Exorbitant Privilege Gained and Lost: Fiscal Implications*

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Abstract

We study three centuries of U.K. fiscal history. Before WW-I, when the U.K. dominated global bond markets, the U.K.'s government debt was not always fully backed by its future surpluses, even after accounting for the seigniorage revenue from convenience yields. As predicted by theories of safe asset determination, investors concentrate extra fiscal capacity in a single country, the global safe asset supplier, based on relative macro fundamentals, and its debt growth may temporarily outstrip what is warranted by its own macro fundamentals. After the relative deterioration in U.K. fundamentals, due to the run-up in debt during WW-I and WW-II, bond investors focused exclusively on the U.K's own macro fundamentals. Since then the U.K. debt has been fully backed by surpluses.

JEL codes: bond pricing, fiscal policy, term structure, convenience yield,exorbitant privilege

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1 Introduction

We measure the fiscal capacity of the United Kingdom over the last three centuries, and compare it to that of the U.S. Consistent with theories of safe asset determination (Farhi and Maggiori, 2018; He, Krishnamurthy, and Milbradt, 2019), the U.K.'s pre-WW-I experience suggests that, as the world' safe asset supplier, it could temporarily borrow more than what seemed warranted by its own macro fundamentals alone.

In the two centuries before WW-I, only about 3/4 of the U.K. debt was backed by future surpluses, according to our estimates, even after accounting for the convenience yields earned by the U.K. Treasury. After WW-II the U.K. lost its position at the center of global finance. Since then, bond market investors rely only on U.K. macro fundamentals matter when assessing its fiscal capacity. Since 1946, the U.K.'s debt has always been more than fully backed by our estimate of future surpluses. In other words, U.K. yields seem too low before WW-I, even after accounting for convenience yields, but not after WW-II.

Our measure of the U.K.'s fiscal capacity accounts for the effect of lower yields from global safe asset demand. In the 19th century, London was the world's financial center, and U.K. government debt, mostly consoles, played a central role in securities markets. Around 1815, the U.K.'s national debt accounted for more than 1/2 of the world's traded securities.[1] Prior to WW-I, the U.K. also found itself at the center of the global trade network. The pound was the world's reserve currency. As a result, throughout the 19th century, the U.K. government had a quasi-monopoly as the world's safe asset supplier.[2] Safe asset demand typically lowers the equilibrium yields on assets below yields on otherwise comparable bonds (Krishnamurthy and Vissing-Jorgensen, 2012). Indeed, U.K. government debt traded at yields that were much lower than government bond yields of other countries on the gold standard. The U.K. appeared to earn "convenience yields" of up to 100 bps on its government debt prior to WW-I. However, the revenue boost if not large enough to close the gap with the fiscal capacity.

The U.S.' 19th century fiscal experience was quite different. As the Secretary of the U.S. Treasury, Alexander Hamilton was frustrated by the United Kingdom's ability to tap bond markets at lower interest rates (Hall, Payne, Sargent, and Szőke, 2021). Throughout the 19th century, U.S. yields were much higher, even though the U.K. had issued more debt relative to its output than the U.S.[3] The U.S. and U.K. yields converged only towards the end of the 19th century.

There is no evidence of the U.K. earning convenience yields after WW-I. The U.K. abandoned

[1] According to contemporary sources cited by Odlyzko (2016).

[2] In recent work, Choi, Kirpalani, and Perez (2022) explore the equilibrium implications of having a monopolist supply the world's safe assets.

[3] To address this, Hamilton set out to buy back U.S. foreign debt owed to France, Spain, and Holland, in order to build a reputation for debt repayment.

the gold standard at the start WW-I, then briefly returned to it in 1925, only to permanently abandon it in 1931. After WW-II, the dollar became the new global reserve currency in the new Bretton-Woods international financial architecture (Eichengreen, 2011). The U.S. took over the baton from the U.K. as the hegemon in the international financial system, and has carried the moniker ever since.

When the U.K. was the hegemon in the international financial system, prior to WW-I, its market value of government debt exceeds our estimates of its fiscal capacity. After WW-II, the U.K.'s relative macro fundamentals had deteriorated sufficiently to cause global investors to look for an alternative global safe asset supplier. The U.K. lost its license to borrow more than its fiscal capacity, at least based on its own macro fundamentals. In this subsample, our estimate of U.K. fiscal capacity acts effectively as an upper bound on its borrowing.

Reflecting the reversal of fortunes, we find that the U.S. borrowing never exceeds its fiscal capacity before WW-I, but does so consistently after WW-II when the U.S. becomes the global safe haven asset. However, we find that the U.S. post-war experience is fundamentally different from the U.K.s' pre-war experience. The gap between fiscal capacity and debt is much larger for the post-war U.S. than the pre-war U.K. According to our estimates, less than 1/3 of U.S. Treasury debt is backed by future surpluses. Much of the average gap post WW-II is due to the sharply rising gap over the past two decades. Our measure of fiscal capacity (inclusive of convenience yields) is strongly positively correlated with observed debt dynamics in the U.K. pre-WW-I but negatively correlated in the U.S. after WW-II.

We measure fiscal capacity using the forward-looking discounted cash flow approach developed by Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2019). To forecast the joint dynamics of taxation revenue, spending and GDP, we use a Vector AutoRegression (VAR) which imposes co-integration of GDP with tax revenues and government spending. The historical sample that covers centuries of government spending and taxation helps to attack the question of fiscal sustainability. In short samples, econometricians have to confront the peso problem. In this setting, the peso problem evokes the possibility of large fiscal adjustments with small probabilities that are anticipated by investors, but do not occur in the sample.

We have to deal with structural breaks in the data generating processes. Prior to WW-I, in the pre-Keynesian era, fiscal policy was fundamentally different. The U.K. and the U.S. were not engaged in counter-cyclical fiscal policy. Spending and tax revenue were roughly constant as a share of output except during times of war. The U.K. government only ran large deficits during war time, not during recessions. Spending/output and taxes/output inherit the risk properties of output. We impute the market or output risk premium to the spending and tax revenue claim to measure fiscal capacity.

After WW-II, spending/output (tax revenue/output) is counter-cyclical (pro-cyclical). As explained by JLVX (2019), imputing the market or output risk premium puts an upper bound on the PDV of surpluses in the post-war era. Our U.K. exercise validates the JLVX (2019) approach to fiscal capacity measurement. Before WWI, our measure of U.K. fiscal capacity is highly correlated (0.90) with the debt/output ratio. After WWII, the correlation drops only slightly.

According to our estimates, prior to WW-I, the U.K. had significant fiscal capacity. Fiscal capacity even exceeds the U.K.'s GDP after the Napoleonic wars. The U.K.'s macro fundamentals matter. The two main drivers of its fiscal capacity are large primary surpluses and large convenience yields. In this pre-WW-I sample, the U.K. runs a large average primary surplus of 2.3%, punctuated by large, transitory deficits of up to 10% of GDP during wars. In addition, the U.K. earns an additional 0.5% of GDP in seigniorage revenue from its ability to sell its bonds at higher prices.

We compare the valuation of debt to the underlying collateral, the surpluses. Our estimates of fiscal capacity look past transitory deficits due to war, as do the bond market investors valuing the debt. While fundamentals (surpluses) matter, they do not fully account for the valuation of U.K.'s debt. Our baseline estimate of fiscal capacity in the pre-1946 sample (69.32%) is 18% points lower than the average debt/GDP ratio (87.06%). The average ratio of fiscal capacity to debt is 74.32%.

This fiscal regime abruptly ends after WW-II. Our measure of fiscal capacity consistently exceeds the market's valuation of the U.K.'s debt after WW-II even after accounting for the seigniorage revenue from the convenience yields. The U.K.'s average post-war debt/GDP ratio of 53.42% is 30% points lower than our estimate of fiscal capacity of 82.03%. On average, the post-war U.K. fiscal capacity exceeds its debt by more than 50%.

The U.K.'s fiscal experience at the start of the 20th century might prove relevant for the U.S. in the 21th century. Being the world's safe asset supplier seems to allow countries to increase debt issuance beyond what conventional measures of fiscal capacity would allow, as investors are less concerned about rollover risk. However, after the U.K. pushed its debt/output ratio above 200% after the end of WW-II, it lost its role as the hegemon of the international financial system.

Prior to WW-I, the United States has much less fiscal capacity than the United Kingdom. First, the U.S. generates small surpluses of less than 0.5% of GDP before WW-I. Second, the U.S. did not earn convenience yields, and was forced to borrow at higher rates than the U.K. The average fiscal capacity estimate for the pre-1946 period is only 23.61% of U.S. GDP, which exceeds the actual average debt/output ratio of 16.53% of GDP. The ratio of fiscal capacity to debt is 169.36%. In the pre-war sample, the U.S. fiscal capacity was determined largely by its own macro fundamentals.

After WW-II, the average U.S. fiscal capacity of 13.20% of U.S. GDP represents only 32.20% of outstanding U.S. debt. Even after accounting for convenience yields, the observed debt/output

ratio is exceedingly high. Towards the end of the sample, the gap between the PDV of surpluses and debt outstanding exceeds U.S. GDP. We conclude that the U.S. post-war experience is quite different from the U.K. pre-war experience. Between 1860 and 1946, the U.S.'s debt is mostly backed by surpluses.

