sample simulations. The simulated sample period is 85 years.

	Data	Model	5%	95%
$E[\Delta y]$	1.80	1.80	-0.40	3.59
$\sigma(\Delta y)$	5.00	2.80	2.55	3.15
$\sigma(\Delta c)$	2.70	2.62	1.82	4.16
$E[r_m - r_f]$	5.59	5.19	2.34	8.54
$\sigma(r_m)$	20.04	7.32	5.81	10.12
$E[r_f]$	0.45	1.48	-0.46	2.98
$\sigma(r_f)$	3.75	1.42	0.90	2.28
$E[r_b]$	1.48	0.75	-1.86	2.97
$\sigma(r_b)$	5.31	4.54	3.69	5.96
$E[pd]$	3.39	3.63	3.01	4.16
$\sigma(pd)$	0.45	0.43	0.24	0.74
$E[B/Y]$	0.40	0.52	0.41	0.63
$\sigma(B/Y)$	0.18	0.08	0.05	0.12
$E[T/Y]$	0.20	0.20	0.19	0.21
$\sigma(T/Y)$	0.02	0.01	0.00	0.02

Table 13: Asset Prices, Debt-to-GDP and Fiscal Uncertainty

Panel A reports estimates from OLS regressions of asset prices on log debt-to-GDP ratio.

$$r_t = \beta_0 + \beta_1 by_t + u_t$$

Excess stock return is the log market return r_m subtracting the log risk free rate r_f. by is the log debt-to-GDP ratio. The real risk-free rate r_f is the nominal risk-free rate minus the four-quarter moving average of past inflation. The government debt return r_b is the log average return across terms to maturity on all the government debt outstanding subtracting the realized inflation. The standard errors are heteroscedasticity and autocorrelation consistent. Panel B reports estimates from OLS regressions of asset prices on the broad-based 3-year fiscal uncertainty. Model is from the benchmark calibration. The reported model moments are the mean, 5% and 95% quantile of β and R^2 in short-sample simulations. The simulated sample period is 85 years.

	Data			Model					
	β	*s.e.*	R^2	β	5%	95%	R^2	5%	95%
A. Debt-to-GDP ratio									
$r_{m,t+1} - r_{f,t}$, 1Q	0.04	(0.01)	0.04	0.04	-0.02	0.10	0.01	0.00	0.03
$r_{m,t+1} - r_{f,t}$, 1Y	0.15	(0.05)	0.11	0.15	-0.07	0.40	0.04	0.00	0.13
$r_{m,t+1} - r_{f,t}$, 3Y	0.41	(0.12)	0.27	0.43	-0.20	1.14	0.10	0.00	0.31
$r_{m,t+1} - r_{f,t}$, 5Y	0.60	(0.13)	0.38	0.65	-0.41	1.76	0.14	0.00	0.45
$r_{f,t}$	-0.04	(0.02)	0.21	-0.09	-0.19	0.01	0.27	0.01	0.65
$r_{b,t+1}$	-0.04	(0.02)	0.09	-0.18	-0.35	-0.03	0.10	0.00	0.26
$r_{b,t+1}$, 10Y	-0.24	(0.12)	0.17	-1.18	-2.43	0.10	0.33	0.01	0.77
$r_{m,t+1}$, 1Y	0.11	(0.05)	0.05	0.06	-0.17	0.35	0.02	0.00	0.08
$r_{m,t+1}$, 3Y	0.29	(0.12)	0.15	0.06	-0.19	0.33	0.02	0.00	0.09
$r_{m,t+1}$, 5Y	0.43	(0.15)	0.22	0.30	-0.95	1.60	0.08	0.00	0.29
B. Fiscal Uncertainty									
$corr(by, uncertainty)$	0.50			0.43	-0.15	0.86			
$r_{m,t+1} - r_{f,t}$, 1Y	0.02	(0.02)	0.02	0.02	0.01	0.03	0.08	0.00	0.18
$r_{m,t+1} - r_{f,t}$, 5Y	0.17	(0.05)	0.21	0.09	0.03	0.17	0.30	0.03	0.59
$r_{f,t}$	-0.002	(0.001)	0.09	-0.01	-0.01	0.00	0.19	0.00	0.53
$r_{b,t+1}$	-0.002	(0.01)	0.00	-0.01	-0.02	-0.01	0.11	0.03	0.23

Table 14: Mechanisms of Fiscal Uncertainty

Panel A reports estimates from OLS regressions of asset prices on log debt-to-GDP ratio.

$$r_t = \beta_0 + \beta_1 by_t + u_t$$

Excess stock return is the log market return r_m subtracting the log risk free rate r_f. by is the log debt-to-GDP ratio. The real risk-free rate r_f is the nominal risk-free rate minus the four-quarter moving average of past inflation. The government debt return r_b is the log average return across terms to maturity on all the government debt outstanding subtracting the realized inflation. The standard errors are heteroscedasticity and autocorrelation consistent. Panel B reports estimates from OLS regressions of asset prices on the broad-based 3-year fiscal uncertainty.

"Tax Vol" is the benchmark calibration that has stochastic volatility. "Vol and Cons" includes both stochastic volatility and uncertain fiscal consolidations. "Cons." has uncertain fiscal consolidations but no stochastic volatility. "Spending" introduce spending shocks in the benchmark. "No Vol" has no stochastic volatility and uncertain fiscal consolidations. The reported model moments are the mean of β and R^2 in short-sample simulations. The simulated sample period is 85 years.

