Fiscal Consequences of the US War on COVID*

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Abstract

Post War-on-COVID-19 interest rate rises and inflation imposed capital losses on federal creditors and motivated the Fed to transfer interest rate risk from private banks to itself. We describe budget-feasible paths for market values of US Treasury debt associated with some projections of taxes and expenditures. We compare prospective paths of US federal taxes, expenditures, interest payments, and debt in the post-COVID period to paths observed after big surges in government expenditures during four 19th- and 20th-century US wars. Government expenditure/GDP surges in past US wars had permanent components and were accompanied by permanent rises in tax collections/GDP ratios. Part of the War on COVID expenditure/GDP surge has persisted, but so far tax collections have not risen relative to GDP. Those two ratios shape prospects for the debt/GDP ratio and US inflation. Since 2000, ratios of tax collection and government expenditures to GDP have departed from 19th and 20th century US patterns. We marshal data and macro theory that pose whether these post-2000 patterns are systemic or transitory.

Keywords: Unpleasant monetarist arithmetic, interest rate and duration risks, transitory, permanent.

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1 Introduction

Panel 1a of Figure 1 displays tax collections and total government expenditures including debt service in the UK during the 18th century, while panel 1b shows estimates of the same series in France during part of the 18th century.[1] The UK data in panel 1a look like a simulation of a Barro (1979) tax-smoothing model: surges in government expenditures and deficits during the UK's four big 18th century wars are followed by peace-time spells in which tax collections equal government expenditures that include costs of servicing government debts. The UK data thus conform to a fiscal "law of gravity" enforced by present-value budget balance that pushes the blue expenditure line towards the red tax collections line, but the data for pre-revolution France in panel 1b don't. The persistent gap between the blue expenditure line and the red tax collections line in panel 1b impelled King Louis XVI to convene the Estates General in order to reform the constitution so that decision makers could agree on bringing those lines together.[2]

Figure 2 depicts US federal expenditures and tax collections from 1776 to 2024, and CBO projections beyond 2024.[3] Vertical black lines indicate 1789, 1900, and 2000, dates that separate a pre-1789 Continental Congress regime, a long 19th century "Hamilton project" regime, a 20th century US dollar hegemon regime, and an emerging 21st century regime.[4] US expenditures persistently exceeded tax collections between 1776 and 1789; coincidentally, US Continental 6% securities traded at between 10 and 20 cents on the Spanish dollar, and zero coupon Continental dollars (currency) traded at less than 1 cent per Spanish dollar.[5] In 1789, the US Constitution realigned state and federal government powers and private interests to sustain monetary-fiscal policies that authors of the US constitution hoped would generate outcomes like the UK panel 1a.[6] That worked for more than 200 years: Figure 2 indicates that during the 19th and 20th centuries, the Barro model's "fiscal law of gravity" held for the US. After 2000, that stopped.

Hall and Sargent (2021) studied monetary and fiscal consequences of the Figure 2 surges in federal expenditures that were associated with eight wars and two violent insurrections. In this paper we add the US War on COVID-19 and update Tables 27.1 and 27.2 that Hall and Sargent (2021) used to account for debt/GDP ratios, inflation rates, and returns on Treasury securities. We describe deviations from earlier patterns that indicate dimensions along which 21st Century US monetary-fiscal policies have so far differed from 19th and 20th century US precedents.[7]

[1]The figure plots data presented and analyzed by Sargent and Velde (1995).

[2]Hobsbawm (1996, pp. 57-58) and Sargent and Velde (1995) describe how that process got out of the King's hands.

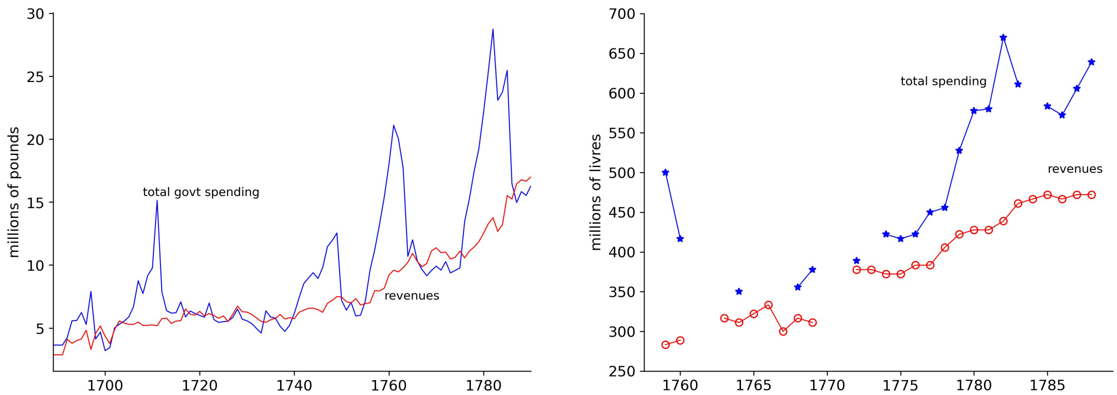
[3]Expenditure and revenue data before 1790 are from Nourse (1791) and Morris (1790). We counted unpaid debt payments as expenditures. Fiscal data from 1790 to 2024 are from the Treasury and the OMB. GDP data are from measuringworth.com and the NIPA.

[4]For us, a regime is a collection of decision rules for managing monetary, fiscal, and financial regulations.

[5]Between 1789 and 1795, the price level in France rose 1040%. Meanwhile, the UK price level rose just 25%. According to Hawtrey (1928), most of this rise in the UK price level was actually imported from France.

[6]See Rodden (2006) and Sargent (2012).

[7]We borrow "21st Century monetary policy" from Bernanke (2022).



(a) UK: 1688 - 1789

(b) France: 1759 to 1789

Figure 1: Government Expenditures and Tax Receipts

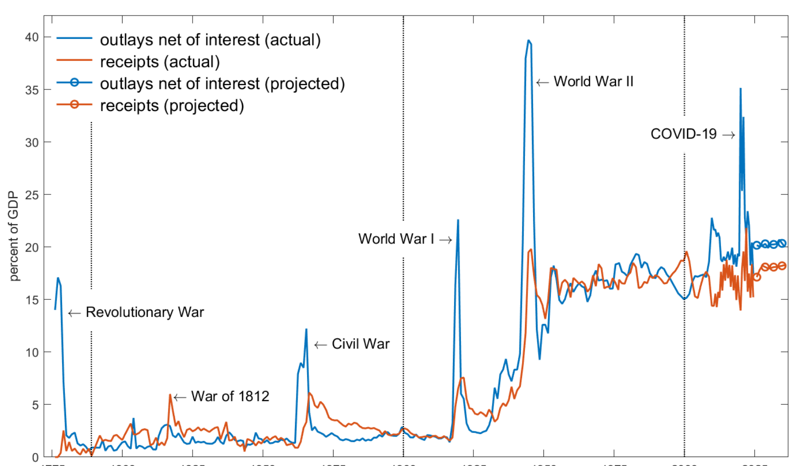


Figure 2: US Federal Government Expenditures and Receipts: 1775 to 2035.

Beneath the government expenditure and tax revenue outcomes portrayed in Figure 2 lie monetary-fiscal policies that we group into three regimes before 2000.[8] In the Revolutionary War regime that preceded 1789, the Continental Congress used inflation to generate ample seigniorage revenues. In the long 19th century regime that prevailed from 1789 until 1914, the US hewed to an international gold standard as part of a plan to earn a reputation for timely debt service that would lower government costs of finance. In big steps in 1933 and 1971 that completed the 20th century regime, the US left the gold standard and used its status as supplier of the principal international means of payment, sometimes to move along a perceived Phillips curve tradeoff between inflation and unemployment, sometimes to use inflation to finance US expenditures. During the 19th regime, the US had resorted to inflationary finance only as a temporary expedient during big wars: Section 4 shows that the US managed post-war inflation very differently in those two pre-2000 regimes.

Section 2 describes an accounting scheme widely used in modern macroeconomic models. Section 3 applies this accounting scheme to US data and shows that, unlike earlier wars, the US financed the war on COVID mostly with overnight loans. Tax revenue did not increase. In the three years since COVID ended, the US ran primary deficits, not the postwar surpluses typical in Figure 2. Nevertheless, high US inflation and real GDP growth offset those primary deficits so much that the debt/GDP ratio actually fell.

Section 4 studies who will pay the bill if after the War on COVID the US inflates away a substantial fraction of the real value of federal bonds, as it did after World War II.[9] Inflation has already imposed real losses on bondholders, and belated Fed interest rates have worsened them. Holders of long-term bonds took big losses, both real and nominal. Holders of short-term bonds saw small nominal gains. Banks and the Fed borrow short and lend long, so those disparate returns affected them adversely. Fed capital losses on Treasury securities are gains for Treasury, so they don't affect the consolidated government budget, but Fed losses on private securities do. Whether private banks' losses affect the consolidated government budget depends on whether the Fed partially insures them against those losses.

Section 5 discusses the striking Figure 2 pattern that wartime surges in government expenditures, while partly temporary, had permanent components. Ratios of government expenditures to GDP have always been higher after major wars than before. So far, the War of COVID appears to be no different. We describe CBO forecasts and the consequence they bring about prospective inflation rates and real returns to US creditors.

Section 6 offers concluding remarks about the deviant post 2000 pattern evident in Figure 2 and speculates about whether it reflects structural features like those in pre 1789 France and the US that were altered then only after political revolutions that rearranged national monetary-fiscal

[8]This grouping is consistent with descriptions of arrangements, actions and outcomes analyzed by Payne and Szőke (2025a,b) and Payne et al. (2025).

[9]Bassetto et al. (2024) provide a closely related, concise, and more formal analysis.

decision making authorities and protocols.

2 Government Budget Arithmetic

> The fiction that the Federal Reserve System is only quasi-governmental and its separation from the departmental organization of the federal administration no doubt alter the impact of political influences and lead to different actions than would be taken if the Reserve System were administratively consolidated with the Treasury. As an economic matter, however, the accounts of the Federal Reserve and the Treasury must be consolidated to determine what monetary action government is taking or to judge what the effects of such action are likely to be.
>
> Friedman (1959, pp. 52-53)

To understand consolidated monetary-fiscal policies that prevailed during the four regimes delineated in Figure 2, we use a version of the accounting system of Bassetto and Sargent (2020) to frame consequences of anticipated and unanticipated inflation, games of chicken between monetary and fiscal authorities, paying interest on reserves, and conducting open market operations in government bonds and private assets. We modify the accounts to make them compatible with the Hall and Sargent (2021, 2022) accounting system deployed in subsequent sections of this paper.[10]

Time t is discrete, starts at $t = -1$, and is indexed by $t \in \{-1, 0, 1, 2, \ldots\}$; Y_t is real GDP at time t, P_t is the price level at time t, M_t is a stock of government-issued fiat currency held by the public at the end of time t, B_{t-1} is a stock of nominal one-period risk-free bonds that the government issues at time $t-1$ and that pay off $R_{t-1}B_{t-1}$ at time t, G_t denotes nominal government purchases, T_t is nominal tax collections, and E_t is a mathematical expectation conditional on information shared by the government and the public at t. Real GDP evolves according to $Y_t = \gamma Y_{t-1}$, where $\gamma = (1 + g)$ is a gross rate of growth on GDP and g is a net rate of growth. The gross nominal interest rate on a one-period government bond issued at t and maturing at $t + 1$ satisfies

$$R_t = \beta^{-1} E_t \Pi_{t+1}, \tag{1}$$

where $\beta \in (0, 1)$ and $\Pi_{t+1} = \frac{P_{t+1}}{P_t}$ is a gross rate of inflation between t and $t+1$ and $\Pi_{t+1} = 1+\pi_{t+1}$, where π_{t+1} is a net rate of inflation. We assume that $\beta\gamma < 1$. The government faces a sequence of budget constraints

$$R_{t-1}B_{t-1} = T_t - G_t + B_t + M_t - M_{t-1}, \quad t \geq 0. \tag{2}$$

[10] See Bassetto et al. (2024) for an extension and econometrically more sophisticated application of an accounting framework like Bassetto and Sargent (2020).

Divide all variables by $P_t Y_t$ and use $Y_t = \gamma Y_{t-1}$ and $R_{t-1} = \beta^{-1} E_{t-1}\left(\frac{P_t}{P_{t-1}}\right)$ and rewrite the preceding equation as

$$\frac{B_{t-1}}{P_{t-1}Y_{t-1}} = \beta\gamma\left(\frac{P_t}{E_{t-1}P_t}\right)\left(\frac{T_t - G_t}{P_t Y_t} + \frac{B_t}{P_t Y_t} + \frac{M_t - M_{t-1}}{P_t Y_t}\right), \quad t \geq 0. \tag{3}$$

Use equation (1), iterate budget constraint (3) forward in time, and rule out an exploding ratio of government debt to GDP to obtain the following restriction on the real value of government debt at the beginning of period t, sequences of fiat money supplies $\{M_t\}_{t=0}^{\infty}$, nominal taxes and government expenditures $\{T_t, G_t\}_{t=0}^{\infty}$, price levels $\{P_t\}_{t=0}^{\infty}$, and real GDP $\{Y_t\}_{t=0}^{\infty}$:

$$\frac{R_{t-1}B_{t-1}}{P_t Y_t} = E_t \sum_{s=t}^{\infty} (\beta\gamma)^{s-t}\left[\frac{T_s - G_s}{P_s Y_s} + \frac{M_s - M_{s-1}}{P_s Y_s}\right]. \tag{4}$$

Here $E_t \sum_{s=t}^{\infty} (\beta\gamma)^{s-t}\left[\frac{M_s - M_{s-1}}{P_s Y_s}\right]$ is the present value of one popular way of measuring seigniorage revenues that accrue to the government from issuing currency. Apply "summation by parts" to verify

$$E_t \sum_{s=t}^{\infty} (\beta\gamma)^{s-t}\left[\frac{M_s - M_{s-1}}{P_s Y_s}\right] = E_t \sum_{s=t}^{\infty} (\beta\gamma)^{s-t}\left[\frac{M_s}{P_s Y_s}\left(1 - \frac{1}{R_s}\right)\right] - \frac{M_{t-1}}{P_t Y_t}, \tag{5}$$

and use equation (5) to represent (4) as

$$\frac{R_{t-1}B_{t-1} + M_{t-1}}{P_t Y_t} = E_t \sum_{s=t}^{\infty} (\beta\gamma)^{s-t}\left[\frac{T_s - G_s}{P_s Y_s} + \frac{M_s}{P_s Y_s}\left(1 - \frac{1}{R_s}\right)\right]. \tag{6}$$

Representations (4) and (6) both assert that the present value of a measure of government liabilities equals the present value of the primary surplus-GDP ratios $\frac{T_s - G_s}{P_s Y_s}$ augmented by "seigniorage revenues" that the government raises by issuing fiat money that bears a net nominal interest rate of zero. The two representations differ in how they define nominal government liabilities and how they account for revenues from printing money. Representation (4) treats $R_{t-1}B_{t-1}$ as the government's nominal liabilities at the start of time t, while representation (6) treats $R_{t-1}B_{t-1} + M_{t-1}$ as the government's nominal liabilities. Representation (4) accordingly views new issues of fiat money as seigniorage, while representation (6) instead treats as seigniorage the arbitrage profits that the government harvests from getting a zero nominal interest-rate loan of M_s.

Representations (4) and (6) link the real value of government debt at the beginning of time t to time t tails of sequences of taxes, government spending, and fiat money. We can define distinct monetary and fiscal policies by dividing decisions about government expenditures, tax collections, and debt management between a Treasury and a central bank. We discuss alternative ways to do that in Section 2.2.

We first turn to inflation as a taxing or defaulting device. A stochastic process for inflation interacts with the government budget in distinct ways: (1) an *anticipated* part of inflation acts as a tax rate on prospective real money balances; (2) an *unanticipated* part of inflation revalues the entire stock of nominal government liabilities (fiat money plus nominal interest-bearing debt). Let's look at both.

