Measuring U.S. Fiscal Capacity using Discounted Cash Flow Analysis*

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October 11, 2022
First draft: March 15, 2022

Abstract

We use discounted cash flow analysis to measure the projected fiscal capacity of the U.S. federal government. We apply our valuation method to the CBO's projections for the U.S. federal government's primary deficits between 2022 and 2052 and projected debt outstanding in 2052. The discount rate for projected cash flows and future debt must include a GDP or market risk premium in recognition of the risk associated with future surpluses. Despite current low interest rates, we find that U.S. fiscal capacity is more limited than commonly thought. Because of the back-loading of projected primary surpluses, the duration of the surplus claim far exceeds the duration of the outstanding Treasury portfolio. This duration mismatch exposes the government to the risk of rising interest rates, which would trigger the need for higher tax revenue or lower spending. Reducing this risk by front-loading primary surpluses requires a major fiscal adjustment.

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1 Introduction

Recently, there has been an active debate about the fiscal capacity of the U.S. and other countries, but there is no consensus on the proper measurement of fiscal capacity. Some economists have argued that we can use the ratio of the government's interest expense over GDP as a measure of fiscal capacity (Furman and Summers, 2020). Others have argued that we should compare the risk-free rate to the growth rate of the economy (Blanchard, 2019; Andolfatto, 2020). Most authors have concluded that low interest rates have substantially increased U.S. fiscal capacity.

We define a country's *projected fiscal capacity* as the present discounted value (PDV) of that country's projected future primary surpluses. We apply our method using the CBO's long-term budget projections as the point estimate of future cash flows.

In standard models with long-horizon investors, the government's debt is fully backed by future surpluses. The measurement of fiscal capacity then becomes a forward-looking valuation exercise. The country's actual fiscal capacity can differ from our projected measure if the market's valuation of the debt exceeds the PDV of projected surpluses. This means that the market is pricing in a large fiscal correction relative to the projections.

Our definition of fiscal capacity differs from the one commonly used by the IMF, the OECD and other institutions who use a marginal definition of fiscal capacity or fiscal space: the ability to issue additional debt in response to a shock (see, e.g., Botev, Fournier, and Mourougane, 2017). These distinct concepts are connected. If a country's projected fiscal capacity is low relative to the value of debt outstanding, then the country's ability to issue additional debt at low interest rates is impaired. Our approach has a number of advantages. First, our measure is easily quantifiable. We come up with a dollar number, not a combination of indicators as in the IMF or OECD approaches. Second, our approach is founded in modern finance. We rule out free lunches for the government and apply textbook finance to the Treasury's balance sheet (see Lucas, 2012, on the importance of proper risk adjustment when evaluating government policies).

We propose a simple, easy-to-implement discounted cash flow approach. As in any valuation exercise, this approach requires estimating the discount rate as well as forecasting the underlying cash flows, tax revenues minus non-interest government spending. A proper discount rate for projected surpluses and future debt must reflect the riskiness of the underlying cash flows. Following Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2019), we develop an upper bound on fiscal capacity by using the expected return on a claim to GDP, also known as the total wealth or market portfolio, to discount future taxes, spending, and future debt. This approach implicitly assumes that surpluses are as risky as GDP. That is a conservative assumption because the surplus/GDP ratio is pro-cyclical. As a result, our risk adjustment is "too small" and our measure of projected fiscal capacity will tend to overstate actual fiscal capacity.

This discount rate is the sum of a maturity-specific risk-free interest rate and the GDP risk premium. We argue that a plausible value for the GDP risk premium should be at least 2.5% per year. When we use this discount rate, the PDV of future debt is well-behaved even when the risk-free rate is lower than the growth rate.

In the discounted cash flow approach, the PDV of debt outstanding in the distant future converges to zero. The transversality condition (TVC) holds, because the discount rate applied to future debt includes a GDP risk premium.[1] Hence our definition of fiscal capacity as the PDV of future primary surpluses. We explore a conservative scenario in which the debt projected by the CBO at the end of the projection horizon is fully backed by subsequent surpluses.

In spite of the secular decline in long rates, we find that U.S. fiscal capacity is limited. The CBO projects average primary surpluses of -3.20% of GDP between 2022 and 2052. The PDV of these projected surpluses is -$21.16 trillion in 2021 dollars. In addition, the CBO-projected debt outstanding in 2052 is 185% of GDP. Starting in 2053, the U.S. would need to generate a steady-state surplus of 2.16% to pay back the debt outstanding in 2052. Discounted back to 2021 at the appropriate discount rate, the 2052 debt is worth about $33.5 trillion. When we combine the PDV of projected surpluses until 2052 of -$21.16 trillion with the PDV of the projected debt outstanding in 2052 of $33.5 trillion, we end up with an upper bound on the projected fiscal capacity of $12.38 trillion. This is our baseline estimate of (an upper bound on) projected fiscal capacity. It falls about $10 trillion short of the actual $22.28 trillion value of all U.S. Treasuries outstanding at the end of 2021. This gap occurs even though we assumed a large, permanent fiscal (primary surplus) correction of 5.36% of GDP per year after 2055 relative to the 2022-52 period.

Alternatively, instead of using the CBO-projected debt in 2052, we can back out the annual surplus after 2052 that is required to match the value of outstanding debt at the end of 2021 to the PDV of all surpluses after 2021. We find that the U.S. would need to run a permanent primary surplus of 2.79% of GDP after 2052, a 5.98% fiscal correction relative to the pre-2052 path for surpluses.

An extended measure of the projected fiscal capacity includes the seigniorage revenue earned by the Treasury. U.S. Treasurys earn a convenience yield because they play a special role in the global financial system. Adding the present value of these seigniorage revenues of $4.04 trillion brings our final estimate for the upper bound on fiscal capacity in 2021 to $16.38 trillion, or 73% of 2021 GDP. This estimates remains substantially below the observed value of debt/GDP at the end of 2021. Despite the current low interest rates (and hence low debt service), and even after considering the special status of Treasuries, we find that U.S. fiscal capacity is quite limited.

There are three potential explanations for the large gap between the PDV of surpluses we

[1] In the discounted cash flow approach, the TVC only fails if the GDP risk premium is smaller than the difference between the growth rate of the economy and the risk-free interest rate. This is not the case for the U.S.

compute and the market's valuation of Treasurys. First, the Treasury market is right and rational market participants anticipate either a large fiscal correction that is not reflected in the CBO's projections or Japan-style financial repression. We quantify this correction in the paper. Second, the market is wrong. Investors–as of the end of 2021–could be overly optimistic about future surpluses or fail to price in future inflation. Mispricing in financial markets can persist for long periods of time. Third, the market may anticipate a switch from the current regime with pro-cyclical primary surpluses to one with counter-cyclical surpluses. Making tax revenues counter-cyclical would lower the discount rate on the tax revenue claim, and making non-interest spending pro-cyclical would increase the discount rate on the spending claim. Section 6 shows that this change is the most potent way of boosting projected fiscal capacity. It is arguably also the most painful and hence least politically feasible way, since it requires belt tightening at the worst possible (high marginal-utility) times.

Projected fiscal capacity may be even more limited than what our calculations suggest for three reasons. First, our estimates only put an upper bound on fiscal capacity, because we assume that surpluses are only as risky as GDP. Second, our estimates of fiscal capacity assume that a major fiscal adjustment will take place after 2052, turning from large primary deficits to large primary surpluses. This is an adjustment unlike any other in U.S. history. Third, the GDP risk premium estimate used in our discount rate is at the lower end of the empirically plausible range. Each of these assumptions, discussed in detail below, increases our estimate of projected fiscal capacity, and shrinks the gap with the observed debt/GDP ratio. Each one makes our calculations conservative, and reinforces our conclusion that fiscal capacity is more limited than commonly thought.

Typically, a pension fund will seek to match the duration of the cash inflows from its portfolio to the duration of the cash outflows to its retirees to avoid interest rate risk. The U.S. Treasury has not matched the duration of its projected cash inflows, primary surpluses, to the duration of its outflows, coupon and principal payments on the debt portfolio. Because of the backloading of projected primary surpluses, the duration of its asset claim is very long (283 years in the baseline model), much longer than the duration of its outstanding bond portfolio (around 5 yrs in 2021) . This creates a large duration mismatch. When rates increase, U.S. fiscal capacity, the present value of future surpluses, decreases dramatically, but the value of its liabilities, the portfolio of outstanding Treasury debt, decreases by much less. As a result, an interest rate increase will require large fiscal adjustments. A mere 1% point increase in yields of all maturities, holding constant nominal GDP growth and projected primary surpluses until 2052, requires an increase in surpluses of 2.67% of GDP each year after 2052 relative to the baseline model.

The large realized changes in interest rates between December 31, 2021 and May 31, 2022, when interest rates moved up anywhere from 130 to 175 basis points along the term structure, are a concrete example of this duration argument. These changes require a massive increase in primary surpluses after 2052 to maintain the same projected fiscal capacity: from 2.16% per year to 6.24% per year.

From an optimal maturity management perspective, i.e., to avoid costly variation in tax rates, the Treasury should either front-load surpluses to shorten the duration of its assets and/or increase the maturity of its outstanding debt. In order to eliminate the duration mismatch completely, we find that the Treasury would have to increasing the primary surplus by 6% of GDP each year between 2022 and 2052 relative to the CBO's baseline projections.

We develop intuition for these quantitative estimates by examining the steady-state in which the surplus is a constant share of GDP. In the steady state, fiscal capacity relative to GDP equals the price/dividend ratio on the GDP claim multiplied by the steady-state surplus/GDP ratio. The price/dividend ratio determines the fiscal capacity per dollar of surplus, expressed as a percent of GDP. This price/dividend ratio depends on the risk-free rate, the term premium, the GDP risk premium, and the expected growth rate of GDP. An increase in the expected growth rate, a decrease in the risk-free rate, a decrease in the term premium, or a decrease in the GDP risk premium all increase fiscal capacity.

We estimate the price/dividend ratio for the total wealth portfolio to be around 86 at the end of 2021, which implies an estimate for total wealth, including human wealth, of about 86 times GDP. To get an upper bound on the fiscal capacity of 99.6% of GDP, the size of the debt/GDP ratio at the end of 2021, the U.S. would need a steady-state primary surplus of 1.16%. Relative to the aforementioned CBO projections of an average primary surpluses of -3.2% between 2022 and 2052, this requires a major fiscal correction.

As in any valuation exercise, our final estimate of fiscal capacity depends on the cash flow projections, including the seigniorage revenue earned on Treasurys, and the discount rate assumptions. Both are subject to considerable uncertainty.

First, our measure of projected fiscal capacity relies on CBO projections of future primary surpluses as well as GDP and interest rate forecasts. The primary surplus projections are not traditional forecasts. To be concrete, Congress can pass new legislation in order to increase tax revenue or decrease non-interest spending. The CBO does not try to forecast such future fiscal policy adjustments. As shown by Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2021), the CBO projections have systematically overstated realized surpluses over the past two decades. Should this overstatement continue, it would render our estimate of fiscal capacity overly generous. Even taking CBO projections at face value, our estimate of fiscal capacity suggest that large fiscal corrections relative to the CBO baseline are anticipated by U.S. Treasury markets.[2] Alternatively, the market may be pricing in some form of real rate distortions or financial repression in the future.[3]

Second, our measurement of fiscal capacity relies on discount rates. We use the discount rates on a claim to GDP, or equivalently, the expected return on the unlevered market portfolio, to derive an upper bound on fiscal capacity. The estimate is sensitive to the discount rate. Choosing a lower discount rate results in higher estimates of fiscal capacity. To arrive at an estimate of fiscal capacity that matches the current valuation of the outstanding Treasury portfolio, we would need a discount rate that is lower than the projected growth rate of the economy. That would imply an implausibly low GDP risk premium and implausibly high valuations of other assets.[4] Lower discount rates also increase the sensitivity of fiscal capacity to interest rate changes, and worsen the duration mismatch. While the literature has argued that low interest rates increase fiscal capacity, the impact of low rates on duration mismatch has not received much attention.

Our forward-looking "valuation" approach in the tradition of Hansen, Roberds, and Sargent (1991) is well-suited for use with the CBO projections. Others pursue a complementary backward-looking "accounting" approach to the question of fiscal sustainability which characterizes debt/output dynamics as a function of past returns and surpluses (see, e.g. Hall and Sargent, 2011; Mehrotra and Sergeyev, 2021). However, this approach is limited because it only considers the realized path of aggregate shocks.

Despite the secular decline in real rates, private investment has stagnated. This phenomenon has been referred to as the secular stagnation (Summers, 2015). Economists have explored whether the U.S. economy is dynamically inefficient, perhaps as result of increased market power (Ball and Mankiw, 2021; Aguiar, Amador, and Arellano, 2021). Farhi and Gourio (2018) countered that risk premia may have increased as real rates have decreased, explaining the low private investment. When using deterministic models (without risk premia), economists may have mistakenly overestimated the NPV of private investment opportunities. Using stochastic models with substantial risk premia lowers the value of private investment opportunities. We make a related point about the government's fiscal capacity. In spite of the secular decline in real rates, the U.S. government's fiscal capacity is more limited once risk premia are accounted for.

Government Ponzi schemes that look promising in deterministic economies typically do not survive exposure to aggregate risk and the presence of long-lived investors (Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2020; Barro, 2020). These schemes also do not survive a close look at the his-

[2]In a classic paper, Bohn (1998) argues that increases in the debt/output ratio predict larger future surpluses, but, in a longer sample and after correcting for small-sample bias, Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2021) find no evidence of this mechanism.

[3]See Acalin and Ball (2022) for evidence on the role of real rate distortions through pegged nominal interest rates before 1951 in the post-war US fiscal experience. More recently, the Bank of Japan has been using yield curve control.

[4]Put differently, we would need to engineer a violation of the TVC to match the valuation of Treasurys given the CBO projections.

torical evidence which suggests that the fiscal capacity of governments has always been limited. For example, the U.K., for which we have the longest continuous fiscal time series data, ran primary surpluses of 2.38% (1.22 %) of GDP between 1729 and 1914 (1946). After 1946, the UK ran primary surpluses of 1.77% of GDP (Chen, Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2022). Our paper contributes to the measurement of these limits.

The paper is organized as follows. Section 2 describes the discounted cash flow analysis approach to measuring projected fiscal capacity and computes the latter in the benchmark scenario. Section 3 analyzes the effect of interest rate risk. Section 4 adds convenience yields. Section 5 analyzes a front-loaded fiscal adjustment. Section 6 analyzes the hypothetical case of counter-cyclical tax revenue. The last section concludes.