	Data		Tax Vol		Vol & Cons.		Cons.		Spending		No Vol	
	β	R^2	β	R^2	β	R^2	β	R^2	β	R^2	β	R^2
A. Debt-to-GDP ratio												
$r_{m,t+1} - r_{f,t}$, 1Q	0.04	0.04	0.04	0.01	0.05	0.01	0.03	0.01	0.04	0.01	0.01	0.00
$r_{m,t+1} - r_{f,t}$, 1Y	0.15	0.11	0.15	0.04	0.18	0.05	0.11	0.02	0.15	0.04	0.02	0.01
$r_{m,t+1} - r_{f,t}$, 3Y	0.41	0.27	0.43	0.10	0.49	0.13	0.30	0.07	0.43	0.10	0.07	0.03
$r_{m,t+1} - r_{f,t}$, 5Y	0.60	0.38	0.65	0.14	0.75	0.18	0.45	0.10	0.65	0.14	0.10	0.05
$r_{f,t}$	-0.04	0.21	-0.09	0.27	-0.11	0.38	-0.09	0.32	-0.09	0.27	-0.06	0.16
$r_{b,t+1}$	-0.04	0.09	-0.18	0.10	-0.21	0.14	-0.16	0.10	-0.18	0.10	-0.07	0.04
$r_{b,t+1}$, 10Y	-0.24	0.17	-1.18	0.33	-1.43	0.48	-0.99	0.46	-1.18	0.33	-0.37	0.17
$r_{m,t+1}$, 1Y	0.11	0.05	0.06	0.02	0.07	0.02	0.01	0.02	0.06	0.02	-0.03	0.02
$r_{m,t+1}$, 3Y	0.29	0.15	0.06	0.02	0.06	0.02	0.02	0.02	0.06	0.02	-0.02	0.02
$r_{m,t+1}$, 5Y	0.43	0.22	0.30	0.08	0.31	0.09	0.10	0.07	0.30	0.08	-0.09	0.07
B. Fiscal Uncertainty												
$corr(by_t, var_t(\tau_{c,t+1}))$	0.50		0.43		0.38		1.00		0.43		0.00	
$r_{m,t+1} - r_{f,t}$, 1Y	0.02	0.02	0.02	0.08	0.02	0.06	0.01	0.02	0.02	0.08		
$r_{m,t+1} - r_{f,t}$, 5Y	0.17	0.21	0.09	0.30	0.10	0.26	0.04	0.10	0.09	0.30		
$r_{f,t}$	-0.002	0.09	-0.01	0.19	-0.01	0.18	-0.01	0.32	-0.01	0.19		
$r_{b,t+1}$	-0.002	0.00	-0.01	0.11	-0.02	0.08	-0.01	0.10	-0.01	0.11		

Table 15: Tax Impact on Growth

The table shows the OLS regressions of economic growth on log tax-to-GDP ratio.

$$\Sigma_{i=1}^{h}\Delta y_{t+i} = \beta_0 + \tau y_t \beta_1 + u_{t+h}$$

The growth Δy is measured as real output, real private consumption or total factor productivity. τy is the log tax-to-GDP ratio. Tax is the federal tax receipts. h is the predictive horizon. The standard errors are heteroscedasticity and autocorrelation consistent. The sample is from 1947:I to 2014:IV. The reported model moments are the mean, 5% and 95% quantile of β and R^2 in short-sample simulations. The simulated sample period is 85 years.

			Data			Model				
h		β	*s.e.*	R^2	β	5%	95%	R^2	5%	95%
	output,	-0.15	(0.04)	0.13	-0.29	-0.62	0.07	0.16	0.00	0.46
1Y	consumption	-0.09	(0.03)	0.06	-0.41	-0.80	-0.04	0.24	0.01	0.55
	TFP	-0.12	(0.03)	0.16	-0.32	-0.74	0.13	0.11	0.00	0.33
	output	-0.66	(0.19)	0.21	-1.43	-4.81	1.85	0.19	0.00	0.55
10Y	consumption	-0.35	(0.15)	0.09	-2.04	-5.19	1.19	0.26	0.00	0.67
	TFP	-0.32	(0.15)	0.13	-1.31	-5.42	2.96	0.15	0.00	0.47

Appendix I. Data

The appendix details the data source.

The government debt data are from Dallas Fed, Flow of Funds, and George Hall. Dallas Fed reports the monthly level of par and market values of gross, non-marketable and net debt from 1942 to 2014. Flow of Funds database reports debt held by the Federal Reserve System and rest of the world. George Hall kindly provides debt data from 1926 to 1941.