There is a wealth of evidence documenting that U.S. Treasurys are expensive relative to corporate bonds (Krishnamurthy and Vissing-Jorgensen, 2012; Bai and Collin-Dufresne, 2019), inflation-indexed bonds (Fleckenstein, Longstaff, and Lustig, 2014) and relative to foreign bonds (Du, Im, and Schreger, 2018; Jiang, Krishnamurthy, and Lustig, 2021; Koijen and Yogo, 2019), even after hedging out the credit, inflation, and currency risk respectively. Recently, HPSS (2021) show that 19th century U.K. consoles were expensive relative to similar U.S. instruments. We also find evidence that U.K yields were persistently lower than foreign yields during the gold standard regime before the start of WW-I.

Our contribution is to compare the valuation of U.K. government bonds not to other bonds but to the underlying collateral, its surpluses. We find that U.K. debt was expensive relative to the underlying collateral in the nineteenth-century, even after accounting for convenience yields, but not as expensive as U.S. debt in the second half of the twentieth century. Put differently, U.K. bond yields were too low before WW-I, and US yields were too low after WW-II, but the U.S. gap is much larger.

Our paper applies the methodology developed by JLVX (2019) to the U.K.'s long financial history. JLVX (2019) conclude that U.S. Treasurys are not backed by future surpluses in the post-WW-II era. This measure of fiscal capacity is driven by a country's macro fundamentals, but includes the convenience yields earned as a result of safe asset demand.

Our evidence helps to discriminate between models of fiscal capacity. First, when a country is the world's safe asset provider, we find evidence that relative macro fundamentals may matter in determining the valuation of its debt (He, Krishnamurthy, and Milbradt, 2019). In coordinating on a single global safe asset, there is strategic complementarity for the investors' payoffs. The investment of an additional investor reduces rollover risk (Cole and Kehoe, 2000) and hence renders the debt safer for all other investors. If the relative fundamentals improve, that may increase the country's ability to borrow at low rates, because of this coordination aspect, even if the absolute macro fundamentals measured by the PDV of surpluses do not warrant this. The imputed seigniorage revenue computed from the convenience yield, as traditionally measured, may not fully capture this safe asset effect.[4]

There is a growing literature in international economics that emphasizes the special role of the dollar as the reserve currency and the U.S. as the world's safe asset supplier (see Gourinchas

[4]Alternatively, we cannot rule out that our estimates of the convenience yields derived by the U.K. as the safe asset supplier are too low. That is another interpretation of our findings.

and Rey, 2007; Caballero, Farhi, and Gourinchas, 2008; Caballero and Krishnamurthy, 2009; Maggiori, 2017; He, Krishnamurthy, and Milbradt, 2018; Gopinath and Stein, 2018; Krishnamurthy and Lustig, 2019; Choi, Kirpalani, and Perez, 2022; Mukhin, 2022).[5] Our work contributes to this literature by exploring the fiscal implications of safe asset supplier status, the U.K. and the U.S., respectively before and after WW-I. Our paper contributes to the literature on the fiscal capacity of the government (Bassetto and Cui, 2018; Blanchard, 2019; Furman and Summers, 2020; Mehrotra and Sergeyev, 2021; Mian, Straub, and Sufi, 2021; Brunnermeier, Merkel, and Sannikov, 2022; Reis, 2021) by focusing on the role of global safe asset demand, similar to the focus of Liu, Schmid, and Yaron (2020).

Second, existing models of fiscal capacity that include seigniorage revenue derived from convenience yields tend to emphasize the special role of government bonds in allowing households and investors to insure against idiosyncratic risks (Bassetto and Cui, 2018; Chien and Wen, 2019; Angeletos, Collard, and Dellas, 2020; Brunnermeier, Merkel, and Sannikov, 2022; Reis, 2021), suggesting the seigniorage revenue would be larger in less financially developed countries with fewer insurance opportunities. Our results instead emphasize the special role of gilts then and Treasurys now in the international financial system as an additional driver of fiscal capacity, creating a role for that country's relative macro fundamentals, as evidenced by the U.K.'s pre-war and the U.S. post-war experience. Global investors coordinate on a single safe asset, concentrating fiscal capacity in one single country that is typically more financially developed, even beyond what is captured by our measure of the seigniorage revenue. As the fundamentals of the U.S. improved relative to the U.K.'s, investors shifted fiscal capacity to the U.S.

Third, there are equilibrium models that generate violations of the TVC including the models developed by Samuelson (1958); Diamond (1965); Blanchard and Watson (1982); Hellwig and Lorenzoni (2009); Dumas, Ehling, and Yang (2021). We impose the transversality condition (TVC) in our work, an optimality condition for long-lives investors. That requires taking a stand on what the right discount rate is to eliminate the terminal value (JLVX (2019)).[6] We include the risk premium on the market or total wealth in the discount rate for spending, taxes and future debt.

[5] Recently, Atkeson, Perri, and Heathcote (2021) report evidence that the U.S. may have exhausted its exorbitant privilege.

[6] Most of the models generating violations of the TVC (i) abstract from aggregate risk premia which would be priced into the terminal value and are likely to enforce the TVC (Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2020; van Wijnbergen, Olijslagers, and de Vette, 2020; Barro, 2020), and (ii) rely on the absence of long-term investors when pricing long-lived assets. The transversality condition on government debt we impose is an optimality condition for the long-lived stand-in investor. In OLG models, because there are no long-lived investors, there is no analogue to the transversality condition as an optimality condition, but there are investors in the real world with a long investment horizon (e.g., the Harvard endowment). If OLG-model-induced violations of the transversality condition are relevant for government debt, these violations would appear for other long-lived assets, like equities.

2 The Historical Cash Flow Dynamics: Stylized Facts

2.1 Data and Cash Flows

For the U.K., we use annual data from 1729 to 2020. The main U.K. dataset we used is *A Millennium of Macroeconomics Data* published by the Bank of England, which contains a broad set of historical macroeconomic and financial market data for the U.K. Our historical (1791-1929) U.S. government finance data were taken from Hall and Sargent (2021), which contain detailed historical government finance information starting 1791. We use other datasets to complement the main dataset, as detailed in Appendix A.

Over the course of three centuries, the U.K. runs positive primary surpluses of 1.36% of the GDP. The top panel of Figure 1 plots the U.K. central government's primary surpluses expressed as a fraction of GDP. The shaded areas are U.K. recessions. Before WW-I, the spending/output, tax/output and surplus/output ratios are largely acyclical. Table 1 reports the summary statistics for the ratios of tax revenue to GDP (τ) and government spending to GDP (g). In the pre-WW-I sample, reported in the top panel, the average U.K. primary surplus is 2.5% of GDP. Throughout the 19th century, the U.K. government was much larger than the U.S. government, as measured by spending and taxation as a % of GDP that are about three times higher in the U.K.

The U.S. surpluses are much smaller than the U.K's. Before WW-I, the U.S. realized a small primary surplus of 0.5%. After WW-II, the U.K. continues to run large primary surpluses of 1.8% of GDP (see bottom panel of Table 1), while the U.S. runs even smaller primary surpluses of 0.1% of GDP. The U.S. has consistently run surpluses of less than 0.1 % of GDP.

The bottom panel of Figure 1 plots the U.K.'s surpluses, where now the shaded areas indicate wars. The U.K. runs primary surpluses throughout the 19th century except during wars. The two largest primary deficits occurred during WW-I (average -33.7% from 1914 to 1918) and WW-II (average - 21.9% from 1939 to 1945) as a direct result of the U.K. entering these wars on the European continent. The moments for the pre-WW-II ear are reported in the middle panel of Table 1. In this sample, the average primary surplus of the U.K. government is 1.2% of GDP.