2 Discounted Cash Flow Analysis

In a deterministic model without aggregate growth risk, the government can always roll over the debt when the risk-free rate is lower than the growth rate of the economy. The government's fiscal capacity may be unlimited.

This argument used in a deterministic setting does not carry over to an economy with priced aggregate growth risk for two reasons. First, the risk-free rate r_t^f cannot always be lower than the realized growth rate g_t. To see why, consider the case in which the aggregate growth rate is independently and identically distributed over time and the price/dividend ratio of a claim to GDP is constant. If r_t^f is always lower than g_t, then the return on going long in a claim to GDP (un-levered equity) and borrowing at the risk-free rate is always positive. Hence, we have created an arbitrage opportunity, not only for the government, but for all investors.[5]

Second, in a world with output growth risk, the Treasury portfolio is risk-free and earns the risk-free rate if and only if the tax claim is less risky than the spending claim (JLVX (2019)). That restriction has bite and it appears to be violated in U.S. data (see JLVX (2020)).[6] Our measure of fiscal capacity rules out free lunches for the government and investors. As pointed out by Lucas (2012), it is critically important to properly price risk when evaluating government policies.

In reality, going long in un-levered equity and short in the risk-free bond is quite risky. To

[5] If $r_t^f < g_t$ in all states of the world, the return on a claim to output would always exceed the risk-free rate: $R_{t+1}^y = \frac{1+pd}{pd}(1+g_t) > 1 + r_t^f$, giving rise to unbounded profit opportunities for a long-lived investor borrowing at the risk-free and going long in unlevered equity. $r_t^f < g_t$ in all states of the world creates arbitrage opportunities not only for the government, but for everyone else. One exception is the case of convenience yields λ_t which drive Treasury yield below the true risk-free rate: $y_t = r_t^f - \lambda_t$. We discus these in section 4. Convenience yields decline when the debt/output ratio increases.

[6] Moreover, the Treasury does not roll over the entire portfolio of debt every few months by issuing T-bills at the risk-free rate. The return on the portfolio of all outstanding Treasurys has exceeded the nominal growth rate of GDP throughout the 1980s and 1990s (Hall and Sargent, 2011).

be compensated for this risk, investors demand a large risk premium (see Mehra and Prescott, 1985). We call this the GDP or unlevered equity risk premium. This object plays a key role in our analysis.

In standard asset pricing models, the government debt is fully backed by future primary surpluses. The debt in 2021 is backed by primary surpluses ($\{T-G\}_{2022}^{2021+H}$), because the PDV of future debt, say $H=200$ years from now, in 2021 dollars, is arbitrarily small. This is often referred to as the no-bubble condition or the transversality condition (TVC).[7]

	Assets		Liabilities
Until $2021+H$	$PV_{2021}(\{T\}_{2022}^{2021+H})$		$PV_{2021}(\{G\}_{2022}^{2021+H})$
After $2021+H$	$PV_{2021}(D_{2021+H})$	$\rightarrow \$0$	
			$D = PV_{2021}(\{T-G\}_{2022}^{2021+H})$

We assume that debt and output evolve together in the long run.

Assumption 1. Debt is co-integrated with output.

Even when the current debt is risk-free (i.e., it has a beta of zero), future debt will be exposed to output risk because it is cointegrated with output. Hence, the discount rate applied to future debt, say in 2221, will include a GDP risk premium rp^y as well as a term premium ($r^f + term + rp^y$). When debt and output are cointegrated, the no-bubble condition is satisfied as long as the discount rate exceeds the growth rate ($r^f + term + rp^y - g > 0$), even when the risk-free is lower than the average growth rate ($r^f < g$). If we turned off all aggregate risk and set the risk premia to zero, the TVC condition would be violated when $r^f - g < 0$.

If we push the horizon out far enough, under mild conditions, the current value of future debt goes to zero $PV_{2021}(D_{2021+H}) \rightarrow 0$, and the value of debt equals the expected present-discounted value of future primary surpluses:[8]

$$D_{2021} = PV_{2021}(\{T-G\}_{2022}^{\infty}. \tag{1}$$

Definition 1. A country's projected fiscal capacity at the end of 2021 is the present-discounted value of future projected primary surpluses: $PV_{2021}(\{T-G\}_{2022}^{\infty}$.

[7]The transversality condition requires that the expected present-discounted value of debt in the far future, $\mathbb{E}_t[M_{t+T}D_{t+H}]$, goes to zero as the horizon H goes to infinity. The TVC is an optimality condition in an economy with long-lived investors. JLVX (2020) show that the TVC is satisfied as long as the GDP risk premium exceeds the gap between the growth rate and the risk-free rate.

[8]This equation is alternatively referred to as the government intertemporal budget constraint or the debt valuation equation. This equation has a long history, going back to seminal work by Hansen et al. (1991). This result, proven in JLVX (2019), follows from imposing (i) the government budget constraint in each period, (ii) no-arbitrage conditions on individual bond prices, and (iii) a transversality condition.

This calculation requires an estimate of the future surpluses and an estimate of the discount rate. We tackle each of these in turn. We perform this calculation as of December 31, 2021. The actual market value of government debt at the end of 2021, D_{2021}, is 99.64% of GDP .

To be clear, there are models, typically without long-lived investors, which can generate bubbles in asset markets for long-lived assets, including bonds. In these models, there are no long-lived investors to enforce the TVC for long-lived assets (see Santos and Woodford, 1997, for a classic reference). Most of these models do not have priced aggregate risk (see Dumas, Ehling, and Yang, 2021, for a recent example). In these models, the debt may not be fully backed by the PDV of surpluses. Instead, debt may be backed by future debt itself, as the PDV of future debt does not tend to zero. We can think of this as a rational bubble.[9]

	Assets		Liabilities
Until $2021+H$	$PV_{2021}(\{T\}_{2022}^{2021+H})$		$PV_{2021}(\{G\}_{2022}^{2021+H})$
After $2021+H$	$PV_{2021}(D_{2021+H})$	$\not\rightarrow \$0$	
			$D = PV_{2021}(\{T-G\}_{2022}^{2021+H} + D_{2021+H})$

We analyze fiscal capacity while ruling out permanent bubbles in the Treasury market. First, many institutional investors with a long horizon such as endowments, pension funds, and sovereign wealth funds are active in U.S. Treasury markets. Second, typically, these bubbles would also appear in other long-lived assets such as stocks, resulting in implausible valuations for these assets. Third, nothing in these models singles out the U.S. as an ideal candidate for engineering these bubbles.

2.1 Cash Flows

The cash flows we need are primary surpluses from 2022 onwards, i.e., federal tax revenues minus federal non-interest spending. We break up this cash flow stream into the cash flow until 2052 and the cash flow after 2052. By value additivity, we can split up the PDV of surpluses as the sum of surpluses until the end of the CBO projection horizon in 2052 and the residual tail value:

$$PV_{2021}(\{S\}_{2022}^{\infty}) = PV_{2021}(\{S\}_{2022}^{2052}) + PV_{2021}(\{S\}_{2053}^{\infty}). \tag{2}$$

2.1.1 Primary Surpluses Until 2052

We use the Congressional Budget Office's long-term budget projections for the U.S. federal government (Supplemental Table 1, Summary Data for the Extended Baseline). It contains the CBO

[9] Brunnermeier, Merkel, and Sannikov (2022) argue that the government can engineer violations of TVC by providing safe assets that serve uniquely as insurance against idiosyncratic risk.

projections for federal non-interest spending, revenues, debt held by the public, and GDP for each fiscal year from 2022 until 2051. These projections are as of May 2022. From the interest cost and debt projections, we can back out an implicit interest rate on the portfolio of outstanding government debt for those same years.

Table 1 lists the CBO's budget projections for the years 2022-2052 (Congressional Budget Office, 2021a,b). The first column reports government revenue as % of GDP. The second column reports government spending excluding interest as % of GDP. The third column reports the projected primary surplus as % of GDP, given by column (1) minus column (2). The U.S. federal government is projected to run large and growing primary deficits until the end of the projection window in 2052. Column (4) reports nominal GDP projections. For 2022 to 2032, we use projections from the May 2022 CBO report.[10] After that, we use the projected real GDP growth rate and the long-run projected rate of inflation.[11] We then compute the implied dollar numbers for projected nominal tax revenue and spending in columns (5) and (6). The CBO also projects interest costs and implied debt/GDP ratios for the federal debt held by the public. These are reported in column (10).[12]

While the CBO forecasts GDP, inflation, and interest rates in unrestricted fashion, the CBO makes projections of future revenues and non-interest spending based only on current law. The CBO assumes that temporary spending and tax changes will expire as provided in the law. However, the CBO projections assume that the federal government continues to pay for Social Security and Medicare even when the trust funds expire.[13]

JLVX (2021) document that CBO projections have been too optimistic over the past two decades. This was not true prior to the late 1990s. While some of the overly optimistic projections are no doubt due to the Great Financial Crisis and Covid-19 crisis, the CBO projected a reduction in deficits well after the GFC and before the Covid-19 crisis that failed to materialize. If this pattern continues, our measure of projected fiscal capacity is likely to overstate the actual capacity.

We do not consolidate the Fed and the Treasury. Such a consolidation would not change the amount of government's liabilities held by the private sector. It would merely imply a shortening of the maturity structure of the debt held by the private sector. Quantitative easing programs buy long-term Treasuries from the private sector and issue short-term bank reserves in return. The

[10] The CBO provides a supplement to the May 2022 fiscal projection report called "An Update to the Budget and Economic Outlook: 2022 to 2032."

[11] Projections from the figures in CBO's May 2022 report "The 2022 Long-Term Budget Outlook."

[12] Supplemental Table 1: Summary Data for the Extended Baseline. This excludes non-marketable debt.

[13] The non-payable part of Social Security and Medicare remain liabilities for the government even after the corresponding trust funds are exhausted. We are grateful to Phillip Swagel and Molly Dahl for explaining the CBO's approach: "The CBO's extended baseline projections follow the agency's 10-year baseline budget projections and then extend most of the concepts underlying those projections for an additional 20 years. In accordance with statutory requirements, CBO's projections reflect the assumptions that current laws generally remain unchanged, that some mandatory programs are extended after their authorizations lapse, and that spending on Medicare and Social Security continues as scheduled even if their trust funds are exhausted."

shorter maturity of the debt held by the public would further exacerbate the maturity mismatch we highlight below. The consolidation would not affect the PDV of projected future surpluses.

2.2 Discount Rates

Our approach confronts risk head-on by using discount rates that reflect the cash flows risk in future spending, tax revenue and future debt outstanding.

2.2.1 Riskiness of Tax Revenues and Non-interest Spending

The CBO projections for future non-interest spending and tax revenue in Table 1 are point estimates; there is substantial uncertainty around the point estimates. This uncertainty is naturally related to the uncertainty in the underlying macroeconomy. Because the underlying cash flows are risky, they cannot be discounted off the Treasury yield curve. As in any valuation exercise, the proper discount rate needs to reflect the systematic riskiness of the cash flows. They key question then becomes: What is the underlying source of aggregate risk to primary surpluses?

To develop some intuition, consider the simplest case in which government spending and tax revenue are a constant fraction of GDP. Then, by definition, these claims are exactly as risky as a claim to GDP. The latter is often referred to as the total wealth or market portfolio (Jensen, 1972; Roll, 1977; Stambaugh, 1982; Lustig, Van Nieuwerburgh, and Verdelhan, 2013). The return on the total wealth portfolio plays a central role in the canonical asset pricing models, ranging from the Sharpe-Lintner CAPM to the version of the Breeden-Lucas-Rubenstein Consumption-CAPM with long-run risks developed by Bansal and Yaron (2004). The total wealth return is often proxied in the asset pricing literature by the unlevered return on the stock market. The idea is that a portfolio that invests in all publicly-listed companies broadly reflects the evolution of the overall economy.[14] We will adopt this approach, recognizing that the stock market is a levered claim to corporate cash flows. This will lead us to un-lever the equity return to arrive at the total wealth return, the return on a claim to future GDP. We discuss the implementation below.

Modeling tax revenue and non-interest spending as a constant fraction of GDP is sensible in the long run. At business cycle frequencies, the ratio of tax revenue to GDP is pro-cyclical while the ratio of non-interest spending to GDP is counter-cyclical (JLVX (2019)). These cyclical patterns imply that a claim to all future tax revenues is riskier than a claim to all future GDP, while a claim to all future non-interest spending is safer than the GDP claim. Intuitively, the spending claim is a hedge that has high payoffs in bad states of the world (recessions, high stochastic discount factor

[14]This effectively assumes that the aggregate dividends from all publicly listed firms have the same riskiness as all corporate cash flows. Publicly-traded firms represent a sizeable share of aggregate corporate cash flows. If anything, shares in the private firms have higher expected returns, because of the illiquidity. As a result, our approach provides a lower bound on the market risk premium.