The stock return and predictors are from Amit Goyal's website. The stock return is the return on S&P 500 index from CRSP. The risk-free rate is the 3-month T-bill. The price-dividend ratio (pd) is the difference between the log of prices and the log of dividends. The dividend yield (dy) is the difference between the log of dividends and the log of lagged prices. The price-earning ratio (pe) is the difference between log of prices and log of earnings. The dividend-earning ratio (d/e) is the difference between log of dividends and log of earnings. Stock return volatility (svar) is the sum of squared daily returns on S&P 500. The book-to-market ratio (bm) is the ratio of book value to market value for the Dow Jones Industrial Average. Net equity expansion (ntis) is the ratio of twelve-month moving sums of net issues by NYSE-listed stocks divided by the total market capitalization of NYSE stocks. Treasury bill rate (tbl) is the 3-month treasury bill rate. Long-term yield (lty) is the long-term government bond yield. Long-term return (ltr) is the long-term government bond return. Term spread (tms) is the difference between the long-term yield on government bonds and the T-bill. Default yield spread (dfy) is the difference between BAA- and AAA- rated corporate bond yields. Inflation (infl) is the CPI inflation. Investment-capital ratio (ik) is the ratio of aggregate (private nonresidential fixed) investment to aggregate capital for the whole economy. Consumption-wealth ratio (cay) is the error correction term calculated from the co-integration of consumption, income, and wealth. Two predictors are constructed separately. GDP gap (gap) is the difference between actual GDP and potential GDP over potential GDP. Potential GDP is from CBO. Government investment-capital ratio (gik) is the ratio of aggregate government investment to aggregate government capital.

Investment-grade and high-yield corporate bond return indices are from Barclay's. Gilchrist and Zakrajŝek (2012) spread is from Simon Gilchrist's website. Moody's Aaa, Aa, A, Baa bond yields are from Bloomberg. 30-year treasury bond yield is from CRSP. General collateral repo rate (Repo) combines two series. It is the banker's acceptance rate from Fred before 1991 and 3-month general collateral repo rate from Bloomberg after 1991. Certificate of Deposits rate (CD) and AA commercial paper rate are from Fred. 1-month and 3-month nominal risk-free rates are from CRSP. Expected inflation in Livingston survey is from Philly Fed. The average return on government debt is from George Hall.

The data on macroeconomic and fiscal variables are from NIPA. In constructing the fiscal uncertainty measure, I use a large panel of quarterly macroeconomic series from FRED-QD database

(McCracken and Ng, 2016). I include all the series that are available from 1948 in Group 1: NIPA, Group 2: Industrial Production, Group 3: Employment and Unemployment, Group 5: Inventories, Orders, and Sales, Group 6: Prices, Group 7: Earnings and Productivity, and Group 9: Money and Credit. I exclude other groups about financial markets. These result in 132 macroeconomics series. ID shows the series number in the database. TC denotes the data transformation: (1) no transformation; (2) Δx_t; (3) $\Delta^2 x_t$; (4)$log(x_t)$;(5)$\Delta log(x_t)$;(6)$\Delta^2 log(x_t)$. (7)$\Delta(x_t/x_{t-1})-1)$. The transformation follows McCracken and Ng (2016). I augment the database with 37 fiscal-policy-related series from NIPA Table 3.2, 3.3, 3.9.5, and 3.10.5. These variables cover the major components of government receipts, consumption, investment, and transfer in the federal and state and local level. I take the ratio between the fiscal variables and nominal GDP and take the log difference.

Fiscal Policy Variables	Federal	State and Local
Current receipts	3.2	3.3
Current tax receipts	3.2	3.3
Personal current taxes	3.2	3.3
Taxes on production and imports	3.2	3.3
Taxes on corporate income	3.2	3.3
Contributions for government social insurance	3.2	
Current transfer receipts	3.2	
Capital transfer receipts	3.2	3.3
Current expenditures	3.2	3.3
Consumption expenditures	3.2	3.3
Compensation of general government employees	3.10.5	3.10.5
Consumption of general government fixed capital	3.10.5	3.10.5
Durable goods	3.10.5	
Nondurable goods	3.10.5	
Services	3.10.5	
Current transfer payments	3.2	3.3
Interest payments	3.2	3.3
Subsidies	3.2	
Gross investment	3.9.5	3.9.5
Structures	3.9.5	
Equipment	3.9.5	
Intellectual property products	3.9.5	
National defense consumption expenditures and gross investment	3.9.5	
Nondefense consumption expenditures and gross investment	3.9.5	

ID	TC	FRED MNEMONIC	DESCRIPTION
			1. NIPA
1	5	GDPC96	Real Gross Domestic Product, 3 Decimal
2	5	PCECC96	Real Personal Consumption Expenditures
3	5	PCDG	Personal Consumption Expenditures: Durable Goods
4	5	PCESV	Personal Consumption Expenditures: Services
5	5	PCND	Personal Consumption Expenditures: Nondurable Goods
6	5	GPDIC96	Real Gross Private Domestic Investment, 3 decimal
7	5	FPI	Fixed Private Investment
8	5	Y033RC1Q027SBEA	Gross Private Domestic Investment: Fixed Investment: Nonresidential: Equipment
9	5	PNFI	Private Nonresidential Fixed Investment
10	5	PRFI	Private Residential Fixed Investment
11	1	A014RE1Q156NBEA	Shares of gross domestic product: Gross private domestic investment: Change in private inventories
16	5	EXPGSC96	Real Exports of Goods and Services, 3 Decimal
17	5	IMPGSC96	Real Imports of Goods and Services, 3 Decimal
18	5	DPIC96	Real Disposable Personal Income
19	5	OUTNFB	Nonfarm Business Sector: Real Output
20	5	OUTBS	Business Sector: Real Output
194	2	B020RE1Q156NBEA	Shares of gross domestic product: Exports of goods and services
195	2	B021RE1Q156NBEA	Shares of gross domestic product: Imports of goods and services
			2. Industrial Production
22	5	INDPRO	Industrial Production Index
23	5	IPFINAL	Industrial Production: Final Products (Market Group)
24	5	IPCONGD	Industrial Production: Consumer Goods
25	5	IPMAT	Industrial Production: Materials
26	5	IPDMAT	Industrial Production: Durable Materials
28	5	IPDCONGD	Industrial Production: Durable Consumer Goods
29	5	IPB51110SQ	Industrial Production: Durable Goods: Automotive products
30	5	IPNCONGD	Industrial Production: Nondurable Consumer Goods
31	5	IPBUSEQ	Industrial Production: Business Equipment
34	1	CUMFNS	Capacity Utilization: Manufacturing (SIC)
198	5	IPMANSICS	Industrial Production: Manufacturing (SIC)
201	1	NAPMPI	ISM Manufacturing: Production Index
205	1	NAPM	ISM Manufacturing: PMI Composite Index