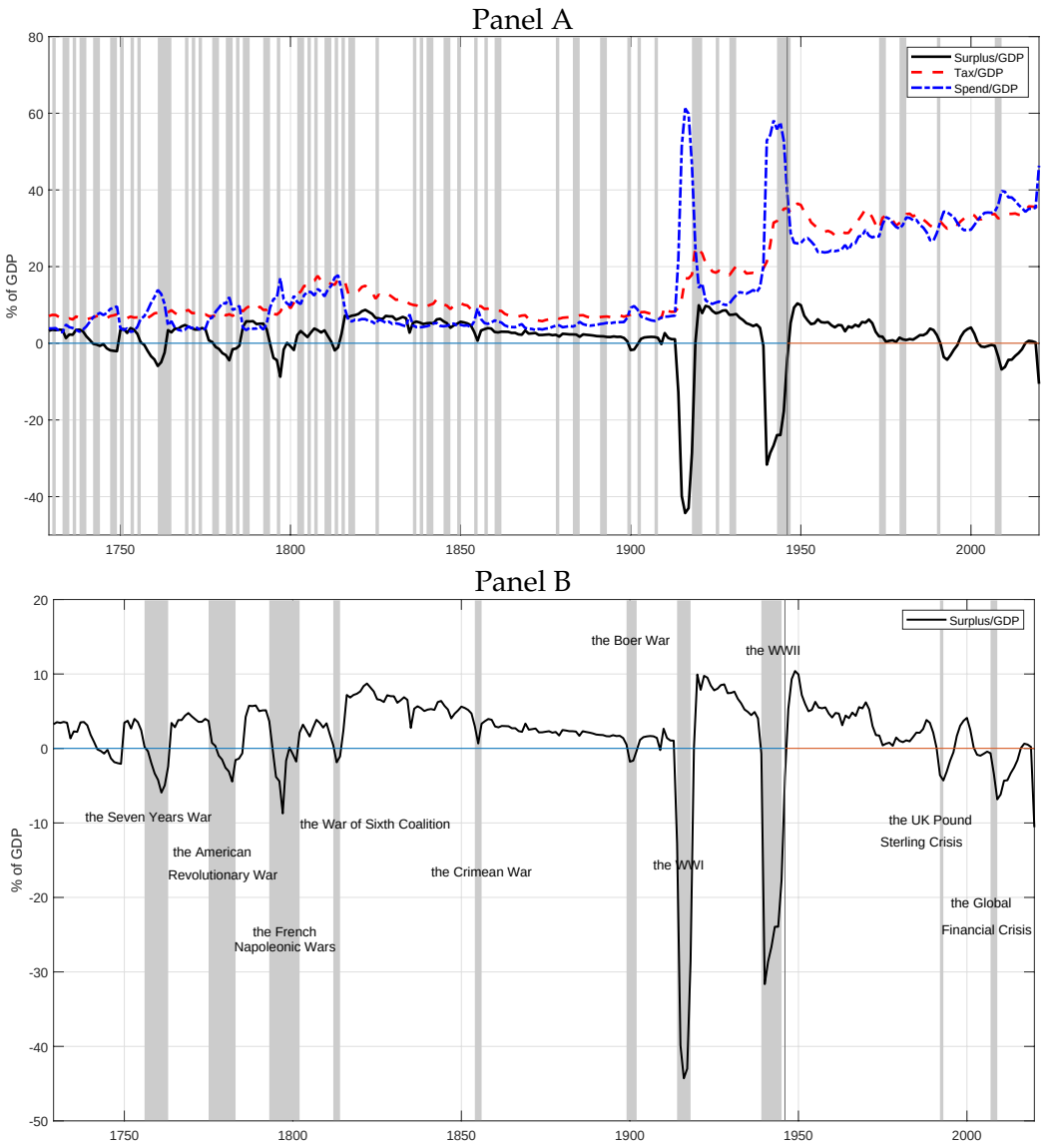
We obtain the market value of the U.K. public debt data using the data constructed by Ellison and Scott (2020), which contains the quantity and market price of every individual bond issued by the UK government starting in 1694. We compute the market value by matching each bond's ID for market price and quantity data, and summing across all individual bonds. The Ellison-Scott dataset includes only marketable debt. We also obtain the market value of the public debt (marketable plus non-marketable) from the *A Millennium of Macroeconomics Data*. Figure 3 plots the evolution of the market value of the public debt scaled by the U.K. GDP over time. The gap between the marketable debt portfolio and the total public debt portfolio from 1914 to 1980

Table 1: Summary Statistics of Government Finance

	mean	std	min	25%	50%	75%	max
Pre 1914 Sample							
Panel A: U.K.							
τ	9.0	2.7	5.8	7.0	7.9	9.8	17.6
g	6.5	3.2	2.9	4.3	5.3	7.5	17.7
$\tau - g$	2.5	3.0	-8.7	1.1	2.6	4.0	8.7
Panel B: U.S.							
τ	2.4	1.0	0.5	1.7	2.2	2.8	6.1
g	2.0	1.5	0.6	1.4	1.7	2.1	12.2
$\tau - g$	0.5	1.7	-8.9	0.1	0.5	1.4	3.3
Pre 1946 Sample							
Panel A: U.K.							
τ	10.8	5.6	5.8	7.2	8.5	12.7	35.2
g	9.6	11.0	2.9	4.4	5.8	10.4	61.2
$\tau - g$	1.2	8.0	-44.3	0.5	2.7	5.0	9.9
Panel B: U.S.							
τ	3.4	3.0	0.5	1.9	2.5	3.5	19.0
g	3.4	4.9	0.6	1.5	1.9	2.4	30.5
$\tau - g$	-0.1	2.8	-16.1	-0.2	0.4	1.4	3.3
1947 – 2020 Sample							
Panel A: U.K.							
τ	32.3	2.0	28.2	30.8	32.7	33.7	36.4
g	30.6	4.6	23.7	26.9	30.3	34.0	46.3
$\tau - g$	1.8	3.9	-10.6	-0.4	1.8	4.7	10.4
Panel B: U.S.							
τ	17.6	1.1	13.9	16.9	17.6	18.4	20.2
g	17.5	2.4	13.0	15.9	17.4	18.4	30.1
$\tau - g$	0.1	2.6	-12.4	-1.0	0.3	1.4	4.8

Note: The table reports summary statistics for the ratio of government spending to GDP (g) and the ratio of tax revenue to GDP (τ) for the U.K. central government and the U.S. federal government. The spending (g) is before interest payments. The surplus is the primary surplus ($\tau - g$). For the US, the full sample is from 1793 to 2020. For the UK, the full sample is from 1729 to 2020. All values are in percentage points.

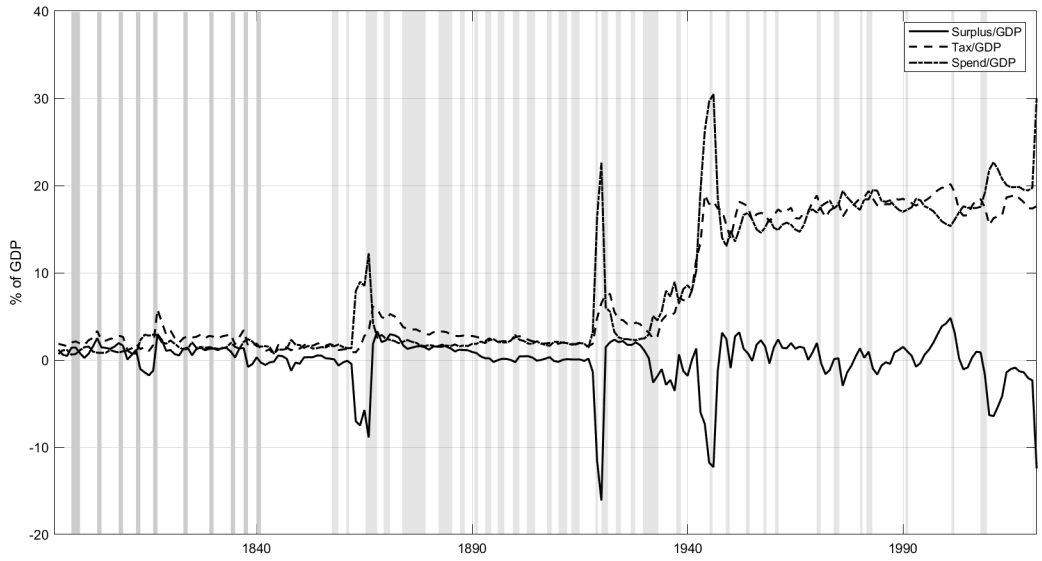
Figure 1: U.K. Primary Surpluses: 1729 – 2020



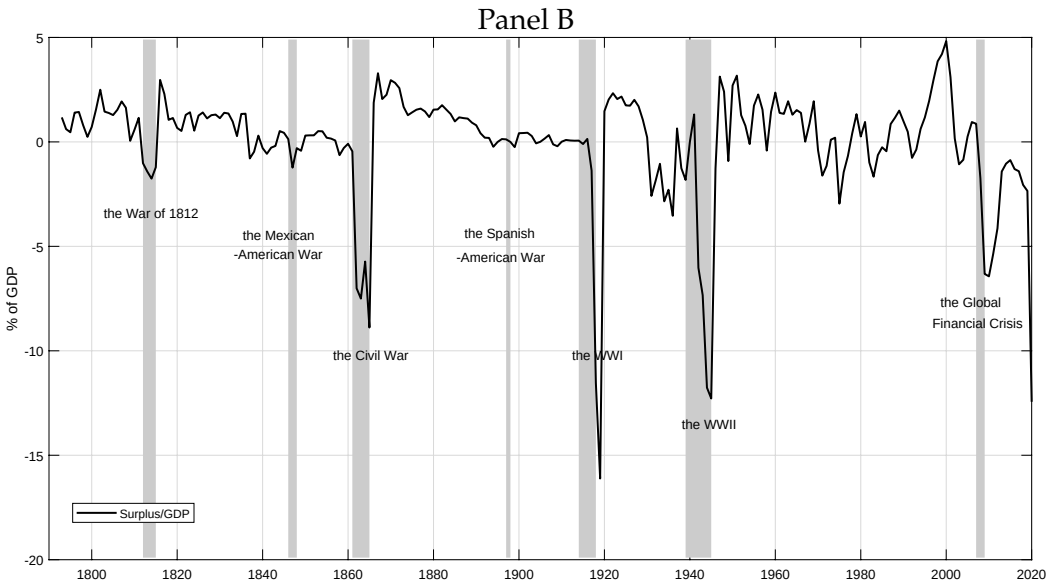
The figure shows the ratio of primary government surpluses to GDP for the U.K. from 1729 to 2020. The primary surpluses are the government revenue minus government spending before interest payments. Panel A shows the primary surpluses to GDP ratio, government spending to GDP ratio (g) and tax revenue to GDP ratio (τ). Shaded areas are recessions defined by Dimsdale and Thomas (2019). In Panel B, the shaded areas are major wars and economic crisis in the UK history that causes large economic impact: The Seven Years' war in 1756-1763, The American revolutionary war 1775-1783, The French Napoleonic Wars in 1793-1802, the War of the Sixth Coalition 1812-1814, Crimean War in 1853-1856, the Boer War in 1899-1092, the World War One in 1914-1918, the World War Two in 1939-1945, the UK Pound Sterling crisis in 1992, the Global Financial Crisis in 2008-2009. Data sources: *A Millennium of Macroeconomics Data*.