Table 1: Fiscal Capacity: Baseline Estimates

Based on CBO projections released in May of 2022. Column (8) reports the discount rates used for spending and tax cash flows in that year. (4), (5), (6), and (11) are in $ billions. Column (9) reports an upper bound on the PDV of projected primary surpluses in 2021 $ billions. Column (10) reports the projected debt/GDP ratio for federal debt held by the public.

year	T/Y	G /Y	(T-G) /Y	Y	T	G	$y_j^{\$}$	$r_j^{\$,y}$	PV(T-G)	D/Y	D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
2022	19.6%	21.9%	-2.3%	$24,694	$4,836	$5,405	0.42%	3.02%	($552.26)	97.9	$24,173
2023	18.6%	20.7%	-2.0%	$26,240	$4,889	$5,419	0.76%	3.36%	($495.70)	96.0	$25,193
2024	18.0%	20.3%	-2.2%	$27,291	$4,924	$5,535	0.99%	3.59%	($549.75)	96.1	$26,217
2025	17.6%	20.1%	-2.5%	$28,271	$4,982	$5,696	1.15%	3.75%	($616.35)	97.5	$27,561
2026	18.0%	20.4%	-2.3%	$29,266	$5,280	$5,962	1.27%	3.87%	($564.72)	98.8	$28,925
2027	18.3%	20.4%	-2.2%	$30,332	$5,548	$6,201	1.36%	3.96%	($517.27)	100.0	$30,326
2028	18.2%	20.6%	-2.4%	$31,487	$5,716	$6,486	1.43%	4.03%	($583.70)	102.0	$32,105
2029	18.1%	20.7%	-2.6%	$32,716	$5,934	$6,773	1.49%	4.09%	($608.55)	103.2	$33,760
2030	18.1%	20.8%	-2.7%	$33,996	$6,161	$7,066	1.55%	4.15%	($627.67)	105.3	$35,808
2031	18.1%	20.9%	-2.7%	$35,318	$6,402	$7,371	1.59%	4.19%	($642.81)	107.5	$37,949
2032	18.2%	21.1%	-2.9%	$36,680	$6,662	$7,722	1.63%	4.23%	($671.66)	109.6	$40,213
2033	18.2%	21.2%	-3.0%	$38,081	$6,938	$8,062	1.67%	4.27%	($680.82)	112.0	$42,636
2034	18.3%	21.3%	-3.0%	$39,519	$7,217	$8,413	1.71%	4.31%	($691.49)	114.4	$45,219
2035	18.3%	21.4%	-3.1%	$40,996	$7,506	$8,779	1.74%	4.34%	($702.29)	117.0	$47,975
2036	18.4%	21.6%	-3.2%	$42,514	$7,801	$9,166	1.77%	4.37%	($718.35)	119.8	$50,926
2037	18.4%	21.7%	-3.3%	$44,074	$8,110	$9,567	1.80%	4.40%	($731.56)	122.7	$54,088
2038	18.4%	21.8%	-3.4%	$45,680	$8,423	$9,975	1.83%	4.43%	($742.66)	125.8	$57,472
2039	18.5%	22.0%	-3.5%	$47,335	$8,749	$10,391	1.85%	4.45%	($749.19)	129.1	$61,087
2040	18.5%	22.1%	-3.6%	$49,035	$9,082	$10,827	1.88%	4.48%	($759.32)	132.5	$64,963
2041	18.6%	22.2%	-3.6%	$50,782	$9,426	$11,272	1.90%	4.50%	($765.37)	136.1	$69,115
2042	18.6%	22.3%	-3.7%	$52,581	$9,782	$11,727	1.92%	4.52%	($768.38)	139.9	$73,568
2043	18.7%	22.4%	-3.8%	$54,443	$10,158	$12,208	1.94%	4.54%	($771.44)	143.9	$78,343
2044	18.7%	22.5%	-3.8%	$56,372	$10,539	$12,685	1.96%	4.56%	($769.40)	148.0	$83,447
2045	18.7%	22.6%	-3.9%	$58,371	$10,939	$13,193	1.98%	4.58%	($769.60)	152.3	$88,909
2046	18.8%	22.7%	-3.9%	$60,444	$11,359	$13,709	2.00%	4.60%	($763.93)	156.7	$94,734
2047	18.8%	22.7%	-3.9%	$62,594	$11,798	$14,219	2.01%	4.61%	($749.74)	161.2	$100,911
2048	18.9%	22.8%	-3.9%	$64,824	$12,260	$14,782	2.03%	4.63%	($743.84)	165.8	$107,481
2049	19.0%	22.8%	-3.9%	$67,132	$12,726	$15,328	2.04%	4.64%	($730.74)	170.5	$114,436
2050	19.0%	22.9%	-3.9%	$69,514	$13,217	$15,900	2.05%	4.65%	($717.59)	175.2	$121,798
2051	19.1%	22.9%	-3.8%	$71,970	$13,733	$16,500	2.07%	4.67%	($704.70)	180.1	$129,588
2052	19.1%	23.0%	-3.9%	$74,505	$14,254	$17,130	2.07%	4.67%	($699.91)	185.0	$137,852
Total PV									$(21,160)		$33,540

M states). Investors prefer such hedges, bidding up their price, and bidding down their expected return. The tax revenue claim has the opposite properties, where tax revenues rise as a share of GDP exactly when investors care least about the extra income (good times, low M states). Hence the tax claim is riskier than a claim to GDP, just like the dividend claim on stocks is riskier than the GDP claim. It carries an expected return and risk premium that exceeds that on the GDP claim. In summary, in the short run, the tax (spending) claim is exposed to more (less) business cycle risk.

In the long run, spending and taxes are both co-integrated with output, and hence (equally) exposed to long-run output risk.[15]

Assumption 2. Government taxes, spending and the value of debt are co-integrated with output.

Cointegration is a necessary condition for fiscal sustainability. When fiscal policy is sustainable, then taxes, spending, debt and output are cointegrated with output. As a result, surpluses are more risky than output in the short run and equally risky in the long run.

Combining the short-run and long-run risk properties, we find that the tax claim is riskier than the GDP claim, which is riskier than the spending claim.[16]

Result 1. The true discount rate for projected tax cash flows is higher than the discount rate for projected spending cash flows: $\mathbb{E}[r^T] \geq \mathbb{E}[r^y] \geq \mathbb{E}[r^G]$, because tax revenue (spending) is riskier (safer) than GDP.

Importantly, this result immediately implies that the government debt portfolio cannot have a zero beta, i.e., be risk-free. The debt will have a positive beta, i.e. carry a positive risk premium.

2.2.2 Upper Bound on Fiscal Capacity

Our approach is to compute an *upper bound* on fiscal capacity. This upper bound obtains when discounting future non-interest spending and tax revenue at the same discount rate, namely the expected return on a claim to GDP: $\mathbb{E}[r^T] = \mathbb{E}[r^G] = \mathbb{E}[r^y]$. By using the same discount rate for the tax and spending claims, we maximize the value of the tax claim because we use a discount rate that is too low, and we minimize the value of the non-interest spending claim because we

[15] A strip is a claim to one dividend payment in the future. When taxes (spending) are cointegrated with GDP, then long-run returns on tax strips and output strips converge (see Proposition 3 in JLVX (2019)). See Backus, Boyarchenko, and Chernov (2018) for a general proof. In the long run, the tax claim, the spending claim, and the output claim are all equally risky.

[16] As explained by JLVX (2019), this rules out that the entire debt portfolio has zero or negative beta. Generating zero-beta debt can only be achieved only if the beta of the tax claim is lower than the beta of the spending claim, i.e. by rendering the tax claim less risky than the spending claim. The empirical evidence points in the opposite direction. In addition, as explained by JLVX (2019), highly persistent deficits are inconsistent with risk-free debt when the debt/output policy is mean-reverting. See also van Wijnbergen, Olijslagers, and de Vette (2020); Barro (2020).

use a discount rate that is too high. Overstating the value of the tax claim and understating the value of the non-interest spending claim results in a value of the primary surplus claim that is unambiguously too large, thus deriving an upper bound on the fiscal capacity.[17] In other words, our measure will tend to overstate fiscal capacity.

Assumption 3. To derive an upper bound, we assume that future spending, tax revenue are all as risky as GDP, and we use the following discount rates: $\mathbb{E}[r^T] = \mathbb{E}[r^y] = \mathbb{E}[r^G]$.

2.2.3 Implementation: Measuring the GDP Risk Premium.

As argued above, we proxy a claim to GDP as the unlevered version of a claim to the dividends of all publicly-listed stocks. Hence, to construct $\mathbb{E}[r^y]$, we begin by constructing a measure of the expected return on equity and unlever this expected return in a second step.

We infer the expected return on a claim to equity from valuations in the stock market. There are many ways one could measure the expected return on stocks: from a vector-autoregressive model (as in JLVX (2019)), from survey expectations (Fernandez, Banuls, and Acin, 2021), or from option markets (Andersen, Fusari, and Todorov, 2015; Binsbergen, Brandt, and Koijen, 2012), to name a few.

For simplicity, we use an off-the-shelf estimate from the private sector. It is an average of two approaches to measure the expected real return on U.S. equities going forward, as of the end of 2021: an earnings-based and a payout yield-based estimate.[18] The earnings-based estimate for the expected real return on U.S. stocks is given by the payout ratio times the earnings/price ratio plus the projected growth rate of earnings:

$$\mathbb{E}[r^{equity}] = D/E \times E/P + g_{EPS} = 0.5 \times 2.8\% + 1.5\% = 2.9\%, \tag{3}$$

where we use the inverse of Shiller's CAPE ratio to measure the E/P ratio, a dividend-payout ratio of 0.5, and an expected growth rate in earnings per share of 1.5% points, all measured at the end of 2021. The payout yield-based estimate for the real expected return on U.S. stocks is given by:

$$\mathbb{E}[r^{equity}] = D/P + NBY + g_{PAGG} = 1.3\% + 0.2\% + 2.7\% = 4.2\%, \tag{4}$$

where D/P is the dividend yield on the S&P 500, NBY is the net buyback yield and g_{PAGG} is a forecast of aggregate U.S. earnings growth, also measured at the end of 2021. We combine these

[17]Our approach is to estimate the expected return on the tax claim and the spending claim by committing to a fully-specified asset pricing model as well as dynamics for fiscal cash flows. This is the first approach pursued by JLVX (2019).

[18]The approach is developed by AQR for its capital market assumptions (see *The Portfolio Solutions Group, AQR*, 2022, for details).

two estimates with equal weights to obtain a blended real expected return of 3.6%. The real risk-free return is estimated to be -1.5%. As a result, we obtain an estimate of 5.1% in excess of the risk-free rate. This number is very close to the 5.5% average (and median) estimate of the U.S. equity risk premium from a recent academic survey (Fernandez et al., 2021).

The equity risk premium is the risk premium on a levered claim. We are interested in the risk premium on an unlevered claim. The debt/equity ratio for the U.S. non-financial corporate sector is roughly 1/2 at the end of 2021, so that the equity/asset ratio is 2/3. As a result, we obtain an unlevered equity premium of 3.4% from a levered equity premium of 5.1% (2/3 of 5.1% is 3.4%). This assumes a zero risk premium on corporate debt.

We also compute an expected excess return of long-term bonds of 0.8%. This means that unlevered equities earn a risk premium rp^y of 2.6% over long-term bonds. This is our measure of the GDP risk premium. The 2.6% GDP risk premium we use here is close to the 2.9% GDP risk premium that comes out of the calibrated disaster model in JLVX (2020). It is also close to the 2.4% risk premium on the total wealth claim obtained by Lustig et al. (2013).[19]

We argue that 2.6% is a low estimate of the annual GDP risk premium for two reasons. First, the average excess return on stocks has been 8% over the 1947–2021 period and may have been at a cyclical low at the end of 2021. Hence the unlevered equity risk premium was unusually low at the time of our measurement. Second, using a higher cost of debt for corporations than the risk-free rate (assuming a positive corporate bond risk premium when unlevering) would also increase the unlevered equity risk premium. Using a lower discount rate will increase our measure of fiscal capacity. This will result in a conservative estimate of projected fiscal capacity, given that we will show that even this generous estimate of fiscal capacity falls short of the outstanding amount of debt at the end of 2021.

To construct the discount rates for discounting tax revenue and spending claims at each horizon h, we start from the nominal zero-coupon bond yield curve at the end of 2021 for maturities from one to thirty years, constructed and updated by Gurkaynak, Sack, and Wright (2006), and then add the output risk premium of 2.6%:

$$\mathbb{E}_t[r^{\$,y}(h)] = y_t^{\$,f}(h) + rp^y. \tag{5}$$

This discount rate is reported in column (8) of Table 1, with the zero-coupon nominal bond yield component of that discount rate listed in column (7).[20]

[19] The latter estimate recognizes that a claim to GDP is potentially different from a claim to the cash flows of all current businesses, because the businesses in the current cohort are short-lived.

[20] We assume that the yield on a 31-year zero-coupon bond equals the yield on a 30-year bond.

2.3 Steady-State Fiscal Capacity

As a warm-up exercise, we compute a measure of steady-state fiscal capacity. In the steady-state, the government runs a constant primary surplus relative to GDP. Given that the tax claim is riskier than the spending claim, an upper bound on the steady-state fiscal capacity is given by the valuation ratio on a claim to GDP times the steady-state surplus. In the steady-state, the valuation of future surpluses is given the price/dividend ratio on a claim to GDP times the steady-state surplus:

$$PV_{2021}^{upper,ss}(\{T-G\}) = \frac{S}{Y}\sum_{j=1}^{\infty}\frac{\mathbb{E}_{2021}(Y_{2021+j})}{(1+r^{\$,y})^j} = pd^y \times \frac{S}{Y} \times Y_{2021}. \quad (6)$$

We use the 30-year zero coupon yield at the end of 2021 to proxy for the long end of the Treasury yield curve, and use the CBO's long-run forecast for real growth of 1.5% and inflation of 2%. The nominal long discount rate minus the nominal growth rate is given by:

$$r^{\$,y} - g = y_{2022}^{\$,f}(30) + rp^y - g = 2.07\% + 2.60\% - (1.50\% + 2\%) = 1.17\%. \quad (7)$$

We can use Gordon's growth formula to compute the valuation ratio for the claim to GDP:

$$pd^y = \frac{1}{r^{\$,y} - g} = \frac{1}{1.17\%} = 85.8 \quad (8)$$

The multiple on a claim to GDP is 85.8.[21] An unlevered company whose cash flows grow at the same rate as the U.S. economy would have a price/dividend ratio of 85.8 in 2021.[22] At this high multiple, total U.S. wealth is about 85.8 times the size of GDP.[23] This historically high multiple reflects low rates and low risk premia at the end of 2021.

Table 2: U.S. Treasury Balance Sheet in Steady-State Example

Treasury Balance Sheet in Market Values. Steady-State Example. Expressed as a multiple of U.S. GDP at the end of 2021. Example based on actual spending/GDP ratio in 2022.

Assets		Liabilities	
$PV_{2021}(\{T\})/Y_{2021}$	$19.78 = 23.06\% \times 85.8$	$PV_{2021}(\{G\})/Y_{2021}$	$18.79 = 21.9\% \times 85.8$
		D/Y_{2021}	$0.99 = 1.16\% \times 85.8$
Total	19.78	Total	19.78

Table 2 shows the U.S. Treasury's balance sheet in market values, expressed as a percentage of GDP. Total assets and total liabilities are exposed to the same cash flow risk. The Treasury cannot

[21] Using a different approach with a no-arbitrage term structure model, Lustig, Van Nieuwerburgh, and Verdelhan (2013) obtain an average U.S. wealth/consumption ratio of 83, a similar value.

[22] If that company were only expected to live for 50 years, the multiple would still be 64.5.