2.1 Anticipated inflation

To study anticipated inflation, we shut down uncertainty, posit a demand function for fiat money and a theory linking nominal interest to inflation, and then put representation (6) to work. We assume that (1) links anticipated inflation to the nominal interest rate. We follow Bassetto and Sargent (2020) by appealing to a cash-in-advance model like ones of Lucas and Stokey (1987) or Lagos (2010) to rationalize a demand function of the Cagan (1956) form $\frac{M_t}{P_{t+1}Y_{t+1}} = h(R_t)$, where $h' \leq 0$ reflects consumers' incentive to economize on real balances when the nominal interest rate is high. It follows that

$$\frac{M_t}{P_t Y_t} = \gamma h(R_t)\Pi_{t+1}, \tag{7}$$

and from equations (1) and (7) that the time t seigniorage-GDP ratio $\frac{M_t}{P_t Y_t}(1 - R_t^{-1})$ equals a function $L(\Pi_{t+1})$ defined as

$$L(\Pi_{t+1}) = \gamma h(\beta^{-1}\Pi_{t+1})(\Pi_{t+1} - \beta). \tag{8}$$

When inflation is negative or near zero, equation (8) asserts that seigniorage revenues are an increasing function of anticipated inflation. At higher inflation rates, two offsetting forces contend: higher inflation increases revenues by increasing the "inflation tax" rate on real balances of fiat money, but decreases them by depressing the representative household's demand for real money balances. These countervailing forces can produce a Laffer curve in the inflation rate. Following Sargent and Wallace (1981), we'll confine our attention to inflation rates Π_{t+1} that are on a "good side" of the Laffer curve where $L'(\cdot) > 0$.[11]

2.2 Unpleasant monetarist arithmetic

When inflation is in a range for which L is increasing, equations (6) and (8) imply that an equivalence class of monetary-fiscal sequences shares the same present value of government revenues from seigniorage:

$$\bar{L} \equiv \sum_{s=0}^{\infty} (\beta\gamma)^s L(\Pi_{s+1}). \tag{9}$$

[11] Bruno and Fischer (1990) and Marcet and Sargent (1989) present stability arguments for the good side of a Laffer curve.

All equilibria in this equivalence class share the same sequence $\{\frac{T_s-G_s}{P_sY_s}\}_{s=0}^{\infty}$ of real primary deficits relative to GDP and the same time-0 real government obligations $(R_{-1}B_{-1}+M_{-1})/P_0$. Invariance of $\bar{L}$ characterizes Sargent and Wallace's (1981) unpleasant monetarist arithmetic.[12] Given initial real liabilities, a fixed profile of real primary deficits, and a fixed present value $\bar{L}$ of seigniorage revenues, *lower* anticipated inflation rate in one period must necessarily be accompanied by *higher* anticipated inflation in other periods in order to keep the government's intertemporal budget constraint satisfied.[13] "Unpleasant monetarist arithmetic" takes as given a sequence $\{\frac{T_s-G_s}{P_sY_s}\}_{s=0}^{\infty}$ of primary deficit-GDP ratios that the monetary authority must accommodate, so a fiscal authority that sets $\{\frac{T_s-G_s}{P_sY_s}\}_{s=0}^{\infty}$ is said to **dominate** a putative monetary authority that sets an accommodating inflation sequence, or what is virtually the same thing in our context, either an accommodating interest rate sequence $\{R_t\}_{t=0}^{\infty}$ or sequence of government portfolios $\{M_t, B_t\}_{t=0}^{\infty}$.[14]

We can imagine another state of affairs in which a monetary authority sets an inflation process to which the fiscal authority must adjust. For example, a monetary authority could adopt a subsection 2.3 price-level targeting policy. That policy would support an equivalence class of government deficit sequences $\{\frac{T_s-G_s}{P_sY_s}\}_{s=0}^{\infty}$ that satisfy representation (6). Within this equivalence class, a government primary deficit in one period must accompany primary surpluses in other periods.

Thus, while equations (1) and (6) tie together sequences $\{M_s, B_s, R_s, \Pi_{s+1}, G_s, T_s, Y_s\}_{s=0}^{\infty}$, they leave much open. The arithmetic underlying the equivalence class left open to a monetary authority by a dominant fiscal authority, and the equivalence class of fiscal policies left open to a fiscal authority by a dominant monetary authority delineate a conflict between a fiscal authority intent on reducing taxes while leaving government expenditures untouched and a monetary authority intent on reining in inflation. That sets the stage for a "game of chicken" in which a monetary authority chooses a sequence of inflation rates to which it thinks the fiscal authority will adjust, while the fiscal authority chooses a sequence of primary surpluses to which it expects the monetary authority to adjust.[15]

2.3 A zero net inflation regime

To study a "price-level targeting regime," set $\Pi_{s+1} = 1, P_s = P_t$, and $M_s - \gamma M_{s-1} = 0 \ \forall s \geq t$, starting at some $t \geq 0$. The present value of seigniorage as defined on the left side of Equation (5)

[12] Werning (2024) provides closely connected characterizations.

[13] Bassetto and Sargent (2020) note that the mean of the sum in (9) in the sense of Chisini (1929), i.e., the constant $\bar{\pi}$ that satisfies $\bar{L} \equiv \sum_{s=0}^{\infty} \beta^s L(\bar{\pi})$, is a useful notion of an intertemporal average of future inflation rates. Prospective primary government surpluses and the real value of initial debt uniquely pin down Chisini mean inflation.

[14] Werning (2024) describes how these three are virtually the same.

[15] Leeper (1991) and Chung et al. (2007) describe alternative ways of coordinating monetary and fiscal policies. Barthélemy and Plantin (2018) and Camous and Matveev (2023) provide sequential formulations of some monetary-fiscal games of chicken.

is $\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}(M_s - M_{s-1}) = \frac{\gamma-1}{1-\beta\gamma}\frac{M_{t-1}}{P_tY_t}$ and $L(1) = \gamma h(\beta^{-1})(1-\beta)$.[16]

2.4 Paying interest on fiat money

If the government takes Milton Friedman, pp. 65-75's (1959) advice and pays interest on all fiat money at gross rate β^{-1} by setting $\Pi_{t+1} = \beta$ for all $t \geq 0$, fiat money becomes equivalent with nominal government debt. Seigniorage as measured by $L(\Pi_{t+1})$ in equation (8) then becomes $L(\beta) = 0$. Temporarily assume an interest-inelastic demand function for real balances money $\frac{M_{t-1}}{P_tY_t} = \bar{h}$ and that the government sets $M_{s-1} = (\beta\gamma)^{s-t}M_{t-1}$ so that $P_s = \beta^{s-t}P_t$ for $s \geq t$. Since $L(\beta) = 0$, Equation (5) implies that

$$\begin{aligned} E_t\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{M_s - M_{s-1}}{P_sY_s}\right] &= \sum_{s=t}^{\infty}(\beta\gamma)^{s-t}L(\beta) - \frac{M_{t-1}}{P_tY_t} \\ &= -\frac{M_{t-1}}{P_tY_t} \end{aligned}$$

The government must acquire and pay out a revenue stream with capitalized value $\frac{M_{t-1}}{P_tY_t}$ that coincides with $\bar{h}$. For example, the government could collect and returns on the "real bills" described in section 2.5 and pay them out as interest on money.

More generally, when $h'(\cdot) < 0$ and the demand function for real balances is interest elastic, paying the risk-free real rate on all base money as we do here can render the price level indeterminate, as noted by Sargent and Wallace (1985) and Sargent (1987, ch. 7). We set this technical issue aside in this paper because the US does not pay interest on all of the fiat money that it issues.

To implement an interest rate floor targeting procedure like ones suggested by Tobin (1960) and Goodfriend (2002), in 2008 the Fed began paying interest, not on all fiat currency as Friedman (1959, ch. 3) had advocated, but on only bank reserves. The Fed's post-2008 policy makes bank reserves equivalent with interest-bearing government debt and substantially increases the ratio $\frac{R_{t-1}B_{t-1}}{M_{t-1}}$ of bonds to money in representation (6), while simultaneously reducing the tax-base $\frac{M_s}{P_s}$ for raising seigniorage as measured by $\frac{M_s}{P_sY_s}\left(1 - \frac{1}{R_s}\right)$. In this way, representation (6) frames concerns about how to finance interest on reserves expressed by Goodfriend (2002), Del Negro and Sims (2015), Reis (2015), and Ennis and Weinberg (2022). The 2008 and 2020 jumps in the ratio $\frac{R_{t-1}B_{t-1}}{M_{t-1}}$ apparent in Figure 4b below confirm the quantitative importance of those concerns.

[16] In this $P_s = P_t$ regime, the nominal value of M_{t-1} is thus "backed" by the seigniorage flow that the government earns from a nominal interest-free loan from holders of fiat money.

2.5 Central Bank Purchases of Real Bills

Suppose that at the end of period $t-1$ the government also owns private nominal assets A_{t-1} that earn a gross nominal one-period rate of return R^A_{t-1}, where R^A_{t-1} can differ from the nominal gross rate of return R_{t-1} on government bonds.[17] In this case, equation (4) is modified to become

$$\frac{R_{t-1}(B_{t-1}-A_{t-1})}{P_tY_t} = E_t\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{T_s+(R^A_{s-1}-R_{s-1})A_{s-1}-G_s}{P_sY_s}+\frac{M_s-M_{s-1}}{P_sY_s}\right]. \qquad (10)$$

Representation (10) differs from representation (4) in two ways. First, the present value of government surpluses on the right hand side is augmented to include profits or losses $(R^A_{s-1}-R_{s-1})A_{s-1}$ on the government's portfolio of private assets. Second, the equation restricts the time t value $\frac{R_{t-1}(B_{t-1}-A_{t-1})}{P_tY_t}$ of the government interest-bearing liabilities net of interest-bearing private assets owned by the government. The corresponding version of representation (6) is

$$\frac{R_{t-1}(B_{t-1}-A_{t-1})+M_{t-1}}{P_tY_t} = E_t\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{T_s+(R^A_{s-1}-R_{s-1})A_{s-1}-G_s}{P_sY_s}+\frac{M_s}{P_sY_s}\left(1-\frac{1}{R_s}\right)\right] \qquad (11)$$

A "real bills doctrine" written into the 1913 Federal Reserve Act directed the Fed to confine its purchases and sales to nominally safe *private* assets, so that $R^A_{t-1}=R_{t-1}$.[18] An increase in M_{t-1} that is "backed" by such an increase in A_{t-1} leaves the left hand side of (11) unchanged, so it puts no upward pressure on the price level. The real bills doctrine thus identifies conditions under which "quantitative easing" is irrelevant for price level determination.[19] However, when $R^A_{s-1}>R_{s-1}$ and $A_{s-1}>0$, the right side of (11) includes earnings from excess returns on the government's portfolio that can be used to help finance government expenditures. Consequences of "quantitative easing" depend on details of how the government allocates those earnings (see Wallace (1981).)

[17] Greenspan (2001) described possible assets for the Fed to purchase after US federal government debt would be extinguished, as some forecast in 2000.

[18] Sargent and Wallace (1982) present a normative case for adopting a real bills rule.

[19] So long as the right side of representation (11) is frozen, increases in the money supply that are accompanied by decreases in B_{t-1} or increases in A_{t-1} that leave the right side unaltered leave P_t unaffected. Also See Wallace (1981).

2.6 Responses to Adverse Fiscal Shocks

Representation (6) and the mathematical expectation of representation (6) conditional on time $t-1$ information imply

$$(R_{t-1}B_{t-1}+M_{t-1})\left(\frac{1}{P_tY_t}-E_{t-1}\frac{1}{P_tY_t}\right)=$$
$$E_t\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{T_s-G_s}{P_sY_s}+\frac{M_s}{P_sY_s}\left(1-\frac{1}{R_s}\right)\right]-E_{t-1}\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{T_s-G_s}{P_sY_s}+\frac{M_s}{P_sY_s}\left(1-\frac{1}{R_s}\right)\right]. \tag{12}$$

Equation (12) delineates possible responses at time t to an adverse fiscal shock like a war that reduces anticipated $\sum_{s=t}^{\infty}(\beta\gamma)^{s-t}\left[\frac{T_s-G_s}{P_sY_s}\right]$. According to equation (12), at time t present value budget balance can be restored in one of three ways. 1. Future seigniorage revenues can be increased by raising prospective inflation rates; or 2. The price level can jump immediately in order to lower the real value of nominal liabilities previously issued by the government; or 3. Taxes or government expenditures or some combination of them can be adjusted to restore the present value of primary government surpluses $\frac{T_s-G_s}{P_sY_s}$ to its initial value. Option 1 resorts to anticipations of higher future inflation. Option 2 uses surprise jumps in the price level to mark down nominal government liabilities.[20] Preserving a pre-surprise price level path requires using option 3.

3 US Data

We align the budget arithmetic presented in Section 2 with US data and explain associated adjustments we must make to officially reported data to carry out our calculations.[21] We then decompose wartime revenues for five wars, two from the 19th century, two from the 20th century, and one – the War on COVID – from the 21st century. Unlike earlier wars, the US mostly financed the War on COVID with overnight loans. The money supply increased dramatically. As fractions of total revenues, with a narrow definition of money, COVID wartime seignorage revenue approached those raised during the Civil War. Unlike the four earlier postwar periods, the US ran primary deficits during the three years since the War on COVID ended. But high inflation and real GDP growth offset them, so the debt/GDP actually declined slightly.

[20]Optimal prediction theory requires that surprises be serially uncorrelated, so surprise inflation is "transitory" in models that assume rational expectations.

[21]Bassetto et al. (2024) provide a related and more econometrically formal analysis of post Covid US policy that uses budget arithmetic like that in Section 2 and Bassetto and Sargent (2020).

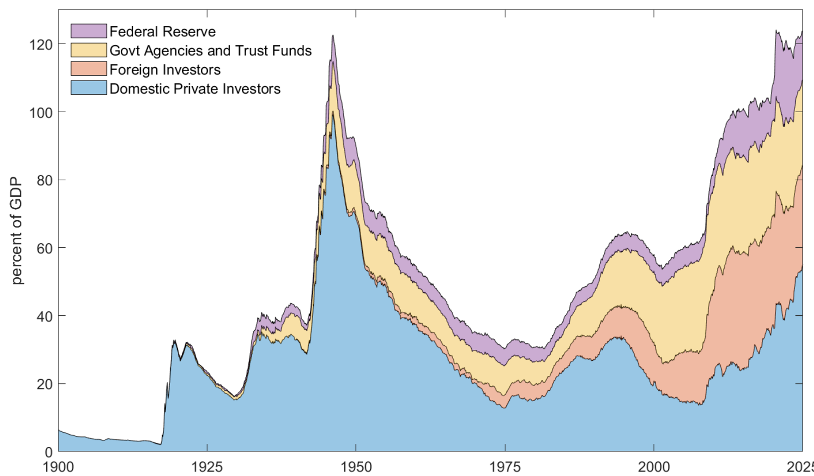


Figure 3: Par Value of US Treasury Debt by Ownership as Percents of GDP: 1900 to 2024

3.1 Aligning Macro Theory with US Data

To align our Section 2 budget arithmetic with US data, we assume that the government issues bonds and buys private securities of various maturities, and that real returns on government debt and private securities vary over time. Let $B_{t-1} = \sum_{j=1}^{n} B_{t-1}^{j}$ be the total nominal value of interest-bearing government debt at $t-1$, where B_{t-1}^{j} is the nominal value of zero coupon bonds of maturity j at $t-1$. Let $r_{t-1,t}^{B}(j)$ be the net *nominal* return between $t-1$ and t on nominal zero-coupon bonds of maturity j. The equality

$$\sum_{j=1}^{n} r_{t-1,t}^{B}(j) B_{t-1}^{j} = r_{t-1,t}^{B} \sum_{j=1}^{n} B_{t-1}^{j} \tag{13}$$

implicitly defines the value-weighted nominal return $r_{t-1,t}^{B}$ on interest-bearing nominal government bonds from $t-1$ to t. We treat private securities A_t in the same way. We formulate the federal government's nominal budget constraint at time t, as

$$G_t + r_{t-1,t}^{B} B_{t-1} + (A_t - A_{t-1}) = T_t + (B_t - B_{t-1}) + r_{t-1,t}^{A} A_{t-1} + (M_t - M_{t-1}), \tag{14}$$

and replace R_{t-1} with $(1 + r_{t-1,t}^{B})$ and R_{t-1}^{A} with $(1 + r_{t-1,t}^{A})$.