Figure 2: U.S. Primary Surpluses: 1793 – 2020

Panel A



Panel B



The figure shows the ratio of primary government surpluses to GDP for the U.S. from 1793 to 2020. The primary surpluses is the government revenue minus government spending before interest payments. Panel A shows the primary surpluses to GDP ratio, government spending to GDP ratio (g) and tax revenue to GDP ratio (τ). The shaded areas are recessions as dated by Davis (2006) for the 1796-1840 period and NBER recessions thereafter. In Panel B, the shaded areas are major wars and economic crisis in the US history: the War of 1812, the Mexican-American War, the Civil War, the Spanish-American War, World War I, and World War II, and the Global Financial Crisis.

consists of the sizable international government loans initiated during WW-I and WW-II.[7] Not surprisingly, the market value of debt/GDP peaked at the end of WW-II. The figure also shows a large increase in the outstanding debt starting in 2008. The debt/GDP ratio exceeded 100% at the end of 2020.

2.2 Convenience Yields

The U.K. was the world's safe asset supplier. Prior to WW-II, we measure the U.K. convenience yields as the yield difference with other sovereigns also on the gold standard. In the absence of default risk, interest rate differences during the gold standard are violations of covered interest rate parity (CIP), provided that the commitment to the gold standard is perceived to be credible. Du, Im, and Schreger (2018); Jiang, Krishnamurthy, and Lustig (2021) attribute these CIP violations in government bond markets to convenience yields driven by safe asset demand.[8]

To be clear, we cannot definitively rule out residual currency risk that differs across countries and currencies. We cannot definitively rule out default risk either. And there were no derivatives in that era available to hedge out these risks. But the evidence is not consistent with non-UK default risk as the main driver of interest rate differences, as we explain below.

We use the short-term interest rate and the long-term interest rate series from Jordà-Schularick-Taylor Macrohistory database (Jordà, Knoll, Kuvshinov, Schularick, and Taylor, 2019).

We obtain yield differences between U.K. and a set of advanced economies on the gold standard: the U.S., Austria, Belgium, France, Germany, Netherlands, Japan, Italy, Denmark, Finland, Norway, Portugal, Spain, Sweden, Switzerland. The short rates are measured as T-bill rates or equivalent money market rates. The long rates are longer yields with maturity of 10 years. For a given year, we keep the countries in the comparison set only if they are on the gold standard. From 1914 to 1925, the U.K. abandoned the gold standard, so the convenience yields are constructed from 1870 to 1914 and 1925 to 1931.

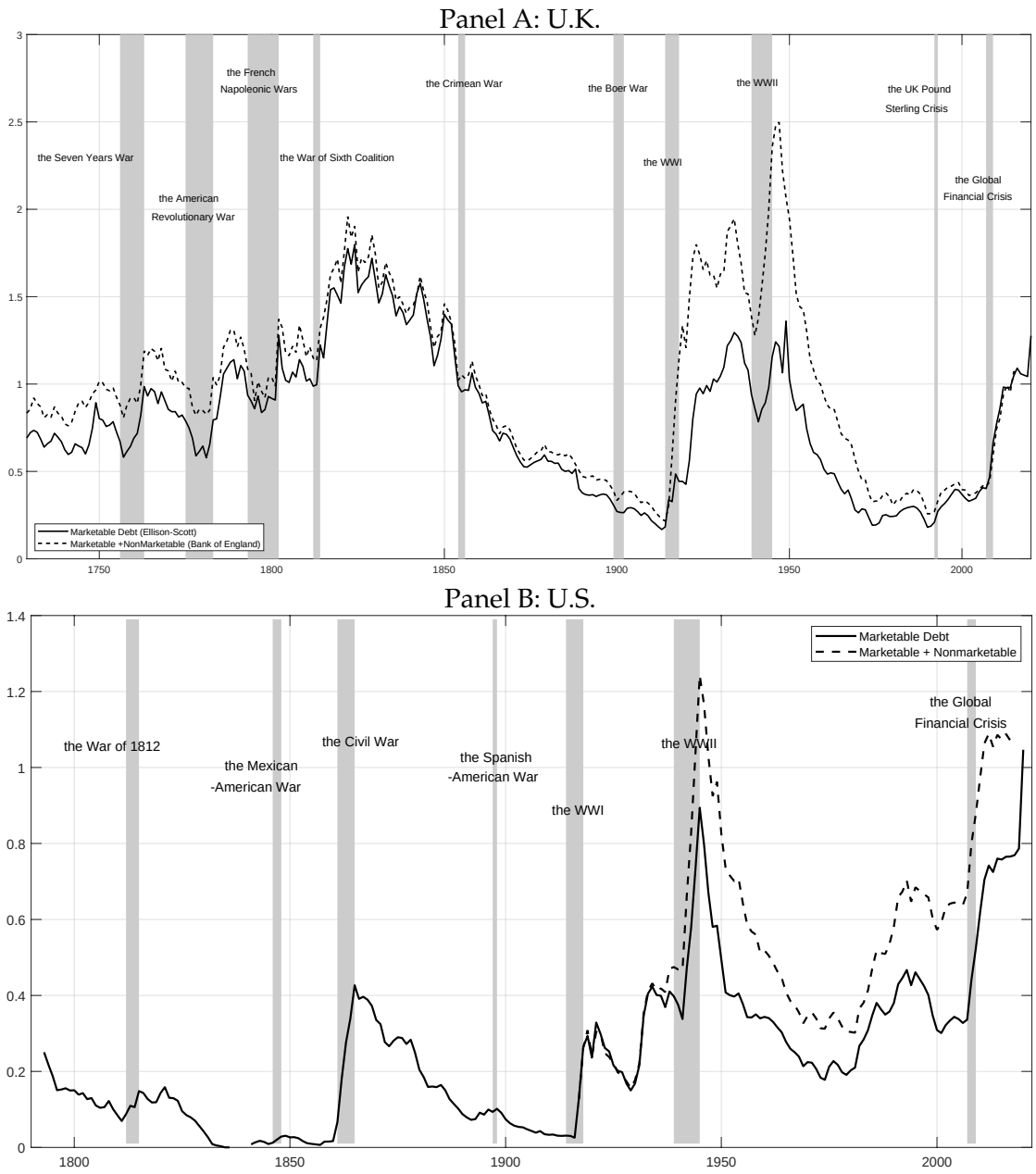
Figure 4 plots the interest rate differentials with the U.K.. At the short (long) end of the maturity spectrum, the sample average is 1.47% (1.10%) before WW-I. During the interbellum (1925 to 1931) the sample average is 0.88% for the short term (0.61% for the long term). After 1950, the average rate difference between U.K. and the rest of the advanced economy is -0.49% for the short term, and -0.68% for the long term. Hence, there is no longer any evidence of the U.K. earning convenience yields.

Our calculations reveal only approximate covered interest rate parity violations, because these securities are not exactly maturity-matched. HPSS (2021) carefully compare the yields on U.S.

[7] According to Ellison and Scott (2020), these international loans were eventually repaid in 2006.

[8] These deviations are more persistent than CIP deviations in money markets documented by Du, Tepper, and Verdelhan (2018) and others, and they predate the Great Financial Crisis.

