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Fiscal Capacity: An Asset Pricing Perspective

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Abstract

This review revisits the literature on fiscal capacity using modern tools from asset pricing. We find that properly accounting for aggregate risk substantially reduces fiscal capacity. In this environment, the gap between the risk-free rate and the expected growth rate is not a sufficient statistic for fiscal capacity. To borrow at the risk-free rate when aggregate growth is risky, governments need to ask taxpayers to insure bondholders against aggregate risk, but governments in advanced economies tend to insure taxpayers against aggregate risk. We use this asset pricing perspective to review alternative mechanisms to boost fiscal capacity that have been explored in the literature.

1. INTRODUCTION

A vast literature in macroeconomics studies the question of government debt capacity and sustainability. This question gained urgency after the response of governments in advanced economies to the global financial crisis of 2008–2010 and to the COVID-19 pandemic in 2020–2021 led to a marked increase in the ratio of government debt to GDP around the world.

We survey the literature on fiscal capacity through the lens of modern finance.[1] We put the US Treasury on the same footing as other economic actors. In the absence of arbitrage opportunities, the Treasury cannot create value through financial engineering. As a result, the cash flow risk of the federal government's tax revenue on the Treasury's balance sheet will have to be absorbed either by riskiness of the market's valuation of its debt or by the federal government's spending. We find that properly pricing this risk substantially reduces fiscal capacity. The Treasury's ability to make risk-free promises is limited, because GDP growth is subject to large shocks, and tax revenues, government spending, and debt are all tied to GDP.

Most of the finance literature on fixed income focuses on the pricing of individual government bonds. In gauging fiscal capacity, we zoom in on the pricing of the portfolio of all government bonds, which brings in issues of future rollover risk. We will focus much of the discussion on the United States. Ultimately, we conclude that the portfolio of US Treasury bonds is expensive relative to the underlying collateral, the surpluses. We call this the US government debt valuation puzzle. The post–World War II US experience is sui generis, and viable explanations of this puzzle will have to be founded on mechanisms that are specific to the United States.

The rest of this review is organized as follows. Section 2 discusses two different approaches to understanding the dynamics of the debt-to-output ratio, one backward-looking and one forward-looking. Both are common approaches to understanding valuation ratios in asset pricing. Section 3 derives our measure of fiscal capacity in a simple model. Section 4 provides results on fiscal capacity under more general conditions. It states the government bond valuation puzzle and discusses potential resolutions. Section 5 discusses the international context.

2. UNDERSTANDING THE DEBT-TO-OUTPUT RATIO

We lay out two approaches to understanding government debt dynamics. The backward-looking accounting approach, commonly used in the macro literature, regards debt as the accumulation of past deficits and borrowing. The forward-looking valuation approach, which mirrors present value calculations in finance (see, e.g., Campbell & Shiller 1988), imputes the variation in the debt-to-GDP ratio to news about future returns or future cash flows.

2.1. Backward-Looking Accounting

Analogous to the price-to-earnings ratio in the stock market, the debt-to-output ratio is a valuation ratio for the entire portfolio of outstanding Treasury bonds. One strand of the literature adopts a backward-looking approach by imputing variation in the debt-to-output ratio to the history of primary surpluses, output growth, inflation, and interest rates.

The market value of government debt D_t is the sum of all outstanding bond prices times quantities, summed over all maturities. Let G_t denote nominal government spending before interest expenses on the debt and T_t denote nominal government tax revenue. The government's static

[1]Recent surveys on the topic of fiscal capacity by D'Erasmo, Mendoza & Zhang (2016), Reis (2022), and Willems & Zettelmeyer (2022) adopt a slightly different perspective and complement ours nicely.

budget constraint states:

$$G_t - T_t + D_{t-1}R_t = D_t, \qquad 1.$$

where we use R_t to denote the gross return on the entire portfolio of marketable debt D_{t-1}. By iterating backward, we can write the debt today as a function of past debt returns and past primary deficits:

$$D_t = \sum_{j=0}^{t-1}(G_{t-j} - T_{t-j})R_{t-j,t} + D_0 R_{0,t}, \qquad 2.$$

where $R_{t-j,t} = \prod_{k=1}^{j} R_{t-j+k}$ is the cumulative return of holding the debt portfolio from time $t-j$ to t, and $R_{t,t} = 1$. We set initial debt to zero: $D_0 = 0$. Then, we can restate this expression to obtain a backward-looking expression for the debt-to-output ratio:

$$\frac{D_t}{Y_t} = \sum_{j=0}^{t} \frac{G_{t-j} - T_{t-j}}{Y_{t-j}} \frac{R_{t-j,t}}{X_{t-j,t}}, \qquad 3.$$

where $X_{t-j,t} = \prod_{k=1}^{j} X_{t-j+k}$, and $X_t = Y_t/Y_{t-1}$ is the gross GDP growth. The determinants of the current debt-to-output ratio are primary deficits, nominal cumulative returns on the debt, and nominal cumulative growth rate of GDP (real GDP growth plus inflation). High deficits, high returns, and low output growth in the past all contribute to a high debt-to-output ratio today. Hall & Sargent (2011) decompose the US postwar debt-to-output dynamics into these components and emphasize the role of higher-than-average real GDP growth and inflation in bringing the debt-to-output ratio back down after World War II.[2]

Traditionally, researchers in macroeconomics have analyzed debt sustainability in deterministic economies or economies in which aggregate risk is not priced. In this environment, the government's cost of capital is the risk-free rate. The central object in this analysis is the difference between the interest rate on the debt and the expected growth rate of the economy ($R^f - X$). If the risk-free rate and the growth rate are constant, then Equation 2 simplifies to

$$\frac{D_t}{Y_t} = \sum_{j=0}^{t} \frac{G_{t-j} - T_{t-j}}{Y_{t-j}} \left(\frac{R^f}{X}\right)^j. \qquad 4.$$

For notational convenience, define $r^f = R^f - 1$ and $x = X - 1$. When $r^f < x$, the government can roll over its debt in perpetuity and run steady-state deficits ($G > T$) with a constant debt-to-GDP ratio as follows:

$$\frac{D}{Y} = \frac{G - T}{Y} \frac{1 + x}{x - r^f}. \qquad 5.$$

Recently, Blanchard (2019) and Mehrotra & Sergeyev (2021) study debt-to-output ratio dynamics in a low-interest-rate environment and evaluate the implications of low rates for government debt sustainability. In dynamically inefficient economies characterized by $r^f < x$, there seems to be no fiscal cost to debt. Ball & Mankiw (2021) and Aguiar, Amador & Arellano (2021) study the effect of government debt on capital accumulation and efficiency in dynamically inefficient economies. Furman & Summers (2020) also study debt dynamics in a low-rate environment. They propose the government's interest cost as a fraction of GDP as a sufficient statistic to gauge fiscal sustainability. All these papers work in environments without aggregate risk.

[2] Hall & Sargent (2021) and Hall et al. (2021) decompose US federal fiscal accounts going back to 1790.

There are limits to what we learn from comparing the realized risk-free rate to the growth rate for two reasons. First, in an economy with aggregate growth risk, the risk-free rate R^f_t cannot be lower than the growth rate of the economy X_t in every state of the world. Consider the simplest case of independently and identically distributed (i.i.d.) growth. The price-to-dividend ratio (*pd*) on a claim to output is then constant, and the return on the GDP claim is $\frac{P^y_{t+1}+Y_{t+1}}{P^y_t} = \frac{(pd+1)Y_{t+1}}{pdY_t} = \frac{1+pd}{pd}X_t$. If the risk-free rate were lower than the growth rate in every state of the world, then the return on a claim to output would exceed the risk-free rate in every state of the world:

$$R^y_t = \frac{1+pd}{pd}X_t > X_t > R^f_t. \tag{6.}$$

This would give rise to unbounded profit (arbitrage) opportunities obtained from borrowing at the risk-free rate and investing in the output claim (going long in unlevered equity). To gauge dynamic efficiency in an economy with growth risk, we need to add a risk premium to the risk-free rate when comparing it to the average growth rate. This is explained in Section 2.2.2.

Second, the expected rate of return on government debt only equals the risk-free rate if government debt has zero beta. As we explain in Section 3.2, manufacturing zero-beta debt imposes tight restrictions on the surplus process. Governments cannot insure taxpayers against aggregate risk if they need to keep the debt risk-free. That is the real fiscal cost of risk-free debt, even when the risk-free rate is below the growth rate of the economy.