To measure real returns realized by bondholders, we make three adjustments to the US Treasury's accounts of debt outstanding and interest payments. First, to include only government debt held by private investors, both domestic and foreign, we net out holdings by the Federal Reserve and Government Agencies and Trust Funds. Figure 3 decomposes the par value of total public debt as shares of GDP from January 1900 to December 2024 into four ownership classes.[22] Second, we use promised payment streams and bond price data from Hall et al. (2022) to construct the market value of Treasury debt. The market value takes into account differences between interest rates and coupon rates when debt was issued, as well as changes in interest rates and repayment probabilities as bonds gradually matured. The market value tells how much the government would have to pay to buy back the entire portfolio of privately held government debt. Third, we measure interest payments $r^B_{t-1,t}$ by the value-weighted return on the portfolio of US Treasury debt. Our measure differs from the US Treasury's series of *Interest Expense on the Debt Outstanding*, an accounting measure that sums coupon payments on Treasury notes and bonds and accrued interest on zero-coupon Treasury bills.[23]

We make further adjustments that account for the Federal Reserve's purchases of Treasury securities and private assets and its expansion of liabilities to pay for these purchases. Figure 4 plots Federal Reserve balance sheet over time. Panel 4a shows how Federal Reserve holdings of Treasuries and private assets (largely mortgage backed securities, denoted MBS) surged in the second quarter of 2020 when the Treasury issued $2.8 trillion in new debt. The Fed increased its holdings of Treasury and mortgage backed securities by $1.8 trillion and continued purchasing more until mid-2022.

Panel 4b indicates that bank reserves (tan) and Treasury deposits (blue) jumped. For about a year after March 2020, bank reserves grew as the Treasury spent its deposits at the Fed. In March 2021, growth in bank reserves slowed markedly while the Fed's reverse repurchase agreements (reverse repos) (red) with money market funds accelerated rapidly. The Fed borrows from money market funds with reverse repos that serve as reserve accounts at the Fed. The Fed pays interest on reverse repos, though at slightly lower rates than on bank reserves.

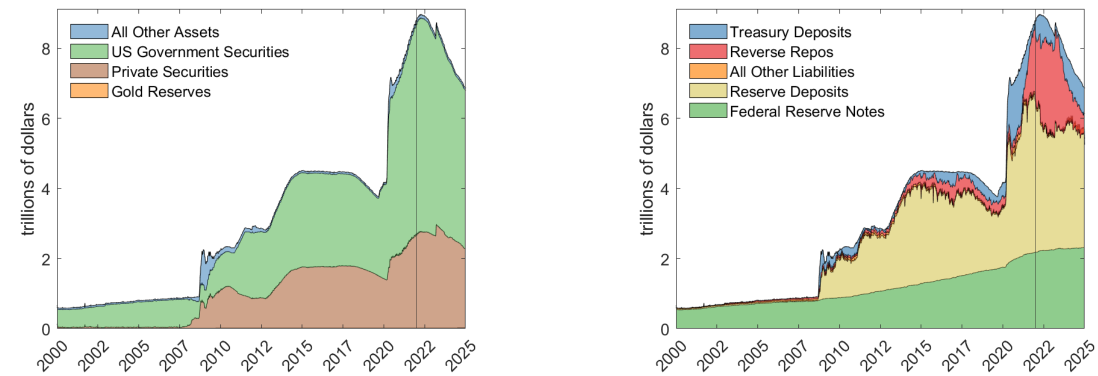
In October 2008, the Federal Reserve began paying interest on reserve deposits. That made them interest-bearing Federal debt. This shows up in Figure 5, which plots Par and Market Values of Treasury Debt Held by Private Investors, as percents of GDP. The green line in Figure 5 graphs the sum of the market value of privately held Treasury debt and interest-bearing reserve deposits plus reverse repos at the Federal Reserve, i.e., a sum of the tan and red areas in panel 4b. Including reserves at the Fed and the Fed's reverse repo positions as interest-bearing debt increases the ratio of privately-held federal debt to GDP from 75.5% to 88.3% as of December 30, 2024.[24]

However, because the Fed uses some of those reserve deposits to purchase private assets, the green line overstates federal interest-bearing debt held by private investors. To adjust for that, the light blue line in Figure 5 plots the market value of the privately-held Treasury debt *plus* reserve

[22] Section 4.1 discusses creditors who own US Treasury debt.

[23] In the Appendix of Hall and Sargent (2021), we explain in detail the relationship between par and market values of government debt and the relationship between returns on the portfolio of Treasuries and the Treasury's measure of interest payments. Also see Hall and Sargent (2011).

[24] We record interest-bearing reserve deposits and reverse repos at the Federal Reserve at their face or par values.



(a) Assets (b) Liabilities and Capital Account

Figure 4: Federal Reserve Balance Sheet: 2000-2024

Vertical line indicates December 31, 2021.

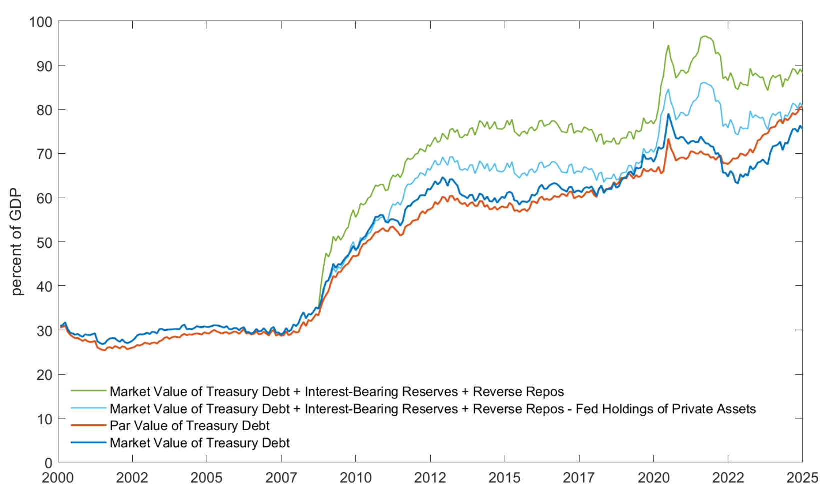
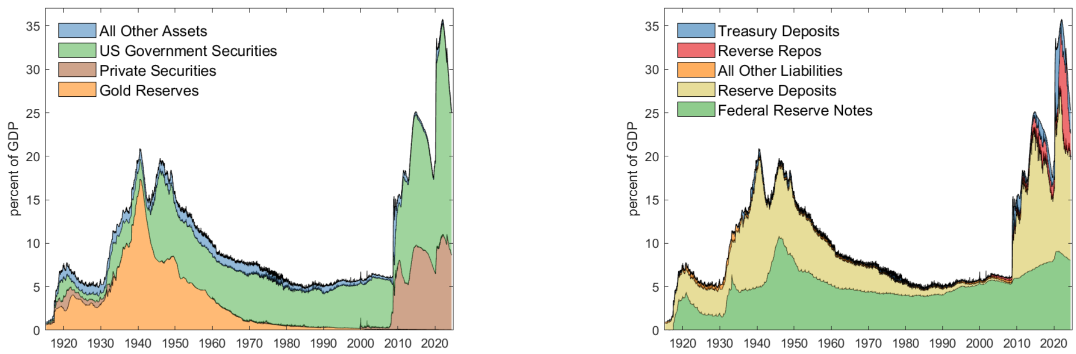


Figure 5: Par and Market Values of Treasury Debt Held by Private Investors, as percents of GDP.

All series are net of Treasury cash balances.



(a) Assets

(b) Liabilities and Capital Account

Figure 6: Federal Reserve Balance Sheet As Percent of GDP: 1915-2024

deposits and reserve repos at the Federal Reserve *minus* Federal Reserve holdings of privately issued securities (i.e., the brown area in panel 4a).[25] The gap between green and light blue lines measures reserve deposits that are "backed" by private securities, a component of Fed open market operations that brings to mind a "real bills" doctrine written into the original 1913 legislation that created the Fed.[26]

The Fed serves as the US Treasury's fiscal agent, so interest-bearing reserve deposits and reverse repos are ultimately backed by the full faith and credit of the US federal government. For that reason, we shall depart from the US government's reporting protocols by including interest-bearing reserve deposits and reverse repos (the green line in Figure 5). We denote this accounting convention by "reserves $\subset B$" in Table 2. Official US government accounts don't include these Federal Reserve liabilities as part of the national debt. Neither do they count against the statutory limit on US government debt.

To compare 20th and 21st Century regimes, Figure 6 plots balance sheets of the Federal Reserve from 1915 to 2024 as percentages of GDP.[27] At its peak during the COVID era, as a share of GDP, the size of the Fed's balance sheet was 1.5 times its size during World War II. Panel 6a indicate that during the 1930s and 40s the Fed dramatically expanded its holdings of Treasury securities. In 2008 the Fed's holdings of private assets (shaded brown) jumped again.

3.2 Financing Wartime Expenditures

Section 2.6 described possible responses to an adverse fiscal shock like a war. Let's compare how the U.S. government financed the War of 1812, the Civil War, World War I, World War II, and the War on COVID-19. What shares of wartime costs were borne by taxes, borrowing, and

[25]We are being guided by equation (11).

[26]Sargent and Wallace (1982) present an historical account and perspective on the real bills doctrine.

[27]The balance sheets in Figure 4 are not scaled by GDP.

money creation? Table 1, which updates Table 27.1 in Hall and Sargent (2021) to include the War of COVID, presents our answers. To prepare Table 1, we divide each term in equation (14) by nominal GDP, P_tY_t, and rearrange terms to get

$$\begin{aligned} \frac{G_t}{P_tY_t} + \left(r^B_{t-1,t}\frac{B_{t-1}}{P_{t-1}Y_{t-1}} - r^A_{t-1,t}\frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) + \left(\frac{A_t}{P_tY_t} - \frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) &= \frac{T_t}{P_tY_t} \\ + \left(\frac{B_t}{P_tY_t} - \frac{B_{t-1}}{P_{t-1}Y_{t-1}}\right) + \frac{M_t - M_{t-1}}{p_tY_t} &+ g_{t-1,t}\frac{B_{t-1} - A_{t-1}}{P_{t-1}Y_{t-1}} \\ +\pi_{t-1,t}\frac{B_{t-1} - A_{t-1}}{P_{t-1}Y_{t-1}} + (\pi_{t-1,t} + g_{t-1,t})\left(r^B_{t-1,t}\frac{B_{t-1}}{P_{t-1}Y_{t-1}} - r^A_{t-1,t}\frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) \end{aligned} \tag{15}$$

where $g_{t-1,t}$ denotes the net growth rate of real GDP and $\pi_{t-1,t}$ denotes the net inflation rate. Government expenditures are on the left, revenues on the right.

For each item in equation (15), we computed an average of that item over the five years before the war and used this as a "peacetime baseline" for that item. We then sum differences between an item in equation (15) and its peacetime baseline.

Table 1 reports our decomposition for the five wars. Consider World War I.[28] The US participated in that war as a belligerent for 20 months, from April 1917 to November 1918. During those months, it spent 36.93% of a single year's GDP on the war and paid its bondholders 3/10 of 1% of a year's worth of GDP. It purchased private assets worth 16/100 of one percent of a year's GDP, bringing the total cost of the war to 37.39% of a year's GDP. We decompose funding sources into tax revenues, debt growth, money growth, GDP growth, inflation, and everything else. The items in columns (5) through (10) sum to 37.39.

The second row reports sources as percentages of total revenue for each war. During World War I, the US raised 20.8% through taxes, 74.3% via interest-bearing debt, and 6.9% via increases in the monetary base, leaving a residual of -2.0% explained by remaining terms.

Columns (5) and (6) indicate that across the four major 19th- and 20th-century wars, shares of war expenses financed by tax revenues increased over time, and shares financed by interest-bearing debt decreased over time. The War on COVID-19 broke this pattern.

During the War on COVID-19, the federal government spent nearly 27% a year's GDP to fight the virus, compensate its bondholders, and purchase private assets. Relative to GDP, in just two years, the US government spent 80% of what it spent over the four years of the Civil War.

For COVID-19, we decompose revenues in two ways. Our first decomposition counts reserve balances at the Federal Reserve as part of base money. According to this decomposition, the federal government raised 86.6% of wartime revenues by money growth. Taxes and interest-bearing debt accounted for only 1.0% and 0.5% of wartime increments in revenues, respectively; 11.9% came from remaining terms.

[28] Table 1 abridges Table 27.1 of Hall and Sargent (2021) but extends it to the War on COVID.

War Start - End	(1) government spending	(2) payouts on net debt	(3) asset purchases	(4) (1)+(2) +(3)	(5) tax revenue	(6) debt growth	(7) money growth	(8) GDP growth	(9) inflation	(10) other
War of 1812										
1812:6 - 1815:2	7.34	-0.20	–	7.14	-2.35	10.60	0.00	-0.16	0.06	-1.01
					-32.9	148.5	0.0	-2.2	0.8	-14.2
Civil War (Union)										
1861:4 - 1865:4	31.04	2.10	–	33.14	2.26	19.74	6.49	1.08	3.95	-0.37
					6.8	59.6	19.6	3.2	11.9	-1.2
World War I										
1917:4 - 1918:11	36.93	0.30	0.16	37.39	7.76	27.79	2.59	0.03	0.68	-1.46
					20.8	74.3	6.9	0.1	1.8	-3.9
World War II										
1941:12 - 1945:8	116.48	2.00	–	118.48	35.80	54.53	11.96	8.99	6.05	1.14
					30.2	46.0	10.1	7.6	5.1	1.0
COVID-19										
2020:1 - 2021:12	20.09	1.01	5.60	26.70	0.27	0.13	23.12	0.91	3.21	-0.94
reserves $\subset M$					1.0	0.5	86.6	3.4	12.0	-3.5
2020:1 - 2021:12	20.09	1.05	5.60	26.74	0.27	18.43	3.46	1.49	4.25	-1.15
reserves $\subset B$					1.0	68.9	12.9	5.6	15.9	-4.3

Table 1: Decomposition of Wartime Revenues from Equation (15)

For each war, the elements in first row are in percent of GDP. Columns 5-10 sum to column 4. The numbers in the second row are percentages of the sum of war-related spending, net debt payments and purchases of private assets (column 4) accounted for by each term on the right side of equation (15). Column 10 is the sum of other means, the cross product, and a residual. Funding by Other Means includes IMF dollar deposits and letters of credit to the IMF, changes in special drawing rights certificates issued to Federal Reserve Banks, and net activities of various federal loan programs.

Since 2008, the Federal Reserve has paid interest on reserve deposits. When we count these reserves as interest-bearing federal debt and subtract them from our measure of Federal Reserve credit, the wartime decomposition for the COVID-19 war becomes 1.0% taxes, 68.9% growth in interest-bearing debt, 12.9% money growth, and 17.2% from the remaining terms. This adjustment re-allocates 68% of the revenues from money growth to interest-bearing debt growth and has no impact on the share of revenue from explicit taxation.

Increases in taxes contributed almost nothing to paying for the War on COVID expenditure surge. We have to go back to the War of 1812 - a time when tariffs were the primary source of tax revenue and the US was at war with its main trading partner, Great Britain – to find an episode when tax revenues contributed less to wartime financing. The federal government financed the war on COVID mostly by overnight loans: bank reserves and reverse repurchase agreements. If we regard these overnight loans as "money," then money growth accounts for 86.6% of the "wartime" financing. If we call these loans "bonds," then issuing bonds contributed a lot, but money growth still accounts for 12.9% of the "wartime financing," a share comparable to the role fiat money growth played in financing the Union efforts during the Civil War. Wartime inflation also augmented COVID-era revenue.

3.3 Post-War Changes in Debt/GDP

From December 2019 to September 2024, the par value of privately-held Treasury debt increased by $9.8 trillion from $14.9 to $24.7 trillion. After we include the Federal Reserve's interest-bearing reserve deposits and reverse repos and net out cash balances held by the Treasury, we learn that federal debts rose $10.7 trillion from $16.4 to $27.7 trillion.

While the *level of debt* increased nearly monotonically, the path of the *debt/GDP ratio* did not. The red line in Figure 5 is the ratio of the par value of privately-held Treasury debt to GDP.[29] This ratio rose from 66.0% in December 2019 to 73.4% in June 2020, then fell to 68.4% in September 2020; during the next 27 months, it stayed within a band between 68.3% and 70.8%.[30] Then from December 2022 to December 2024, this privately held debt to GDP increased from 69.8% to 80.5%.