Figure 3: The Market Value of Outstanding Debt to GDP

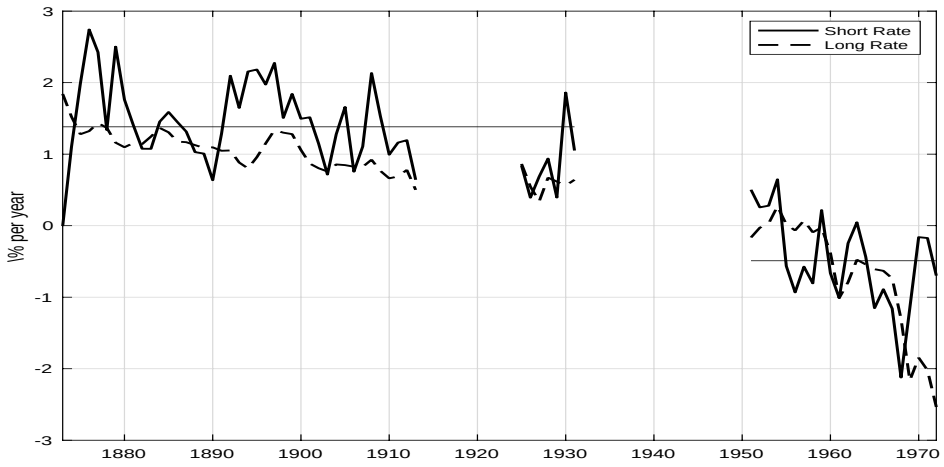


Panel A plots the ratio of the nominal market value of outstanding government debt divided by nominal GDP for the U.K. GDP data is from *A Millennium of Macroeconomics Data* published by the Bank of England. The market value of debt is constructed as follows. We multiply the nominal price (bid/ask average) of each cusip by its total amount outstanding (normalized by the face value), and then sum across all issuance (cusip). The series is annual from 1729 until 2020. Data Source: *A Millennium of Macroeconomics Data* and Ellison and Scott (2020). Panel B plots the the ratio of the nominal market value of outstanding government debt divided by nominal GDP for the U.S. The Nominal GDP data is from Hall and Sargent (2021). We obtain the marketable debt data for the period 1793 to 1946 from Hall and Sargent (2011), and for the period 1946 to 2020 from CRSP. The nonmarketable debt data is from Hall and Sargent (2011).

and U.K. consoles during the 19th century. They find even larger interest rate differentials, but they attribute part of these to larger perceived default risk on U.S. bonds. Our measures of CIP

Figure 4: Long-term and Short-term Interest Rate Differences with the U.K.

Figure plots interest rate differences with the U.K. constructed using the long rates and the short rates. We obtain the rate differences between U.K. and a set of advanced economies on the gold standard: the U.S., Austria, Belgium, France, Germany, the Netherlands, Japan, Italy, Denmark, Finland, Norway, Portugal, Spain, Sweden, Switzerland. For a given year, we keep the countries in the comparison set only if they are on the gold standard. The convenience yield is the cross sectional average of the rate differences. Data Source: Jordà-Schularick-Taylor Macrohistory database.



deviations are larger at the short end of the maturity spectrum. This maturity structure is less consistent with default risk, and more consistent with convenience yields as the main driver of these persistent interest rate differences. If non-U.K. default risk was driving these differences, we would expect to see an upward sloping term structure of the CIP deviations, at least on average.

Based on this calculation of convenience yields, the sample average of short-term convenience yields is 138 basis points per annum, and that of long-term convenience yields is 100 basis points per annum from 1873 to 1931. In the pre-WW-II sample, the U.K. government bond portfolio consists of only long-term bonds (with an average maturity of 94 years), indicating the government bond portfolio carries only long-term convenience yields. Our convenience yield estimates start only from 1873.

In our calculations below, we assume that the seigniorage revenue earned on government bonds is a constant fraction of the U.K. GDP. The average convenience yield earned by the U.K. government from 1873 to 1931 of 100 basis points translates to 0.47% of U.K. GDP. We assume this ratio is constant throughout the pre-WW-II sample, since convenience yields will tend to decline as the government issues more debt[9]

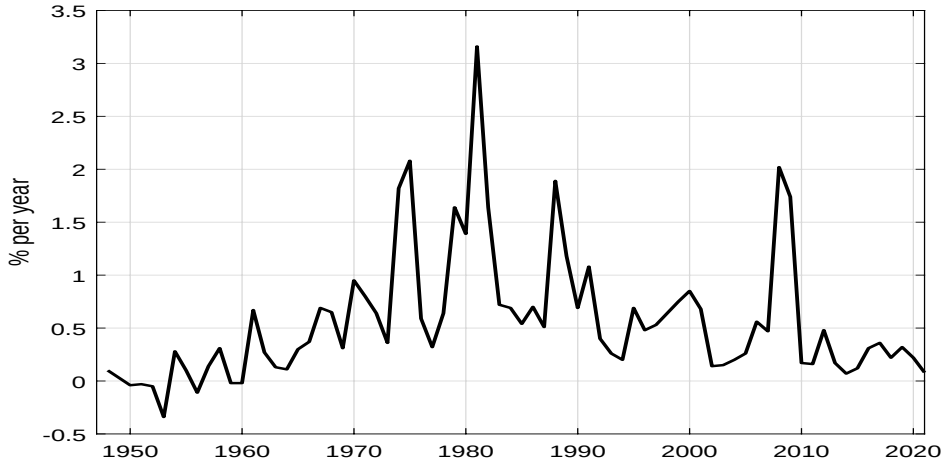
Figure 5 plots the U.S. convenience yields. Given the switch to floating exchange rates after the demise of Bretton-Woods, we cannot simply use interest rate differences to measure convenience yields.[10] To proxy for the U.S. convenience yield $\lambda_t(1)$, we first construct the spread cy_t between

[9]This would be consistent with a Cobb-Douglas specification of the utility derived from safe assets and consumption, if agents derive direct utility from safe assets. In the case, the expenditure shares are constant.

[10]The interest rate difference between the U.S. and other major economies under the gold standard (from 1945 to

Figure 5: U.S. Convenience Yields

This figure plots the convenience yields for the U.S.from 1947 to 2020. To estimate the convenience yields, we first construct the spread cy_t between the 3-month Treasury yield and a risk-free benchmark, which is the 3-month CD rate from 1964 and the 3-month banker's acceptance rate before 1964. We assume that bills earns 100% of cy_t,1-year bonds earn 90% of cy_t, and 2-year bonds earn 80% of cy_t and so on. 10-yr and beyond earns zero cy_t. The following plot reports the overall convenience yields weighted by maturity structure of the bond portfolio. The maturity structure is estimated from the CRSP monthly Treasury database.



the 3-month Treasury yield and a risk-free benchmark, which is the 3-month CD rate from 1964 and the 3-month banker's acceptance rate before 1964. Figure 5 plots this spread. The average convenience yield is 0.36% per year over the period 1947—2020.

3 Measuring Fiscal Capacity

3.1 Fiscal Capacity Without Convenience Yields

We follow the approach by JLVX (2019) (henceforth JLVX) in evaluating the UK government budget constraint. Let G_t denote nominal government spending before interest expenses on the debt, T_t denote nominal government tax revenue, and $S_t = T_t - G_t$ denote the nominal primary surplus. Let $P_t^{\$}(h)$ denote the price at time t of a nominal zero-coupon bond that pays \$1 at time $t+h$, where h is the maturity. There exists a multi-period stochastic discount factor (SDF) $M_{t,t+h}^{\$} = \prod_{k=0}^{h} M_{t+k}^{\$}$ is the product of the adjacent one-period SDFs, $M_{t+k}^{\$}$. By no arbitrage, bond prices satisfy $P_t^{\$}(h) = \mathbb{E}_t\left[M_{t,t+h}^{\$}\right] = \mathbb{E}_t\left[M_{t+1}^{\$} P_{t+1}^{\$}(h-1)\right]$. By convention $P_t^{\$}(0) = M_{t,t}^{\$} = M_t^{\$} = 1$ and $M_{t,t+1}^{\$} = M_{t+1}^{\$}$. The government bond portfolio is stripped into zero-coupon bond positions $Q_{t,h}^{\$}$, where $Q_{t,h}^{\$}$ denotes the outstanding face value at time t of the government bond payments due at time $t+h$. $Q_{t-1,1}^{\$}$ is the total amount of debt payments that is due today. The outstanding debt reflects all past bond issuance decisions, i.e., all past primary deficits. Let D_t denote the mar-

1971 are on average 58 bps per annum for the short-term interest rate, slightly higher than the sample average 36 basis points per annum using our main proxy.

ket value of the outstanding government debt portfolio. As shown in JLVX, the market value of the outstanding government bond portfolio equals the present risk-adjusted discounted value of current and future primary surpluses:

$$D_t \equiv \sum_{h=0}^{H} P_t^{\$}(h) Q_{t-1,h+1}^{\$} \quad = \quad \mathbb{E}_t \left[\sum_{j=0}^{\infty} M_{t,t+j}^{\$} (T_{t+j} - G_{t+j}) \right] \equiv P_t^T - P_t^G, \tag{1}$$

where the cum-dividend value of the tax claim and value of the spending claim are defined as:

$$P_t^T = \mathbb{E}_t \left[\sum_{j=0}^{\infty} M_{t,t+j}^{\$} T_{t+j} \right], \quad P_t^G = \mathbb{E}_t \left[\sum_{j=0}^{\infty} M_{t,t+j}^{\$} G_{t+j} \right].$$

Equation (1) relies only on the existence of a SDF, i.e., the absence of arbitrage opportunities, not on the uniqueness of the SDF, i.e., complete markets. It imposes a transversality condition (TVC) that rules out a rational government debt bubble: $\mathbb{E}_t \left[M_{t,t+T} D_{t+T} \right] \to 0$ as $T \to \infty$. Eq. (1) defines fiscal capacity for a country that does not earn convenience yields.