There is one exception to the no-arbitrage restriction on risk-free rates and growth rates: convenience yields. Convenience yields measure how much return investors are willing to give up, over and above the compensation for time value of money and risk, for the privilege to own safe and liquid government bonds. A large empirical literature has found convenience yields on US government bonds (Longstaff 2004; Krishnamurthy & Vissing-Jorgensen 2012; Nagel 2016; van Binsbergen, Diamond & Grotteria 2022). US Treasury bonds are typically expensive relative to Treasury Inflation-Protected Securities (TIPS) (Fleckenstein, Longstaff & Lustig 2014), corporate bonds (Bai & Collin-Dufresne 2019), foreign sovereign bonds (Du, Im & Schreger 2018; Koijen & Yogo 2020; Z. Jiang, Krishnamurthy & Lustig 2021), and duration-matched stocks (van Binsbergen 2020). The US Treasury has a quasi-monopoly on the supply of dollar-denominated safe assets, and the dollar is the world's reserve currency. As a result, the US Treasury earns seigniorage revenue from its ability to sell Treasury bonds at prices that exceed the price of a synthetic Treasury constructed from other securities. This gives the Treasury a limited arbitrage opportunity. The convenience yield λ_t lowers the returns on Treasury bonds below the true risk-free rate: $R^{\text{Treas}}_t = R^f_t - \lambda_t$. The expression for the debt-to-output ratio instead becomes:

$$\frac{D_t}{Y_t} = \sum_{j=0}^{t}\left(\frac{G_{t-j}}{Y_{t-j}} - \frac{T_{t-j}}{Y_{t-j}}\right)\frac{R^{\text{Treas}}_{t-j,t}}{X_{t-j,t}}. \tag{7.}$$

A government that has enjoyed higher convenience yields in the past arrives with less debt in the current period. In this case, we can have the Treasury yield below the growth rate $r^f_t - \lambda_t < x_t < r^f_t$ in all states of the world without creating arbitrage opportunities, because private investors borrow at the higher risk-free rate. However, there are limits to how much fiscal capacity convenience yields can generate. As the government keeps issuing more bonds, the convenience yields decline (Krishnamurthy & Vissing-Jorgensen 2015): $\lambda'_t\left(\frac{D_t}{Y_t}\right) < 0$.[3] Mian, Straub & Sufi (2021) analyze the role of convenience yields earned by the Treasury in debt-to-output dynamics. When

[3] Choi, Kirpalani & Perez (2022) explore how safe asset providers may be strategically undersupplying debt in order to keep convenience yields high.

D/Y is low enough, in the Goldilocks region, $x + \lambda(\frac{D}{Y}) > r^f > x$ and the government can run small steady-state deficits while keeping the debt-to-output ratio sufficiently low. In contrast, when D/Y crosses a threshold, $x + \lambda(\frac{D}{Y}) < r^f$, in the austerity region, the government is forced to run steady-state surpluses.

2.2. Forward-Looking Valuation

Next, we introduce aggregate growth risk into the analysis. The backward-looking approach is limiting because we are constrained to examine one particular sample path. Instead, we now adopt a forward-looking valuation approach to the question of fiscal sustainability. In an economy subject to priced, permanent aggregate shocks, the government's ability to make risk-free promises is limited: growth is risky, even if, on average, $r^f < x$. We insist on pricing the entire government bond portfolio, as well as other risky assets such as equities, which is useful to pin down the magnitude of the price of growth risk.

This literature starts with the seminal work by Hansen, Roberds & Sargent (1991). In the valuation approach, the market value of government debt is dictated by the discounted value of future government surpluses. Specifically, we can iterate forward the one-period government budget constraint in Equation 1 to obtain

$$D_t = \mathbb{E}_t\left[\sum_{j=1}^{T} M^{\$}_{t,t+j}(T_{t+j} - G_{t+j})\right] + \mathbb{E}_t\left[M^{\$}_{t,t+T}D_{t+T}\right], \qquad 8.$$

where $M^{\$}_{t,t+h} = \prod_{k=0}^{h} M^{\$}_{t+k}$ denotes the multiperiod stochastic discount factor (henceforth the SDF). In deriving this expression for fiscal capacity, we only rely on the existence of an SDF, i.e., the absence of arbitrage opportunities, not on the uniqueness of the SDF, i.e., complete markets (Z. Jiang et al. 2019).

This result implies that the market value of the outstanding government bond portfolio equals the present risk-adjusted discounted value of current and future primary surpluses over the next T periods plus the risk-adjusted discounted value of the debt that will need to be financed T periods from now, $\mathbb{E}_t[M^{\$}_{t,t+T}D_{t+T}]$. This second term highlights the rollover risk on the government bond portfolio. Even if all currently outstanding debt expires shortly, investors are still concerned about the government's ability to roll over the debt in the future.

A large class of models additionally impose a transversality condition (TVC) or no-bubble condition that drives the discounted value of future debt to zero as we increase the horizon:

$$\lim_{T\to\infty} \mathbb{E}_t\left[M^{\$}_{t,t+T}D_{t+T}\right] = 0. \qquad 9.$$

Under the TVC, we obtain the standard intertemporal government budget constraint (IGBC):

$$D_t = \mathbb{E}_t\left[\sum_{j=1}^{\infty} M^{\$}_{t,t+j}(T_{t+j} - G_{t+j})\right]. \qquad 10.$$

This IGBC implies that a higher debt-to-output ratio today can be attributed to higher expected future primary surpluses (cash flows) or lower expected future returns (discount rates). This is the counterpart for Treasury bonds of the Campbell-Shiller expression for the log of the price-to-dividend ratio in the stock market. In influential work on fiscal sustainability in the United States, Bohn (1998) documents evidence that higher debt-to-output ratios forecast higher primary surpluses. In related work, Cochrane (2019) applies a Campbell-Shiller decomposition to the US debt-to-output ratio and attributes half of the variation in the debt-to-GDP ratio to variation in future primary surpluses and half to varying discount rates. After correcting for small sample bias (Stambaugh 1986; Boudoukh, Israel & Richardson 2021), Z. Jiang et al. (2021b) conclude that no statistical evidence has been found of a discount rate or cash flow channel. A higher US debt-to-output ratio today does not reliably forecast lower future returns on Treasury bonds nor does it predict higher primary surpluses. Rather, fluctuations in the debt-to-GDP ratio at time t predict fluctuations in the debt-to-GDP ratio at time $t + T$. In equity markets, discount rate variation is the main driver of stock valuation ratios (Cochrane 2011). Not so in bond markets. The valuation of the debt is surprisingly insensitive to the macro fundamentals that ought to determine them.

2.2.1. The no-bubble condition and models without long-lived investors.

The TVC is an optimality condition in models with long-lived investors. In models without long-lived investors, this optimality condition is not imposed, creating room for bubbles not only in bonds but also in other long-lived assets (Samuelson 1958, Diamond 1965, Blanchard & Watson 1982, Hellwig & Lorenzoni 2009). Dumas, Ehling & Yang (2021) characterize initial conditions that sustain a rational bubble in government debt in a deterministic overlapping generations (OLG) model.

In a class of macro models, government bonds are special because they enable investors to self-insure against idiosyncratic risk (see Bassetto & Cui 2018; Chien & Wen 2019; Angeletos, Collard & Dellas 2020; Reis 2021; Brunnermeier, Merkel & Sannikov 2022). The self-insurance services of government debt generate a form of convenience yields, which increase the fiscal capacity of the government. In such settings, government debt markets can sustain bubbles. This class of models has a testable prediction. The extra fiscal capacity from convenience yields is proportional to the demand for insurance, i.e., the quantity of unspanned risk that investors need to self-insure against (Reis 2021). This feature implies that the seigniorage revenue ought to be larger in less financially developed countries with more (residual) idiosyncratic risk.

In an economy with priced aggregate GDP growth risk, the TVC (Equation 9) is likely to be satisfied. Assuming that debt and GDP are cointegrated, and denoting the long-run debt-to-GDP ratio by d, the TVC becomes

$$\lim_{T\to\infty} \mathbb{E}_t\left[M^{\$}_{t,t+T} D_{t+T}\right] = d \lim_{T\to\infty} \mathbb{E}_t\left[M^{\$}_{t,t+T} Y_{t+T}\right] = 0. \qquad 11.$$

Since shocks to GDP growth are priced, they carry a risk premium that we shall call the GDP risk premium, RP. The SDF should reflect this risk and discount future output at a rate $r^f + RP$. As long as $r^f + RP > x$, the second term in Equation 11 is zero; the TVC holds.