[23] In 2021, that's about $5.8 million per American. Most of this the PDV of future labor income.

financially engineer risk away. The risk in the tax process on the left hand side of the ledger has to show up on the right hand side in spending risk or in the riskiness of the debt. If the S/Y ratio is constant, then the surplus inherits the risk properties of a GDP claim. In this simple case, the discount rate for a GDP claim is the right discount rate for the surplus claim. And the valuation of debt would be 0.99 times GDP, as shown in Table 2. However, as we have explained, S/Y is actually pro-cyclical in the data, implying that the surplus claim is riskier than the output claim. As a result, our calculation produces an upper bound on fiscal capacity.

In the right column of Table 2, we start from the 2022 spending ratio of 21.9%. We need a steady-state primary surplus of 1.16% of GDP to get to an upper bound on fiscal capacity that includes the observed debt/GDP ratio of 99.7% as of the end of 2021: $85.8 \times 1.16\% = 99.7\%$ of 2021 GDP. In the left column, we back out the implied steady-state tax ratio T/Y of 23.06% that is needed. The implied value of the tax claim is almost 20 times GDP.

The U.S. gets an additional 85.8% of GDP in fiscal capacity (maximum) per 1% of steady-state primary surplus $\frac{S}{Y}$. As noted above, our GDP risk premium estimate is low, resulting in a high price-dividend ratio on the GDP claim. As a result, our calculation produces high estimates of fiscal capacity, holding fixed the projected surpluses. In addition, the secular decline in real rates over the past decades has boosted U.S. fiscal capacity per % of primary surplus.

However, the CBO does not project any surpluses over its projection horizon. Column (3) in Table 1 reports the actual projected primary deficits. The CBO projects average deficit of 3.19% of U.S. GDP between 2022 and 2052. One would need a large, permanent fiscal correction of 4.35% of GDP (from -3.19% to 1.16%) to reconcile this back-of-the-envelope upper bound with the actual value of U.S. Treasury debt/GDP. For this to work out exactly, the steady-state surplus/GDP ratio would have to be a-cyclical.

2.4 Baseline Estimate of Fiscal Capacity

Next, we carry out our main analysis, which is to compute fiscal capacity as spelled out in equation (11). We discount each CBO projected cash flow, column (5) minus (6) of Table 1, with the discount rate $r^{\$,y}(h)$, shown in column (8), to arrive at the present discounted value listed in column (9).[24] The sum of the PDV of primary surpluses from 2022-2052 adds up to minus \$21.16 trillion dollars:

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) = \sum_{h=1}^{31} \frac{T_{2021+h} - G_{2021+h}}{(1+r^{\$,y}(h))^h} = -\$21.16 \text{ tr.} \tag{9}$$

[24] Alternatively, we could discounted projected cash flows in constant dollars using the yields on real zero coupon bonds. The results are quite similar.

This is the sum of column (9) starting with -$552 bn, the PDV of deficit in 2022, until and including -$699.9 bn, the PDV of the 2052 deficit.

According to the CBO debt projections, reported in column (10) of Table 1, the debt outstanding will equal 185% of U.S. GDP at the end of 2052. This would amount to approximately $138 trillion in nominal debt, as shown in column (11).

We assume that surpluses are a constant fraction of GDP in each year after 2053. Furthermore, we impose that equation (1) holds at the end of 2052, namely that the projected debt/output ratio in 2052 (see column (10)) is fully backed by surpluses:

$$\left(\frac{D}{Y}\right)_{2052} = \frac{S}{Y} \times PV_{2052}(\{Y\}_{2053}^{\infty}) \tag{10}$$

Given that we have the CBO's projection for the debt/GDP ratio at the end of 2052, we can back out what constant surplus/GDP ratio is needed in the years after 2052 to satisfy (10). This implied surplus/GDP ratio will be positive since the projected debt/GDP ratio in 2052 is 185% of GDP, as shown in the last row of column (10) of Table 1.

What do we need to assume about surpluses starting in 2053 to justify this number as the present-discounted value of future primary surpluses, as in equation (10)? Recall that the multiple on a claim to GDP at the end of 2021 is 85.8. It seems reasonable and conservative to use this same multiple at the end of 2052. The valuation multiple of 85.8 at the end of 2021 is high relative to its historical mean because of low long-term nominal rates and a low risk premium, and is likely to revert back to its long-run mean. Using the historical average multiple would result in a higher required annual average primary surplus after 2052 to justify the same debt/output ratio at the end of 2052. This does not affect the present value of debt in 2052, only the required surpluses to repay this debt. To obtain a valuation of the debt outstanding at the end of 2052 equal to 185% of GDP, the U.S. federal government would need to generate an annual primary surplus of 2.16% after 2052 ($2.16\% \times 85.8 = 185\%$).

Assuming (10), our 2021 fiscal capacity estimate in (2) can be rewritten as the sum of the PDV of primary surpluses until the end of the projection horizon and the PDV of outstanding (projected) debt:

$$PV_{2021}(\{S\}_{2022}^{\infty}) = PV_{2021}(\{S\}_{2022}^{2052}) + PV_{2021}(D_{2052}). \tag{11}$$

Figure 1 plots the time path of projected primary surpluses; the red line is the baseline case. Until 2052, it plots the projected primary surpluses from the CBO. After 2052, the primary surplus is assumed to be equal to 2.16%, the surplus needed to enforce the intertemporal budget constraint at the end of 2052.

The debt outstanding at the end of 2052, projected to be 185% of GDP, also needs to be dis-

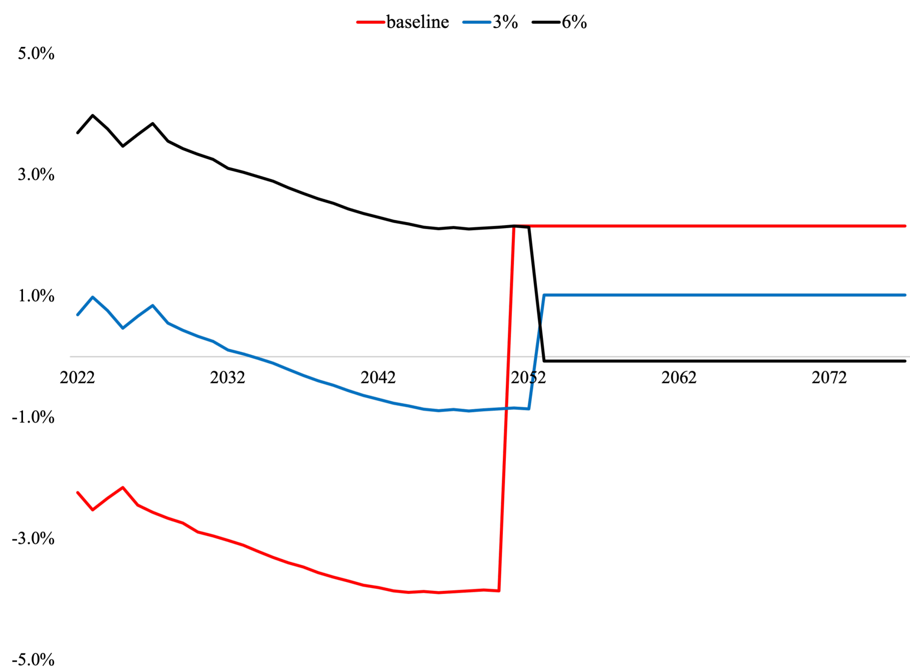

Figure 1: CBO Projections of Primary Surplus

Red line: Baseline CBO projections of primary surplus for 2022-2052, followed by primary surpluses after 2052 needed to pay back the debt in 2052. Blue line: Increase in primary surpluses between 2022-52 by 3.0% of GDP each year, followed by primary surpluses after 2052 needed to pay back the debt in 2052. Black line: Increase in primary surpluses between 2022-52 by 6.0% of GDP each year, followed by primary surpluses after 2052 needed to pay back the debt in 2052.

counted back to 2021 using the same discount rate used for the primary surplus cash flow in 2052. The second term in equation (11) is given by:

$$PV_{2021}^{upper}(D_{2052}) = \left(\frac{D}{Y}\right)_{2052} \times \frac{\mathbb{E}_{2021}(Y_{2052})}{(1+r_{31}^{\$,y})^{2052-2021}} = \$33.54 \text{ tr.} \tag{12}$$

In our approach, future debt is assumed to be as risky as output. The future debt/output ratio in 2052 is constant across all possible output growth paths, but, of course, the debt itself is subject to GDP growth risk. The discount rate we use is the one appropriate for the stochastically growing GDP claim. Discounted back to the end of 2021, the PDV of D_{2052} is $33.5 trillion.

When we add up the discounted value of debt outstanding in 2052 and the surpluses between 2022 and 2052, we obtain our baseline fiscal capacity estimate of $ 12.38 trillion:

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) + PV_{2021}^{upper}(D_{2052}) = -\$21.16 \text{ tr.} + \$33.54 \text{ tr.} = \$12.38 \text{ tr.} \tag{13}$$

The key observation is that this fiscal capacity estimate falls about $10 trillion short of the actual valuation of debt in 2021 of $22.3 trillion. In sum, our projected fiscal capacity bound cannot be reconciled with the actual valuation of debt at the end of 2021, given the baseline CBO projections of future primary surpluses, debt, and realistic discount rates.

This is surprising result in light of four observations that bear repeating. First, this is an upper bound on fiscal capacity by virtue of discounting the fiscal cash flows at the GDP discount rate (rather than at the higher tax and lower spending discount rates). Second, the CBO's primary surplus projections have tended to be too high compared to realized values over the past two decades. Third, our point estimate for the GDP risk premium is, if anything, low. Fourth, we have assumed that the U.S. will generate primary surpluses after 2052 that are large enough to rationalize the projected value of outstanding debt in 2052. This would constitute a sea change from what we have observed in the past many decades. Relaxing any of these four assumptions would result in an even lower value for projected fiscal capacity and an ever larger wedge between the estimated fiscal capacity and the observed debt/GDP ratio at the end of 2021. Those are the four reasons that our estimate of projected fiscal capacity is conservative: if anything too high rather than too low.

2.5 Discounting Future Debt

The right discount rate for debt outstanding far in the future includes the GDP risk premium when output and debt are cointegrated. The reason is that GDP is the far future is uncertain, and hence risky.[25] In our calculation, we use 2.07% for the nominal long yield, 2.60% for the GDP risk premium and 3.50% for the long-run nominal growth rate g. These values imply that the TVC is satisfied (4.67% $>$ 3.5%). Importantly, this long-run discount rate that includes a GDP risk premium is the right discount rate for future debt regardless of the short-term debt/output, tax, and spending dynamics, and even when the current debt is risk-free, i.e., has a zero beta.

If we had used the risk-free yield curve, without adding the GDP risk premium, when discounting future debt, then the discounted value of future debt in 2052 would have been \$73.15 tr in 2021 dollars. The present value of the deficits until 2052 would have been -\$33.15 tr. We would have obtained a fiscal capacity estimate of \$40 tr. at the end of 2021, comfortably above the observed debt/GDP ratio at the end of 2021. The federal government's debt is projected to grow faster than output, and the discount rate (2.07%) is lower than the growth rate of output (3.50%). This is essentially the $r < g$ approach to fiscal sustainability. As we push the final period T further out, the PDV of debt outstanding at T does not converge to zero.

From a standard finance perspective, the $r < g$ argument is flawed, unless the GDP risk premium is zero. Future debt outstanding cannot be discounted using the risk-free yield curve unless the future debt's valuation is known today, or unless its valuation is insensitive to the growth rate of output. This cannot be the case when debt and output are co-integrated, a necessary condition for fiscal sustainability (see Assumption 2), even if current debt is risk-free (zero-beta). As a result, discounting future debt at the risk-free rate is not consistent with fiscal sustainability. When discounted at a discount rate that includes the GDP risk premium, the value of future debt is much smaller, and the fiscal capacity estimate does not increase if we push T out further into the future.

Suppose we took the counterfactual view that the entire debt portfolio really had a zero beta, because the tax claim was less risky than the spending claim. Then, we could discount the projected surpluses until 2052 off the risk-free yield curve. However, we would still need to discount the future debt at the proper discount rate which includes the GDP risk premium. The estimated projected fiscal capacity would then become:

$$PV_{2021}^{upper}(D_{2052}) = \frac{D_{2052}}{(1 + r_{31}^{\$,y})^{2052-2021}} = -\$33.74 \text{ tr.} + \$33.54 \text{ tr.} = -\$0.20 \text{ tr.} \tag{14}$$

We would end up near-zero fiscal capacity, because the projected deficits increase in present value when discounted at a lower rate. This calculation shows that even discounting future primary surpluses over the next thirty years at the risk-free rate results in a low estimate of fiscal capacity as long as debt in the far future is discounted using a conceptually coherent discount rate.

[25] If the debt/output ratio is stationary, the necessary condition for the transversality condition (TVC) to be satisfied, $\lim_{H\to\infty} \mathbb{E}_t[M_{t+H}D_{t+H}] = 0$, is $y^{\$,f}(H) + rp^y > g + \frac{1}{2}\sigma^2$, for some long horizon H and where σ is the volatility of output growth (see JLVX (2020), for details).

This discussion raises a related question: How low would the GDP risk premium have to be to result in a fiscal capacity estimate that matches the observed debt/GDP ratio at the end of 2021.[26] The answer is 1.37% per year. However, at this risk premium, the TVC fails because the discount rate is lower than the GDP growth rate and the economy is dynamically inefficient:

$$r^{\$,y} - g = y^{\$,f}_{2022}(30) + rp^y - g = 2.07\% + 1.37\% - (1.50\% + 2\%) < 0. \tag{15}$$

The steady-state multiple on claim to GDP tends to ∞. This has troubling valuation implications. An unlevered firm whose cash flows are expected to grow at the rate of U.S. output growth would have an infinite valuation. We conclude that a value of 1.37% or lower for the GDP risk premium is implausibly low. In the baseline scenario, we cannot match the valuation of debt without engineering a violation of the TVC.

2.6 Reverse Engineering

Given our assumptions and Result 1, the debt cannot be risk-free. The CBO assumes that the debt can be rolled over until 2052 at the projected interest rates. Even though the CBO does project an increase in interest rates in the long-term, its projected interest rates may not be consistent with the true risk characteristics of the debt, implied by our analysis. The calculation of our benchmark fiscal capacity measure above, which takes the CBO interest rate projections until 2052 as given, can then be interpreted as consistent with notion of persistent mispricing.