ID	TC	FRED MNEMONIC	DESCRIPTION
			3. Employment and Unemployment
35	5	PAYEMS	All Employees: Total Nonfarm Payrolls
36	5	USPRIV	All Employees: Total Private Industries
37	5	MANEMP	All Employees: Manufacturing
38	5	SRVPRD	All Employees: Service-Providing Industries
39	5	USGOOD	All Employees: Goods-Producing Industries
40	5	DMANEMP	All Employees: Durable goods
41	5	NDMANEMP	All Employees: Nondurable goods
42	5	USCONS	All Employees: Construction
43	5	USEHS	All Employees: Education and Health Services
44	5	USFIRE	All Employees: Financial Activities
45	5	USINFO	All Employees: Information Services
46	5	USPBS	All Employees: Professional and Business Services
47	5	USLAH	All Employees: Leisure and Hospitality
48	5	USSERV	All Employees: Other Services
49	5	USMINE	All Employees: Mining and logging
50	5	USTPU	All Employees: Trade, Transportation and Utilities
51	5	USGOVT	All Employees: Government
52	5	USTRADE	All Employees: Retail Trade
53	5	USWTRADE	All Employees: Wholesale Trade
54	5	CES9091000001	All Employees: Government: Federal
57	5	CE16OV	Civilian Employment
58	2	CIVPART	Civilian Labor Force Participation Rate
59	2	UNRATE	Civilian Unemployment Rate
60	2	LNS13008397	Of Total Unemployed, Percent Unemployed Less than 5 Weeks
61	2	LNS13025703	Of Total Unemployed, Percent Unemployed 27 Weeks and over
62	2	LNS14000012	Unemployment Rate: 16 to 19 years
63	2	LNS14000025	Unemployment Rate: 20 years and over, Men
64	2	LNS14000026	Unemployment Rate: 20 years and over, Women
65	5	UEMPLT5	Number of Civilians Unemployed for Less Than 5 Weeks
66	5	UEMP5TO14	Number of Civilians Unemployed for 5 to 14 Weeks
67	5	UEMP15T26	Number of Civilians Unemployed for 15 to 26 Weeks
68	5	UEMP27OV	Number of Civilians Unemployed for 27 Weeks and Over
74	5	HOABS	Business Sector: Hours of All Persons
76	5	HOANBS	Nonfarm Business Sector: Hours of All Persons
77	1	AWHMAN	Average Weekly Hours of Production and Nonsupervisory Employees: Manufacturing
202	2	UEMPMEAN	Average (Mean) Duration of Unemployment
203	2	CES0600000007	Average Weekly Hours of Production and Nonsupervisory Employees: Goods-Producing
204	1	NAPMEI	ISM Manufacturing: Employment Index
			5: Inventories, Orders, and Sales
94	1	NAPMSDI	ISM Manufacturing: Supplier Deliveries Index
206	1	NAPMNOI	ISM Manufacturing: New Orders Index
207	1	NAPMII	ISM Manufacturing: Inventories Index