Z. Jiang et al. (2020) show that the TVC is satisfied in a calibrated no-arbitrage dynamic asset pricing model, because $r^f + RP > x$ (even though $r^f < x$). Similarly, in a rare disaster equilibrium asset pricing model, Barro (2020) shows that the economy may not be dynamically inefficient even when $r^f < x$. There are no bubbles in government debt, and fiscal capacity is limited by the present discounted value (PDV) of future primary surpluses. Models that abstract from aggregate risk or assume that the GDP risk premium is quantitatively negligible effectively grant the government an arbitrage opportunity when $r^f < x$, an opportunity that is unavailable to other market participants.

2.2.2. The risk on the Treasury balance sheet.

When the TVC holds, Equation 10 states that the market value of the outstanding government bond portfolio equals the present risk-adjusted discounted value of current and future primary surpluses. We refer to the right-hand side of Equation 10 as the fiscal capacity of the government. The debt is fully backed by future surpluses. This is not just a hypothetical exercise. The primary surplus cash flows $\{S_t = T_t - G_t\}$ can be earned by an investment strategy that buys and holds the entire government debt portfolio and participates in all issuances and redemptions. Fiscal capacity depends on this surplus stream and how it is discounted. A key tenet of asset pricing is that the discount rate of any cash flow stream should reflect the risks in that cash flow stream, not the labels of the underlying securities. Lucas (2012) emphasizes the importance of using the right risk-adjusted discount rate when evaluating government investment projects. We apply that basic principle here, considering both short-run and long-run risk.

In the short run, primary surpluses in advanced economies are strongly pro-cyclical. This is because tax revenues are higher in expansions than in recessions, and government spending is lower in expansions than in recessions. Government transfer spending in particular rises strongly in recessions. Because recessions are high-marginal utility times, and surpluses are low in those times, the surplus claim carries a business cycle risk premium.

In the long run, tax revenues and government spending are growing at the same rate as GDP; they are cointegrated. The ratios of tax revenues to GDP and government spending to GDP are stationary. Tax revenue and spending processes inherit the long-run risk from the GDP process. They carry the same long-run risk premium as a GDP claim.

Ever since the works by Lucas (1978) and Mehra & Prescott (1985), standard dynamic equilibrium asset pricing models assume that the stock market acts as a levered claim to the aggregate endowment in the economy. In such models, the GDP risk premium equals the unlevered equity risk premium. The high observed equity risk premium then implies that the GDP risk premium *RP* must also be nontrivial. Indeed, an important strand of the asset pricing literature (Bansal & Yaron 2004; Alvarez & Jermann 2005; Hansen & Scheinkman 2009; Borovička, Hansen & Scheinkman 2016; Backus, Boyarchenko & Chernov 2018) argues that permanent shocks to GDP (long-run risk in cash flows more broadly) with a large market price of risk are needed to account for the observed risk premium in long-lived assets such as stocks.[4] In the next section, we provide a simple example that assumes a GDP risk premium of 3%.

In summary, the surplus process contains both short-run and long-run risk. The discount rate for the surplus process must reflect that risk and contain a risk premium. To illustrate the shrinkage in fiscal capacity, we rewrite Equation 10 using the definition of covariances:

$$D_t = \sum_{j=1}^{\infty} P_t^{\$}(j)\mathbb{E}_t\left[S_{t+j}\right] + \sum_{j=1}^{\infty} \mathrm{Cov}_t\left(M_{t,t+j}^{\$}, T_{t+j}\right) - \sum_{j=1}^{\infty} \mathrm{Cov}_t\left(M_{t,t+j}^{\$}, G_{t+j}\right). \qquad 12.$$

The first term on the right-hand side is the present discounted value of all expected future surpluses, where the discounting is done using risk-free bond prices, $P_t^{\$}(j)$. It is the valuation of the surplus claim by a risk-neutral investor. In this risk-neutral world, fiscal capacity is solely determined by the government's ability to generate current and future surpluses and by the risk-free rates. Lower risk-free rates increase fiscal capacity. The second and third terms reflect the riskiness of the surplus process and arise in the presence of stochastic discount rates, i.e., risk-averse investors. If tax revenues tend to be high when times are good (the marginal utility as measured by $M_{t,t+j}^{\$}$ is low), then the second term is negative. If government spending tends to be

[4]If the dividend process on the aggregate stock market is cointegrated with GDP, then the risk premium on a long-dated dividend strip equals the risk premium on a long-dated GDP strip. The equity risk premium, which is approximately 7% per year in historical data, is the weighted average of the risk premia on the dividend strips of the various maturities. Because the term structure of dividend strip risk premia is downward-sloping (van Binsbergen, Brandt & Koijen 2012), short-dated dividend strip risk premia are higher and long-dated dividend strip risk premia are lower than 7% per year.

high when times are bad (the marginal utility as measured by $M^{\$}_{t,t+j}$ is high), then the third term is positive. If both are true, then the covariance terms unambiguously lower the government's fiscal capacity. Put differently, the risk-neutral present-value of future surpluses will need to be higher by an amount equal to the covariance terms to support a given, positive amount of government debt D_t. These covariance terms first appear in the work by Bohn (1995) in the context of a simple-consumption capital asset pricing model (CAPM). Z. Jiang et al. (2019) are the first to quantify these terms in a realistic model of risk and return. They find that the covariance terms not only have the hypothesized sign but are also quantitatively important. We review this evidence below.

A version of the debt valuation Equation 10 holds in the presence of default risk on government debt. The only difference is that government bond prices now reflect the default risk. W. Jiang et al. (2022) study fiscal capacity in a model with aggregate risk where the government can default on its debt and taxation and inflation are distortionary. Chernov, Schmid & Schneider (2020) develop a structural model of monetary and fiscal policy, in which the government has no alternative but to default in some states of the world. Their model can account for elevated credit default swap (CDS) risk premia in advanced economies like the United States during the global financial crisis. Pallara & Renne (2019) also consider the effect of default on sovereign CDS risk premia. In related work, Croce, Nguyen & Schmid (2012) and Croce et al. (2012) consider the effect of equilibrium fiscal risk on other asset prices. Liu, Schmid & Yaron (2020) study the risk of safe assets from deficit-driven tax and consumption volatility.

3. A STYLIZED MODEL ECONOMY

The Treasury cannot make aggregate risk disappear through financial engineering. The riskiness of the surpluses will show up in the risk premium on debt. In this section, we consider the simplest possible environment to make this point. The market value of government debt is a fixed fraction d of GDP, tax revenues are a fixed fraction τ of GDP, and government spending net of interest expenditures on the debt is a fixed fraction γ of GDP. GDP growth is risky, i.i.d. with a mean of x and a volatility of σ. We start by analyzing the leading case in which the tax and spending cash flows make the government debt portfolio risky. We then ask what the tax process must look like to render the debt risk-free.

3.1. Risky Government Debt: Treasury Insures Taxpayers

We set $\tau = 25\%, \gamma = 22.5\%, r^f = 1.5\%, x = 2\%$, and $RP = \xi\sigma = 3\%$, the product of the market price of risk of output growth shocks $\xi = 1$ and the volatility of output growth $\sigma = 3\%$. Let GDP be \$10 trillion in expectation in the first year. Then, tax revenue is \$2.5 trillion, spending is \$2.25 trillion, and the primary surplus is \$0.25 trillion in expectation in the first year. All fiscal cash flows grow at a rate of GDP.

The value of a claim to GDP is the expected present discounted value of an asset with cash flows equal to GDP. The appropriate discount rate r_Y for the GDP claim is the sum of the risk-free rate of $r^f = 1.5\%$ plus the GDP risk premium of $RP = 3\%$. The price-to-dividend ratio on the GDP claim is $1/(r^f + RP - x) = 1/(1.5\% + 3\% - 2\%) = 40$. Given that expected GDP is \$10 trillion in the first year, the value of the GDP claim is \$10 $\times$ 40 = \$400 trillion.

As long as the GDP risk premium is mildly positive ($RP = \xi\sigma > x - r^f$ or the Sharpe ratio on the GDP claim $\xi > 0.166$), the TVC is satisfied in this economy. This is true even though the risk-free rate is lower than the rate of growth of the economy. In this model, a bubble in government debt would carry over to other long-lived assets, such as a claim to GDP or the stock market. This example illustrates why it is sensible to rule out violations of the TVC.