In December 2019, the market value of privately-held debt (the dark blue line) exceeded its par value by $350 billion. The ratio of the market value of debt to GDP rose from 68.3% in December 2019 to 77.1% in June 2020, but it declined throughout 2021 and 2022. By December 2022, it was only 67.1%. Measured at its market value, the debt/GDP ratio was *lower* at the end of 2022 than it had been before the outbreak of COVID-19, and by December 2024, the market value of privately held debt was $1.5 trillion less than its par value. Counting the Fed's interest-bearing reserve deposits and reverse repos as debt (see the green and light blue lines) increases

[29]All series in this figure net out Treasury cash balances.

[30]Section 2.6 directs us to consider this as a response to the adverse COVID-19 fiscal shock.

the debt/GDP ratio for most of 2021.

We posit that the War on COVID-19 fiscal surge ended on December 31, 2021. We decompose postwar changes in the debt/GDP ratio that occurred from the start of 2022 to end of 2024 into contributions made by nominal returns paid on Treasury securities net of returns paid on private assets, GDP growth, inflation, the primary deficit, and seignorage. By rearranging the terms in equation (15), we get:

$$\begin{aligned}\frac{B_t}{P_tY_t} - \frac{B_{t-1}}{P_{t-1}Y_{t-1}} \quad = \quad & \left(r^B_{t-1,t}\frac{B_{t-1}}{P_{t-1}Y_{t-1}} - r^A_{t-1,t}\frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) - g_{t-1,t}\frac{B_{t-1}-A_{t-1}}{P_{t-1}Y_{t-1}} \\ & -\pi_{t-1,t}\frac{B_{t-1}-A_{t-1}}{P_{t-1}Y_{t-1}} + \frac{G_t - T_t}{P_{t-1}Y_t} - \frac{M_t - M_{t-1}}{P_{t-1}Y_t} + \left(\frac{A_t}{P_tY_t} - \frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) \\ & -(\pi_{t-1,t} + g_{t-1,t})\left(r^B_{t-1,t}\frac{B_{t-1}}{P_{t-1}Y_{t-1}} - r^A_{t-1,t}\frac{A_{t-1}}{P_{t-1}Y_{t-1}}\right) \qquad (16)\end{aligned}$$

where $g_{t-1,t}$ denotes the net growth rate of real GDP, and $\pi_{t-1,t}$ denotes the net inflation rate.

The left side of equation (16) records the change in the debt/GDP ratio. The first term on the right side is interest payments on government debt minus interest earned on the Federal Reserve's holdings of private assets as a share of GDP. The subsequent two terms record changes in the net debt/GDP ratio contributed by real GDP growth and inflation. The next four terms are the primary deficit, Federal Reserve credit, and purchases of private assets by the Federal Reserve as shares of GDP. The final term is a cross-product of two growth rates.

Columns (1) - (3) of table 2 report the change in the debt-GDP ratio over the fifteen year period following the end of each war. For each war, columns (4) - (10) of the first row report components attributable to (i) nominal interest payments, (ii) GDP growth, (iii) inflation, (iv) the primary deficit, (v) the cross-term, (vi) money growth, and (vii) a residual. Nominal interest payments, primary deficits and and asset purchases increase the debt/GDP ratio. GDP growth, inflation, and money growth diminish it. Hence the elements in columns (4) - (10) sum to column (3). Entries in the second row are percent changes in the debt/GDP ratio accounted for by each component.

For the War of 1812, the Civil War, and World War I, a bimetallic or gold standard set the value of the U.S. dollar. After each of these wars, the biggest contributions to reducing debt/GDP ratios were primary surpluses followed by real GDP growth. Positive nominal returns to bondholders and price deflation dampened these reductions. Postwar deflations increased the market value of US federal debt relative to GDP and real returns paid to government creditors.

In the post-World War II era, primary surpluses were not the largest contributors to post-war declines in debt/GDP ratios; inflation and real GDP growth made bigger contributions.[31] In particular, in the 24 months after World War II price controls in June 1946, the price level rose

[31] Hall and Sargent (2011) provides a more complete account of contributions to debt/GDP ratio changes from inflation, growth, and nominal returns paid on debts of different maturities since World War II.

46%, inflating way nearly half the value of the debt.

For the COVID postwar period, we have only three years of data. In the first row of table 2 we measure debt by the market value of privately-held Treasury debt net of Treasury cash balances; this is the dark blue line in Figure 5. It counts the Fed's holdings of reserves and reverse repos as money. With this accounting convention, the debt/GDP ratio *rose* from 71.5% in December 2019 to 75.6% in December 2024. The second row counts the Fed's holdings of reserves and reverse repos as interest-bearing federal debt, corresponding to the green line in Figure 5. Under this accounting convention, from the end of 2021 to the end of 2024, the debt/GDP ratio *fell* from 95.4% to 88.3%. This reduction in the debt/GDP ratio occurred despite large primary federal deficits that would have driven the debt/GDP ratio up by 9.4 percentage points without those other contributions. Those deficits were offset by real GDP growth and inflation. The Fed's recent shrinking of its balance sheet reduced the money supply and the Fed's Treasury debt holdings; that increased Treasury debt held by private investors.

As happened soon after World War II, high unanticipated inflation and associated negative real returns contributed to the reduction of debt/GDP ratio. We offer the following back-of-the-envelope calculation to put the capital losses inflicted by these sources into perspective. The federal government ran primary deficits for the 36 months from January 2022 to December 2024, totaling \$2.6 trillion. On December 31, 2021, the market value of the Treasury debt held by private investors stood at \$18.1 trillion. Over the next 36 months, investors lost 3.4% in nominal holding period returns and another 13.2% due to inflation, delivering real losses of $\$18.1 \times 0.166 = \$3.0$ trillion that more than offset the primary deficits during this period. In the next section, we examine the consequences for federal bondholders.

4 Fiscal Consequences of Inflation

The inflation surge that began in the second half of 2020 imposed real losses on bondholders and some owners of entitlements to future government payment streams.[32] It also motivated the Federal Reserve to raise interest rates, triggering falls in nominal prices of Treasury and other fixed-income securities. We analyze bondholders' returns since the start of the War on COVID; owners of long-term bonds have taken big real and nominal losses, while holders of short-term bonds have seen small nominal gains. Our accounts differ from the Treasury's because the Treasury ignores capital gains and losses when computing its interest costs. Actual holding period returns on US Treasury debt are much more volatile than are average interest rates computed from official Treasury accounts.

Private banks have suffered losses on their loan portfolios, including Treasuries and mortgage backed securities. The Fed has taken capital losses on its portfolio of Treasury debt and mortgage

[32] But not to recipients of Social Security payments. They are indexed to a price index.

	100 × Debt/GDP			Contributions						
	(1) end of war	(2) end of post-war	(3) change	(4) nominal payouts $r\frac{B}{PY} - r\frac{A}{PY}$	(5) real GDP growth $g\frac{B}{PY}$	(6) inflation $\pi\frac{B}{PY}$	(7) primary deficit $\frac{G-T}{PY}$	(8) money growth $\frac{M-M_{-1}}{PY}$	(9) asset purchases $\frac{A}{PY} - \frac{A_{-1}}{P_{-1}Y_{-1}}$	(10) Other
War of 1812										
1815-1830	11.6	3.4	-8.2	10.5	-5.6	4.9	-19.4	–	–	1.4
				128	-68	60	-237	–	–	17
Civil War (Union)										
1865-1880	22.1	15.6	-6.5	21.4	-14.5	13.5	-29.5	1.2	–	1.4
				329	-223	208	-454	18	–	22
World War I										
1919-1929†	28.6	20.2	-8.4	12.5	-6.4	2.4	-20.3	2.0	–	1.3
				149	-76	29	-242	24	–	16
World War II										
1945-1960	90.1	35.7	-54.4	14.3	-15.8	-38.9	-13.0	-0.3	–	-0.8
				26	-29	-71	-24	-1	–	-1
COVID-19										
2022-2024‡	71.5	75.6	4.1	1.1	-4.1	-6.7	9.4	9.8	-3.2	-2.3
res $\subset M$				28	-101	-164	232	241	-78	-57
2022-2024	95.4	88.3	-7.1	0.2	-5.4	-9.0	9.4	2.1	-3.2	-1.3
res $\subset B$				2	-76	-126	132	30	-44	-18

Table 2: Decomposition of Post-War Changes in Debt/GDP Ratio

† 10 years, ‡ 3 years.
For each war, the elements in the first row are in percent of GDP. Treasury debt is its end-of-year market value net of holdings of the Federal Reserve and government accounts and the balance in the Treasury. Columns (4) - (10) sum to column (3). The elements in the second row are the percentages in changes in the debt/GDP ratio accounted for by each contribution.
Other includes other means, the cross term, and the error term.
res $\subset M$ means that Fed's holdings of reserves and reverse repos are counted as money.
res $\subset B$ means that Fed's holdings of reserves and reverse repos are counted as interest-bearing debt.

backed securities. Since the Fed's portfolio is more heavily weighted toward long-duration debt than the aggregate portfolio, the Fed has absorbed duration risk from the private sector. Since 2008, the Fed has used interest income (measured by the flow of coupons) on its portfolio of long-term securities to pay interest on banks reserves and reverse repurchase agreements. This "carry trade" made money from 2008 to 2022, but since 2022 it has suffered losses.

The duration of US Treasury debt declined during the past four years. That makes it harder to use surprise inflation to inflate away the debt and increases the amount of surprise inflation required to inflate away a given real amount of debt in response to an adverse fiscal shock.

4.1 Who Lends to the US Treasury?

Figure 3 describes Federal Reserve, Government Agencies and Trust Funds, foreign investors, and domestic private investors ownership shares of US Treasury debt from 1900 to 2024. Before World War I, domestic private investors owned nearly all US Treasury debt, many directly through their deposits in national banks. But as Figure 3 and Table 3 indicate, that has changed. At the end of 2022, of the over $31 trillion in total debt outstanding (measured at its par value), 17.2% was held by the Federal Reserve, 21.9% by government accounts and trust funds, 23.4% by foreign investors, and 37.5% by domestic private investors. Of the $6.9 trillion in Treasury debt owned by government agencies and trust funds, over 75% was held by three trust funds: the Social Security Old Age, Survivors and Disability (OASDI) Trust Fund, the Department of Defense Military Retirement Fund, and Office of Personnel and Management Civil Retirement Funds. These funds hold mostly nonmarketable debt. Of the $7.3 trillion in Treasury debt held by foreigners, 1/3 was held by entities residing in Japan, Mainland China, and the United Kingdom. As for domestic private investors, US banks and other depository institutions held $1.7 trillion of US Treasuries, about 5% of total outstanding debt.

4.2 Capital Losses on US Treasury Securities

Figure 7 plots the Effective Fed Funds Rate, the Award Rate on Reverse Repurchase Agreements, and the yield on Treasuries at a 10-year constant maturity from January 2000 to December 2024. Evidently, in this time interval, the Federal Reserve set the Fed Funds Rate near zero during two episodes: one that began in December 2008 in response to the financial crisis and another in March 2020 during the start of the War on COVID-19. In a belated response to the surge in US inflation that began in the second half of 2020, on March 17, 2022, the Federal Reserve initiated a sequence of eleven increases that raised the Federal Funds Rate from a target range of 0-0.25% to 5.25-5.50% in late July 2023. The Fed maintained this target rate range until September 17, 2024, when it cut the target range 50 basis points to 4.75-5.00%; in November and December the Fed cut the target range to 4.25-4.50%. The award rate on reverse repurchase agreements moved

Creditor	Par Value (in billions)		Percent of Total
Federal Reserve	$5,398.1		17.2%
Gov't Agencies and Trust Funds	6,867.5		21.9
OASDI Trust Fund		2,830	
DoD Military Retire Fund		1,355	
OPM Civil Service Retire Fund		1,007	
Foreign Investors	7,318.7		23.4
Japan		1,076.3	
China		867.1	
United Kingdom		654.5†	
Domestic Private Investors	11,763.0		37.5
Depository Institutions		1,715.8‡	
Total	$31,347.3		100%

Table 3: Treasury Debt Ownership: December 2022

† We suspect that some of these entities don't physically reside in the UK.
‡ Flow of Funds, Table L.210 (sum of lines 25-28, 53).

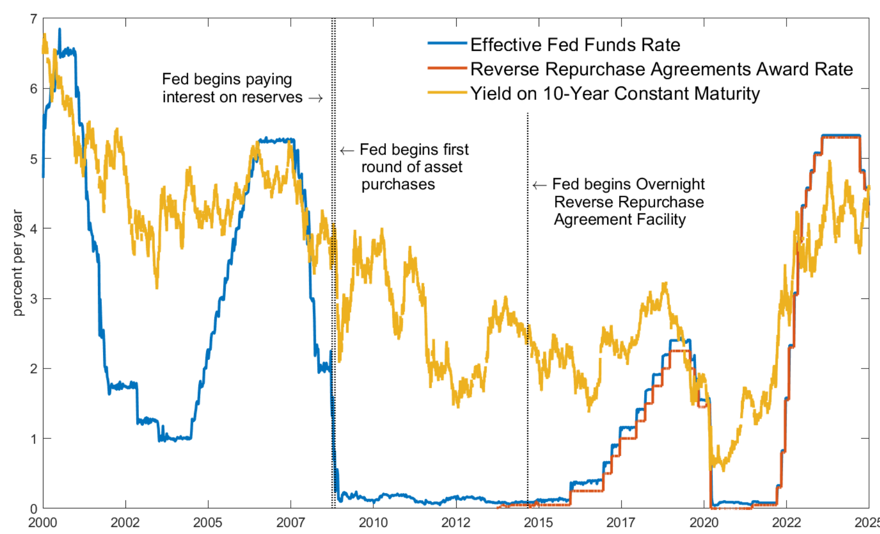


Figure 7: Effective Federal Funds Rate, Reverse Repurchase Award Rate, and Yield on US Treasury Securities of 10-Year Constant Maturity

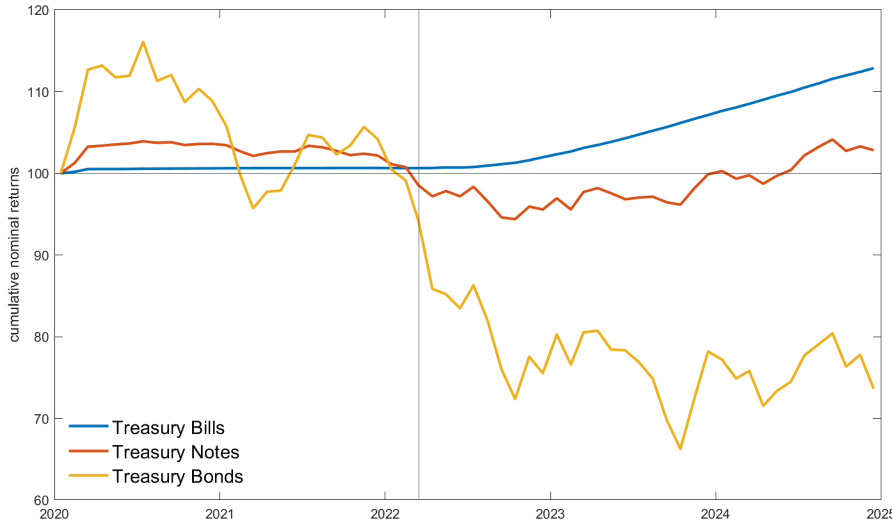


Figure 8: Cumulative Nominal Returns on Treasury Bills, Notes and Bonds

The vertical line denotes March 17, 2022, the date of the first increase in the Fed Funds rate.

in tandem with the Fed Funds rate.

Long-term rates rose throughout 2021, 2022, and 2023. The yield on Treasuries at a 10-year constant maturity rose from a low of 0.55% in July 2020 to 4.95% in October 2023. Since then the 10-year rate retreated and, at the end of 2024, stood at 4.55%. Surges in interest rates across the entire term structure resulted in capital losses in many Treasury notes and bonds.