ID	TC	FRED MNEMONIC	DESCRIPTION
			6. Prices
96	6	PCECTPI	Personal Consumption Expenditures: Chain-type Price Index
98	6	GDPCTPI	Gross Domestic Product: Chain-type Price Index
99	6	GPDICTPI	Gross Private Domestic Investment: Chain-type Price Index
100	6	IPDBS	Business Sector: Implicit Price Deflator
101	6	DGDSRG3Q086SBEA	PCE: Goods (chain-type price index)
102	6	DDURRG3Q086SBEA	PCE: Durable goods (chain-type price index)
103	6	DSERRG3Q086SBEA	PCE: Services (chain-type price index)
104	6	DNDGRG3Q086SBEA	PCE: Nondurable goods (chain-type price index)
105	6	DHCERG3Q086SBEA	PCE: Services: Household consumption expenditures (chain-type price index)
106	6	DMOTRG3Q086SBEA	PCE: Durable goods: Motor vehicles and parts (chain-type price index)
107	6	DFDHRG3Q086SBEA	PCE: Durable goods: Furnishings and durable household equipment (chain-type price index)
108	6	DREQRG3Q086SBEA	PCE: Durable goods: Recreational goods and vehicles (chain-type price index)
109	6	DODGRG3Q086SBEA	PCE: Durable goods: Other durable goods (chain-type price index)
110	6	DFXARG3Q086SBEA	PCE: Nondurable goods: Food and beverages purchased for off-premises consumption (chain-type price index)
111	6	DCLORG3Q086SBEA	PCE: Nondurable goods: Clothing and footwear (chain-type price index)
112	6	DGOERG3Q086SBEA	PCE: Nondurable goods: Gasoline and other energy goods (chain-type price index)
113	6	DONGRG3Q086SBEA	PCE: Nondurable goods: Other nondurable goods (chain-type price index)
114	6	DHUTRG3Q086SBEA	PCE: Services: Housing and utilities (chain-type price index)
115	6	DHLCRG3Q086SBEA	PCE: Services: Health care (chain-type price index)
116	6	DTRSRG3Q086SBEA	PCE: Transportation services (chain-type price index)
117	6	DRCARG3Q086SBEA	PCE: Recreation services (chain-type price index)
118	6	DFSARG3Q086SBEA	PCE: Services: Food services and accommodations (chain-type price index)
119	6	DIFSRG3Q086SBEA	PCE: Financial services and insurance (chain-type price index)
120	6	DOTSRG3Q086SBEA	PCE: Other services (chain-type price index)
121	6	CPIAUCSL	Consumer Price Index for All Urban Consumers: All Items
123	6	PPIFGS	Producer Price Index by Commodity for Finished Goods
124	6	PPIACO	Producer Price Index for All Commodities
125	6	PPIFCG	Producer Price Index by Commodity for Finished Consumer Goods
126	6	PPIFCF	Producer Price Index by Commodity for Finished Consumer Foods
127	6	PPIIDC	Producer Price Index by Commodity Industrial Commodities
128	6	PPIITM	Producer Price Index by Commodity Intermediate Materials: Supplies and Components
129	1	NAPMPRI	ISM Manufacturing: Prices Index
131	5	WPU0561	Producer Price Index by Commodity for Fuels and Related Products and Power: Crude Petroleum (Domestic Production)
214	6	PPICRM	Producer Price Index by Commodity for Crude Materials for Further Processing
215	6	PPICMM	Producer Price Index by Commodity Metals and metal products: Primary nonferrous metals
216	6	CPIAPPSL	Consumer Price Index for All Urban Consumers: Apparel
217	6	CPITRNSL	Consumer Price Index for All Urban Consumers: Transportation
218	6	CPIMEDSL	Consumer Price Index for All Urban Consumers: Medical Care
220	6	CUUR0000SAD	Consumer Price Index for All Urban Consumers: Durables
222	6	CPIULFSL	Consumer Price Index for All Urban Consumers: All Items Less Food
223	6	CUUR0000SA0L2	Consumer Price Index for All Urban Consumers: All items less shelter

ID	TC	FRED MNEMONIC	DESCRIPTION
			7. Earnings and Productivity
134	5	CES2000000008	Average Hourly Earnings of Production and Nonsupervisory Employees: Construction
135	5	CES3000000008	Average Hourly Earnings of Production and Nonsupervisory Employees: Manufacturing
137	5	COMPRNFB	Nonfarm Business Sector: Real Compensation Per Hour
138	5	RCPHBS	Business Sector: Real Compensation Per Hour
140	5	OPHNFB	Nonfarm Business Sector: Real Output Per Hour of All Persons
141	5	OPHPBS	Business Sector: Real Output Per Hour of All Persons
142	5	ULCBS	Business Sector: Unit Labor Cost
144	5	ULCNFB	Nonfarm Business Sector: Unit Labor Cost
145	5	UNLPNBS	Nonfarm Business Sector: Unit Nonlabor Payments
225	6	CES0600000008	Average Hourly Earnings of Production and Nonsupervisory Employees: Goods-Producing
			9. Money and Credit
162	5	AMBSLREAL	Real St. Louis Adjusted Monetary Base
167	5	BUSLOANS	Commercial and Industrial Loans, All Commercial Banks
168	5	CONSUMER	Consumer Loans at All Commercial Banks
169	5	NONREVSL	Total Nonrevolving Credit Owned and Securitized, Outstanding
170	5	REALLN	Real Estate Loans, All Commercial Banks
172	5	TOTALSL	Total Consumer Credit Owned and Securitized, Outstanding
226	6	DTCOLNVHFNM	Consumer Motor Vehicle Loans Owned by Finance Companies, Outstanding
227	6	DTCTHFNM	Total Consumer Loans and Leases Owned and Securitized by Finance Companies, Outstanding
228	6	INVEST	Securities in Bank Credit at All Commercial Banks

Appendix II. Robustness

The results in stock return predictability in Section 2.2 are robust across many dimensions. First, I address the high persistence of the debt-to-GDP ratio. I use the efficient test by Campbell and Yogo (2006) that corrects for the endogeneity bias (Stambaugh, 1999) and provides an accurate approximation to the finite-sample distribution of test statistics under flexible degrees of persistence (stationary, local-to-unity, and unit root). The results confirm that the predictability is present after considering the persistence of the predictor. Second, in the benchmark case, the government debt is defined as the market value of net debt held by the public. I consider other definitions and components of debt that have different economic interpretations (non-marketable debt, book value, intergovernmental holding, fed holding, foreign holding). The results are similar to the benchmark case. Third, I verify the forecasting power using data from UK and Canada who has arguably little default risk and stationary debt-to-GDP ratio.

Persistence One key concern is the high persistence of the predictor. The debt-to-GDP ratio has a persistence of 0.957 at annual frequency. The stationarity of debt-to-GDP ratio is examined thoroughly in the literature, and there is no convincing evidence of a unit root (Bohn, 2005). If the debt-to-GDP ratio is nonstationary, with probability one it will implausibly diverge to infinity.