Let P_t^T and P_t^G denote the present value of future tax revenues and government spending:

$$P_t^T = \mathbb{E}_t\left[\sum_{k=1}^{\infty} M_{t,t+k} T_{t,t+k}\right], \qquad P_t^G = \mathbb{E}_t\left[\sum_{k=1}^{\infty} M_{t,t+k} G_{t,t+k}\right].$$

The value of the government debt D is equal to P^T minus P^G. Under our simplifying assumptions, the forward-looking expression for the debt-to-GDP ratio d in Equation 10 becomes

$$d = \frac{T}{Y}\frac{P^T}{T} - \frac{G}{Y}\frac{P^G}{G} = \frac{\tau - \gamma}{r^f + RP - x}, \qquad 13.$$

where $1/(r^f + RP - x)$ is the price-to-dividend ratio on the tax, spending, and GDP claims, all of which are equal to 40. Because the ratios of tax revenues to GDP and government spending to GDP are constant, the expected growth rate in tax revenues and government spending equals the growth rate of GDP x, and the riskiness of the tax revenue and spending claims equals that of the GDP claim. The expected returns on tax and spending claims are equal to that on the GDP claim: $r_T = r_G = r_Y = r^f + RP = 4.5\%$. Because both expected cash-flow growth rates and expected returns are equalized, so are price-to-dividend ratios.

Table 1 shows the Treasury's balance sheet in market values. The present risk-adjusted discounted value of the tax claim is \$2.5 × 40 = \$100 trillion and of the spending claim is \$2.25 × 40 = \$90 trillion. The value of the surplus claim is their difference of \$0.25 × 40 = \$10 trillion, which equals the market value of debt by the IGBC (Equation 10). With a debt of \$10 trillion and a GDP of \$10 trillion, the debt-to-GDP ratio equals $d = 100\%$. In this example, the right discount rate for future primary surpluses is 4.5%, as the surpluses are exactly as risky as output.

Moreover, the Treasury's balance sheet also allows us to characterize the systematic risk exposures of these claims. As shown in **Table 1**, the risk in tax revenue has to be absorbed either by the valuation of debt or by spending. Z. Jiang et al. (2020) show that the government's cost of funding is determined as a weighted average of the discount rate on taxes and spending:

$$r_D = \frac{P^T}{D} r_T - \frac{P^G}{D} r_G \quad \text{and} \quad \beta_D = \frac{P^T}{D}\beta_T - \frac{P^G}{D}\beta_G. \qquad 14.$$

The equation for expected returns on the left can be restated in terms of risk exposures or betas on the right. The betas measure the covariance of a return with the SDF, which here only depends on GDP growth, divided by the variance of the SDF. The riskiness of debt (β_D) is fundamentally determined by the riskiness of the spending and tax revenue cash flows (β_G and β_T). This formula highlights the trade-off between insuring bondholders and taxpayers. Recall that bondholders are long a claim to tax revenues; taxpayers are short this claim since they must pay the taxes. Holding fixed β_G, if the government insures taxpayers by rendering the tax revenue process riskier (higher β_T), which requires lower tax payment in high marginal utility states, then there is less insurance of bondholders (higher β_D).

Table 1 Treasury balance sheet with risky debt

Assets		Liabilities	
$PV(T)$	\$100 = \$2.5 × 40	$PV(G)$	\$90 = \$2.25 × 40
		D	\$10 = \$0.25 × 40
Total	\$100	Total	\$100

In this example, tax, spending, and debt all have a beta of 1 and an implied price-to-dividend ratio of 40. The tax is \$2.5 trillion in expectation in the first year, and the spending is \$2.25 trillion.
$PV(T)$ is the value of the tax claim P^T, $PV(G)$ is the value of the spending claim P^G, and D is the value of government debt.

To simplify the discussion, we normalize the beta of the GDP claim to 1. Then, since tax revenues and government spending are proportional to GDP, they are equally risky: $\beta_T = \beta_G = 1$. We have the following expressions for the expected return and the beta of debt:

$$r_D = \frac{100}{10} r_T - \frac{90}{10} r_G = 10 r_Y - 9 r_Y = r_Y \quad \text{and} \quad \beta_D = \frac{100}{10}\beta_T - \frac{90}{10}\beta_G = 10\beta_Y - 9\beta_Y = \beta_Y = 1.$$

In this example, even when the tax and spending claims are equally risky, government debt has a positive beta of 1. With a positive amount of debt outstanding, investors who buy the government debt portfolio are net long a claim to output. The output risk in spending does not fully offset the output risk in tax revenue.

The fiscal cost is not zero even though the risk-free rate is below the growth rate ($r^f - x = -0.5\%$). The correct fiscal cost must reflect the output risk premium: $r^f + RP - x = 2.5\%$. Using $r^f - x$ as the measure of the fiscal cost is off by 3%, the GDP risk premium. The surplus claim is not risk-free and neither is the government debt. Since the debt is a constant fraction of GDP, the debt inherits the risk properties of the GDP claim. The government's interest payments are also as risky as GDP, because they too represent a constant fraction of GDP.

This example is not realistic. In reality, governments in developed countries choose tax revenue processes that are riskier than GDP. Tax revenue falls as a share of GDP in recessions and rises as a share of GDP in expansion. Furthermore, both government discretionary and government transfer spending increase as a fraction of GDP in recessions. The global financial crisis illustrates these dynamics. US federal tax revenue decreased from 17.7% of GDP in 2007 to 14.5% in 2009; US federal spending increased from 18.8% of GDP at the end of 2007 to 24.4% at the end of 2009. The pro-cyclicality of tax revenues increases β_T; the counter-cyclicality of spending lowers β_G. Since $\beta_T > \beta_Y > \beta_G, r_T > r_Y > r_G$. The strong pro-cyclicality of the surplus makes the surplus claim even riskier. Concretely, if $\beta_T = 1.1 > 0.9 = \beta_G$, then average tax revenues must increase from 25% of GDP to 31.44% of GDP to support the same 100% debt-to-GDP ratio. The cost of debt is now $r_D = 10.9\% \gg r_Y$, because $\beta_D = 3.14 \gg 1$.

3.2. Risk-Free Government Debt: Treasury Insures Bondholders

The literature often assumes that government debt is risk-free without articulating the restrictions that this entails on the surplus process. Here, we elucidate these restrictions for our simple example economy. We keep the earlier assumption that government spending is a constant fraction of GDP and ask what restrictions risk-free debt imposes on the process for taxes.

All parameters are the same as in the previous example, except that we lower expected tax revenue/GDP from $\tau = 25\%$ to $\tau = 22\%$. The expected primary deficit is now 0.5% of GDP. The debt is engineered to be risk-free. By "risk-free debt" we mean zero-beta debt ($\beta_D = 0$)—debt whose value does not fluctuate with the intertemporal marginal rate of substitution of the investor, i.e., with the state of the economy. When $\beta_D = 0$, the cost of debt equals the risk-free rate: $r_D = r^f$. Manufacturing risk-free debt ($\beta_D = 0$) requires a low β_T. From Equation 14, with $\beta_D = 0$, we obtain:

$$\beta_T = \frac{P^G}{D + P^G}\beta_G < \beta_G, \qquad 15.$$

where the last inequality assumes that there is a positive amount of debt outstanding ($D > 0$). To insure bondholders by keeping the debt safe, the tax beta must be lower than the spending beta. Tax revenues move less than one-for-one with GDP. A decline in GDP coincides with a smaller decline in tax revenues, which means that tax rates (tax revenue/GDP) must go up in high marginal utility states. For the United States, such behavior of tax revenues is clearly counterfactual.