Let's compute ex-post returns for marketable Treasury securities for 2020 to 2024, for which we have prices from the CRSP database. Annual nominal returns categorized by Treasury security type were:

	2020	2021	2022	2023	2024
Bills	0.73%	0.05%	1.30%	5.07%	5.36%
Notes	4.89	-1.38	-6.47	4.51	2.96
Bonds	15.93	-4.26	-27.51	3.51	-5.82
TIPS	10.35	5.79	-10.42	4.08	-2.59
total value-weighted return	6.10%	-1.37%	-9.31%	4.58%	1.83%

A bond price is more sensitive to changes in interest rates the longer its duration. Consequently holders of long-term Treasury bonds incurred much larger losses than holders of short-term Treasury bills.[33] Starting with an initial investment of $100 on January 1, 2020, and with continuous reinvesting of proceeds, Figure 8 plots cumulative nominal returns on Treasury securities by security type. Since the Fed began raising the Fed Funds rate, long-term Treasury bondholders have lost 25% of their initial investment. A US government creditor who held a representative value-weighted portfolio of the US Treasury securities from from January 1, 2020 and sold in December 2024 earned a total nominal return 1.1% over the 5 years. Instead, if that same investor purchased in January 2021 and sold in December 2024, she lost 4.7%.[34]

4.3 Misleading Accounting

Blanchard and Sachs (1981) noted that because official accounts are not aligned with ones used in macroeconomic theories like those presented in section 2, US official accounts misrepresent interest payments on federal debt. In 2022, the US Treasury reported spending $774,679 million in gross interest payments on Treasury Debt Securities. Dividing this number by the gross par value of US Treasury debt at the end of June 2022 to compute a rate of return yields:

$$100 \times \frac{\$774,679}{\$30,568,581} = 2.53\%.$$

Official accounting measures of debt and interest payments neglect capital gains and losses, an especially misleading omission during periods of high inflation.

Figure 9 presents differences between our mark-to-market accounting and the Treasury's accounting by plotting three measures of the rate of return on Marketable Treasury Debt held by the Public from 2011 to 2024. The blue line is the rate of return implied by US reported Interest Expense on the Public Debt Outstanding

$$r_t^{implied} = \frac{\text{official interest payments during month } t}{\text{par value of the debt at the beginning of month } t},$$

while the yellow line is the Treasury's reported Average Interest Rate on Total Marketable Debt[35] These two (misleading) return series track each other closely. Both series are always positive and remarkably smooth. The red line is the value-weighted holding period returns computed for

[33]These returns are consistent with Vanguard ETF and mutual fund returns. Consider the annual returns of the following four funds from 2020 to 2024:

	2020	2021	2022	2023	2024
Ultra-Short Term Treasury (VUSB)	N/A	0.12%	-0.43%	5.56%	5.66%
Mid-Term Treasury (VGIT)	7.66%	-2.57	-10.67	4.42	1.32
Long-Term Treasury (VGLT)	17.71	-5.03	-29.44	3.69	-6.46
Inflation-Protected Securities (VIPSX)	10.90	5.56	-11.95	3.65	1.75

[34]Gomez-Cram et al. (2024) link the timing of these losses to news of higher future government deficits. They report similar losses on government debt for the United Kingdom, Germany, and France.

[35]See `https://fiscaldata.treasury.gov/datasets/`.

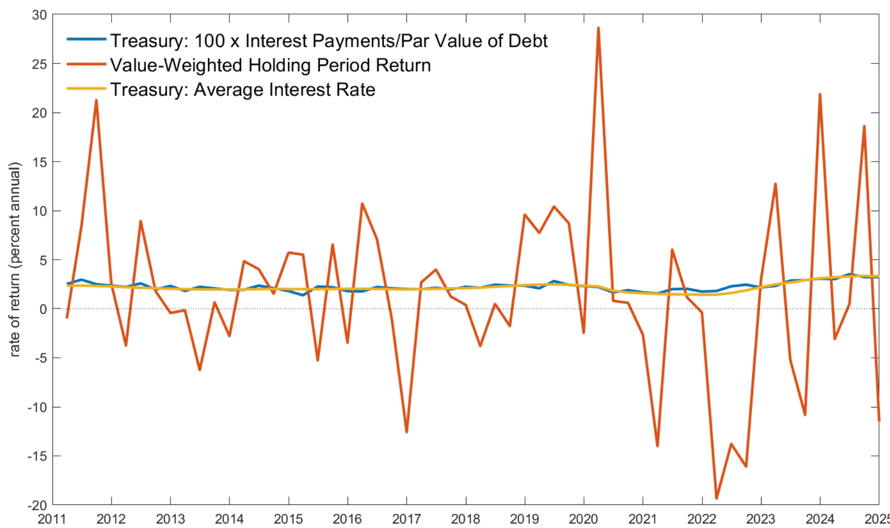


Figure 9: Three Measures of the Nominal Rate of Return on Marketable Treasury Debt Held by the Public

All returns are reported at an annual rate. Underlying data are monthly. We aggregate the returns to the quarterly frequency to smooth the seasonality in scheduled coupon payments.

marketable debt outstanding from CRSP. It is often negative and also quite volatile.

Table 4 reports means and standard deviations of the three nominal return series appearing in Figure 9. The table also presents returns adjusted for inflation using the CPI. Since 2011, on average, holding period returns have been below official interest expenses, and real returns have been negative.

4.4 Exposures of Bonds to Interest Rate and Inflation Risks

Panel 10a reports dollars (both coupon and principal payments) that the Treasury has promised to pay its creditors each year for the subsequent 30 years as of December 2019 and December 2024.[36] At almost all maturities, the number of dollars promised by the Treasury increased over the COVID period.

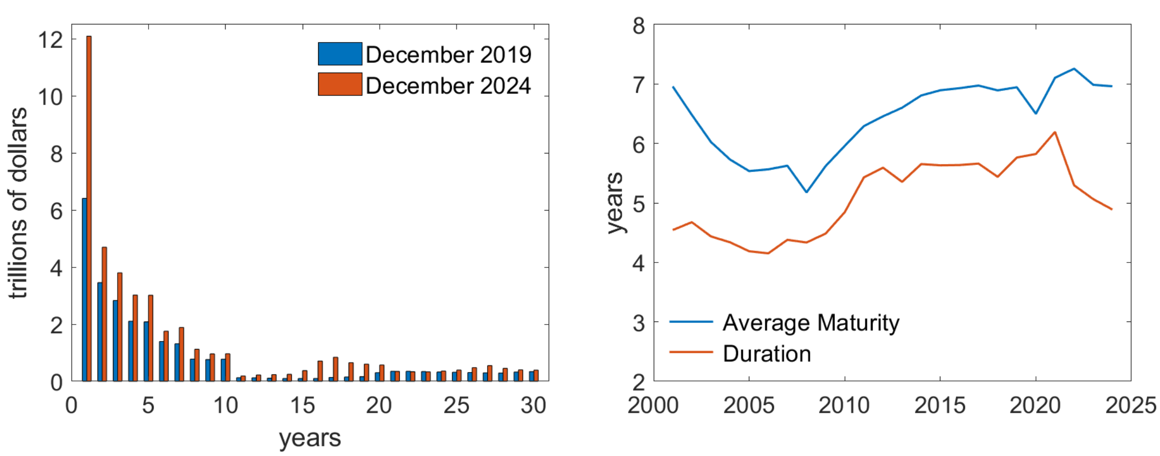
Debt service profiles indicate the sensitivity of market values of Treasury debt to changes in interest rates. Figure 10b plots the modified Macaulay's duration, denoted by D^*, and the average maturity of the Treasury's promised cashflows (both coupon and principal payments) on

[36] In Panels 10a and 10b we use marketable debt held by the public, which includes debt held by both private investors and the Federal Reserve. Thus, we exclude nonmarketable debt, such as savings bonds and debt held by government agencies and trust funds.

	Nominal	Real
Implicit Treasury Return	2.25	-0.35
	[0.45]	[2.56]
Treasury Average Interest	2.17	-0.44
	[0.46]	[2.66]
Holding Period Return	1.56	-1.02
	[9.15]	[10.29]

Table 4: Means and Standard Deviations of Three Measures of the Rate of Return on Marketable Treasury Debt Held by the Public: 2011-2024

Quarterly returns reported at an annual rate. Standard deviations are reported in brackets below the means.



(a) Debt Service Profile: 2019 and 2024 (b) Average Maturity and Duration

Figure 10: Debt Service Profile, Average Maturity, and Duration of Marketable Treasury Debt held by the Public.

Debt Held by the Public includes debt held by private investors and by the Federal Reserve. Duration is the modified Macaulay duration. Both series are measured annually at the end of the year.

December 31 of each year.[37] From 2019 to 2024, these two variables along with implied yields to maturity were:

	December 31 of					
	2019	2020	2021	2022	2023	2024
average maturity (in years)	6.95	6.50	7.11	7.26	6.99	6.96
modified duration (in years)	5.76	5.82	6.19	5.30	5.06	4.89
yield to maturity (percent)	1.96	1.09	1.42	3.45	3.47	3.92

The average maturity of federal debt rose in 2022, but as yields increased durations fell; the duration of a promised cash flow and the sensitivity of its price to interest rate risk are typically lower when yields across all maturities are higher.

To measure the impact on the market value of Treasury debt of a one basis point (or 0.01 percentage point) parallel shift in Treasury yields across all maturities, a textbook formula relates a change in a yield to maturity (Δy) to a change in bond prices:

$$\frac{\Delta P}{P} = -D^* \times \Delta y. \tag{17}$$

At the end of 2021, a one basis point increase in the yield would have decreased the market value of the debt by 0.062%. Formula (17) provides back-of-the-envelope estimates for decreases in the market value of the Treasury's portfolio of marketable securities of -2.7% and -15.0% in 2021 and 2022 respectively.[38]

Table 2 indicates that the 2022 reduction in the debt/GDP ratio due to inflation more than offset the primary federal budget deficit.[39] Missale and Blanchard (1994) note that an opportunistic government is more tempted to use surprise inflation to reduce its debt/GDP ratio the bigger is its debt and the longer is that debt's duration and that government creditors understand that. Fearing confiscatory surprise inflations, they don't buy long-duration government debt when a debt/GDP ratio is high. Despite Missale and Blanchard's logic, panel 10b shows that the duration of the US Treasury portfolio remains high relative to what it was before 2010. Nevertheless, as discussed in subsection 4.6, the Federal Reserve's Treasury portfolio is over-weighted toward long-duration bonds, and private investors have indeed reduced their holdings.

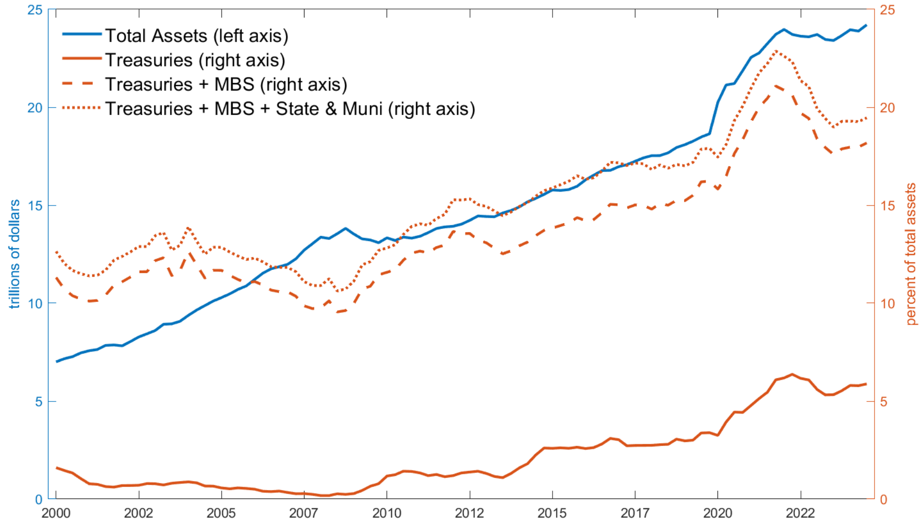


Figure 11: Total Bank Assets (left axis) and Bank Holdings of Treasuries, Mortgage Backed Securities, and State and Municipal Bonds as Percents of Total Assets (right axis)

Source: FDIC, Assets and Liabilities of FDIC-Insured Commercial Banks and Savings Institutions.

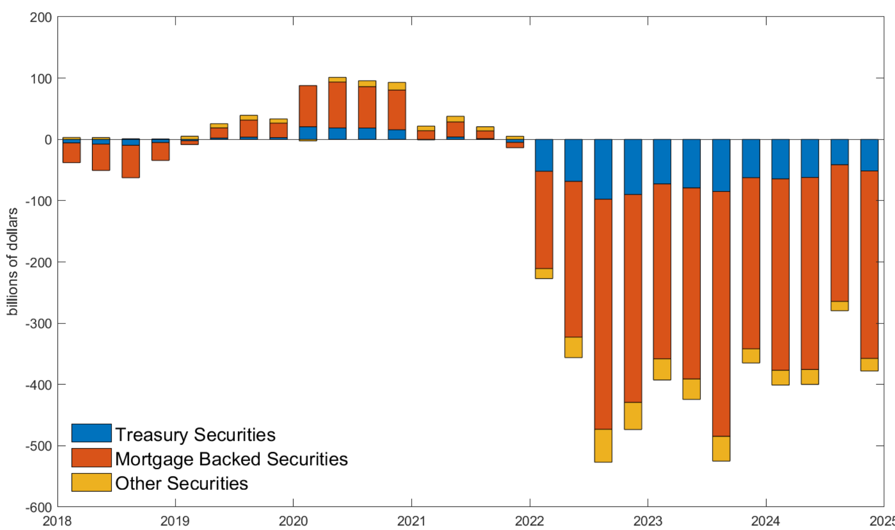


Figure 12: Unrealized Gains and Losses at Commercial Banks and Other Depository Institutions

Source: FFIEC, Call Reports, Schedule RC-B.

4.5 Capital Losses by Depository Institutions

Table 3 indicates that in December 2022, commercial banks and other depository institutions held \$1.7 trillion in Treasury securities (about 5% of the gross outstanding stock). Figure 11 plots total bank assets (left axis) and bank holdings of Treasuries, mortgage-backed securities, and state and municipal bonds as shares of total bank assets (right axis). In mid-2020, the US Treasury began distributing payments to individuals and businesses as instructed by the CARES Act. Total assets at commercial banks and savings institutions surged in 2020 after individuals and businesses deposited CARES Act benefits into their bank accounts. Banks responded by holding more Treasury and mortgage-backed securities as shares of their total assets. In 2022 those securities suffered capital losses that were only partially offset by gains in 2023 and 2024.

Figure 12 plots unrealized gains and losses recorded by bank call reports. For the fourth quarter of 2024, unrealized losses on bank balance sheets totaled \$378 billion. Of these losses, \$52 billion were on US Treasuries, \$306 billion were on residential and commercial mortgage back securities, and \$21 billion were on government agency debt, asset-backed securities, and state and municipal securities. Jiang et al. (2023a) detected only limited banks' purchases of hedges that would have offset these losses. Jiang et al. (2023b) found that in 2023 the market value of the US banking system was \$2 trillion lower than recorded by book values and that almost 190 US banks would become insolvent if half of their uninsured depositors were to withdraw their deposits. This situation incentivized the Fed to step in *ex post* to insure those deposits.

In Spring 2023, Silicon Valley Bank, Signature Bank, and First Republic, three midsize US banks, failed.[40] When depositors recognized large unrealized losses on these banks' assets, they withdrew deposits. The Federal Deposit Insurance Corporation (FDIC) took over the three banks and almost immediately agreed to insure all depositors, including those over the prior limit of \$250,000.

To head off additional bank runs, the Federal Home Loan Banks (FHLB) began accepting mortgages as collateral for high-interest loans to commercial banks, thus joining the Fed as another lender of last resort. In addition, the Federal Reserve started a Bank Term Funding Program (BTFP) through which it makes loans of up to one-year maturity to banks and other depository institutions in exchange for collateral in US Treasuries, US agency securities, and US agency mortgage-backed securities that the Fed does not mark to market. In a significant break from

[37] We treat principal and coupon payments symmetrically. The US Treasury typically reports the average maturity of just its promised principal payments; see for example, Table FD-5 of the *Treasury Bulletin*. Hence, our measure of average maturity is longer than the Treasury's measure.

[38] In section 4.2, we reported losses for the aggregate Treasury portfolio of -1.4% and -9.3% in 2021 and 2022 respectively.

[39] Hall and Sargent (2022) estimate that inflation accounted for 71% of the post-World War II reduction in the debt/GDP ratio; but, in 1945 a much larger share of the debt held by private investors consisted of longer-term Treasury notes and bonds than is the case today.

[40] A fourth bank, Silvergate Capital Corp., volunteered to self-liquidate.