The high persistence of the predictor leads to potential invalidity of the inference in two ways. First, if the innovation to the predictor and innovation to the return are correlated, there is a small-sample bias (Stambaugh, 1999). Second, the high degree of persistence results in a nonstandard asymptotic distribution. I use the efficient test by Campbell and Yogo (2006) to address both problems. They propose a Bonferroni test that corrects for the endogeneity and provides an accurate approximation to the finite-sample distribution of test statistics under flexible degrees of persistence (stationary, local-to-unity, and unit root). In Table A1, the test results confirm that the conventional t-test in Table 1 is valid. The 95% confidence interval does not include zero at all horizons and sample periods. The main reason is that the correlation between innovations of debt-to-GDP ratio and return ρ_{ue} is close to zero, while the correlations are very high in a variety of valuation ratios.

Components of Government Debt In the benchmark case, the government debt is defined as the market value of net debt held by the public. There are other definitions and components of debt that have different economic interpretations. The gross level includes debt held by the government accounts that does not represent what the government owes.[19] A portion of the debt is non-marketable and cannot be traded in secondary markets. Given quantitative easing and the

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[19] These accounts include the Social Security Trust Fund, federal employee retirement funds, the Unemployment Trust Fund, etc.

rapid growth of foreign investors, the debt held by the Federal Reserve System and foreigners are of interest on their own. Moreover, the commonly reported value is the par value not marked to market. In comparison, the benchmark definition is a more accurate measure in that net debt is more relevant than gross debt to measure the indebtedness of the government and market value reflects up-to-date information in yields changes. Nevertheless, I entertain all the definitions in the following analysis. The correlations of different debt-to-GDP ratios are around 0.9. Table A2 reports the results. The difference between various definitions is small in that all the coefficients are around 0.15, and R^2 around 10% at the annual horizon. Results are similar at other horizons. Therefore, the different definitions and decomposition of the government debt share the same forecasting power. As we see, the choice of benchmark is innocuous. In the last row, I define debt-to-GDP ratio as the ratio of net debt and potential GDP that capture the ideal level of trend GDP without business cycles, measured by Congress Budget Office. The predictability results remain in this setting. In fact, the denominator plays the role of normalization.[20]

International Evidence I verify the forecasting power using data from other countries. I use the debt-to-GDP ratio of each country to predict the excess return on the country's MSCI Index. One obvious mechanism is that default probability increases with debt-to-GDP ratio, thus affecting the asset prices on all the markets. This sovereign default premium should be of first order in most countries. In this paper, I focus on the default-free case and left the interesting default mechanism for future research. I choose countries that have arguably no default risks. The finding in the US market also shows up in Canada and UK in Table A3. The coefficients are statistically significant, and the magnitude is around 0.2, close to 0.15 in the US. In Germany and Japan, the debt-to-GDP ratios have a clear upward trend in the sample. So I exclude them from this test. This trending debt could be due to country-level heterogeneity. It is clear that a trend does not serve the role of a predictor.

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[20] Debt-to-Consumption ratio and Debt-to-Industrial-Production ratio yield similar results. Therefore, the forecasting information is in debt and price instead of the various denominators. Similarly, the price-dividend ratio and price-earning ratio have similar forecasting power.

Table A1: Bonferroni Test of Predictability

The table reports the Bonferroni test of predictability in Campebll and Yogo (2006).

$$r_{m,t+1} - r_{f,t} = \alpha + \beta by_t + u_{t+1}$$

$$by_{t+1} = \mu + \rho by_t + e_{t+1}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. by is the log debt to GDP ratio. h is the predictive horizon. The log debt-to-GDP ratio is modeled as an autoregressive process. The table shows the point estimate β and 95% confidence interval based on the Bonferroni-Q test. $\rho_{ue} = corr(u_{t+1}, e_{t+1})$.

Period	h	β	95% CI	ρ_{ue}
1929-2014	1Y	0.15	[0.06, 0.24]	0.03
	2Y	0.30	[0.09, 0.49]	-0.12
	3Y	0.37	[0.12, 0.63]	0.08
1947-2014	1Q	0.04	[0.02, 0.06]	-0.01
	1Y	0.16	[0.06, 0.26]	0.06

Table A2: Predictability of Excess Stock Returns

The table reports estimates from OLS regressions of future excess stock returns on log debt-to-GDP ratio and other control variables.

$$\Sigma_{i=1}^{h}(r_{m,t+i} - r_{f,t+i-1}) = \beta_0 + by_t\beta_1 + pd_t\beta_2 + u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. *by* is the log debt-to-GDP ratio. The predictive horizon is indicated in the name of the panel. The first column show the component of debt used to construct the debt-to-GDP ratio. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample is from 1947:I to 2014:IV.