3.2 Campbell-Shiller Decomposition of Tax and Spending Claim

Consider the holding period return on the tax claim T and the spending claim G:

$$R_{t+1}^T = \frac{P_{t+1} + T_{t+1}}{P_t} = \frac{\frac{T_{t+1}}{T_t}(1 + PD_{t+1}^T)}{PD_t^T},$$

$$R_{t+1}^G = \frac{P_{t+1} + G_{t+1}}{P_t} = \frac{\frac{G_{t+1}}{G_t}(1 + PD_{t+1}^G)}{PD_t^G}.$$

Let r_t^i denote the log holding period return $\log(R_t^i)$ and pd_t^i denotes the log price-dividend ratio for $i = \{T, G\}$, the tax claim and the spending claim, respectively:

$$pd_t^T = p_t^T - \log T_t = \log \left(\frac{P_t}{T_t} \right); pd_t^G = p_t^G - \log G_t = \log \left(\frac{P_t}{G_t} \right),$$

where price is measured at the end of the period and the cash flow is over the same period. When we log-linearize the return equation around the mean log price/dividend ratio, iterate forward, take expectations, and impose a TVC, we obtain the following expressions for the log price/dividend ratios of the tax claim and the spending claim:

$$pd_t^T \quad = \quad \frac{\kappa_0^T}{1 - \rho_T} + \mathbb{E}_t \left[\sum_{j=1}^{\infty} \rho_T^{j-1} \Delta \log T_{t+j} \right] - \mathbb{E}_t \left[\sum_{j=1}^{\infty} \rho_T^{j-1} r_{t+j} \right], \tag{2}$$

$$pd_t^G = \frac{\kappa_0^G}{1-\rho_G} + \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho_G^{j-1}\Delta\log G_{t+j}\right] - \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho_G^{j-1}r_{t+j}\right], \tag{3}$$

where the linearization coefficient ρ_i depends on the mean of the log price/dividend ratio pd_0^i:

$$\rho_i = \frac{e^{pd^i}}{e^{pd^i}+1} < 1, \quad \kappa_0^i = \log(1+\exp(pd_0^i)) - \rho_i pd_0^i, \quad i = \{T, G\}. \tag{4}$$

The details of the derivation are in the Appendix.

Restating the value equivalence equation (1), the discounted present value of primary surpluses PV_t^s scaled by GDP Y_t is given by:

$$D_t = \frac{PV_t^s}{Y_t} = \frac{P_t^T}{Y_t} - \frac{P_t^G}{Y_t} = \tau_t\exp(pd_t^T) - g_t\exp(pd_t^G). \tag{5}$$

Below, we estimate the fiscal capacity given in (5) using the expressions of the price/dividend ratios (2) and (3). This requires measuring both the cash flows $\{\Delta\log T_{t+j}, \Delta\log G_{t+j}\}$ and the discount rates. The latter are the sum of a long-term bond yield and a risk premium relative to that long-term bond yield. We use rp_t^G and rp_t^T to denote the log risk premium on the spending and tax claim, respectively. We turn to measurement of cash flows and discount rates next.

3.3 Fiscal Capacity With Convenience Yields

As discussed above, U.K. government bonds carried convenience yields before the U.K. abandoned the gold standard. Since the U.K. government can sell its government bonds at a higher price, the presence of a convenience yield produces an additional source of seigniorage revenue. The convenience yield, λ_t, is the government bonds' expected returns that investors are willing to forgo under the risk-neutral measure. Assuming a uniform convenience yield across the maturity spectrum, the Euler equation for a Treasury bond with maturity $h+1$ is:

$$e^{-\lambda_t} = \mathbb{E}_t\left[M_{t+1}\frac{P_{t+1}^{\$}(h)}{P_t^{\$}(h+1)}\right].$$

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

$$E_t\left[\sum_{j=0}^{\infty}M_{t,t+j}^{\$}\left(T_{t+j} - G_{t+j} + (1-e^{-\lambda_{t+j}})\sum_{h=1}^{H}Q_{t+j,h}^{\$}P_{t+j}^{\$}(h)\right)\right] = \sum_{h=0}^{H}Q_{t-1,h+1}^{\$}P_t^{\$}(h), \tag{6}$$

where $\sum_{h=0}^{H}Q_{t-1,h+1}^{\$}P_t^{\$}(h)$ on the right-hand side denotes the cum-dividend value of the govern-

ment's debt portfolio at the start of period t, and $\sum_{h=1}^{H} Q^{\$}_{t+j,h} P^{\$}_{t+j}(h)$ on the left-hand side denotes the ex-dividend value of the government's debt portfolio at the end of period $t+j$. Eq. (6) defines fiscal capacity in the presence of convenience yields. If the quantity of current and future outstanding government debt is positive, then a positive convenience yield acts as an additional source of revenue, akin to seigniorage revenue, and expands the government's fiscal capacity.

Fiscal capacity with convenience yields can we written with an additional term which reflects the value of the seigniorage revenue stream from convenience:

$$D_t = \frac{PV^s_t}{Y_t} = \frac{P^T_t}{Y_t} - \frac{P^G_t}{Y_t} = \tau_t \exp(pd^T_t) + k_t \exp(pd^K_t) - g_t \exp(pd^G_t). \tag{7}$$

where $k_t = K_t/Y_t$, $K_{t+j} = (1 - e^{-\lambda_{t+j}}) \sum_{h=1}^{H} Q^{\$}_{t+j,h} P^{\$}_{t+j}(h)$, and pd^K_t the log price-dividend ratio on the claim to $\{K_{t+j}\}$.

4 Steady-state Analysis of Fiscal Capacity

Our first set of results derive and implement a steady-state measure of fiscal capacity. This exercise has the virtue that it only requires us to take a stance on long-run averages. In the next section, we extend the analysis to obtain a time-varying measure of fiscal capacity, based on more detailed assumptions on the dynamics of the economy.

4.1 Discount Rates and Valuation Ratios

We use rp^i_0 for $i = \{T, G, Y\}$ to denote the steady-state risk premium on the tax claim, spending claim, and GDP claim relative to a long-term bond yield:

$$\mathbb{E}[r^i_{t+1}] = y^{\$}_0(1) + yspr^{\$}_0 + rp^i_0.$$

The long-term bond yield is the sum of the short-term bond yield, $y^{\$}_0(1)$, and the yield spread, $yspr^{\$}_0$, which measures the difference between the 10- and 1-year government bond yield.

We can think of the GDP claim as an unlevered claim to the stock market:

$$rp^Y_0 = \mathbb{E}[r^Y_t] - (yspr^{\$}_0 + y^{\$}_0(1)) \approx \frac{1}{1 + \frac{D}{E}} rp^M_0.$$

where rp^M_0 is the unconditional expected return on the stock market minus the long-term bond yield, and where D/E is te debt/equity ratio of the corporate sector.

The average log price/dividend ratio on the GDP claim satisfies:

$$pd_0^Y(1-\rho_Y) - \kappa_0^Y = x_0 + \pi_0 - y_0^{\$}(1) - yspr_0^{\$} - rp_0^Y$$

where x_0 is the unconditional mean of real GDP growth, π_0 is the unconditional mean inflation rate, and with linearization constants:

$$\rho_Y = \frac{e^{pd_0^Y}}{e^{pd_0^Y}+1}, \quad \kappa_0^Y = \log(1+\exp(pd_0^Y)) - \rho_Y pd_0^Y.$$

4.2 Steady-State Fiscal Capacity Without Convenience Yields

To obtain our measure of *steady-state* fiscal capacity without convenience yields, we evaluate the expression for D_t in (1) at the unconditional mean of all variables:

$$D_0 = \tau_0 \exp(pd_0^T) - g_0 \exp(pd_0^G).$$

A country can run deficits in the steady-state ($\tau_0 < g_0$) and maintain non-negative debt capacity ($D_0 \geq 0$) if and only if $\exp(pd_0^T) > \exp(pd_0^G)$. This requires that the tax process is less risky than the spending process: $rp_0^T < rp_0^G$. JLVX (2019) shows that this constellation of risk premia is inconsistent with the U.S. tax and spending data after WW-II. We return to this discussion in detail below.

4.3 Risk Premia on Tax and Spending Claims

All that is missing to compute the steady-state fiscal capacity is a value for the risk premium on the tax and spending claims: rp_0^T and rp_0^G. We assume that these risk premia are equal to the GDP risk premium: $rp_0^T = rp_0^Y = rp_0^G$. This assumption implies that expected returns are equal:

$$\mathbb{E}[r_{t+1}^G] = \mathbb{E}[r_{t+1}^T] = \mathbb{E}[r_{t+1}^Y] = y_0^{\$}(1) + yspr_0^{\$} + rp_0^Y.$$

Since the unconditional growth rates of tax revenues and government spending must equal GDP growth by cointegration, it follows that $pd_0^T = pd_0^G = pd_0^Y$ and $\rho_T = \rho_G = \rho_Y$.