Alternatively, we can insist that the debt be priced correctly today given the CBO projections. Instead of using the CBO's projected debt/output ratio, we can back out the steady-state surplus after 2052 that is needed in order to obtain an estimate for fiscal capacity at the end of 2021 that equals the market value of outstanding debt:

$$PV^{upper}_{2021}(\{T-G\}^{2052}_{2022}) + PV^{upper}_{2021}(D_{2052}) = -\$21.16 + \$43.45 = \$22.284 \text{ tr.} \tag{16}$$

To obtain \$43.45 trillion for the present value of debt in 2052, we need annual primary surpluses of 2.79% from 2053 onwards:

$$PV^{upper}_{2052}(\{T-G\}^{2052}_{2022})/Y_{2052} = \frac{S}{Y} \times PV_{2052}(\{Y\}^{\infty}_{2053} = 2.79\% \times 85.8 = 239\%, \tag{17}$$

This can be interpreted as a debt/output ratio in 2052 of 239%, instead of the 185% projected by

[26] Cochrane (2020) articulates the view that fiscal capacity is simply what the market says it is. In other words, we back out the discount rate that sets the fiscal capacity equal to the market value of debt. However, the risk premium on the market or the GDP risk premium is not a free parameter. We find that this reverse-engineered GDP risk premium violates the TVC, implying unbounded valuations for companies.

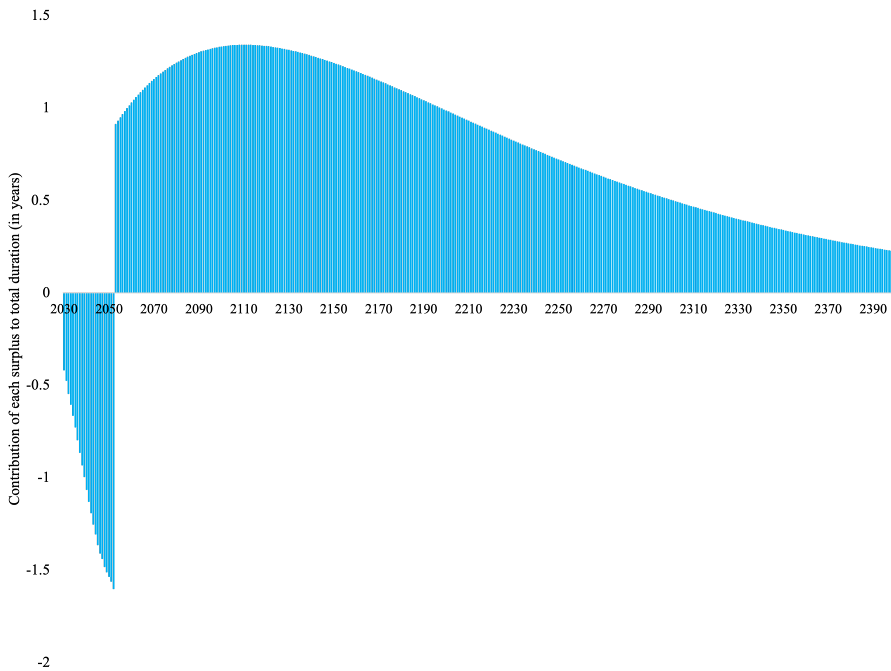

Figure 2: Duration Composition in Baseline Scenario. Contribution of each payment $\frac{k \times PV(S_{2021+k})}{\sum_{h=1} PV(S_{2021+h})}$ to the total duration in the CBO baseline projection. The duration (measured in years) is the sum of the plotted contributions.

the CBO.

What explains the difference with the CBO projection of 185%? If we roll over the debt at the GDP discount rate in column (8) of Table 1 until 2052, instead of using the CBO projected interest rates, the projected debt/output ratio is 239% rather than 185%. This reverse engineering exercise imposes that the debt be correctly priced and that the interest rates Treasury pays on the debt reflect the risk.

3 Interest Rate Risk

3.1 Duration

The duration of the primary surplus claim is very high in the baseline scenario because the surpluses are extremely back-loaded; recall the red line in Figure 1. The McCauley duration of the surplus claim is 283.2 years.[27] Figure 2 plots the contribution of each payment at horizon k to the total duration $\frac{k \times PV(S_{2021+k})}{\sum_{h=1} PV(S_{2021+h})}$. The duration is the sum of all bars.

Given this high duration of the surplus claim, U.S. fiscal capacity is very sensitive to the yield

[27] If we (somewhat implausibly) assume that the Treasury pays back all outstanding debt at the end of 2052 in one large bullet payment rather than with gradual future surpluses, then the duration of the surplus claim becomes 44.7 years.

curve. We present two sets of calculations, one for a hypothetical 100 basis point parallel shift up in the yield curve, and one for the actually observed changes in the yield curve in the first five months of 2022.

3.2 Parallel Shift in Yield Curve

We study a 100 basis points parallel upward shift in the yield curve, holding constant all other parameters, including nominal GDP growth. Increasing interest rates while holding nominal GDP growth constant amounts to an increase in the real growth-adjusted yield, i.e., in $r - g$. This increase could reflect, for example, the unwind of Quantitative Easing programs.[28] The upward shift in yields increases the discount rate of future surpluses and of future debt by 100 basis points, as shown in columns (8) and (9) of Table 3. We also add an additional 100 basis points to the CBO's projected net interest cost as a fraction of debt in each year between 2022 and 2052, as shown in column (4) of Table 3.[29] This extra interest cost affects the debt dynamics via $D_{t+1} = D_t \times R_{t+1} + S_{t+1}$. We compute these projected debt dynamics using the original projected primary surpluses and the CBO's interest rate projections plus 100 basis points.

The projected debt outstanding in this high-rate scenario grows to 223.0% of GDP in 2052 or to \$166.17 trillion, as shown in columns (11) and (12). Because of the 100 basis point rate increase, the steady-state multiple of a claim to GDP decreases from 85.8 to 46.2. Starting in 2053, the U.S. now has to generate a steady-state primary surplus of $4.83\% = \frac{223\%}{46.2}$, an increase by 2.67% of GDP relative to the corresponding number in the baseline scenario of 2.16%, i.e., before the interest rate change.[30] Hence, an increase in rates of 100 basis points, holding constant nominal GDP growth, implies a 2.67% of GDP increase in annual surpluses starting in 2053. The increase in surpluses starting in 2053 divided by the increase in rates is 2.67×. This multiple is the signature of the duration mismatch on the Treasury's balance sheet.

A dramatic increase in long-run future surpluses is one adjustment mechanism in response to the interest rate increase. Alternatively, if investors believe the government is unable to generate surpluses of this size, the valuation of the Treasury portfolio has to decline, triggering a sell off and a widening of default spreads.

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[28] Economists have found that large-scale asset purchases by the Federal Reserve have successfully lowered long term yields (Krishnamurthy and Vissing-Jorgensen, 2011; D'Amico, English, López-Salido, and Nelson, 2012; Joyce, Lasaosa, Stevens, and Tong, 2020), with estimates ranging from 50-100bps declines. This implies that in the absence of QE, nominal long-term bond yields would be higher by that amount. The assumption that the GDP risk premium does not change is consistent with a narrow convenience yield view, as discussed further below.

[29] The CBO reports net interest /GDP and GDP projections from which we back out an estimate of the effective interest rate on debt R_t .

[30] The estimate of the upper bound on fiscal capacity is now at \$12.03 tr, which is close to the baseline number. The key point, however, is that this assumes 4.83% of GDP in primary surplus starting in 2053 compared to 2.16% of GDP in the baseline case.

Table 3: Fiscal Capacity with Higher Interest Rates

Based on CBO projections . Column (8) reports the discount rates used for spending and tax cash flows in that year, a 100 basis point increase relative to baseline. Column (4) reports the projected CBO's Net Interest Cost over Debt plus 100 basis points. Columns (5), (6), (7), and (12) are in $ billions. Column (10) reports an upper bound on the PDV of projected primary surpluses in 2021 $ billions . Column (12) reports the Debt dynamics: $D_{t+1} = D_t \times R_{t+1} + (T_{t+1} - G_{t+1})$. R_{t+1} is taken from Column (4).

year	T/Y	G /Y	(T-G) /Y	NI/D	Y	T	G	$y_j^{\$}$	$r_j^{\$,y}$	PV(T-G)	D/Y	D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2022	19.6%	21.9%	-2.3%	2.8%	$24,694	$4,836	$5,405	1.42%	4.02%	($546.95)	95.1	$23,475
2023	18.6%	20.7%	-2.0%	2.8%	$26,240	$4,889	$5,419	1.76%	4.36%	($486.24)	94.0	$24,669
2024	18.0%	20.3%	-2.2%	3.1%	$27,291	$4,924	$5,535	1.99%	4.59%	($534.13)	95.4	$26,040
2025	17.6%	20.1%	-2.5%	3.3%	$28,271	$4,982	$5,696	2.15%	4.75%	($593.15)	97.7	$27,615
2026	18.0%	20.4%	-2.3%	3.5%	$29,266	$5,280	$5,962	2.27%	4.87%	($538.31)	100.0	$29,256
2027	18.3%	20.4%	-2.2%	3.6%	$30,332	$5,548	$6,201	2.36%	4.96%	($488.39)	102.1	$30,967
2028	18.2%	20.6%	-2.4%	3.8%	$31,487	$5,716	$6,486	2.43%	5.03%	($545.90)	104.5	$32,907
2029	18.1%	20.7%	-2.6%	3.9%	$32,716	$5,934	$6,773	2.49%	5.09%	($563.74)	107.0	$35,022
2030	18.1%	20.8%	-2.7%	4.0%	$33,996	$6,161	$7,066	2.55%	5.15%	($575.94)	109.8	$37,322
2031	18.1%	20.9%	-2.7%	4.1%	$35,318	$6,402	$7,371	2.59%	5.19%	($584.25)	112.7	$39,810
2032	18.2%	21.1%	-2.9%	4.1%	$36,680	$6,662	$7,722	2.63%	5.23%	($604.69)	115.9	$42,519
2033	18.2%	21.2%	-3.0%	4.2%	$38,081	$6,938	$8,062	2.67%	5.27%	($607.14)	119.3	$45,432
2034	18.3%	21.3%	-3.0%	4.2%	$39,519	$7,217	$8,413	2.71%	5.31%	($610.82)	122.9	$48,556
2035	18.3%	21.4%	-3.1%	4.3%	$40,996	$7,506	$8,779	2.74%	5.34%	($614.50)	126.6	$51,904
2036	18.4%	21.6%	-3.2%	4.3%	$42,514	$7,801	$9,166	2.77%	5.37%	($622.61)	130.6	$55,504
2037	18.4%	21.7%	-3.3%	4.3%	$44,074	$8,110	$9,567	2.80%	5.40%	($628.07)	134.7	$59,374
2038	18.4%	21.8%	-3.4%	4.4%	$45,680	$8,423	$9,975	2.83%	5.43%	($631.58)	139.1	$63,531
2039	18.5%	22.0%	-3.5%	4.4%	$47,335	$8,749	$10,391	2.85%	5.45%	($631.12)	143.6	$67,989
2040	18.5%	22.1%	-3.6%	4.5%	$49,035	$9,082	$10,827	2.88%	5.48%	($633.61)	148.4	$72,784
2041	18.6%	22.2%	-3.6%	4.6%	$50,782	$9,426	$11,272	2.90%	5.50%	($632.63)	153.5	$77,943
2042	18.6%	22.3%	-3.7%	4.6%	$52,581	$9,782	$11,727	2.92%	5.52%	($629.12)	158.8	$83,495
2043	18.7%	22.4%	-3.8%	4.7%	$54,443	$10,158	$12,208	2.94%	5.54%	($625.67)	164.3	$89,472
2044	18.7%	22.5%	-3.8%	4.8%	$56,372	$10,539	$12,685	2.96%	5.56%	($618.12)	170.1	$95,891
2045	18.7%	22.6%	-3.9%	4.8%	$58,371	$10,939	$13,193	2.98%	5.58%	($612.45)	176.1	$102,791
2046	18.8%	22.7%	-3.9%	4.9%	$60,444	$11,359	$13,709	3.00%	5.60%	($602.20)	182.3	$110,186
2047	18.8%	22.7%	-3.9%	5.0%	$62,594	$11,798	$14,219	3.01%	5.61%	($585.45)	188.6	$118,078
2048	18.9%	22.8%	-3.9%	5.0%	$64,824	$12,260	$14,782	3.03%	5.63%	($575.36)	195.2	$126,517
2049	19.0%	22.8%	-3.9%	5.0%	$67,132	$12,726	$15,328	3.04%	5.64%	($559.89)	201.9	$135,508
2050	19.0%	22.9%	-3.9%	5.1%	$69,514	$13,217	$15,900	3.05%	5.65%	($544.63)	208.7	$145,085
2051	19.1%	22.9%	-3.8%	5.1%	$71,970	$13,733	$16,500	3.07%	5.67%	($529.80)	215.8	$155,287
2052	19.1%	23.0%	-3.9%	5.2%	$74,505	$14,254	$17,130	3.07%	5.67%	($521.22)	223.0	$166,174
Total PV										$(18,077)		$30,109

As mentioned, one can reverse-engineer the GDP risk premium that sets the fiscal capacity equal to the market value of debt. If we had assumed—counter-factually—that the GDP risk premium were 1.37% per year rather than 2.60% per year, the duration of the surplus claim would be 651, more than twice the baseline value. While a lower GDP risk premium increases fiscal capacity, it increases the sensitivity of that fiscal capacity to increases in interest rates. From a policy perspective, this means that duration and roll-over risk are especially high when discount rates are low.

3.3 Higher Interest Rates of 2022

The first several months of 2022 saw a dramatic increase in interest rates. Between December 31, 2021 and May 31, 2022, the two-year zero-coupon bond yields rose by 176 basis points, the 10-year bond yield by 133 basis points, and the 30-year bond yield by 131 basis points. We now explore what this shift in the term structure implies for our measure of fiscal capacity.