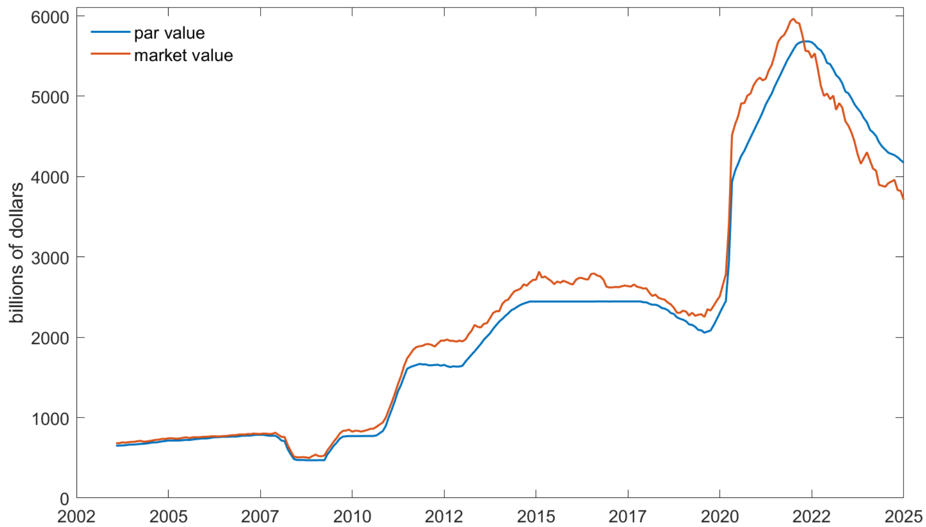
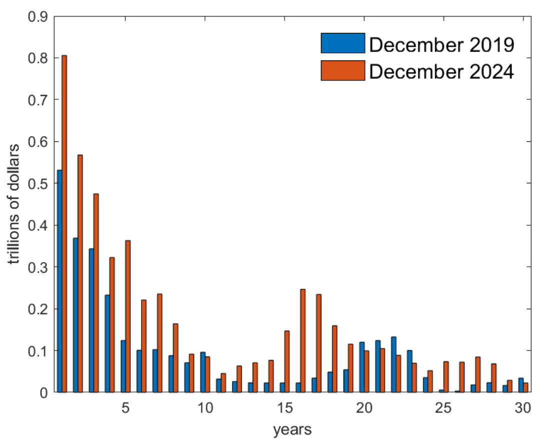
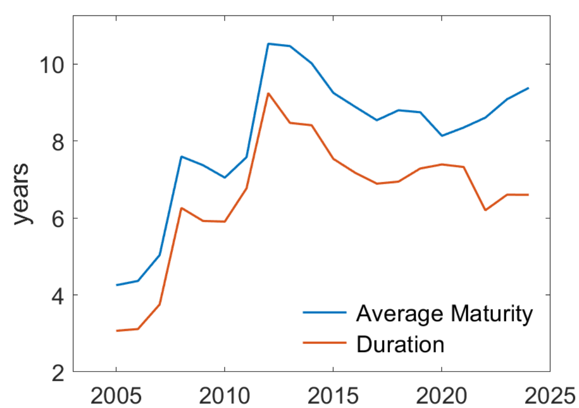


Figure 13: Par and Market Value of the Federal Reserve's Holdings of Treasury Securities



(a) Debt Service Profile: 2019 and 2024



(b) Average Maturity and Duration

Figure 14: Debt Service Profile, Average Maturity, and Duration of Marketable Treasury Debt held by the Federal Reserve.

Duration is the modified Macaulay duration. Both series are measured annually at the end of the year.

longstanding discount window policy that had adhered to a "Bagehot rule" that "seeks to value securities collateral at a fair market value estimate," the Fed now values collateralized assets at par under the BTFP.[41]

Banks quickly signed up for this new Fed lending facility: Figure 4a indicates that during two weeks in March 2023 the Federal Reserve's balance sheet grew by nearly $400 billion. This increase coincided with increases of $300 billion in private securities discounted by the Fed and increases of $60 billion in Treasury securities held by the Fed under repurchase agreements. The Fed increased bank reserves and reverse repurchase agreements to acquire these additional assets.

By valuing collateral at par, the Fed has created an asymmetric payoff that encourages banks to employ a "Hail Mary" strategy analyzed by Silber (2021): the Fed provides troubled banks an incentive to gamble for resurrection by buying high-coupon, long-duration Treasury bonds whose values swing inversely with changes in interest rates. If long-term rates fall, the banks earn capital gains; but if interest rates continue to rise, these bonds incur capital losses that the banks will pass on to the Fed and the FDIC.

4.6 Federal Reserve Capital Losses

Table 3 indicates that the Federal Reserve held $5.4 trillion in Treasury securities as well as its $2.6 trillion of mortgage-backed securities (MBS) in December 2022. By December 2024, the Fed had reduced its holding of Treasuries to $4.3 trillion and its holdings of MBSs to $2.3 trillion.

Figure 13 plots par and market values of the Federal Reserve's holdings of Treasury securities. The blue line corresponds to the green-shaded area in panel 4a. At its peak, in July 2020, the market value of the Fed's portfolio *exceeded* its par value by $653 billion. During 2022, the market value of the portfolio fell by $821 billion relative to its par value. In December 2024, the market value was $463 billion (or 11.1%) *less* than the par value of the portfolio.[42]

We estimate that holding period returns on the Fed's Treasury portfolio were -1.8% and -10.8% in 2021 and 2022 respectively; since then then Fed has earned +4.8% in 2023 and +0.8% in 2024. Cecchetti and Hilscher (2024) note that since Federal Reserve's losses on Treasury securities are gains by the Treasury, then they are economically irrelevant intra-federal-government transfers if all that matters are our section 2 consolidated government budget constraints.[43] But the Fed's

[41]This makes interpreting US debt reports less informative, confounding the conceptual difficulties described in Hall and Sargent (2011). These misleading accounting practices could become more concerning in light of the Fed's post-2008-financial crisis establishing "lender of last resort facilities" to more and more institutions and now adding what Bernanke (2022) calls "buyer of last resort" facilities.

[42]The Federal Reserve recognizes these substantial unrealized losses on its balance sheet. Table 4 of SOMA (2024) records that during 2022 and 2023 the Fed suffered $1,080.4 and $948.4 billion in unrealized losses, respectively. By the end of 2023, the Fed's portfolio of Treasury securities had $585.2 billion in unrealized losses. The Fed has another $363.3 billion in unrealized losses on its MBS holdings, nearly all of which have maturities longer than ten years.

[43]But see Bassetto and Sargent (2020, sec. 6).

losses on its portfolio of private assets are different because they represent a transfer from US taxpayers to private sector debtors.

Fed open market operations called "quantitative easing" have altered the maturity structure of debt held by private investors. Evidently, the Federal Reserve's portfolio of Treasury securities has tilted toward longer-term issues, notes, and bonds. Treasury bills comprise a relatively small share. The Federal Reserve's holdings of Treasury securities from 2021 to 2024 (in billions of dollars) were

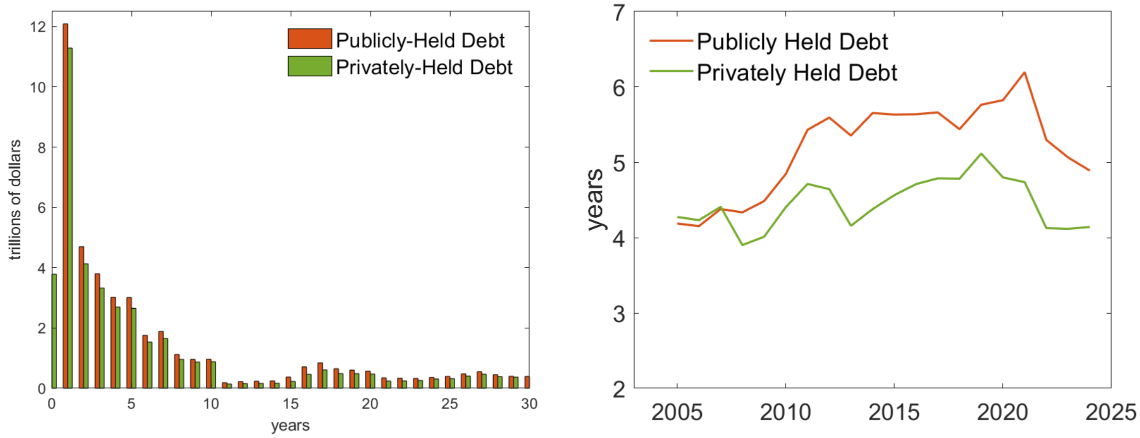
	December of			
	2021	2022	2023	2024
Bills	\$326.0	\$291.2	\$222.4.1	\$195.3
Notes and Bonds	4,846.5	4,702.4	4,077.1	3,629.4
TIPS	383.2	377.4	365.6	341.6
Floating-Rate Notes	24.3	27.2	11.7	6.3
Total	\$5,580.1	\$5,398.1	\$4,676.6	\$4,172.7

In December 2022, \$17.8 trillion in marketable Treasury notes and bonds were outstanding. The Fed owned \$4.7 trillion, 26.5% of these obligations.

Figure 14a reports nominal amounts (both coupon and principal payments) that the Treasury has promised to pay the Federal Reserve each year for the subsequent 30 years as of December 2019 and December 2024, and in Figure 14b we report the modified Macaulay's duration and the average maturity of the promised cashflows (both coupon and principal payments) from its holdings of Treasury securities on December 31 of each year. Comparing these numbers to Figures 10a and 10b, which report these statistics for the aggregate Treasury portfolio, indicates that the Fed's portfolio has both a higher average maturity and a longer duration than the aggregate Treasury portfolio.

To portray influences of the Fed's holdings on the maturity structure of private holdings of Treasuries, Figure 15a plots the dollars (both coupon and principal payments) that the Treasury has promised to pay public holders (which include the Fed) as of December 2024. These red bars are the same as the red bars in Figure 10a. We make two adjustments to construct the debt service profile of privately-held debt. First, we net out the Federal Reserve's holdings of marketable Treasury securities (see Figure 14a). Second, we recognize that to pay for these purchases, the Fed issued overnight bank reserves and reverse repurchase agreements that we count as "zero-maturity" privately-held debt. Thus, the green bars in Figure 15a show how the Fed has altered the Treasury's scheduled payouts to private investors. At all maturities greater than zero, the Fed has reduced the quantity of Treasury debt held by private investors. To finance that, the Fed made \$4.5 trillion overnight loans to private investors.[44]

[44]Note that measured interest costs on US Treasury debt include coupon payments to the Federal Reserve, but they exclude the Fed's interest payments on reserves and reverse repurchase agreements.



(a) Debt Service Profile: 2024

(b) Duration

Figure 15: Debt Service Profile and Duration of Marketable Treasury Debt held by the Public and Marketable Treasury Debt and Federal Reserve Debt held by Private Investors

Publicly-held Treasury Debt includes the Federal Reserve's holdings; Privately-held Debt does not. Duration is the modified Macaulay duration measured annually at the end of the year.

As a consequence, the duration of the portfolio of the privately-held marketable debt jointly issued by the Treasury and the Federal Reserve is substantially lower than the portfolio of publicly-held marketable Treasury debt. Figure 15b shows that differences in these maturity structures emerged along with the Fed's first quantitative easing program in 2008 and have persisted since then. At the end of 2021, the duration of privately-held debt was 4.7 years, while the duration of publicly-held Treasury debt was 6.1 years. Over the next three years, durations declined and the gap narrowed; at the end of 2024, the durations of privately- and publicly-held debt were 4.1 and 4.9 years, respectively. By buying long-term Treasuries and mortgage backed securities, the Federal Reserve transferred duration risk from private investors to itself.

4.7 Financing interest on reserves

Following the recommendation by Goodfriend (2002), the Federal Reserve finances its interest payments on reserves and reverse repurchase agreements from proceeds earned investing in long-duration Treasury and mortgage-backed securities. Goodfriend (2014) noted that this policy has caused the Federal Reserve to run a "bond market carry trade," borrowing overnight to buy long-duration assets without hedging any of its interest rate or duration risk. Net income from this carry trade is then remitted to the Treasury.

The Federal Reserve's net income is the difference between the interest income generated from

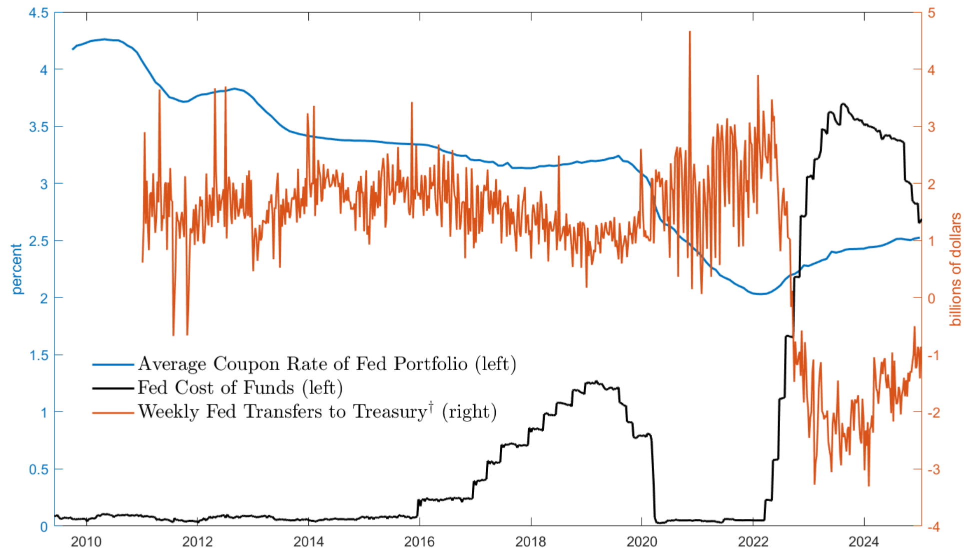


Figure 16: Federal Reserve's Average Coupon Rate, Cost of Funds, and Transfers to Treasury

† Federal Reserve transfers to Treasury are the Fed's weekly remittances before September, 14, 2022. After September, 14, 2022, these transfers are the weekly increments of the Fed's deferred asset, a negative Fed liability that represents cumulative shortfalls in the Fed's earnings. Fed remittances to the Treasury have been suspended until the deferred asset is paid down to zero.

its holdings of Treasury securities and private assets and the interest expense of its liabilities.[45] However, unlike in the equations in Section 2.5 in which net earnings are the difference between the holding period returns on private assets and government bonds, the Federal Reserve, like the Treasury, measures interest income by the flow of coupon payments and ignores the capital gains and losses we document in Section 4.6.[46] Thus, the measurement issues discussed in Section 4.3 re-emerge.

Figure 16 illustrates the measured earnings path of the Fed's carry trade. Following the Federal Reserve's definition of net income, the blue line is our estimate of the average coupon rate of the Federal Reserve's portfolio of Treasury and mortgage backed securities.[47] The black line

[45]The Federal Reserve earns income primarily from interest earned on the securities it holds and its provision of services to banks and government agencies. The Fed's expenses consist mainly of interest payments to banks, operating expenses, and miscellaneous other items. Its earnings net of expenses are distributed in one of three ways: 1) remittances to the Treasury; 2) as dividends to member banks; 3) as earnings retained in the Reserve Bank's surplus account; or else are 4) recorded in other comprehensive loss (following standard accounting procedures).

[46]SOMA (2024, p. 34) states "For securities that are held to maturity, unrealized gains or losses fall to zero over time as their price reverts to par at maturity. The SOMA's unrealized gain or loss position has no effect on net income or Federal Reserve remittances to the Treasury unless assets are sold and those gains or losses are realized."

[47]If we plotted the estimated holding period returns on the Fed's portfolio of Treasuries and MBSs, the series would look similar to the one reported in Figure 9.

is a value-weighted average of the Fed Funds rate, the award rate on reverse repos, and interest paid on currency (i.e., zero), a measure of the Fed's cost of funds. Evidently, from 2010 to late 2022, the Fed's coupon rate was consistently above its cost of funds, indicating that the Fed's carry trade made money. But when the Fed raised the overnight interest rate in 2022, it raised its own cost of funds. Starting in early September 2022, the Fed's carry trade started losing money because its borrowing costs exceeded earnings from its portfolio of Treasury and mortgage-backed securities.[48] As a consequence, as the red line records, the Fed's earning remittances to the Treasury turned negative.