In our example, $\beta_T = (90/100)\beta_G = 0.9$. This implies that $r_T = r^f + \beta_T(r_Y - r^f) = 4.2\%$. The expected return (risk premium) on the tax claim has to equal 4.2% (2.7%) in order for the debt to

Table 2 **Treasury balance sheet with risk-free debt**

Assets		Liabilities	
$PV(T)$	$100 = $2.2 × 45.5	$PV(G)$	$90 = $2.25 × 40
		D	$10
Total	$100	Total	$100

In this example, tax beta is 0.9, spending beta is 1, and debt beta is 0. As a result, the price-to-dividend ratio is 45.5 for the tax claim and 40 for the spending claim. The tax is $2.2 trillion in expectation in the first year and the spending is $2.25 trillion. $PV(T)$ is the value of the tax claim P^T, $PV(G)$ is the value of the spending claim P^G, and D is the value of government debt.

be risk-free ($r_D = r^f = 1.5\%$). The tax process is safer than the spending process, which has a risk premium of 3%. The lower risk premium for the tax process reflects the fact that the tax rate is counter-cyclical. Given $r_T = 4.2\%$, the price-to-dividend ratio of the tax claim is 45.5. The value of the tax claim is $\$2.2 \times 45.5$, which is $100 trillion. The value of the spending claim is $\$2.25 \times 40 = \$90$ trillion. The value of the surplus claim is their difference: $\$100 - \$90 = \$10$ trillion. This equals the market value of the debt. Given that GDP is also $10 trillion, the debt-to-GDP ratio is 100%. **Table 2** shows the Treasury's balance sheet with risk-free debt.

How can the debt-to-GDP ratio be 100% while the expected annual future primary surplus is −0.5% of GDP on average? Bondholders, who collectively own all outstanding government debt now and in the future, own a claim to future surpluses. The government provides insurance to bondholders by delivering positive (negative) primary surpluses when GDP growth is lower (higher) than average. Since recessions are high marginal utility periods for risk-averse bondholders, this insurance is valuable to bondholders. In the current period, bondholders pay an insurance premium of $0.05 (0.5% of GDP) to protect themselves against recessions, when they receive a larger surplus payout. This insurance policy is worth $10 trillion (100% of GDP) in present value, hence the positive value of the debt.

The zero-beta debt case looks like the case described by Blanchard (2019). As Equation 5 indicates, the government can roll over the debt and even run a small perennial deficit. There is no violation of the TVC constraint for the government debt portfolio ($r_Y = r^f + RP > x$), even though the government generates negative surpluses on average and the risk-free rate is lower than the growth rate ($r^f < x$). However, there is a hidden fiscal cost. In order to provide insurance to bondholders and keep the debt risk-free, the government must generate positive surpluses in recessions by raising taxes and holding spending constant as a fraction of GDP. Increasing taxes in recessions is painful to risk-averse taxpayers. The government manufactures risk-free debt by shifting aggregate output risk from bondholders onto taxpayers. Taxpayers are selling insurance policies to bondholders.

The higher the outstanding debt-to-output ratio, the safer the tax claim has to become to keep the debt safe. At a debt-to-GDP ratio of 200% rather than 100% (engineered by setting $\tau = 21.5\%$), $\beta_T = (90/110)\beta_G = 0.82$, $r_T = 3.95\%$, and the value of the tax claim goes up from $100 to $110. Taxpayers owe more tax in present risk-adjusted discounted value. They are providing more valuable insurance to bondholders.

Making the government spending process more realistic by making the government spending-to-GDP ratio counter-cyclical amplifies these results because it lowers β_G. Keeping the debt safe now requires an even lower β_T, i.e., an even riskier tax process from the perspective of the taxpayer.[5]

[5]Z. Jiang et al. (2020) derive intertemporal restrictions on the tax processes required to keep the debt safe for realistically calibrated processes of spending-to-GDP and the debt-to-GDP ratios. When the dynamics

3.3. Convenience Yields: Treasury Earns Seigniorage Revenue

As argued above, the United States is in a unique position as the world's safe asset supplier. Investors are willing to pay more for the government bonds of the global safe haven country than justified by the present-discounted value of the cash flows those bonds pay. Equivalently, US Treasury yields are lower than the risk-free rate r_t^f by an amount equal to the convenience yield λ_t.

If the TVC holds, the value of the government debt portfolio equals the value of future surpluses plus the value of future seigniorage revenue from the convenience services the debt provides:

$$D_t = \mathbb{E}_t\left[\sum_{j=1}^{\infty} M_{t,t+j}^{\$}\left(T_{t+j} - G_{t+j}\right)\right] + \mathbb{E}_t\left[\sum_{j=0}^{\infty} M_{t,t+j}^{\$} D_{t+j}(1 - e^{-\lambda_{t+j}})\right]. \qquad 16.$$

We denote the seigniorage revenue from convenience by $K_t = (1 - e^{-\lambda_t})D_t$, the present discounted value of this seigniorage revenue stream by P_t^K, and the expected return on this claim by r_K. The government's cost of funding becomes

$$r_D = \frac{P^T}{D} r_T - \frac{P^G}{D} r_G + \frac{P^K}{D} r_K. \qquad 17.$$

Krishnamurthy & Vissing-Jorgensen (2012) estimate convenience yields on US Treasury bonds of 73 basis points per annum on average between 1926 and 2008. **Table 3** shows the Treasury's balance sheet. We return to the risky debt example from Section 3.1, with $\tau = 25\%$ and

Table 3 Treasury balance sheet with risky debt and convenience yields

Panel A: A-cyclical convenience yields			
Assets		**Liabilities**	
$PV(T)$	\$77.4 = \$2.5 × 30.96	$PV(G)$	\$69.66 = \$2.25 × 30.96
$PV(K)$	\$2.260 = \$0.073 × 30.96		
		D	\$10 = (\$0.25 + \$0.073) × 30.96
Total	\$79.66	Total	\$79.66
Panel B: Counter-cyclical convenience yields			
Assets		**Liabilities**	
$PV(T)$	\$77.4 = \$2.5 × 30.96	$PV(G)$	\$69.66 = \$2.25 × 30.96
$PV(K)$	\$3.68 = \$0.073 × 50.41		
		D	\$11.4
Total	\$81.08	Total	\$81.08

In this example, tax and spending have a beta of 1 and an implied price-to-dividend ratio of 30.96, as the risk-free rate is now 2.23%. The tax is \$2.5 trillion in expectation in the first year, and the spending is \$2.25 trillion. The seigniorage revenue is \$0.073 trillion in expectation in the first year. In panel *A*, we assume the seigniorage revenue has a beta of 1 and hence a price-to-dividend ratio of 30.96. In panel *B*, we assume the seigniorage revenue has a beta of 0.584 and hence a price-to-dividend ratio of 50.41. These assumptions lead to a different amount of debt value.
$PV(T)$ is the value of the tax claim P^T, $PV(G)$ is the value of the spending claim P^G, $PV(K)$ is the value of the seigniorage revenue claim P^K, and D is the value of government debt.

of the debt-to-output and spending-to-output processes are calibrated to match the data, they show that the government has limited ability to insulate taxpayers from tax increases when it wants to keep the debt risk-free. There is a large normative literature on optimal taxation that focuses on representative agent economies with distortionary taxes, following Barro's (1979) seminal work on tax smoothing. Aiyagari et al. (2002) were the first to derive the optimal tax and debt policy when the government issues zero-beta debt.

$\gamma = 22.5\%$. The interest rate on Treasuries is 1.5%, but the risk-free rate is 2.23% because of the 0.73% convenience yield. The discount rate on spending and tax claims is now 5.23%, which is the true risk-free rate of 2.23% plus the GDP risk premium of 3% times a beta of 1. The price-to-dividend ratio on the tax and spending claims is $1/(5.23\% - 2\%) = 30.96$. The expected primary surplus is \$0.25 per year. Future surpluses generate 77.4% of GDP in debt capacity, obtained from $\$0.25 \times 30.96$. This is substantially lower than the 100% of GDP we had in Section 3.1 because the true risk-free rate is higher, lowering the discounted value of the same future surpluses. Each 1% in primary surplus/GDP now generates only 30.96% of GDP in extra fiscal capacity compared to 40% before.

A key (empirical) question is what the risk properties of convenience yield revenues are. We consider two cases. In **Table 3*A***, we assume that seigniorage revenue is a constant fraction of GDP. Then the seigniorage revenue claim has a beta of 1 and must be discounted at a rate of $r_K = 5.23\%$. The discounted value of all future seigniorage revenue equals 22.6% of the current GDP, obtained from $\$.073/(5.23\% - 2\%)$, whereas the current seigniorage revenue is $\$.073 = 0.73\% \times \$10$ trillion or 0.73% of the GDP. The total debt capacity of the government is still 100% of GDP but is now made up of future surpluses (77.4%) and seigniorage revenues (22.6%).