In a first exercise, we assume that this interest rate change only affects the rate at which we discount future surpluses but leaves future debt projections unchanged (as well as tax revenue, spending, and GDP projections).[31,32] The fiscal capacity bound becomes:

$$PV_{2021}^{upper}(\{S\}_{2022}^{2052}) + PV_{2021}^{upper}(D_{2052}) = -\$17.19 \text{ tr.} + \$22.78 \text{ tr.} = \$5.59 \text{ tr.} \tag{18}$$

We observe a substantial decline in fiscal capacity from the rise in interest rates, from \$12.38 tr to \$5.59 tr. At the new, higher rates, the valuation ratio of the GDP claim declines from 85.8 to 40.3. Servicing the same 185% debt/GDP after 2052 now requires annual surpluses of 4.59% of GDP compared to 2.16% of GDP. Even though the fiscal adjustment after 2052 is more than twice as large, the fiscal capacity estimate falls by more than half.

Arguably, it is implausible that the CBO would not revise its interest rate forecast when projecting future debt service and future debt in light of these interest rate increases. To consider this additional effect, we add 156 basis points to the CBO's interest rate forecast in each year from 2022–2052. This 156 basis points is the increase in the 5-year bond yield between 12/31/2021 and 5/31/2022, where the 5-year maturity is chosen since it corresponds to the average maturity of the outstanding government bond portfolio. Under this assumption, the interest rate on the debt

[31] As in the previous exercise, increasing interest rates while keeping nominal GDP growth rates constant amounts to an increase in the real growth-adjusted return $r - g$. Such an increase in real rates is consistent with the data. The 10-year inflation-indexed treasury bond yield increased from -1.04% on 12/31/2021 to +0.21% on 05/31/2022, an increase of 125 basis points.

[32] To do full-fledged counter-factual exercises, one would ideally like to use a general equilibrium model where GDP, inflation, interest rates, and fiscal policy are endogenously determined. A recent paper along these lines is Elenev, Landvoigt, Shultz, and Van Nieuwerburgh (2021). Such a model would need to take a stance on what the fundamental shocks are that gave rise to the changes in equilibrium interest rates: short-term or long-term productivity shocks, demand shocks, fiscal policy shocks, monetary policy shocks, etc. This is outside the scope of the current paper.

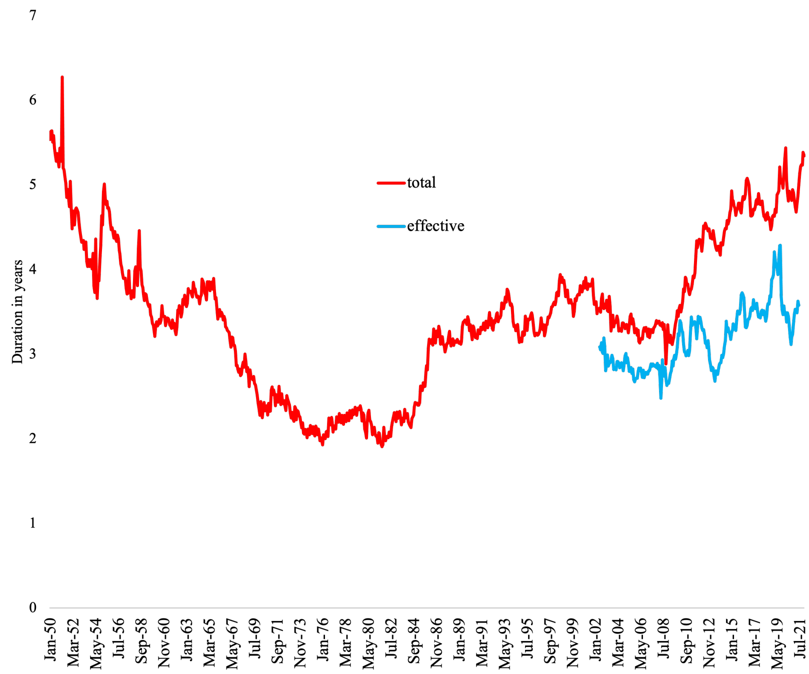

Figure 3: Duration of Treasurys held by the public. Data from CRSP Treasurys.

portfolio is 3.35% in 2022 and rises to 5.72% by 2052. We adjust the debt dynamics to account for the extra interest cost. The debt in 2052 becomes \$187.5 tr (251.6% of GDP) compared to \$137.9 tr (185.0% of GDP) in the baseline. The upper bound on fiscal capacity becomes \$13.79 tr., but that reflects the assumption that the surplus after 2052 now needs to be 6.24% per year compared to 4.59% in the previous exercise. In short, the fiscal capacity measure remains similar to the baseline value of \$12.38 tr. but now the annual surpluses that need to be produced after 2052 are nearly triple what they were in the baseline. The massive change in required future fiscal adjustment reflects the high duration of the surplus claim at the end of 2021, when rates were very low, and the realization of a substantial increase in rates since then.

3.4 Debt Management

To eliminate duration risk, the Treasury would have to match the duration of its inflows to the duration of its outflows. The duration of the outstanding Treasurys is currently around 5 years as shown in Figure 3. In the baseline scenario, the U.S. Treasury faces an extreme type of duration mismatch between its cash inflows (the surpluses) and cash outflows (the principal and coupon payments), a direct result of the back-loading of surpluses. This creates rollover risk and/or costly variation in future taxes, and suggests that the Treasury should shift towards longer-maturity debt (Bhandari, Evans, Golosov, Sargent et al., 2017).

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. In an optimal taxation framework, Bhandari et al. (2017) show that the Ramsey planner wants to approximately match the duration of the projected surpluses, conditional on current tax rates, to the duration of the Treasury portfolio.

4 Adding Seigniorage from Convenience Yields

The U.S. is different because of its unique role as the world's safe asset supplier. Our calculations capture this by quantifying the seigniorage revenue from convenience yields. Our benchmark analysis abstracted from any convenience yields the Treasury earns on its sales of Treasurys. This section augments our baseline estimate of projected fiscal capacity with the present value of the revenue stream the government earns from convenience yields.

The U.S. is the world's safe asset supplier. As a result, the U.S. earns seigniorage revenue from its monopoly on the creation of safe, dollar-denominated assets. JLVX (2019) estimate that the U.S. earns around 60 basis points per annum in convenience yields on the entire U.S. Treasury portfolio. The U.S. has a current debt/output ratio of 99.6% at the end of 2021. When the average convenience yield is 0.60% per annum, the Treasury collects $0.60\% \times 99.6\% = 0.598\%$ of GDP in convenience-yield revenues per year. We assume that this revenue source is a constant fraction of GDP.

Assumption 4. The seigniorage revenue on Treasurys is a constant fraction of GDP.

This assumption of a constant seigniorage/GDP ratio implies that convenience yields decline as the debt/output ratio increases (to 185% of GDP in 2052 in the baseline model). Krishnamurthy and Vissing-Jorgensen (2012) provide evidence on downward-sloping demand curves for safe assets.[33,34] More recently, Mian, Straub, and Sufi (2021) analyze debt/output ratio dynamics in low interest rate environments when the government earn seigniorage from the convenience yields on government bonds, but face a downward sloping demand curve for liquidity and safety.

Table 4 reports the detailed calculations that account for convenience yields. Column (10) reports the seigniorage revenue in billions of dollars equal to 0.598% of GDP. Column (11) then discounts the seigniorage revenue back to 2021 dollars using the baseline discount rates. The sum

[33] In preference terms, if investors had utility defined over consumption and safe asset services, a constant expenditure share corresponds to an elasticity of substitution of one for the services provided by safe assets. The expenditure share accounted for by convenience yields is constant.

[34] Under the higher interest rate scenarios considered in the previous section, seigniorage revenue from convenience yields would be constant as a fraction of GDP even though convenience yields (seigniorage revenue divided by debt outstanding) would be falling as the debt/GDP ratio increased.

Table 4: Fiscal Capacity with Convenience Yields

Based on CBO projections released in May of 2022. (3), (4), (5) and (10) in $ billions. Column (10) reports an estimate of the seigniorage revenue collected by the Treasury. We use a convenience yield of 60 bps. per annum. PDV of projected surpluses (8) and seigniorage (11) measured at the end of 2021.

year	T/Y	G /Y	Y	T	G	$y_j^{\$}$	$r_j^{\$,y}$	PV(T-G)	D/Y	CS	PV(CS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
2022	19.6%	21.9%	$24,694	$4,836	$5,405	0.42%	3.02%	($552.26)	97.9	$147.63	$143.30
2023	18.6%	20.7%	$26,240	$4,889	$5,419	0.76%	3.36%	($495.70)	96.0	$156.87	$146.85
2024	18.0%	20.3%	$27,291	$4,924	$5,535	0.99%	3.59%	($549.75)	96.1	$163.15	$146.79
2025	17.6%	20.1%	$28,271	$4,982	$5,696	1.15%	3.75%	($616.35)	97.5	$169.01	$145.87
2026	18.0%	20.4%	$29,266	$5,280	$5,962	1.27%	3.87%	($564.72)	98.8	$174.97	$144.71
2027	18.3%	20.4%	$30,332	$5,548	$6,201	1.36%	3.96%	($517.27)	100.0	$181.33	$143.63
2028	18.2%	20.6%	$31,487	$5,716	$6,486	1.43%	4.03%	($583.70)	102.0	$188.24	$142.72
2029	18.1%	20.7%	$32,716	$5,934	$6,773	1.49%	4.09%	($608.55)	103.2	$195.59	$141.89
2030	18.1%	20.8%	$33,996	$6,161	$7,066	1.55%	4.15%	($627.67)	105.3	$203.24	$141.02
2031	18.1%	20.9%	$35,318	$6,402	$7,371	1.59%	4.19%	($642.81)	107.5	$211.14	$140.05
2032	18.2%	21.1%	$36,680	$6,662	$7,722	1.63%	4.23%	($671.66)	109.6	$219.28	$138.99
2033	18.2%	21.2%	$38,081	$6,938	$8,062	1.67%	4.27%	($680.82)	112.0	$227.66	$137.83
2034	18.3%	21.3%	$39,519	$7,217	$8,413	1.71%	4.31%	($691.49)	114.4	$236.26	$136.57
2035	18.3%	21.4%	$40,996	$7,506	$8,779	1.74%	4.34%	($702.29)	117.0	$245.09	$135.22
2036	18.4%	21.6%	$42,514	$7,801	$9,166	1.77%	4.37%	($718.35)	119.8	$254.16	$133.79
2037	18.4%	21.7%	$44,074	$8,110	$9,567	1.80%	4.40%	($731.56)	122.7	$263.49	$132.29
2038	18.4%	21.8%	$45,680	$8,423	$9,975	1.83%	4.43%	($742.66)	125.8	$273.09	$130.74
2039	18.5%	22.0%	$47,335	$8,749	$10,391	1.85%	4.45%	($749.19)	129.1	$282.98	$129.15
2040	18.5%	22.1%	$49,035	$9,082	$10,827	1.88%	4.48%	($759.32)	132.5	$293.15	$127.51
2041	18.6%	22.2%	$50,782	$9,426	$11,272	1.90%	4.50%	($765.37)	136.1	$303.59	$125.84
2042	18.6%	22.3%	$52,581	$9,782	$11,727	1.92%	4.52%	($768.38)	139.9	$314.35	$124.15
2043	18.7%	22.4%	$54,443	$10,158	$12,208	1.94%	4.54%	($771.44)	143.9	$325.48	$122.46
2044	18.7%	22.5%	$56,372	$10,539	$12,685	1.96%	4.56%	($769.40)	148.0	$337.01	$120.79
2045	18.7%	22.6%	$58,371	$10,939	$13,193	1.98%	4.58%	($769.60)	152.3	$348.96	$119.13
2046	18.8%	22.7%	$60,444	$11,359	$13,709	2.00%	4.60%	($763.93)	156.7	$361.36	$117.49
2047	18.8%	22.7%	$62,594	$11,798	$14,219	2.01%	4.61%	($749.74)	161.2	$374.21	$115.88
2048	18.9%	22.8%	$64,824	$12,260	$14,782	2.03%	4.63%	($743.84)	165.8	$387.54	$114.29
2049	19.0%	22.8%	$67,132	$12,726	$15,328	2.04%	4.64%	($730.74)	170.5	$401.34	$112.71
2050	19.0%	22.9%	$69,514	$13,217	$15,900	2.05%	4.65%	($717.59)	175.2	$415.58	$111.14
2051	19.1%	22.9%	$71,970	$13,733	$16,500	2.07%	4.67%	($704.70)	180.1	$430.26	$109.57
2052	19.1%	23.0%	$74,505	$14,254	$17,130	2.07%	4.67%	($699.91)	185.0	$445.42	$108.37
Total								$ (21,161)	$ 33,540		$ 4,041

of all this discounted seigniorage revenue between 2022 and 2052 is $ 4.04 trillion in 2021 dollars. The upper bound on fiscal capacity is revised upwards by this amount to $16.4 trillion:

$$PV^{upper}_{2021}\left(\{T-G\}^{2052}_{2022}\right)+PV^{upper}_{2021}\left(D_{2052}\right)+PV^{upper}_{2021}\left(\{CS\}^{2052}_{2022}\right)=\$12.38+\$4.04=\$16.42\text{ tr.} \quad (19)$$

This number is still almost $6 trillion short of the actual December 2021 value of government debt of $22.28 tr.

Under the assumption that seigniorage revenue continues to be a constant share of GDP after 2052, the government needs to run a smaller annual surplus of 1.56% $(= 2.16\% - 0.60\%)$ of GDP after 2052, rather than 2.16%, to service the debt outstanding at the end of 2052. The smaller surpluses after 2052 also mean that the duration of the surplus claim is shorter than in the benchmark analysis.

Global investors may allocate additional borrowing capacity to the world's safe asset supplier, as argued by He, Krishnamurthy, and Milbradt (2019), not captured by the convenience yields. This may have been the case for the UK in the 19th century, but that privilege proved to be transitory (CJLVX (2022)). While we cannot definitively rule out that the U.S. government is one of the only countries to have permanently escaped the intertemporal budget constraint by engineering a bubble in the bond market, it seems prudent to assume that this is not the case, especially from the perspective of future U.S. generations.

Broad and narrow convenience yields. In our analysis above, we kept the discount rate used to discount future surpluses and future debt unchanged when introducing convenience yields. Implicitly, this assumed that there was a decline in the risk premium (of 60 basis points) that exactly offset the implied increase in the true risk-free yield (of 60 basis points). JLVX (2019) refer to this as a *narrow convenience yield*, a convenience yield which does not accrue to asset classes other than Treasurys. By not increasing the discount rate when the true risk-free rate increased, we did not decrease the present value of the seigniorage revenue from convenience yields as well as the present value of primary surpluses, If anything, this overstated the extra fiscal capacity that convenience yields generated. Since we showed that this generous upper bound on fiscal capacity inclusive of convenience yields is still too low, our results are conservative.