Why is the GDP risk premium a plausible imputation for the risk premia on tax revenue and spending claims? First, in the long run, the tax claim and spending claim are exposed to the same long-run risk as the output claim, because of co-integration with output. Hence, they should carry the same long-run risk premia. Second, in the short-run, the tax claim and spending claim are exposed to business cycle risk. We distinguish between two regimes.

In the pre-war regime, the tax/output and spending/output ratios are largely a-cyclical. To

show this, Appendix B reports market return betas and GDP growth betas for spending growth and tax revenue growth, and shows that these betas are close to one at business cycle frequencies. Since both tax and spending claims are exposed to the same short-run and long-run risk as the GDP claim, they should carry the same expected return.

In the post-WW-II regime, tax revenue as a share of GDP is pro-cyclical. In a regression of tax revenue growth on GDP growth, the slope is greater than one (Appendix B). This high GDP-growth beta at short horizons indicates that the tax claim is riskier than the GDP claim. In contrast, spending growth has a negative GDP growth beta at short horizons due to the counter-cyclicality of government spending. The spending claim is less risky than the GDP claim. Given the same long-run risk but different short-run risk, we obtain: $rp_0^T \geq rp_0^y \geq rp_0^G$. Assuming that $rp_0^T = rp_0^Y = rp_0^G$ results in an *upper bound* on fiscal capacity in he post-ware era. This is because the assumption increases the value of the tax claim (by discounting it at a rate that is too low) and reduces the value of the spending claim (by discounting it at a rate that is too high), thereby increasing the value of their difference. Put differently, this is a generous bound for the underlying amount of fiscal capacity.

Countries with higher GDP growth x_0 and lower real rates $y_0^{\$}(1) - \pi_0$ have higher pd_0^Y, i.e., higher fiscal capacity per % point of surplus/GDP, as emphasized recently by Blanchard (2019); Furman and Summers (2020); Mehrotra and Sergeyev (2021). However, as shown by JLVX (2019), the term spread $yspr_0^{\$}$ and the GDP risk premium also affect pd_0^Y. The GDP risk premium in particular affects fiscal capacity in quantitatively important ways.

4.4 Quantifying the GDP Risk Premium

Starting from the average stock market return, unlevering it, and subtracting an average long-term bond yield, JLVX (2019) find a GDP risk premium rp_0^Y of 3% relative to long bonds for the post-war U.S. sample.

A similar value is appropriate for the U.K. According to our calculations, the unconditional (geometric average or compound) equity risk premium in the UK's pre-WW-I sample is 3.21% between 1813-1870. Around 1900, the U.K. non-financial corporate debt/equity ratio is roughly 1/3, based on the corporate sector financial claims in 1900.[11] We estimate an unlevered equity or GDP risk premium $rp_0^Y = 3.21\% \times 1/(1+1/3) = 2.4\%$. In the post-WW-II U.K. sample, the unconditional equity risk premium relative to the short-term risk-free rate is 4.88%. With the estimated debt/equity ratio 0.266, we obtain a GDP risk premium 3.61% relative to the short rate. The slope of the yield curve is 0.80%. Hence, we obtain an approximate unlevered premium of

[11] Data source: *A Millennium of Macroeconomics Data*, sheet A62.

2.81% relative to the long term bond.[12] Based on this evidence, and for ease of comparison across samples and with the U.S., we assume a 3% GDP risk premium for the U.K. in all subsamples. At various points, we do robustness with respect to this important parameter.

4.5 Steady-State Fiscal Capacity With Convenience

As discussed above, U.K. bonds earned a convenience yield λ_0 of 100 basis points per year pre-WW-II. We interpret this as a *narrow* convenience yield, i.e., it affects only government bonds but not other risky assets such as a claim to GDP. Hence, when we allow for a narrow convenience yield λ_0, we assume that this convenience yield raises the true risk-free rate (without convenience) by λ_0 and lowers the true risk premium on the GDP claim by the same λ_0. As a result, the expected return on GDP claim is unchanged, and so is the discount rate for the revenue and spending claims.

As discussed above, we assume that seigniorage revenues from convenience are a constant fraction of U.K. GDP in the pre-WW-II era. Given the average debt/GDP ratio in this period, the 1% convenience yield results in an average seigniorage revenue of $k_0 = 0.47\%$ of U.K. GDP. This convenience yield revenue is discounted at the same rate as tax revenue and government spending, namely by the expected return on the GDP claim. Each percentage point of additional seigniorage revenue/GDP yields an additional $exp(pd_0^Y)$ in fiscal capacity.

4.6 Results for the Pre-WW-II Sample

U.K. The left panel of Table 2 reports the U.K. steady-state analysis of the fiscal capacity for different samples. We start with the pre-WW-I sample in the first column. In the two centuries preceding WW-I, the average primary surplus was 2.38% of GDP. The U.K. ran large primary surpluses.

The expected real return on the output claim is $y_0^{\$}(1) + yspr_0^{\$} - \pi_0 + rp_0^Y = 5.92\%$. The average price/dividend ratio for the GDP claim is $\exp(pd_0^Y) = 20.68$. Per 1% of primary surplus, the U.K. government can borrow another 20.68% of GDP. The U.K.'s steady-state fiscal capacity without convenience yields is:

$$\tau_0 \exp(pd_0^T) - g_0 \exp(pd_0^G) = (\tau_0 - g_0) \exp(pd_0^Y) = (8.96 - 6.58)\% \times 20.68 = 49.14\%$$

U.K. fiscal capacity based only on the present value of future surpluses is well below the observed debt/GDP ratio of 86.45% pre-WW-I.

[12] Alternatively, we estimate the average of the log unlevered equity return for both subsamples. The pre-WWII estimate for the U.K. is 2.04% and the post-WWII estimate is 3.84%.

Table 2: Steady-state Analysis of Fiscal Capacity

	U.K.			U.S.		
	1729 – 1914	1729 – 1946	1947 – 2020	1793 – 1914	1793 – 1946	1947 – 2020
x_0	1.58	1.52	2.26	4.08	4.02	2.95
$yspr_0$	-0.01	0.17	0.80	-0.12	0.07	0.89
π_0	0.16	0.59	4.79	0.77	1.10	3.16
$y_0^{\$}$	3.47	3.34	5.64	4.50	4.06	4.26
κ_0^Y	0.19	0.18	0.11	0.12	0.10	0.10
ρ_Y	0.95	0.96	0.98	0.98	0.98	0.98
$\exp(pd_0^Y)$	20.68	22.22	42.10	39.06	49.17	48.52
τ_0	8.96	10.82	32.34	2.42	3.35	17.60
g_0	6.58	9.60	30.56	1.97	3.41	17.55
s_0	2.38	1.22	1.77	0.46	-0.06	0.05
λ_0	1.07	1.00	0.00	0.00	0.00	0.56
Seign./Y	0.45	0.47	0.00	0.00	0.00	0.11
	Steady-state at $z = 0$					
$PV(S)/Y$	49.14	27.18	74.71	17.79	-2.84	2.66
$PV(S+CY)/Y$	58.88	37.97	74.71	17.79	-2.84	9.40
	Sample Averages					
D/Y	86.45	87.06	53.42	11.91	16.53	40.99
$PV(S)/Y$	54.15	57.26	82.03	20.18	23.61	5.91
$PV(S+CY)/Y$	64.25	69.32	82.03	20.18	23.61	13.20
$PV(S)/D$	62.64	65.77	153.56	169.36	142.87	14.41
$PV(S+CY)/D$	74.32	79.63	153.56	169.36	142.87	32.20
$\rho(PV(S+CY)/Y, D/Y)$	0.90	0.80	0.74	0.13	0.62	-0.17

The top panel reports the moments of the data that are inputs into the stead-state fiscal capacity estimation. The bottom two panels report estimates of fiscal capacity for the U.K. and the U.S. All values are in percentage points, except for the pd ratio $\exp(pd_0^Y)$ and κ_0^Y. We use an unlevered equity or output risk premium rp_0^Y of 3% in all subsamples. In case of convenience yields, we use narrow convenience yields, which raise the actual risk-free rate by λ_0 and lower the output risk premium by λ_0, leaving the discount rate unchanged. D denotes the market value of debt.

How much additional fiscal capacity does the U.K. government receive as a result of its average 1.07% annual convenience yield pre-WW-I? The resulting seigniorage revenue is 0.45% of U.K. GDP. The pre-WW-I steady-state fiscal capacity estimate is $(8.96 - 6.58 + 0.45)\% \times 20.68 = 58.88\%$ of GDP. Our 58.88% estimate of the U.K.'s fiscal capacity before WW-I comes closer to but remains below the average debt/GDP ratio of 86.45%.

Next, we turn to the pre-1946 sample, which includes the interbellum. The results are reported in the second column of Table 2. The average surplus is heavily influenced by the inclusion of WW-I and WW-II. The pre-1946 sample surplus is only $10.82 - 9.60 = 1.22\%$ of GDP. After accounting for seigniorage revenue of 0.47% of U.K. GDP, the pre-WW-I steady-state fiscal capacity estimate is $(10.82 - 9.60 + 0.47)\% \times 22.22 = 37.97\%$. Again, our fiscal capacity estimate is well below the observed debt/GDP ratio of 87.06%.