In **Table 3*B***, we assume that the seigniorage revenue claim has a beta of $\beta_K = 0.584$. This value results from the balance of two forces. In the long-run, seigniorage revenues are cointegrated with GDP. The seigniorage revenue inherits the long-run discount rate from output and has a long-run beta of 1. In the short run, convenience yields can be counter-cyclical, even strongly so, as investors clamor for the safety of Treasury bonds during turbulent times. The short-run beta is negative. Moving from the very short run to the very long run, the beta rises. However, due to the pull from cointegration, it is difficult to get the beta of the entire seigniorage revenue claim down to zero, even if the beta is highly negative in the short-run.[6] In this case, seigniorage revenue accounts for 36.8% of GDP [$\$0.73/(2.23\% + 0.584 \times 3\% - 2\%)$ divided by GDP of \$10]. The government's cost of funds is $r_D = 4.82\%$, which is lower than the 5.23% in the first case with $\beta_K = 1$. The total debt capacity of the government is now 114% of GDP, made up of the present value of future surpluses (77.4%) and the present value of seigniorage revenues (36.8%). In this second case, the seigniorage revenue additionally reduces the riskiness of the Treasury's overall balance sheet and increases its fiscal capacity.

The debt capacity of 114% in the world with convenience yields is only 14% points higher than the 100% debt capacity without convenience yields (Section 3.1). Two opposing forces create the modest effect on fiscal capacity. On the one hand, convenience yields generate more seigniorage revenue to the government, increasing fiscal capacity. On the other hand, by raising the true risk-free rate, they lower the present discounted value not only of the seigniorage revenue stream but also of the surplus stream, lowering fiscal capacity. Indeed, the cost of debt of $r_D = 4.82\%$ is higher than the 4.5% without convenience yields. The offsetting cash flow and discount rate effects imply that convenience yields are not a panacea for creating fiscal capacity.

4. QUANTIFYING THE US FISCAL CAPACITY

We now quantify the US fiscal capacity by calculating the PDV of future surpluses, the right-hand side of Equation 10. We do so under two different assumptions on future primary surpluses.

[6]Concretely, if the 1-year seigniorage beta is −2, increasing by 0.5 each year to 0 in year 5, rising by 0.2 each year until reaching 1 in year 10, and remaining constant at 1 thereafter, then the (appropriately weighted) average beta is $\beta_K = 0.584$. This is substantially above 0, despite the extreme assumption on short-run betas.

Table 4 **Treasury balance sheet based on Congressional Budget Office (CBO) projections**

Assets		Liabilities	
$PV(T_{2021}^{2051})$	\$124.24	$PV(G_{2021}^{2051})$	\$145.36
$PV(S_{2051}^{\infty})$	\$35.22		
		D	\$14.10
Total	\$159.46	Total	\$159.46

This calculation is based on May 2022 CBO projections of tax revenue and noninterest spending until 2052. The multiple for the T claim, the G claim, and the debt D is $1/(r^f + RP - g) = 1/(1.5\% + 3\% - 2\%) = 40$.
$PV(T_{2021}^{2051})$ denotes the present value as of 2021 of the tax revenues between 2022 and 2051. $PV(G_{2021}^{2051})$ denotes the present value as of 2021 of government non-interest spending between 2022 and 2051. $PV(S_{2051}^{\infty})$ denotes the present value as of 2021 of the primary surpluses after 2051. D is the current value of government debt.

4.1. Using Congressional Budget Office Projections

In the first approach, followed by Z. Jiang et al. (2022), we use the projections from the Congressional Budget Office (CBO) as the point estimate for future primary surpluses. The CBO projects tax revenue and noninterest spending under current law for each of the next 31 years. As of May 2022, the projections pertain to the years 2022 to 2052. The CBO also forecasts GDP and interest rates, which can be combined with the surplus projections to arrive at the projected debt-to-GDP ratio at the end of 2052.

Table 4 uses the same assumptions on $r^f = 1.5\%$, $x = 2\%$, and $RP = 3\%$ as in Section 3.1. The price-to-dividend ratios on the output, tax revenue, and spending claims equal 40. In order to back the projected 185% debt-to-GDP ratio at the end of 2052, the government must run annual primary surpluses of 4.625% per year from 2053 onward (185%/40). To discount these surpluses, we use the discount rate of 4.5%, which includes the 1.5% risk-free rate and the 3% GDP risk premium. The present value of the surpluses between 2022 and 2052 is −\$21.1 trillion, while the present value of the debt at the end of 2052 is \$35.2 trillion. The resulting fiscal capacity at the end of 2021 is \$14.1 trillion. This is \$8.2 trillion below the \$22.3 trillion in debt outstanding at the end of 2021. As Z. Jiang et al. (2022) show, adding seigniorage revenue from convenience increases the fiscal capacity estimate but still leaves it well short of the observed debt-to-GDP ratio.

Considering aggregate risk and calibrating the GDP risk premium to match observed asset moments, and hence choosing it high enough, is quantitatively important for this calculation. Lowering the GDP risk premium from 3% to 2% per year increases fiscal capacity from \$14.1 trillion to \$22.5 trillion, which is as high as the observed debt-to-GDP ratio. Conversely, increasing the GDP risk premium from 3% to 4% lowers the fiscal capacity estimate to \$8.2 trillion.

These fiscal capacity estimates are generous for two reasons. First, we assume an unprecedented reversal in fiscal policy after 2052, when the economy is assumed to turn from 30 years of large deficits (−3.2% on average in 2022–2052) to running a 4.635% annual surplus after 2052. This would require a political effort the likes of which we have not seen in the United States in the last 75 years. Second, with pro-cyclical tax revenue and counter-cyclical government spending, we should be discounting future tax revenues at a higher rate ($r_T > r_Y$) and future spending at a lower rate ($r_G < r_Y$). By discounting both cash flow streams at the GDP discount rate r_Y, we are increasing the value of the tax claim and reducing the value of the spending claim, both of which make the present value of the surplus claim too large. Hence, this calculation provides an upper bound on fiscal capacity.

An important implication of the CBO scenario is that surpluses are back-loaded. The duration of the surplus claim (under our discount rate of $r_Y = 4.5\%$) is 171 years. This is the duration of the government's assets. Meanwhile, the duration of government liabilities, the outstanding portfolio of debt, is approximately 5 years. There is a substantial duration mismatch. When interest rates rise, the market value of government liabilities falls, but the market value of government assets (i.e., the claim to primary surpluses) falls by much more due to their higher duration. To restore the intertemporal budget condition after the rate rise, the government needs to raise more revenues. To illustrate this point, consider a 1% point increase in the risk-free rate from 1.5% to 2.5%. Under this scenario, the projected debt in 2052 rises from 185% to 223% of GDP. The price-to-dividend ratio on the GDP claim falls from 40 to 28.6. In order to back the 223% debt, the government now needs to run 7.8% primary surpluses annually (223%/28.6) rather than 4.6% surpluses before the rate increase.

In order to be fully hedged against interest rate risk, the Treasury should match the projected surplus (cash inflows) in each period to the coupon and principal payments (cash outflows), much like what a pension fund would typically try to do. To a first order, this requires matching the duration of the Treasury portfolio to the duration of the projected surpluses. This could be accomplished by lengthening the average maturity of outstanding debt and/or bring the surpluses forward in time (see also Bhandari et al. 2017).

4.2. Using Vector Autoregression Forecasts

The second approach, followed by Z. Jiang et al. (2019), is to propose a statistical model for future tax revenue and noninterest spending. They model tax revenue-to-GDP and government spending-to-GDP ratios as a function of macroeconomic and financial variables. Based on annual data for the United States from 1947 to 2020, they estimate a vector autoregression (VAR) model where macrofundamentals affect fiscal cash flows and vice versa. This VAR model includes GDP growth and hence captures the cyclicality of tax and spending ratios discussed above. It also imposes cointegration between tax revenues, spending, and GDP, which induces long-run mean-reversion dynamics. The VAR model captures multiple aggregate sources of risk beyond GDP growth that may matter for taxes and spending: inflation, interest rates, the price-to-dividend ratio in the stock market, and shocks to tax and spending rates themselves. The VAR model does a good job predicting intermediate- and long-horizon tax and spending ratios.

To turn the expected future tax and spending ratios from the VAR into a measure of fiscal capacity, one needs discount rates for tax and spending claims, $\mathbb{E}_t[r^T_{t+j}]$ and $\mathbb{E}_t[r^G_{t+j}]$. Z. Jiang et al. (2019) pursues two methods.