Component of Debt	*by*	(*t*-stat)	R^2	*by*	(*t*-stat)	R^2
		1Q			1Y	
Net Debt	0.04	(2.89)	0.03	0.14	(3.38)	0.10
Gross Debt	0.03	(2.29)	0.02	0.12	(2.74)	0.06
Marketable Debt	0.04	(2.77)	0.03	0.15	(3.39)	0.09
Net Debt Book Value	0.04	(2.85)	0.03	0.15	(3.40)	0.10
Gross Debt Book Value	0.03	(2.26)	0.02	0.13	(2.83)	0.07
Marketable Debt Book Value	0.04	(2.75)	0.03	0.16	(3.45)	0.10
Net Debt exclud. Fed Holding	0.03	(2.53)	0.03	0.13	(2.97)	0.09
Net Debt exclud. Foreign Holding	0.04	(2.89)	0.03	0.14	(2.87)	0.09
Net Debt/Potential GDP	0.04	(2.94)	0.03	0.15	(3.53)	0.11
		3Y			5Y	
Net Debt	0.37	(5.70)	0.30	0.55	(4.57)	0.39
Gross Debt	0.33	(3.81)	0.19	0.50	(2.87)	0.25
Marketable Debt	0.40	(5.28)	0.25	0.60	(3.67)	0.31
Net Debt Book Value	0.40	(5.78)	0.31	0.59	(4.96)	0.40
Gross Debt Book Value	0.37	(4.01)	0.20	0.56	(3.14)	0.27
Marketable Debt Book Value	0.45	(5.44)	0.27	0.67	(4.01)	0.34
Net Debt exclud. Fed Holding	0.33	(4.35)	0.24	0.43	(3.34)	0.28
Net Debt exclud. Foreign Holding	0.35	(4.52)	0.25	0.42	(4.20)	0.26
Net Debt/Potential GDP	0.38	(4.81)	0.26	0.55	(3.68)	0.34

Table A3: Predictability of Excess Stock Returns

The table reports estimates from OLS regressions of future excess stock returns on log debt-to-GDP ratio.

$$\Sigma_{i=1}^{h}(r_{m,t+i} - r_{f,t+i-1}) = \beta_0 + by_t\beta_1 + u_{t+h}$$

Excess stock return is the log market return r_m subtracting the log risk-free rate r_f. Long-horizon excess returns are the cumulative summation of the one-period excess returns. by_t is the log debt-to-GDP ratio. h is the predictive horizon. The t-statistics are based on heteroscedasticity and autocorrelation consistent standard errors. The sample from 1980 to 2013.

		Gross Debt			Net Debt		
	h	by	(t-stat)	R^2	by	(t-stat)	R^2
Canada	1Y	0.26	(1.97)	0.10	0.10	(1.46)	0.07
	3Y	0.43	(2.92)	0.14	0.17	(2.37)	0.10
UK	1Y	0.15	(1.83)	0.06	0.17	(1.97)	0.09
	3Y	0.35	(1.94)	0.06	0.36	(2.15)	0.08

Appendix III. VAR Analysis on Yield Spreads

I further study the dynamics relationship between debt-to-GDP ratio and yield spreads by analyzing the impulse response functions and variance decomposition in a vector autoregression framework. I estimate a five-variable VAR

$$Z_t = \Phi Z_{t-1} + u_t \tag{30}$$

$$Z_t = [\Delta gdp_t,\ svar_t,\ by_t^{book},\ by_t,\ spread_t] \tag{31}$$

The VAR includes GDP growth, stock market volatility, book-value debt-to-GDP ratio, market-value debt-to-GDP ratio and a yield spread. I use an identification strategy that recursively orders the variables as above. The third "book shock" increases the book value of debt but is orthogonal to output and market volatility contemporaneously. I interpret this shock as an exogenous net issuance of government bond that is non-discretionary and not based on the economic and financial conditions. The fourth "market shock" is a shock to the market value of government debt, holding book value constant. Through the lens of the model, the book shock is u_b, the shock to the amount of bonds, in Equation (23). This shock raises debt-to-GDP ratio and thus uncertainty of fiscal consolidations, leading to higher risk premia. The market shock is w_τ, the shock to the exogenous stochastic volatility on the tax rate, in Equation (20). This shock lowers the return on debt, raises debt-to-GDP ratio through the discount rate channel, and increases quantity of risk and thus risk premia. In comparison, if liquidity channel dominates, these two shocks will decrease risk premia.

I estimate the impulse response of yield spreads to the two debt-to-GDP shocks. I switch different spread into the VAR to keep the parsimony of the system. Figure A1 shows the impulse response of the spreads in corporate bond market where credit risks are important. Both book and market shock increase Gilchrist and Zakrajšek (2012) spread and Moody's spreads. The effects are statistically significant, especially in the market shock. Figure A2 shows the impulse response of the spreads in money market where credit risks are less important (Repo-Bill, CD-Bill, Paper-Bill, FFR-Bill). The effect of both shocks are negative and significant on all the spreads . These results confirm the analysis in Section 2.3 that government debt has differential effects on different markets.

Next, I measure the importance of the effects by variance decomposition. Table A4 presents how much of the forecast error variance of the yield spreads can be attributed to the book shock and the market shock. The debt-to-GDP ratio shocks explain 9% of the one-year forecast error variance of GZ spread, 7% of the Aaa-Treasury spread, 15% of the Baa-Aaa spread and around 20% of yield spreads in money market. Therefore, the effect of government debt is quantitatively important to the dynamics of the yield spreads in both corporate bond and money markets.