Recently, Reis (2021) has convincingly argued that convenience yields on U.S. Treasurys could be much larger than 60 basis points per year. While larger convenience yields generate an additional source of revenue that expands fiscal capacity, they also generate a discount rate effect that shrinks fiscal capacity. The reason is that large convenience yields are likely *broad convenience yields*, which apply to assets beyond U.S. Treasuries. Such broad convenience yields raise the true risk-free interest rate (on risk-free assets without convenience) but also the discount rate on risky assets such as the GDP claim. Risk premia declines do not fully offset the risk-free rate effect.

Higher discount rates lower the present value of the seigniorage revenue stream and the primary surplus stream, all else equal. Hence, it is not clear that even much larger convenience yields actually result in more fiscal capacity.

5 Front-loaded Fiscal Adjustment

So far, we have established that the current level of debt is higher than our upper bound on fiscal capacity, even after including seigniorage revenue from convenience yields. This raises the question how the U.S. economy can increase its fiscal capacity. A natural answer is that it must increase its surpluses.

This section implements a counterfactual exercise by asking by how much CBO primary surplus projections have to rise in order to obtain a fiscal capacity estimate consistent with the 99.7% debt/output ratio at the end of 2021. We consider level shifts that raise the surplus/GDP ratio in each year from 2022 until 2052. This policy change also affects the debt dynamics. We compute these projected debt dynamics, $D_{t+1} = D_t \times R_{t+1} + S_{t+1}$, using the new projected primary surpluses and the CBO's interest rate projections. When performing this counterfactual, we make the following assumption.

Assumption 5. We assume the surplus changes relative to the CBO baseline do not change the projected growth rate of GDP nor the yield curve.

We first consider an increase in the primary surplus by 3.0% points of GDP in each of the years between 2022 and 2052 relative to the CBO projection. This fiscal adjustment increases the PDV of surpluses between 2022 and 2052 from -\$21.16 tr in the baseline to -\$0.88 tr. Hence, a fiscal adjustment of 3.0% per year nearly eliminates all deficits over the next 31 years in present value. The higher primary surpluses decreases the value of debt outstanding at the end of 2052 to 87.5% of GDP. Discounted back to 2021, that is \$15.86 tr. Combined, this raises the upper bound on fiscal capacity from \$12.38 tr in the benchmark to \$14.97 tr:

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) + PV_{2021}^{upper}(D_{2052}) = -\$0.88 \text{ tr.} + \$15.86 \text{ tr.} = \$14.97 \text{ tr.} \tag{20}$$

In this counter-factual exercise, the U.S. Treasury front-loads the fiscal adjustment, compared to the benchmark case in which the government waits until after 2052 before running primary surpluses. In this front-loaded case, the U.S. only needs a 1.02% annual primary surplus after 2052, less than half the 2.16% annual surplus number in the baseline. Figure 1 plots this front-loaded path of surpluses in black. In this scenario, the duration of the surplus claim declines to 126 years from 283 years in the baseline.

Next, we repeat the projected fiscal capacity calculation assuming increases in the surplus/GDP ratio in each of the years between 2022 and 2052 relative to the CBO projection ranging from 0.0% per year (baseline) to 8.0% per year in one percentage point increments. Figure 4 plots the projected fiscal capacity on the y-axis against the increase in the projected surplus/GDP ratio for the period 2022–2052. The previous example of a 3.0% increase lies in the middle of this graph.

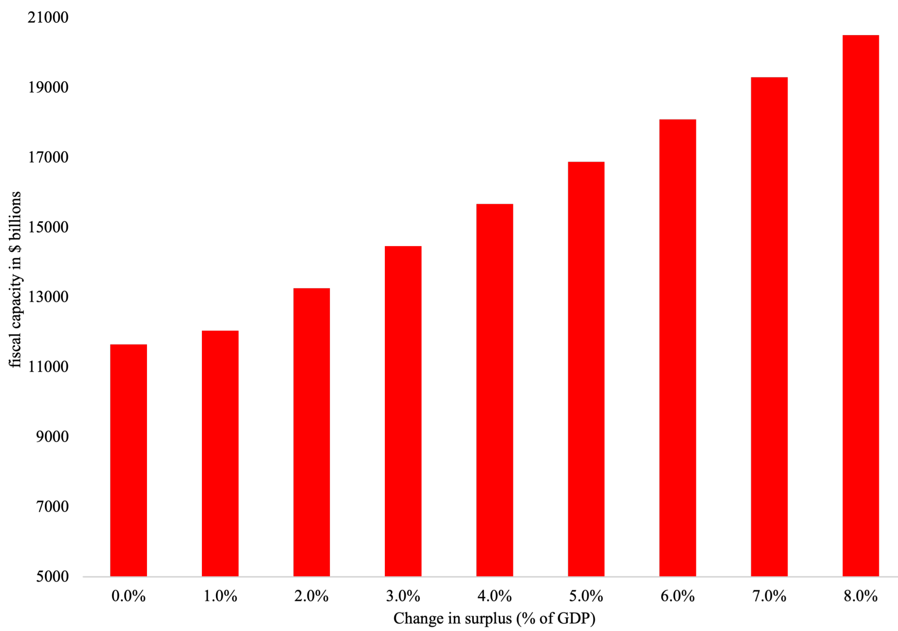

Figure 4: Fiscal Capacity For Additional Surpluses in 2022–52

Fiscal Capacity in $ billions on vertical axis. Horizontal axis: Change in primary surplus as % of U.S. GDP in each year between 2022 and 2052 relative to the Baseline CBO Projection.

To get to an upper bound on fiscal capacity of $18.3 trillion, we need an extra primary surplus of 6.0% of GDP in all years between 2022 and 2052. Table 5 provides all of the details of the calculation. This scenario pushes the debt/GDP ratio into negative territory by 2050. The fiscal capacity bound reaches:

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) + PV_{2021}^{upper}(D_{2052}) = \$19.39 \text{ tr.} - \$1.09 \text{ tr.} = \$18.30 \text{ tr.} \quad (21)$$

Once we factor in the $4.04 trillion in convenience yield revenues, this scenario of 6.0% additional surpluses between 2022–2052 produces a fiscal capacity estimate that essentially matches the observed debt outstanding of $22.28 trillion as of the end of 2021. Figure 1 also plots this 6.0% extra surpluses path of completely front-loaded surpluses in blue. In this scenario, the government can run a small primary deficit of 0.07% of GDP in each year after 2052.

Figure 5 plots the contribution of each surplus cash flow to the overall duration of the sur-

Table 5: Fiscal Capacity with 6% Extra Surplus in 2022–52

Based on CBO primary surplus projections plus an additional 6.0% of GDP in primary surplus for each year from 2022 until 2052. Column (8) reports the discount rates used for spending and tax cash flows in that year. Column (4) reports projected Net Interest Cost over Debt. (5), (6), (7) and (12) in $ billions. Column (10) reports an upper bound on the PDV of projected primary surpluses in 2021 $ billions . Column (12) reports the Debt dynamics: $D_{t+1} = D_t \times R_{t+1} + (T_{t+1} - G_{t+1})$, where R_{t+1} is taken from Column (4).

year	T/Y	G /Y	(T-G) /Y	NI/D	Y	T	G	$y_j^{\$}$	$r_j^{\$,y}$	PV(T-G)	D/Y	D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2022	25.6%	21.9%	3.7%	1.8%	$24,694	$6,318	$5,405	0.42%	3.02%	$885.92	88.2	$21,770
2023	24.6%	20.7%	4.0%	1.8%	$26,240	$6,464	$5,419	0.76%	3.36%	$978.13	80.5	$21,124
2024	24.0%	20.3%	3.8%	2.1%	$27,291	$6,561	$5,535	0.99%	3.59%	$923.46	75.3	$20,538
2025	23.6%	20.1%	3.5%	2.3%	$28,271	$6,678	$5,696	1.15%	3.75%	$847.66	70.8	$20,029
2026	24.0%	20.4%	3.7%	2.5%	$29,266	$7,036	$5,962	1.27%	3.87%	$887.63	66.5	$19,450
2027	24.3%	20.4%	3.8%	2.6%	$30,332	$7,368	$6,201	1.36%	3.96%	$924.26	62.0	$18,792
2028	24.2%	20.6%	3.6%	2.8%	$31,487	$7,605	$6,486	1.43%	4.03%	$848.70	57.8	$18,195
2029	24.1%	20.7%	3.4%	2.9%	$32,716	$7,897	$6,773	1.49%	4.09%	$815.51	53.8	$17,595
2030	24.1%	20.8%	3.3%	3.0%	$33,996	$8,201	$7,066	1.55%	4.15%	$787.59	50.0	$16,985
2031	24.1%	20.9%	3.3%	3.1%	$35,318	$8,521	$7,371	1.59%	4.19%	$762.76	46.3	$16,356
2032	24.2%	21.1%	3.1%	3.1%	$36,680	$8,863	$7,722	1.63%	4.23%	$723.27	42.9	$15,729
2033	24.2%	21.2%	3.0%	3.2%	$38,081	$9,223	$8,062	1.67%	4.27%	$702.49	39.6	$15,073
2034	24.3%	21.3%	3.0%	3.2%	$39,519	$9,588	$8,413	1.71%	4.31%	$679.15	36.4	$14,387
2035	24.3%	21.4%	2.9%	3.3%	$40,996	$9,965	$8,779	1.74%	4.34%	$654.79	33.3	$13,671
2036	24.4%	21.6%	2.8%	3.3%	$42,514	$10,352	$9,166	1.77%	4.37%	$624.36	30.4	$12,937
2037	24.4%	21.7%	2.7%	3.3%	$44,074	$10,754	$9,567	1.80%	4.40%	$596.13	27.6	$12,182
2038	24.4%	21.8%	2.6%	3.4%	$45,680	$11,164	$9,975	1.83%	4.43%	$569.46	25.0	$11,406
2039	24.5%	22.0%	2.5%	3.4%	$47,335	$11,589	$10,391	1.85%	4.45%	$546.99	22.4	$10,599
2040	24.5%	22.1%	2.4%	3.5%	$49,035	$12,024	$10,827	1.88%	4.48%	$520.44	19.9	$9,772
2041	24.6%	22.2%	2.4%	3.6%	$50,782	$12,473	$11,272	1.90%	4.50%	$497.62	17.6	$8,918
2042	24.6%	22.3%	2.3%	3.6%	$52,581	$12,937	$11,727	1.92%	4.52%	$477.64	15.3	$8,033
2043	24.7%	22.4%	2.2%	3.7%	$54,443	$13,424	$12,208	1.94%	4.54%	$457.62	13.1	$7,114
2044	24.7%	22.5%	2.2%	3.8%	$56,372	$13,921	$12,685	1.96%	4.56%	$442.89	10.9	$6,147
2045	24.7%	22.6%	2.1%	3.8%	$58,371	$14,441	$13,193	1.98%	4.58%	$426.05	8.8	$5,135
2046	24.8%	22.7%	2.1%	3.9%	$60,444	$14,986	$13,709	2.00%	4.60%	$415.28	6.7	$4,058
2047	24.8%	22.7%	2.1%	4.0%	$62,594	$15,553	$14,219	2.01%	4.61%	$413.25	4.6	$2,885
2048	24.9%	22.8%	2.1%	4.0%	$64,824	$16,150	$14,782	2.03%	4.63%	$403.18	2.5	$1,633
2049	25.0%	22.8%	2.1%	4.0%	$67,132	$16,754	$15,328	2.04%	4.64%	$400.44	0.4	$274
2050	25.0%	22.9%	2.1%	4.1%	$69,514	$17,388	$15,900	2.05%	4.65%	$397.83	-1.7	($1,203)
2051	25.1%	22.9%	2.2%	4.1%	$71,970	$18,051	$16,500	2.07%	4.67%	$394.96	-3.9	($2,803)
2052	25.1%	23.0%	2.1%	4.2%	$74,505	$18,724	$17,130	2.07%	4.67%	$387.75	-6.1	($4,513)
Total PV										$19,393		$(1,098)

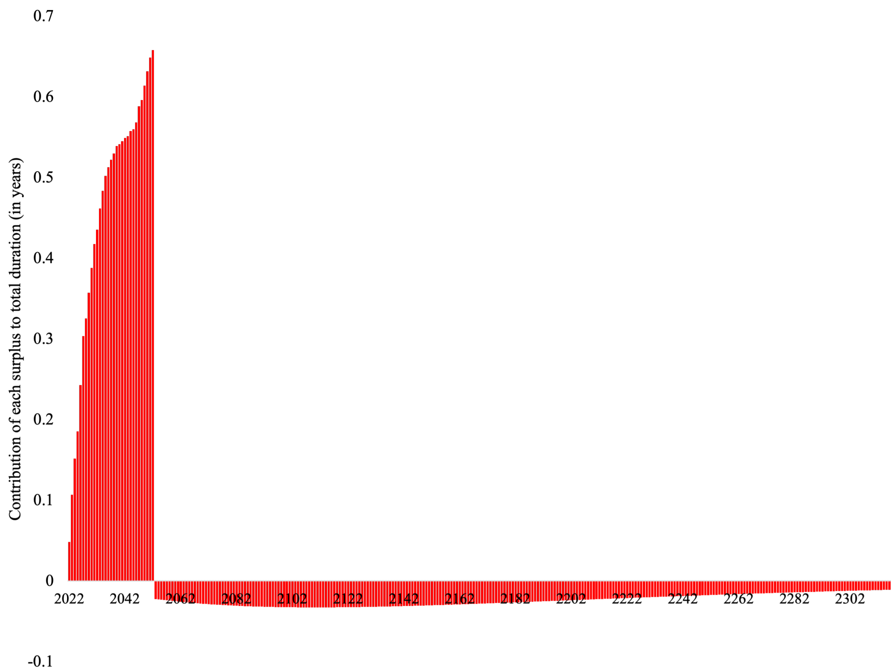

Figure 5: Duration Composition in Front-loaded Scenario

Contribution of each payment $\frac{k \times PV(S_{2021+k})}{\sum_{h=1} PV(S_{2021+h})}$ to total duration. Primary surplus: CBO Baseline Projection +6% of GDP in each year between 2022 and 2052. The duration (in years) is the sum of the bars shown.

plus claim in this front-loaded scenario with 6% additional surpluses. This surplus claim has a duration of 6.95 years, which is close to that of the outstanding Treasury portfolio.[35] In sum, if the government wants to match the duration of the surpluses (cash inflows) to the duration of the outstanding portfolio of Treasury debt (cash outflows), it needs to raise annual surpluses relative to the CBO scenario by about 6.0% per year over the next 31 years. Suffice to say that this is a massive fiscal effort.