The liability side of the Fed's balance sheet records these earning remittances due to the US Treasury as a *flow* when they are positive; but since late 2022 the Fed suspended all remittances and recorded the cumulative losses as a *stock*, labeled euphemistically as a "deferred asset." As of December 25, 2024, this liability stood at -$215.2 billion.[49] The Fed anticipates paying off this deferred asset when its carry trade eventually turns profitable again. To adjust for this stock-flow peculiarity, the red line in Figure 16 reports first-differences of the deferred asset series starting September 14, 2022. Since then, the Fed has lost between $1 and $3 billion each week. These losses aren't counted as federal expenditures, and they don't contribute to the official federal budget deficit.

Goodfriend (2002, 2014) anticipated times when Fed net earnings would be negative and suggested several ways to manage the Fed's cash flow. To manage that possibility, he suggested that instead of transferring 100% of net earnings to the Treasury, the Fed should retain a share of earnings to be held in the central bank's surplus capital account. The Fed could then run down these earnings during times of negative net earnings. The Fed did not follow that recommendation, but perhaps it now wishes it had because it may be forced to ask the Treasury or Congress to cover its operating costs if its carry-trade losses become sufficiently large. Doing that would probably bring unwanted discussions about Fed independence.

5 Taxes, Spending, and Debt

We compare paths of spending, taxes, and debt during and after the US War on COVID to paths during and after other major US wars. We detect patterns that endured from the early 1800s to the 1980s. During times of peace, the US federal government covered its ordinary expenditures with taxes. During four major wars – the War of 1812, the Civil War, World War I, and World War II – the US mostly just issued debt. During these four big wars, taxes increased but much less

[48] Levin et al. (2022) discuss the impacts of higher interest rates on the Fed's expanded balance sheet. Further, the Federal Reserve is not the only central bank to run this "bond market carry trade." Cecchetti and Hilscher (2024) document and discuss the fiscal impact of losses incurred by the Federal Reserve, the European Central Bank, the Bank of England, and the Swiss National Bank.

[49] Figure 4 shows that the Fed's balance sheet reports assets and liabilities of a little over $7 trillion at the end of 2024.

than spending. Although expenditures and taxes both fell after each of these big four wars, taxes stayed high enough to sustain post-war primary surpluses. After all four big wars, expenditures as fractions of GDP failed to return to their pre-war levels. Instead, the federal government grew during these four wars and stayed higher permanently. Thus, over the last 230 years, wartime federal expenditures have had both temporary and permanent components. And so did taxes.

Some of these patterns prevailed during the War on COVID, but not all of them. The federal government paid for the large unexpected surge in expenditures in 2020 and 2021 by borrowing and printing money. But unlike those earlier big wars, taxes were not increased enough to sustain a post-war primary surplus.

To analyze possible outcomes, we supplement our three years of post-War on COVID data with CBO for projections of spending, revenues, debt and other series. Consistent with historical patterns, the CBO (2025) projects expenditures as a share of GDP will be permanently higher from 2025 to 2035 than they were before the pandemic. Inconsistent with historical patterns, tax revenues as a share of GDP are not projected to increase relative to pre-pandemic levels. For the next ten years, the federal government will run primary *deficits* – not *surpluses*. In sharp contrast to expenditure surges associated with big 20th century US wars, CBO (2025) projects that the par value of federal debt as a share of GDP will increase – not decrease – over the next ten years. Ingredients of this projection are the CBO's projections of persistent primary deficits, low inflation rates, and large returns to bondholders. To acknowledge our uncertainty about prospective inflation rates and returns to bondholders, we project debt/GDP ratios under different assumptions about them, while maintaining the CBO's projections of primary deficits and real GDP. Under plausible assumptions about higher inflation rates and lower returns, debt/GDP ratios would fall as bondholders help pay for those persistent primary deficits.

5.1 Permanent Components of Expenditure Increases

Figure 2 plots actual and projected US federal government receipts and expenditures from 1775 to 2035. During the War of 1812, the Civil War, World War I, and World War II, government spending rose while taxes increased much less. Hence, these wars were largely financed by issuing debt and printing money. As we documented in table 1, taxes accounted only for 20.8% and 30.2% of the revenue that the US raised to fight World War I and World II, respectively – and much less for the War of 1812 and the Civil War.

After each of the four big wars, government spending fell while tax revenues remained elevated, so the government ran a primary surplus for many years. These primary surpluses were used to service debt incurred during the war. These patterns are broadly consistent with a government's responses to a *temporary* government spending shock in a Barro (1979) tax-smoothing model. While those wartime spending surges had temporary components, they also had permanent components. Enduring changes in the size and composition of government spending and

War Start - End (US entry -)	Fiscal Years†	G/Y prewar	G/Y war	G/Y postwar	T/Y prewar	T/Y war	T/Y postwar
War of 1812							
1812:6 - 1815:2	1812-1815	0.88	2.72	1.82	1.95	1.37	3.14
Civil War (Union)							
1861:4 - 1865:4	1861-1865	1.58	7.79	2.50	1.42	1.87	4.72
World War I							
1914:7 - 1918:11	1915-1919	1.88	9.10	3.17	1.94	3.30	5.03
(1917:4 -)	1917-1919	1.76	14.07	3.17	1.80	4.39	5.03
World War II							
1939:9 - 1945:8	1940-1946	8.21	25.43	14.00	5.52	12.89	15.86
(1941:12 -)	1942-1946	8.31	31.97	14.00	6.15	15.43	15.86
COVID-19							
2020:1 - 2021:12	2020-2021	19.18	29.02	20.49	17.12	17.05	17.84

Table 5: Average government spending net of interest payments and tax receipts as percents of GDP for five years prior to a war, during a war, and ten years after a war.

The postwar numbers for COVID-19 are computed using CBO (2023), CBO (2024), and CBO (2025) reported actual data for 2022-2024 and projections for 2025-2031.

taxation have followed large US wars. Figure 2 indicates that expenditure surges during the War of 1812, the Civil War, World War I, and World War II were followed by permanent rises in federal expenditures as fractions of GDP.[50]

Table 5 reports average spending and revenue as shares of GDP for the pre-war, war, and post-war periods for four large US military wars and the COVID-19 pandemic. The table confirms impressions gleaned from Figure 2: after each major war, government spending as a share of GDP (G/Y) increased relative to pre-war values.

Federal financing of the War on COVID shares some, but not all, patterns detected across previous wartime expenditure surges. In the War on COVID, taxes accounted for only 1.3% of the total revenue raised, a much smaller share than in the Civil War, World War I, and World War II. We already have three years of post-COVID data. To think about prospects for future years, we rely on the analysis of the Congressional Budget Office (CBO) to project paths of taxes, expenditures, and debt.

Look at Figure 17. For the three post-COVID years (2022-2024), outlays net of interest averaged 21.3% of GDP (up from 19.2% of GDP pre-COVID) and tax revenue averaged 17.7%

[50]Rothbard (2017, chs. 12-13) described forces that contributed to outcomes during and after World War I. Edwards (2014) examined 11 US wars and estimated that for every $1 increase in wartime spending, the US federal government spent another $0.50 (in present value) during the following 80 years on transfer payments and in-kind benefits provided to veterans and their spouses and other survivors. Hall and Sargent (2021, Figs. 27.6, 27.8) indicate that other important components of federal expenditures also increased permanently.

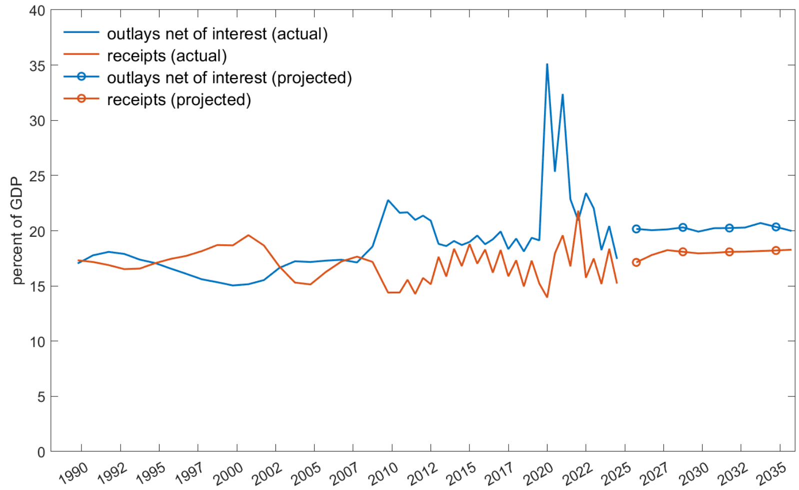


Figure 17: US Federal Government Expenditures and Receipts: 1989 to 2035.

Outlays are net of official interest payments. 1989-2010 annual by fiscal year; 2011-2024 monthly data aggregated to 6-month periods. Outlays and Receipts for 2025-2035 are from Table B-1 of CBO (2025).

of GDP (up from 17.1% of GDP pre-COVID). Like earlier wars, expenditures and tax revenues were both higher after the war than before, but unlike earlier wars, revenues were lower than expenditures as the federal government ran postwar primary deficits. Assuming, as Congress requires it to do, that laws now governing taxes and spending will not change, the CBO projects that these patterns will continue through at least 2035. From 2025 to 2035, federal government expenditures (net of interest payments) and tax revenue will average 20.2% and 18.0% of GDP, respectively, implying persistent primary deficits.

5.2 Debt/GDP's Destiny

Prospective primary deficits are likely to cause the par value of US Treasury debt to increase over the next ten years. Some analysts forecast that the debt/GDP ratio will increase. The CBO's Table B-1 of CBO (2025) projects alternative measures of the debt/GDP ratio. Ominously, the CBO reports

> From 2025 to 2035, debt swells as increases in mandatory spending and interest costs outpace growth in revenues. Federal debt held by the public rises from 100 percent of GDP this year to 118 percent in 2035, surpassing its previous high of 106 percent of GDP in 1946.

Later, they state

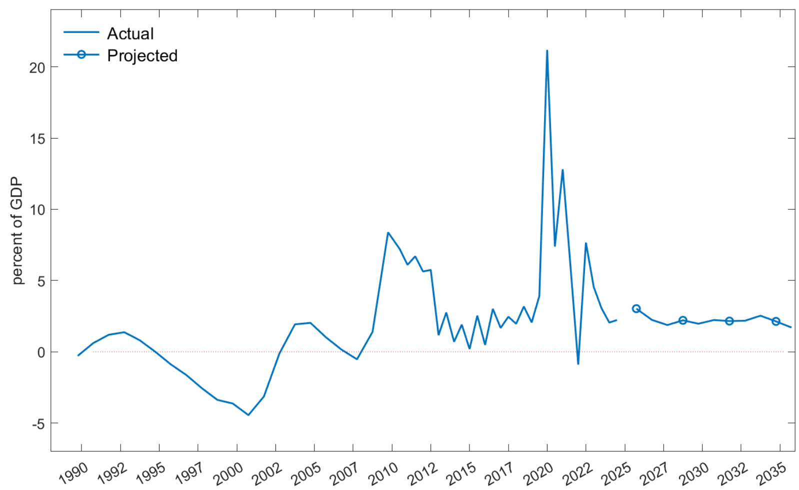


Figure 18: US Federal Government Primary Deficits: 1989-2035

1989-2010 annual by fiscal year; 2011-2024 monthly data aggregated to 6-month periods; 2025-2035 computed from Table B-1 of CBO (2025) projections.

> Net outlays for interest increase as debt mounts. Interest costs exceed outlays for defense from 2025 to 2035 and exceed outlays for nondefense discretionary programs from 2027 to 2035. From 2027 on, interest costs will be greater in relation to GDP than at any point since at least 1940.

Let's assess these projections.

First, consider the CBO's statements about the federal government's interest costs. In Figure 19 we plot the Treasury's Net Interest series as a share of GDP. As we can see, consistent with the CBO's analysis, interest costs, as measured by the Treasury and the CBO, climbed from 1.2% to nearly 3.5% of GDP from the second half of 2021 to the third quarter of 2024.

In Figure 20, we plot the Treasury's Net Interest series as a share of GDP, and we now add Net Payouts to Investors as a Percent of GDP. Net Payouts to Investors are defined as: $r_{t-1,t} \times B_{t-1}$ where $r_{t-1,t}$ is the value-weighted ex-post holding period return on debt held by the public, and B_{t-1} is the end of period $t-1$ market value of debt held by the public.[51] Note that the blue line

[51] The holding period return is the value-weighted ex-post holding period return on all marketable debt held by the public. We compute Interest Payments using data from the US Treasury's Interest Expense on the Public Debt Outstanding. To make the data comparable to our measure of the holding period returns, we sum the interest expense on public issues: accrued interest expense, amortized discount, amortized premium for Treasury Bills, Treasury Notes, Treasury Bonds, Treasury Inflation Protected Securities (TIPS), Inflation Protected Securities (TIPS), and Int. Expense Inflation Compensation (TIPS). Since CRSP does not compute the holding period returns on Floating Rate Notes (FRNs), we exclude them from the analysis. FRNs currently comprise 2% of the marketable debt held by the public.

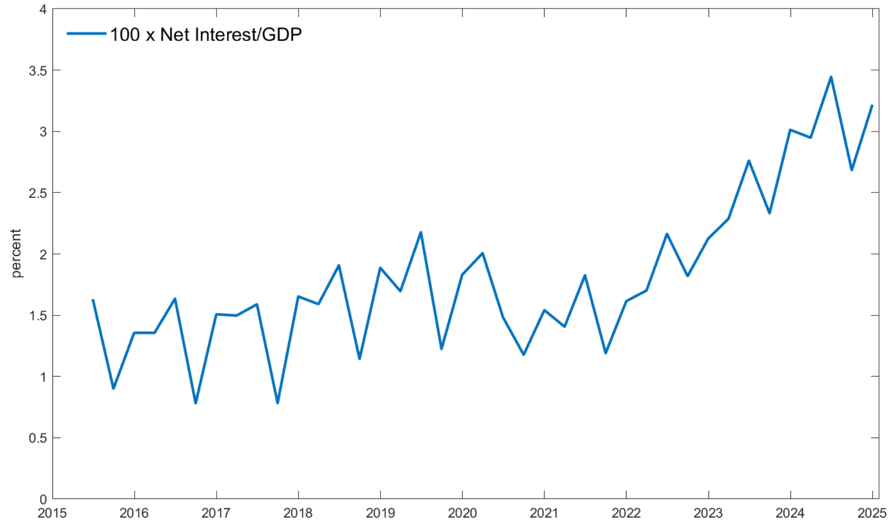


Figure 19: Official Net Interest Costs as a Percent of GDP

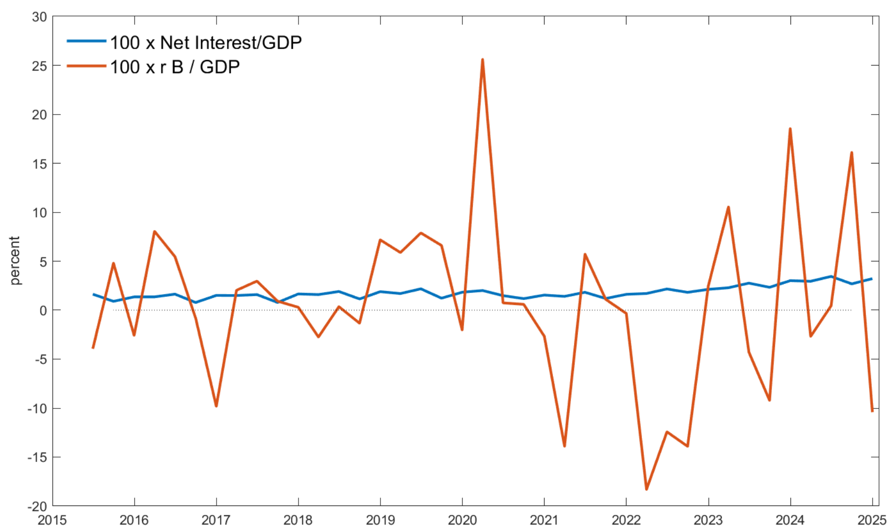


Figure 20: Official Net Interest Costs and Net Payouts to Investors as a Percent of GDP

	100 × Debt/GDP			Contributions					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2024:9	2035:9	change	nominal payouts	real GDP growth	inflation	primary deficit	money growth	Other
				$r_t \frac{B_{t-1}}{Y_{t-1}}$	$g_t \frac{B_{t-1}}{Y_{t-1}}$	$\pi_t \frac{B_{t-1}}{Y_{t-1}}$	$\frac{G_t - T_t}{Y_t}$	$\frac{M_t - M_{t-1}}{Y_t}$	
CBO: Par Value	82.6	95.8	13.2	39.9	-17.2	-19.0	24.2	-15.1	0.4

Table 6: Decomposition of Changes in Debt/GDP Ratio From CBO Projections

CBO: Par value is Public Debt minus Federal Reserve's holdings from Table B-3 of CBO (2025).
Other includes other means and the cross term.

in Figure 20 is the same blue line as in Figure 19, but the scale of the y-axis differs across the two figures. Predictably, these two series exhibit similar patterns to the rate of return series plotted in Figure 9.