The first method sets $\mathbb{E}_t[r^T_{t+j}] = \mathbb{E}_t[r^G_{t+j}] = \mathbb{E}_t[r^Y_{t+j}]$. As argued above, this results in an upper bound for fiscal capacity. Since the VAR state vector contains the 1-year nominal Treasury yield, the slope of the term structure (5-year minus 1-year Treasury yield), and inflation, they model $\mathbb{E}_t[r^Y_{t+j}]$ using the VAR-implied dynamics for the 5-year real interest rate and add a constant GDP risk premium $\tilde{RP}$. This GDP risk premium is relative to the long-term interest rate rather than the short rate, i.e., it removes the term premium. The advantage of this approach is that it delivers a dynamic upper bound on fiscal capacity that is easy to estimate. Using bootstrapping, it is straightforward to compute confidence intervals around the fiscal capacity bound.

Figure 1*a* shows the resulting measure of fiscal capacity, the expected risk-adjusted discounted value of future surpluses. The observed debt-to-GDP ratio is always above the upper bound on fiscal capacity, except for a brief period in the late 1990s. The gap between the two lines has increased dramatically in the last 20 years of the sample, especially following the global financial crisis and the COVID-19 crisis. This result that the observed debt-to-GDP ratio exceeds the fiscal capacity bound confirms the results from the simple example in Section 3 and the CBO-based calculations in Section 4.1.

This finding is puzzling considering that our measure of fiscal capacity is an upper bound because of (*a*) the discount rate assumption that went into the calculation and (*b*) the mean reversion

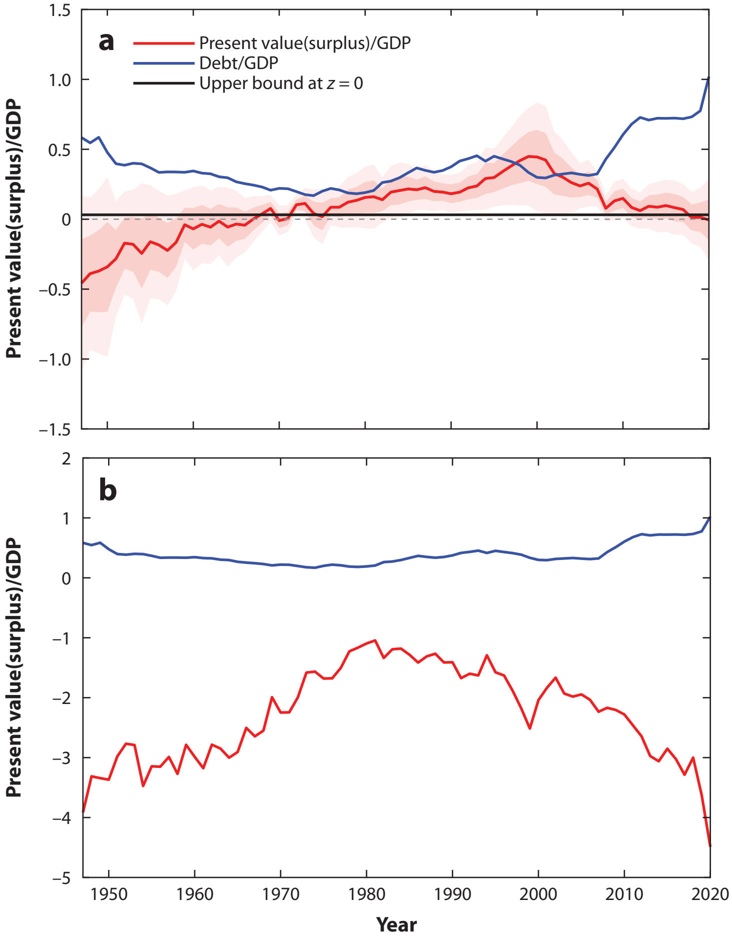

Figure 1

US fiscal capacity measures. Panel *a* plots the upper bound on the present value of government surpluses (*red line*) and the actual debt (*blue line*). Both time series are scaled by GDP. The GDP risk premium, relative to the long-term bond yield, is set equal to 3%. One– and two–standard error confidence intervals are plotted in dark and light red shaded areas, respectively, and are generated by bootstrapping 10,000 samples of the vector autoregression residuals. Panel *b* plots the present discounted value of the government surplus using the stochastic discount factor approach (*red line*) and the market value of government debt (*blue line*). Both time series are scaled by GDP. The sample period in both panels is 1947 until 2020.

dynamics induced by cointegration. In particular, in the last part of the sample, tax revenues are far below their long-run trend with GDP, and government spending is above its long-run trend with GDP. The VAR model assumes that these imbalances will correct in the future. In other words, it predicts a strong rise in future surpluses. Nevertheless, the fiscal capacity measure at the end of the sample is close to zero. The reason is the wrong-way risk properties of the surplus process, which lower fiscal capacity dramatically.

The second method is to take a stance on an asset pricing model, i.e., the SDF $M^{\$}_{t,t+j}$ in Equation 10. Z. Jiang et al. (2019) consider an exponentially affine SDF model where the shocks to the state variables in the SDF are the priced aggregate sources of risk. They estimate the (time-varying) market prices of risk associated with these shocks by matching the time series of nominal and real bond yields across the maturity structure and the stock price-to-dividend ratio in the postwar sample. Intuitively, this model results in dynamic price-to-dividend ratios for taxes and spending, P_t^T/T_t and P_t^G/G_t, which in turn depend on time-varying expected returns (and risk premia) and time-varying expected cash flow growth rates for taxes and spending. Combining these price-to-dividend ratios with the tax/GDP and spending/GDP time series via Equation 10 results in a second dynamic measure of fiscal capacity.

This measure has the advantages that it is not an upper bound but the actual present value of surpluses and that the SDF prices stocks and (nominal and real) bonds of various maturities. It has the drawbacks that it depends on the specific SDF model and that estimation of the model is computationally intensive, which makes the computation of standard errors on the capacity measure infeasible.

Figure 1*b* shows the result from the second approach. The fiscal capacity measure averages −229% of GDP, far below the average market value of outstanding government debt of 39% of GDP. The valuation gap measures the difference between the market value government debt and the present value of surpluses. The valuation gap-to-GDP ratio is 268% on average. The gap widens substantially in the last 20 years of the sample. In other words, the US government has been issuing government debt while simultaneously decreasing the expected surpluses to back up the debt. The gap reaches 551% of the GDP in 2020. This large gap will deepen further due to a large fiscal response to the COVID-19 pandemic in 2021 and 2022 and growing deficits from entitlement programs thereafter.[7]

4.3. Resolving the Bond Valuation Puzzle

Z. Jiang et al. (2019) refer to the gap between the observed market value of government debt and the present discounted value of future surpluses as the government bond valuation puzzle. There are several candidate explanations for this puzzle.

4.3.1. Convenience yields. Seigniorage revenue from convenience creates additional fiscal capacity, but as argued in Section 3.3, conventional estimates of convenience yields are too small to close the gap. Higher estimates of convenience yields tend to be broader measures of convenience, so that higher risk-free rates increase the discount rates used to discount surpluses. The cash-flow effect from higher seigniorage revenue from convenience is offset by discounting that cash-flow stream, as well as the surplus stream, at a higher rate. The more detailed computations by Z. Jiang et al. (2019) confirm this.

4.3.2. Violations from transversality. One way of interpreting the valuation gap is as a measure of the size of the bubble in Treasury markets. We argued in Section 2.2.1 that violations from TVC are harder to sustain in the presence of aggregate risk that receives a properly high price of risk. Recall that with a 3% GDP risk premium, the risk-free rate would need to be nearly 3% points below the expected growth rate of the economy to obtain a violation from transversality. Lowering the risk premium for compensation to aggregate cash flow risk not only makes it difficult to account for phenomena like the equity risk premium but also may result in bubbles in other long-lived assets.

4.3.3. Global safe asset supplier and relative fundamentals. Bubbles could reflect the usefulness of government debt as a self-insurance device. But the self-insurance motive does not fully

[7]In related work, van Wijnbergen, Olijslagers & de Vette (2020) develop an equilibrium asset pricing model and apply the valuation method to evaluate the public sector debt of the Netherlands.

describe the US fiscal experience in the post–World War II era. US Treasury bonds play a special role in the global financial system, partly because the United States is more financially sophisticated (Maggiori 2017), and presumably there is less demand for idiosyncratic risk insurance in the United States than in other less-developed countries.