Table A4: Variance Decomposition

The table reports variance decomposition of a VAR that includes GDP growth, stock market volatility, book-value debt-to-GDP ratio, market-value debt-to-GDP ratio and a yield spread. The spreads include: Gilchrist and Zakrajŝek (2012) spread index (GZ spread), the spreads between Moody's Aaa, Aa, A, Baa bond yield and 30-year treasury bond yield, the spread between general collateral repo rate (Repo), Certificate of Deposits rate (CD) , AA commercial paper (Paper) rate, federal funds rate (FFR) and treasury bill rate. *h* shows the horizon of the forecast error decomposition. The reported values are in percentage point.

	book shock				market shock			
h	1	4	12	20	1	4	12	20
GZ spread	0.81	0.84	0.78	0.74	8.83	8.20	6.85	6.50
Aaa-Treasury	0.10	0.07	0.08	0.10	8.34	6.63	6.38	6.49
Aa-Treasury	0.13	0.10	0.14	0.28	11.65	8.15	8.52	8.99
A-Treasury	0.75	0.62	0.66	1.12	13.01	8.01	11.79	13.33
Baa-Treasury	4.13	3.27	2.85	3.20	10.81	6.14	11.00	12.53
Baa-Aaa	14.41	10.88	8.83	9.98	5.53	3.91	14.63	16.96
Repo-Bill	9.60	9.20	9.15	10.08	2.55	14.67	23.16	23.09
CD-Bill	0.02	0.47	1.50	2.37	10.28	18.94	27.78	28.07
Paper-Bill	5.97	6.08	6.52	7.36	0.74	8.61	16.00	16.12
FFR-Bill	7.36	7.68	7.95	8.82	0.57	9.52	18.55	18.82

Figure A1: Impulse Response Functions to a 1 s.d. Shock

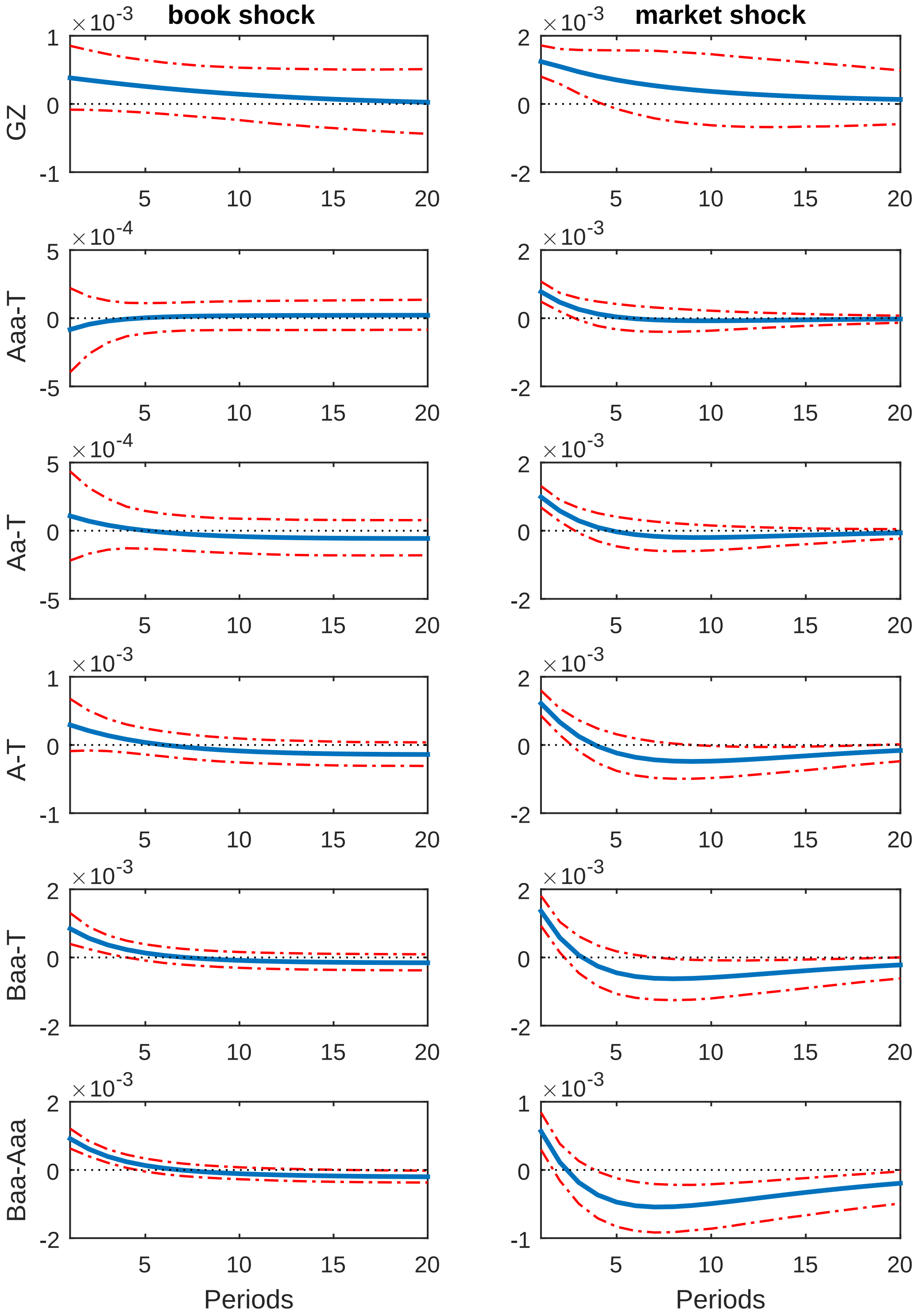

Figure A2: Impulse Response Functions to a 1 s.d. Shock