The payout series is much more volatile than the official interest payment series. To understand why this series is so volatile, consider the first quarter of 2020.[52] During that quarter, the market value of publicly-held marketable debt was about \$18 trillion, and the quarterly holding period return on this portfolio was 7.1%. Hence, bondholders received a $(0.071 \times \$18)$ \$1.3 trillion payout. That quarter, GDP was \$21.7 trillion at an annual rate, so quarterly-GDP was \$5.4 trillion. Thus this payout as a percent of GDP was $100 \times 1.3/5.4 = 24\%$.

The payouts bondholders receive are significantly more volatile, and returns on Treasury debt are considerably more risky than implied by the Treasury's and CBO's accounting measure of interest costs. Hence any projection about the economic cost the federal government will pay to borrow (i.e., what bondholders will receive) must come with large uncertainty bands.

With this uncertainty about borrowing costs in mind, let us turn to the CBO's projections of the debt/GDP ratio.

Debt held by the Public includes that held by the Federal Reserve. To align the CBO's projections with our analysis, we measure debt as *Debt held by the Public* - *Federal Reserve's Holdings of Debt Held by the Public*. The CBO's measure is very close to our measure of *Debt held by Private Investors*.[53] The dashed line in Figure 21 projects a path of the par value of privately held debt as a percent of GDP that we constructed from projections of total outlays, revenue, net interest payments, and Federal Reserve holdings of debt and forecasts of real and nominal GDP provided in the CBO's data supplements.

Table 6 decomposes these projections using equation (16).[54] The table asserts that the ratio of

[52]In all our reported calculations, we compute holding returns and bondholders' payouts monthly and then aggregate this series to the quarterly frequency.

[53]Since the CBO's measure of *Federal Financial Assets* is much broader than our measure of *Net Treasury Balances*, we do not net out either series from either measure of debt. Unlike our analysis earlier in this paper, we do not net out any asset holdings by the Federal Reserve or other assets held by the Treasury.

[54]Yagan (2025) performs a similar debt decomposition.

privately held debt to GDP will rise 13.2 percentage points from 82.6 in September 2024 to 95.8 in September 2035.[55] Primary deficits and payouts to Treasury creditors push the debt/GDP ratio up, while real GDP growth, inflation and money growth push it down.[56] Of course, CBO forecasts for the nominal returns on US Treasury debt, real GDP growth, and inflation (as measured by the GDP deflator) underlie these projections. The CBO forecasts that from 2025 to 2035, these series will grow on average at the annual rates below:

	average growth rate 2025-2035
nominal returns	3.5%
real GDP growth	1.8%
inflation (GDP deflator)	2.0%

Congress has constrained the CBO to measure US Treasury debt and interest payments by the accounting measure used by the US Treasury. Hence implicit in these forecasts are assumptions that the market value of the debt always equals its par value and that US creditors incur neither capital losses nor gains on coupon-bearing debt. Those faulty conventions for accounting for interest costs induce errors in the CBO's Debt/GDP projections.

If one temporarily overlooks that misleading accounting convention and accepts the CBO's financing cost along with the CBO's projections for spending and tax revenues, we infer the following paths for the next ten years: 1. government spending, net of interest payments, will average 20.2% of GDP; 2. tax revenue will average 18.0% of GDP; and 3. nominal returns to bondholders will average 3.5%, and inflation will average 2.0% implying a real return of 1.5% per year. Accepting such projections at face value, Arslanalp and Eichengreen (2023) argue that there is little political or economic scope to change any of these three fiscal projections or the forecast of GDP and thus conclude that "high public debts are here to stay."[57]

But as mentioned earlier, we prefer not to constrain ourselves to use the CBO's faulty interest cost conventions and instead use the conventions to which macroeconomic and public finance

[55] Unlike the decomposition done in table 2, in this decomposition we measure debt at its par value rather than its market value. We measure the nominal returns to the bondholders by dividing reported interest costs by the value of the debt. We measure money growth by the change in the Federal Reserve's Holdings of Debt Held by the Public.

[56] The negative term in column (8) reflects the CBO's projection that the Fed will increase its holdings of Treasury debt from $4.5 trillion in 2025 to $9.9 trillion in 2035, reducing the amount of debt private investors must hold.

[57] They question whether sufficient political support could be assembled to put in place financial repressions that would extract more seigniorage from government creditors. They also say, as pointed out by Missale and Blanchard (1994), that a low average maturity of federal debt in the hands of the public reduces government revenues yielded by a given unexpected inflation. Also see Aizenman and Marion (2011) and Hilscher et al. (2022). But Missale and Blanchard's force operates in both directions: Since the maturity structure is much shorter today than it was in 1946 (see Figure 10 of Hall and Sargent (2022)), if the federal government wants to inflate away part of its debt today, it will have to push inflation much higher than it was in the late 1940s.

theory direct us to use.[58] Thus, we find it enlightening to study the consequences of adjusting the CBO's calculations by correcting the misleading interest cost calculation that Congress imposes on the CBO. We do this to facilitate comparisons with previous post-war US fiscal adjustments, for example, with table 2 where we calculated that high inflation and low nominal returns to bondholders accounted for roughly 45% of the post-World War II debt paydown.

An assumption underlying the CBO's projections is that the Treasury will be able to issue increasingly large quantities of new Treasury debt while interest rates and inflation decline over the next ten years. If demand for Treasury debt becomes more price-elastic or if market forces or Congressional legislation eventually impose an upper bound on Treasury debt, something has to give: some components of the CBO's input paths must change. To proceed, we study how the CBO's projections would change under two sets of assumptions:

1. We retain the CBO's projections for inflation and real GDP growth but scale the CBO's path of interest costs so bondholders will earn either low nominal returns averaging 2.5% per year or, in an alternative high nominal return scenario, earn an average return of 4.5% per year. The 2.5% nominal return is slightly higher than the nominal returns bondholders earned during the ten years immediately after World War II. The 4.5% nominal return roughly matches the current yield on ten-year Treasury notes. We'll continue to project that inflation will average 2.0% so that under the 2.5% nominal return assumption, bondholders will still earn positive real returns.

   Figure 21 presents our first set of reconstructed projections. Under the CBO's assumptions (dashed line), the debt/GDP ratio will climb to 95.8% by 2035. Under the high return assumption (dotted line), the debt/GDP ratio will rise to over 105.5% by 2035. Under the low return assumption (dotted line), the debt/GDP ratio stabilizes at just above 86%.

2. We repeat the exercise assuming that inflation is 1% higher each year than the CBO's projects. We present the second set of projections in Figure 22. Under the CBO's returns (dashed line), the debt/GDP ratio will climb to only 86.3% by 2035. Under the high return assumption (dotted line), the debt/GDP ratio will rise to 94.9% by 2035; under the low return assumption (dotted line), it will decline to 77.6%.

These back-of-the-envelope calculations illustrate a range of possibilities that flow from alternative plausible assumptions about the real returns that market outcomes will require the US federal government to pay its bondholders, where "plausible" means consistent with some episodes in US history like the ones from which we extracted the 2.5% and 4.5% scenarios.

Maybe "this time is different," and we are now in uncharted waters. Since US bondholders and others now confront a situation in which the status quo for tax and expenditure sequences is

[58]Hall and Sargent (2011) describe accounting conventions from macroeconomic theory that we recommend and implement.

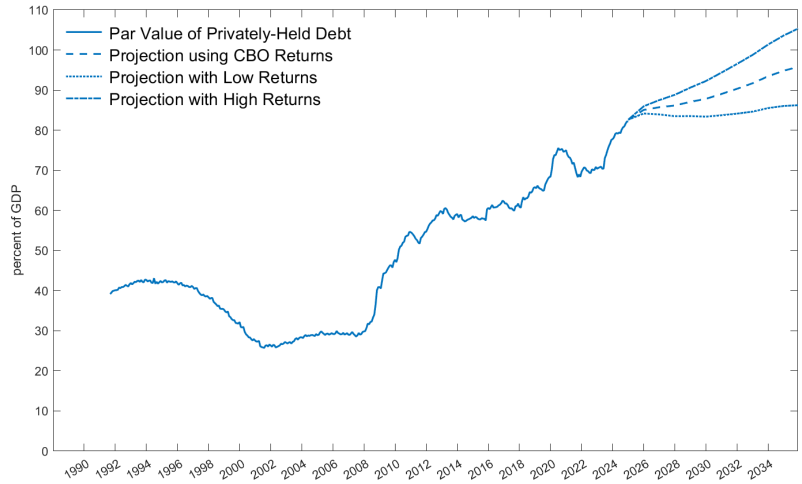


Figure 21: Par Value of Privately-Held Debt, Actual and Projected, as Percents of GDP.

Actual data are monthly through September 2024. The three projections are annual by fiscal year based on the projections and forecasts underlying CBO (2025).
Dashed line: Nominal return on the debt is the CBO's projection.
Dotted line: Nominal return on debt average 2.5% per year.
Dash-dotted line: Nominal return on debt averages 4.5% per year.

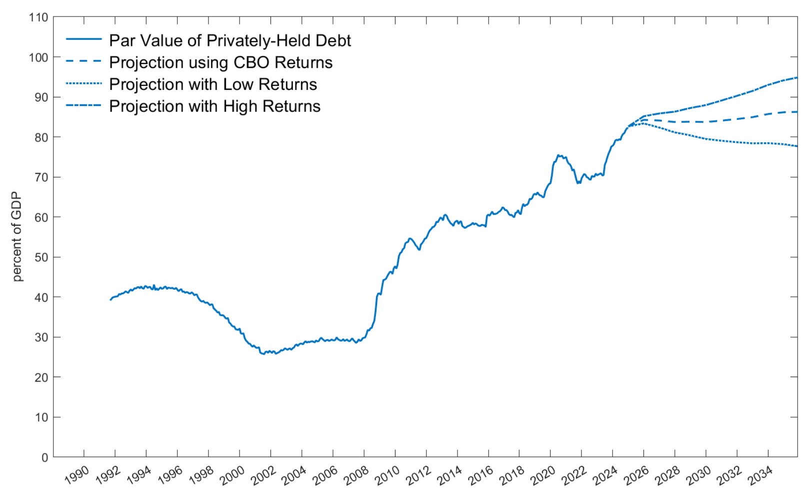


Figure 22: Par Value of Privately-Held Debt, Actual and Projected, as Percents of GDP Assuming Higher than Projected Inflation.

Actual data are monthly through September 2024. The three projections are annual by fiscal year based on the projections and forecasts underlying CBO (2025). All three projections assume inflation will be 1% higher each year than projected by the CBO.
Dashed line: Nominal return on the debt is the CBO's projection.
Dotted line: Nominal return on debt averages 2.5% per year.
Dash-dotted line: Nominal return on debt averages 4.5% per year.

widely regarded as unsustainable in the sense of not being budget-feasible, maybe patterns from the past won't be disrupted. Well-informed observers disagree about prospective US government debt/GDP paths. Thus, Acalin and Ball (2023) argue that the post-World War II period is not a good guide to the current situation since, going forward, it is unlikely that the debt/GDP ratio will fall for the same reasons it did after 1946. The Economist (2023) concurs, stating:

> Yet inflation only reduces debt when it is unexpected. If bondholders anticipate fast-rising prices, they will demand higher returns, pushing up the government's interest bill. Persistent inflation helped after the second world war only because policymakers held down nominal bond yields in a policy known as financial repression. Until 1951 the Federal Reserve capped long-term rates by creating money to buy bonds. Later a ban on paying interest on bank deposits would redirect savings to the bond market.

Perhaps we need to look at outcomes of adverse fiscal shocks beyond World War II and the three other wars we analyzed in Tables 1 and 2. Thus, we return to the plots of expenditures and tax revenues for the UK and France in Figure 1 and in pre-1789 period of the US in Figure 2. In the case of France and the early U.S., the debt/GDP ratio only came down after fiscal crises forced bondholders to accept low returns in exchange for commitments of future primary surpluses.

6 Concluding Remarks

Persistent US government deficits since 2000 call to mind Sargent and Wallace (1981) and Section 2 games of chicken in which distinct tax collection, government expenditure, and inflation rate authorities pretend to set sequences that are budget feasible only if the pretenses of one or both of the other authorities are abandoned. Each participant in such a game of chicken uses prospects of government debts high enough to provoke a debt crisis as a tool that it will use to convince one or both of the other authorities to change its continuation path. By limiting the present value of seigniorage, a determined monetary authority can restrain the present value of government deficits. And vice versa. This arithmetic leaves open whether the tax collection or government expenditure sequence does the lion's share of adjusting. Behaviors of US policy makers during the 19th century and 20th century regimes provide little guidance on how this will play out. US federal budget games of chicken started only in the 1980s, when President Reagan succeeded in using tax cuts and growing budget deficits to help persuade President Clinton to restrain spending in the 1990s to help generate fiscal surpluses. But when President George W. Bush handed large and growing deficits to President Obama, he responded by handing even larger deficits and debts to President Trump, who handed primary deficits to President Biden whose American Rescue Plan of 2021, Inflation Reduction Act of 2022, and other spending and loan forgiving commitments handed them back to President Trump.

Eventual outcomes will depend on the political-economic decision making processes that shape distinct tax collection, government expenditure, and inflation rate authorities' choices. Thinking about the sources of those choices can raise unpleasant possibilities. The persistent US government deficits since 2000 in Figure 2 bring to mind persistent deficits in both France and the US before 1789 (see Panel 1b of Figure 1). Those deficits were *structural*, i.e., they were "equilibrium outcomes" of pre-1789 political regimes in the US and France. Those outcomes changed only after the US and French 1789 political revolutions put in place new fiscal regimes. George Washington, Alexander Hamilton, and other US founders presided over a "second American revolution" that replaced the Articles of Confederation with the US Constitution of 1789 because they did not like the (equilibrium) deficit process the implied depreciated valuations of government debt that the pre-1789 Articles of Confederation regime had fostered.[59]

The striking 1789 Figure 2 break in the US government deficit process is widely credited to the subtle understanding and foresight of authors of the US Constitution in rearranging interests and decision making authorities. In designing the US Constitution they kept in mind the UK arrangements that had produced the fiscal outcomes in Panel 1a of Figure 1 (see McDonald (1985)). Things worked out well and quickly for the Americans. It took longer to eliminate fiscal deficits in France, where the law of unintended consequences had freer rein than in the US:[60]

> The government's [fiscal] crisis gave the aristocracy and the parlements their chance. They refused to pay without an extension of their privileges. ... The Revolution thus began as an aristocratic attempt to recapture the state. This attempt miscalculated ... for it underestimated the independent intentions of the 'Third Estate'—the fictional entity deemed to represent all who were neither nobles nor clergy, but in fact dominated by the middle class.
>
> Hobsbawm (1996, p. 58)

Milton Friedman said that governments confront problems only when they become crises. We hope that Friedman is wrong in this instance and that post-2000 US fiscal deficits turn out to be transitory and do not permanently disrupt US institutions.

[59] See Ellis (2016, ch. 1) and Sargent (2012).

[60] Sargent and Velde (1995) tell how French revolutionaries improvised monetary-fiscal actions in their efforts to service government securities issued by the pre-1789 French government, while also paying for a wartime surge in government expenditures. Each of these policies involved tweaks in terms that appear in our Section 2 accounting framework, including a "real bills" episode from 1789 to 1791 during which the government issued paper currency called assignats backed by claims to newly nationalized church lands, a fiscal repression episode enforced by the 1793-1794 Terror designed to push up the base $\bar{h}$ for the raising seigniorage via money creation, and a 1794-1796 classic hyperinflation yielding high inflation tax rate revenues. Sargent and Velde tell how in 1797 the Revolutionary government abruptly ended that hyperinflation by repudiating 2/3 of the national debt, eliminating the net-of-interest government deficit, and refraining from printing paper money and reinstating gold and silver coins. In 1799, Napoleon Bonaparte became first consul and for the next 15 years used resources confiscated from conquered territories to finance French government expenditures.

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