Farhi & Maggiori (2018) and He, Krishnamurthy & Milbradt (2019) study the multiple-equilibria aspect of government debt valuation and examine the role of relative fiscal fundamentals in the coordination problem among bond investors. By coordinating on a single country, global investors reduce that country's rollover risk. As a result, this country may be allowed to borrow more than what is warranted by its own macro fundamentals. Consistent with this view, Z. Jiang, Krishnamurthy & Lustig (2022) find that foreign investors are willing to accept low dollar-weighted returns from the US Treasury bonds,[8] and Z. Jiang, Richmond & Zhang (2022) show that global demand for US debt assets is particularly high.

As predicted by these theories of safe asset demand, Chen et al. (2022) find that global bond investors reward the world's supplier of safe assets with extra fiscal capacity, beyond what is warranted by the country's own macro fundamentals (future surpluses) and conventional measures of seigniorage revenues from convenience yields. The United Kingdom's pre–World War I fiscal experience is consistent with this type of coordination mechanism in global bond markets. When a country is chosen to be the safe asset supplier, each additional investor renders the debt safer by reducing rollover risk. When the country's relative macro fundamentals deteriorate, this extra fiscal capacity can disappear, as happened to the United Kingdom after World War I.

4.3.4. Mispricing.

One interpretation, explored in more depth in Z. Jiang et al. (2021a), is that the entire government debt portfolio is mispriced. The no-arbitrage condition in Equation 10 is violated. This could be the case, even though the no-arbitrage condition for each currently outstanding bond is satisfied. Bond market investors are too sanguine about future rollover risk. To quantify this overoptimism, Z. Jiang et al. (2021a) start from the observed dynamics in the market value of debt-to-GDP ratio and ask what present-discounted value of surpluses is consistent with it. They then compare this PDV to the one obtained when modeling tax and spending policy rules (using the VAR model of the previous section). They find that, since the late 1990s, the debt-implied PDV of surpluses have consistently and persistently exceeded realized surpluses and surplus forecasts resulting from tax and spending policy rules.

4.3.5. Fiscal correction.

A fifth possibility is that future tax or spending dynamics will self-correct but that we have not seen those states of the world yet. Z. Jiang et al. (2019) find that this fiscal correction would have been expected to occur in the United States with a high probability every year for the past few decades in order to rationalize the market value of debt. The high probabilities are hard to reconcile with investor rationality, unless these fiscal corrections occur in high marginal utility states of the world.

Elenev et al. (2021) pursue such an explanation. In their structural model, the fiscal authority runs counter-cyclical spending and pro-cyclical tax policies as long as the debt-to-GDP ratio remains below a threshold Δ. Once the debt-to-GDP ratio exceeds Δ, fiscal policy switches from active (macroeconomic stabilization) to passive (controlling the debt). In this austerity region, the fiscal authority raises labor income taxes to bring the debt back down toward the

[8]Tabova & Warnock (2022) look at a much shorter sample (2003–2019) and also find that foreign investors earn low dollar-weighted returns relative to buy-and-hold returns, which is consistent with the findings of Z. Jiang, Krishnamurthy & Lustig (2022) though not as low as in the full sample (1980–2021).

threshold Δ.[9] In the calibration by Elenev et al. (2021), which matches many features of the US economy and generates a substantial GDP risk premium and a highly persistent debt-to-GDP ratio, Δ is around 115% of GDP.

4.3.6. Large-scale asset purchases and financial repression. In Japan, private investors have been net sellers of long-dated government bonds since 2015. Japan has now moved large fractions of the supply of long-dated government bonds off private balance sheets onto the balance sheets of the central bank. But even in the eurozone, the European Central Bank purchased more government bonds than member states issued during the pandemic. And in the United States, the Federal Reserve bought essentially all of new issuance of long-term bonds in the quantitative easing programs mounted in response to the pandemic. This raises the possibility that market prices on government bonds have been kept artificially high by unconventional monetary policy and financial repression. Acalin & Ball (2022) highlight the role of real rate distortions through pegged nominal interest rates in the United States before 1951.

5. INTERNATIONAL EVIDENCE AND US EXCEPTIONALISM

The methods for computing fiscal capacity discussed above apply across countries. So does the observed increase in debt over the past two decades. Does that mean that there is a government bond valuation puzzle in each country? No. We argue that the US case is unique.

First, in developing countries, bad news about future surpluses tends to be accompanied by declines in bond prices and hence in the market value of the debt. This stands in sharp contrast with the United States, where bond prices seem rather insensitive to bad fiscal news (Z. Jiang et al. 2021b).[10] Second, developing countries do not have pro-cyclical surpluses (Talvi & Vegh 2005, Mendoza & Ostry 2008). Running counter-cyclical surpluses creates substantial fiscal capacity. Third, developing countries have higher average surpluses. Fourth, developing countries have substantially lower debt-to-GDP ratios. For these reasons, there is no valuation puzzle for developing market debt.

Chen et al. (2022) study the fiscal capacity of the United Kingdom in detail, going back to the year 1729. They argue that the United Kingdom before World War II (and especially before World War I) was a lot like the United States after World War II in that its government debt was the global safe-haven asset. As such, the United Kingdom enjoyed a substantial convenience yield before World War II but not after. The present risk-adjusted discounted value of future surpluses and seigniorage revenues from convenience averaged to 68% of UK GDP for the 1729–1946 period. Over this period, government debt/GDP averaged to 87%. That is, only 78% (= 68%/87%) of debt was backed by surpluses and convenience yields. The United Kingdom had a lot of fiscal capacity, especially since the government was much smaller in those days, but its debt still exceeded our measure of fiscal capacity. Bond investors awarded the United Kingdom

[9]This threshold is the highest possible debt-to-GDP ratio such that the debt remains safe with probability one. Since labor income taxation is distortionary when labor supply is not perfectly inelastic, and hence there is a Laffer curve at work, Δ cannot be arbitrarily large. If the fiscal authority waits too long to raise taxes, the tax rate increases necessary to bring the debt back down become so large that the economy is on the wrong side of the Laffer curve. Not enough tax revenue can be raised to prevent the debt from exploding for every path of economic shocks. Policy makers may contemplate raising other taxes besides labor income taxes at high levels of debt. Many such taxes also come with important distortions, e.g., wealth taxes create incentives to hide or move assets.

[10]Z. Jiang (2021) embeds a fiscal layer into financial intermediation and shows that bad fiscal news in the United States can actually trigger a flight to safety in the intermediary sector and paradoxically strengthen the dollar.

with additional borrowing ability because of its privileged position as the safe asset hegemon. After World War II, the United Kingdom ceded this position to the United States. Since then, the United Kingdom lost seigniorage revenues from convenience and cut its debt to 53% of GDP. The debt was well below our fiscal capacity estimate of 82% post–World War II. For comparison, our estimated fiscal capacity (upper bound) including convenience yields for the United States after 1947 is only 13%. This is far below the observed average debt of 40%. The US fiscal capacity covers only 32% of its debt post–World War II, the government bond valuation puzzle discussed above. Global bond market investors now shower the United States with an ability to borrow in similar fashion as they did to the United Kingdom before World War I.

Japan has the highest debt-to-GDP ratio among the developed economies, around 250% of GDP in 2022 according to the International Monetary Fund. Yet Japan has also ran persistent primary deficits. Japan has been at or near the zero lower bound for nominal interest rates for 20 years. One potential resolution, offered by Mian, Straub & Sufi (2021) and Elenev et al. (2021), is that at or near the zero lower bound deficits (higher government spending or lower taxes) could stimulate aggregate demand. This, combined with unconventional monetary policy, can create additional fiscal capacity. Finally, it is hard to gauge the market's valuation of Japanese government debt given that most of it is actively bought only by the central bank.

6. CONCLUDING THOUGHTS

Over the course of 2022, both nominal and real long-term bond yields increased by a large amount, as central banks in advanced economies started to increase rates and shrink their balance sheets. The market value of government debt was marked down. In the context of our framework, this means the market has revised down its estimates of the fiscal capacity of these governments. A good example of this dynamic is the September 2022 UK tax reduction announcement, which caused a large and instantaneous decline in long-term government bond prices. The insensitivity regime of bond prices to fiscal fundamentals in the United States may be drawing to a close as well.

DISCLOSURE STATEMENT

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