6 Counter-cyclical Tax Regime

Can the U.S. run steady-state deficits and maintain fiscal capacity, as many have claimed? Not according to standard finance, unless the U.S. federal government changes the fiscal regime from counter-cyclical to pro-cyclical. The U.S. Treasury would have to render the tax claim less risky than the spending claim. Only in that case would our upper bound calculation fail, because Assumption 1 fails. In this case, the U.S. taxpayers would be providing insurance to bondholders (JLVX (2020)). This insurance premium would allow the U.S. to run steady-state deficits.

Hence, the only way to reconcile the CBO projections with the value of U.S. Treasurys, is to use

[35] The duration is sensitive to the additional surplus. Raising the additional surplus from 6.0% to 6.1% per year until 2052 lowers the duration from 6.95 to 3.45 years.

Table 6: U.S. Treasury Balance Sheet in Steady-State Counter-cyclical Tax Example

Treasury Balance Sheet in Market Values. Steady-State Example. Expressed as a multiple of U.S. GDP at the end of 2021. Example based on actual spending/GDP ratio in 2022. In this example, the risk premium on the tax claim is 22 bps. lower than the risk premium on the spending claim.

Assets		Liabilities	
$PV_{2021}(\{T\})/Y_{2021}$	$19.71 = 18.71\% \times 105.3$	$PV_{2021}(\{G\})/Y_{2021}$	$18.79 = 21.9\% \times 85.8$
		D/Y_{2021}	$0.99 = 18.71\% \times 105.3 - 21.9\% \times 85.8$
Total	19.71	Total	19.71

a much lower discount rate for the tax cash flows than for the spending cash flows. Importantly, this is necessary if we want the entire debt to be zero beta or risk-free. However, this condition is not satisfied in post-war U.S. data, because of the pro-cyclical nature of tax revenue and the counter-cyclical nature of spending (JLVX (2019)). We explore this hypothetical scenario, but we emphasize that we do not think this regime shift is either likely or desirable.

If the U.S. government were to radically change its future fiscal policy and raise more tax revenue as a share of GDP in recessions, this would make the tax claim less risky than the spending claim. We entertain this possibility because this regime change can sustain (modest) steady-state deficits. In this regime, taxpayers and transfer recipients provide insurance against business cycle risk to the bondholders. Taxpayers pay more taxes as a fraction of GDP in recessions, while transfer recipients receive less. To make this concrete, when taxpayers wake up in a recession, the CBO should be projecting larger tax revenue as a fraction of GDP in PDV, and smaller spending as a fraction of GDP than in an expansion, meaning that the bottom row of column (9) in Table 1 increases (decreases) when a recession (expansion) starts .

In the steady-state, the valuation of future surpluses is given the price/dividend ratio on a claim to GDP times the steady-state surplus:

$$PV_{2021}^{upper}(\{T-G\}_{2052}^{\infty}) = \sum_{h=1}^{\infty} \frac{T_{2021+h}}{(1+r^{\$,t}(h))^h} - \sum_{h=1}^{\infty} \frac{G_{2021+h}}{(1+r^{\$,g}(h))^h} = (pd^t \times \frac{T}{Y} - pd^g \times \frac{G}{Y}) \times Y_{2021}. \tag{22}$$

If the tax claim is less risky, and the price/dividend ratio on the tax claim exceeds that on the spending claim, $pd^g < pd^t$, then a steady-state deficit is consistent with positive fiscal capacity. Table 6 provides a simple example, starting from the actual spending/output ratio for 2022. If the multiple on the tax claim is boosted to 105.3, then the U.S. government can run a steady-state deficit of 3.19%, the CBO-projected average deficit. The implied debt/output ratio is still 0.99. The government can engineer this outcome by committing to a pro-cyclical fiscal policy (leaning with the wind) that raises taxes T/Y in bad times, thus lowering the risk premium. However, this is not a free lunch. Taxpayers are being asked to bear more business cycle risk in order to provide insurance to bondholders, allowing the government to earn an insurance premium each year that is 3.19% of GDP. This is counterfactual. Governments in advanced economies typically provide insurance against business cycle risk.[36]

Let's turn to the detailed CBO projections. Suppose that the tax claim's appropriate discount rate is 100 basis points lower than that the discount rate for the output claim. Table 7 reports the calculations. Now, the sum of (the upper bound on) the PDV of the tax revenue minus spending cash flows from 2022-2052 adds up to -$847 billion dollars:

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) = \sum_{h=1}^{31} \frac{T_{2021+j}}{(1+r^{\$,y}(h)-0.01)^h} - \sum_{h=1}^{31} \frac{G_{2021+j}}{(1+r^{\$,y}(h))^h} = -\$0.85 \text{ tr.} \tag{23}$$

The lower discount rate for the tax revenue claim expands our estimate of fiscal capacity. In this case, the total PDV of deficits, computed as the difference between the sum of columns (9) and columns (10), has shrunk from $21.16 tr to $ 0.85 trillion. If we combine this with the $33.54 trillion in PDV of future debt, we end up with a total value of $32.7 trillion for the value of debt at the end of 2021.

$$PV_{2021}^{upper}(\{T-G\}_{2022}^{2052}) + PV_{2021}^{upper}(D_{2052}) = \$32.69 \text{ tr.} \tag{24}$$

This measure of projected fiscal capacity comfortably exceeds the current debt outstanding at the end of 2021. This exercise goes to show that the nature of risk in tax revenues (and government spending) is crucial for the magnitude of the projected fiscal capacity. A radical fiscal regime shift of the kind entertained in this section, where tax rates go up in recessions, seems unlikely because of the pain it would inflict on taxpayers.

7 Conclusion

We develop a new approach based on textbook finance to assess the government's projected fiscal capacity and we apply this framework to the CBO's projections of the federal government's primary surpluses. Using plausible discount rate assumptions, we measure the fiscal capacity of the U.S. federal government implied by the May 2022 CBO projections. In spite of the historically low interest rates at the end of 2021, the upper bound on fiscal capacity is only around 56% of the observed debt outstanding in 2021.

From the vantage point of standard, neoclassical finance, our findings would imply that the Treasury market has likely priced in a large fiscal correction relative to the CBO baseline projections. In this scenario, future surpluses will increase to close the gap. However, we cannot rule

[36] See JLVX (2020) for evidence on the GDP growth betas of U.S. taxes and spending over longer horizons. They find large positive GDP growth betas for taxes at shorter horizons, and negative GDP growth betas for spending.

Table 7: Fiscal Capacity with Counter-Cyclical Tax Revenues

Based on CBO projections released in May of 2022. Columns (4), (5), (6), and (12) are in $ billions. Columns (9) and (10) report the PDV of tax revenue and spending in 2021 $ billions, respectively. The discount rate used for the tax claim is 100 basis points lower than that used for the spending claim.

year	T/Y	G /Y	(T-G) /Y	Y	T	G	$y_j^{\$}$	$r_j^{\$,y}$	PV(T)	PV(G)	D/Y	D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2022	19.6%	21.9%	-2.3%	$24,694	$4,836	$5,405	0.42%	3.02%	$4,740.22	$5,246.47	97.9	$24,173
2023	18.6%	20.7%	-2.0%	$26,240	$4,889	$5,419	0.76%	3.36%	$4,667.08	$5,072.90	96.0	$25,193
2024	18.0%	20.3%	-2.2%	$27,291	$4,924	$5,535	0.99%	3.59%	$4,560.75	$4,979.69	96.1	$26,217
2025	17.6%	20.1%	-2.5%	$28,271	$4,982	$5,696	1.15%	3.75%	$4,469.39	$4,915.89	97.5	$27,561
2026	18.0%	20.4%	-2.3%	$29,266	$5,280	$5,962	1.27%	3.87%	$4,583.17	$4,931.48	98.8	$28,925
2027	18.3%	20.4%	-2.2%	$30,332	$5,548	$6,201	1.36%	3.96%	$4,657.12	$4,911.99	100.0	$30,326
2028	18.2%	20.6%	-2.4%	$31,487	$5,716	$6,486	1.43%	4.03%	$4,636.87	$4,917.44	102.0	$32,105
2029	18.1%	20.7%	-2.6%	$32,716	$5,934	$6,773	1.49%	4.09%	$4,650.55	$4,913.48	103.2	$33,760
2030	18.1%	20.8%	-2.7%	$33,996	$6,161	$7,066	1.55%	4.15%	$4,662.85	$4,902.70	105.3	$35,808
2031	18.1%	20.9%	-2.7%	$35,318	$6,402	$7,371	1.59%	4.19%	$4,676.14	$4,889.04	107.5	$37,949
2032	18.2%	21.1%	-2.9%	$36,680	$6,662	$7,722	1.63%	4.23%	$4,695.09	$4,894.36	109.6	$40,213
2033	18.2%	21.2%	-3.0%	$38,081	$6,938	$8,062	1.67%	4.27%	$4,715.35	$4,881.23	112.0	$42,636
2034	18.3%	21.3%	-3.0%	$39,519	$7,217	$8,413	1.71%	4.31%	$4,728.10	$4,863.04	114.4	$45,219
2035	18.3%	21.4%	-3.1%	$40,996	$7,506	$8,779	1.74%	4.34%	$4,738.61	$4,843.22	117.0	$47,975
2036	18.4%	21.6%	-3.2%	$42,514	$7,801	$9,166	1.77%	4.37%	$4,744.45	$4,824.82	119.8	$50,926
2037	18.4%	21.7%	-3.3%	$44,074	$8,110	$9,567	1.80%	4.40%	$4,749.69	$4,803.35	122.7	$54,088
2038	18.4%	21.8%	-3.4%	$45,680	$8,423	$9,975	1.83%	4.43%	$4,749.26	$4,775.27	125.8	$57,472
2039	18.5%	22.0%	-3.5%	$47,335	$8,749	$10,391	1.85%	4.45%	$4,748.01	$4,742.30	129.1	$61,087
2040	18.5%	22.1%	-3.6%	$49,035	$9,082	$10,827	1.88%	4.48%	$4,742.43	$4,709.73	132.5	$64,963
2041	18.6%	22.2%	-3.6%	$50,782	$9,426	$11,272	1.90%	4.50%	$4,735.76	$4,672.62	136.1	$69,115
2042	18.6%	22.3%	-3.7%	$52,581	$9,782	$11,727	1.92%	4.52%	$4,727.50	$4,631.66	139.9	$73,568
2043	18.7%	22.4%	-3.8%	$54,443	$10,158	$12,208	1.94%	4.54%	$4,721.94	$4,593.42	143.9	$78,343
2044	18.7%	22.5%	-3.8%	$56,372	$10,539	$12,685	1.96%	4.56%	$4,711.61	$4,546.68	148.0	$83,447
2045	18.7%	22.6%	-3.9%	$58,371	$10,939	$13,193	1.98%	4.58%	$4,702.92	$4,504.00	152.3	$88,909
2046	18.8%	22.7%	-3.9%	$60,444	$11,359	$13,709	2.00%	4.60%	$4,696.07	$4,457.38	156.7	$94,734
2047	18.8%	22.7%	-3.9%	$62,594	$11,798	$14,219	2.01%	4.61%	$4,689.75	$4,403.10	161.2	$100,911
2048	18.9%	22.8%	-3.9%	$64,824	$12,260	$14,782	2.03%	4.63%	$4,685.91	$4,359.44	165.8	$107,481
2049	19.0%	22.8%	-3.9%	$67,132	$12,726	$15,328	2.04%	4.64%	$4,676.48	$4,304.70	170.5	$114,436
2050	19.0%	22.9%	-3.9%	$69,514	$13,217	$15,900	2.05%	4.65%	$4,669.42	$4,252.18	175.2	$121,798
2051	19.1%	22.9%	-3.8%	$71,970	$13,733	$16,500	2.07%	4.67%	$4,664.32	$4,201.80	180.1	$129,588
2052	19.1%	23.0%	-3.9%	$74,505	$14,254	$17,130	2.07%	4.67%	$4,670.11	$4,167.90	185.0	$137,852
Total										$(846.4)	$ 33,540	

out that Treasurys are mispriced. Treasury investors may be optimistic about future surpluses or they may fail to price in future inflation. In this case, bond yields will need to increase to close the gap.

Many authors have emphasized that low rates create additional fiscal capacity for the U.S., but they have ignored the impact of low rates on the risk of future fiscal adjustment due to the duration mismatch. The back-loading of surpluses creates a large duration mismatch between the government's assets, its future surpluses, and its liabilities, its promised coupon and principal payments on the Treasury portfolio. Because of the backloading of future surpluses, the Treasury faces a duration mismatch between its cash inflows and outflows. Modest increases in interest rates, of the kind the U.S. economy experienced in the first half of 2022, then lead to sharp increases in the size of required fiscal adjustments.

Our analysis highlights a shortcoming in the standard fiscal sustainability analysis, namely the practice of discounting future primary surpluses and future debt at the risk-free interest rate to measure fiscal capacity. This standard practice ignores a basic insight from finance that the discount rate should always reflect the risk of the cash flows. Fiscal cash flow projections are always made relative to GDP projections. But the future course of the economy is unknown, and hence fundamentally risky. Future primary surpluses inherit the risk in future GDP and are at least as risky as future GDP unless the government chooses counter-cyclical primary surpluses. Hence, future surpluses should be discounted at a rate that includes a risk premium that is at least as large as the GDP risk premium.

To be clear, there is considerable uncertainty about the GDP risk premium. Our baseline estimate for the total wealth valuation multiple is 85. A lower risk premium and a higher multiple leads to higher estimates of fiscal capacity, but this would imply counterfactual valuation multiples well in excess of 100 for unlevered companies growing at the same rate as the U.S. economy. Lower discount rates also lead to an even larger duration mismatch between the government's assets and liabilities, and hence even larger fiscal vulnerability to the risk of rising interest rates. Model uncertainty is not a panacea to get us out of the fiscal conundrum.

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