Our conclusion that the U.K. debt was not fully backed in the pre-war era seems robust. The two parameters that are hardest to pin down are the GDP risk premium rp_0^Y and the average seigniorage revenue/GDP ratio k_0. We need to decrease the GDP risk premium by half, from 3% to 1.5% per year, thereby boosting $\exp(pd_0^Y)$ to 30.55, to ensure that the average debt is fully backed by the steady-state surpluses inclusive of seigniorage revenue in the pre-WW-I period. Given a narrow convenience yield λ_0 of 1%, this means that the effective GDP risk premium (without convenience) is only 0.5% per annum. That seems implausibly low. Alternatively, we would have to multiply the convenience yield by more than a factor of three (resulting in seignorage revenue of 1.75% of GDP) to ensures that the debt is fully backed by surpluses.

U.S. The pre-WW-II results for the U.K. stand in sharp contrast to those for the U.S. The right panel of Table 2 reports the same analysis for the U.S. The U.S. has much lower fiscal capacity than the U.K. in the first half of the sample for two reasons. First, because the U.S. generates much smaller surpluses: 0.46% of GDP before WW-I and -0.06% including the interbellum. Second, because the U.S. does not earn convenience yields pre-WW-II. The average fiscal capacity estimate for the pre-1946 period is only 23.61%. But because the U.S. government did not borrowing much, our low estimate of the U.S. fiscal capacity still exceeds the actual average debt/output ratio of 16.53% of GDP. In contrast to the U.K., U.S. debt seems to be fully backed by future surpluses, i.e., fiscal fundamentals.

As an aside, because the U.S. was growing at a much faster rate (real GDP growth of 4.02%) than the U.K. (1.52%), the U.S. could have boosted its fiscal capacity by 49.17% per % of GDP in surpluses, compared to only 22.22% in the case of the U.K. However, the U.S. seemed unable or unwilling to generate larger average surpluses in the 19th century, despite its high growth rate.

4.7 Results for Post-WW-II Sample

U.K. The U.K. steady-state analysis for the Post-WW-II sample is shown in the third column of Table 2. As explained above, our imputation of the GDP risk premium to the tax and spending risk premia results in an upper bound on fiscal capacity for the post-WW-II era. We also recall that the U.K. loses its convenience yield in this period.

One key difference between the pre- and the post-WW-II sample is that the expected real return on the GDP claim is 4.61%, about 125 basis points lower than in the pre-WW-II sample. With a lower discount rate, the steady-state valuation ratio of the output claim for the post-WW-II sample increases to 42.10. A higher $\exp(pd_0^Y)$ raises the U.K.'s fiscal capacity for each percentage point of surpluses/GDP. As a result, the U.K.'s fiscal capacity is higher in the post-WW-II era compared to the pre-WW-II era despite lower average surpluses than in the pre-WW-I era and the absence of convenience yields:

$$\tau_0 \exp(pd_0^T) - g_0 \exp(pd_0^G) = (\tau_0 - g_0) \exp(pd_0^Y) = (32.34 - 30.56)\% \times 42.10 = 74.71\%$$

The steady state fiscal capacity of 74.71% exceeds the post-war debt/output ratio of 53.42%. The U.K. debt is more than fully backed by the surpluses in the post-WW-II period.

U.S. These results stand in sharp contrast to those in the U.S. Steady-state fiscal capacity without convenience yields is 2.66% of GDP due to the minimal surpluses of 0.05% of GDP in post-WW-II U.S. data. Once the convenience yield is considered, our measure of fiscal capacity rises to 9.40%. This number is far below the observed average debt/GDP ratio of 40.99%. Less than 1/3 of the market value of debt is backed by future surpluses inclusive of seigniorage revenue from convenience yields.

Given that the U.S. tax process is quite risky—see the high tax beta shown in Appendix B—its actual fiscal capacity based on macro fundamentals is likely much lower than our upper bound indicates. Interestingly, the tax process in the U.K. is less risky compared to the one in the U.S. This makes the contrast between the U.S. and U.K. results even more surprising.

This conclusion about the lack of fiscal capacity in post-WW-II U.S. is robust. Even if we lowered the GDP risk premium from 3% to 2% (which amounts to an effective output risk premium of 1.43% once the convenience yield is accounted for), thereby increasing $exp(pd_0^Y)$ to 95, the implied steady-state fiscal capacity would still only be 15% of GDP. The conclusion of low fiscal capacity is hard to avoid given that the U.S. is not generating surpluses after WW-II.

5 Dynamic Analysis of Fiscal Capacity

In this section, we extend the prior analysis to allow for dynamics in (i) expected tax revenue and spending growth rates, and (ii), in the expected return on the GDP claim. We continue to make our assumptions that the risk premia on T and G claims are constant and equal to the GDP risk premium.

5.1 VAR Model of Cash Flow Dynamics

We propose a vector auto-regression (VAR) model to capture the dynamics in expected cash flows and discount rates in the economy.

We assume that the $N \times 1$ vector of state variables $\boldsymbol{z}$ follows a Gaussian first-order VAR:

$$\boldsymbol{z}_t = \boldsymbol{\Psi} \boldsymbol{z}_{t-1} + \boldsymbol{u}_t = \Psi \boldsymbol{z}_{t-1} + \boldsymbol{\Sigma}^{\frac{1}{2}} \boldsymbol{\varepsilon}_t, \tag{8}$$

with $N \times N$ companion matrix Ψ and homoscedastic innovations $\boldsymbol{u}_t \sim i.i.d.\mathcal{N}(0, \Sigma)$. The Cholesky decomposition of the covariance matrix, $\boldsymbol{\Sigma} = \Sigma^{\frac{1}{2}} \left(\Sigma^{\frac{1}{2}}\right)'$, has non-zero elements on and below the diagonal. In this way, shocks to each state variable u_t are linear combinations of its own structural shock $\boldsymbol{\varepsilon}_t$, and the structural shocks to the state variables that precede it in the VAR, with $\boldsymbol{\varepsilon}_t \sim i.i.d.\mathcal{N}(0, I)$. Table 3 summarizes the variables we include in the state vector, in order of appearance of the VAR. The vector $\boldsymbol{z}$ contains the state variables demeaned by their respective sample averages.

To capture the government's cash flows, the VAR includes $\Delta \log \tau_t$ and $\Delta \log g_t$, the log change in tax revenue-to-GDP and the log change in government spending-to-GDP in its eighth and tenth rows. It also includes the log level of revenue-to-GDP, τ_t, and spending-to-GDP, g_t, in its ninth and eleventh rows. First, this fiscal cash flow structure allows spending and revenue growth to depend

Table 3: State Variables

Position	Variable	Mean	Description
1	π_t	π_0	Log Inflation
2	$y_t^{\$}(1)$	$y_0^{\$}(1)$	Log 1-Year Nominal Yield
3	$yspr_t^{\$}$	$yspr_0^{\$}$	Log 10-Year Minus Log 1-Year Nominal Yield Spread
4	x_t	x_0	Log Real GDP Growth
5	Δd_t	μ_d	Log Stock Dividend-to-GDP Growth
6	d_t	$\log d_0$	Log Stock Dividend-to-GDP Level
7	pd_t	$\overline{pd}$	Log Stock Price-to-Dividend Ratio
8	$\Delta \log \tau_t$	μ_τ	Log Tax Revenue-to-GDP Growth
9	$\log \tau_t$	$\log \tau_0$	Log Tax Revenue-to-GDP Level
10	$\Delta \log g_t$	μ_g	Log Spending-to-GDP Growth
11	$\log g_t$	$\log g_0$	Log Spending-to-GDP Level

not only on its own lag, but also on a rich set of macroeconomic and financial variables. Lagged inflation, GDP growth, interest rates, the slope of the term structure, the stock price-dividend ratio, and dividend growth all predict future revenue and spending growth. Innovations in the fiscal variables are correlated with innovations in these macro-finance variables. Second, it is crucial to include the level variables τ_t and g_t. When there is a positive shock to spending, spending tends to revert back to its long-run trend with GDP. Similarly, after a negative shock to tax revenue, future revenues tend to increase back to their long-run level relative to GDP. This mean reversion captures the presence of automatic stabilizers and of corrective fiscal action, as pointed out by Bohn (1998). Put differently, without inclusion of τ_t and g_t, all shocks to spending and tax revenues are permanent rather than mean-reverting.[13] As a result, in the long run, claims to taxes, spending and GDP all earn the same risk premium because they are exposed to the same long-run risk.

We also include both the change and the level of the log dividend/GDP ratio d_t as the fifth and sixth elements of the VAR. This specification imposes cointegration of dividends and output.

In the baseline specification, we do not include the log debt/output ratio in the state vector. Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2021) show that the U.S. debt/output ratio has no predictive ability for surpluses or debt returns. We include the debt/output ratio for the U.K. in a robustness exercise.

5.2 VAR Estimates

We estimate equations 1-5, 7, 8, and 10 of (8) using OLS, separating the pre-1946 and post-1946 samples. We do not zero out any of the elements in Ψ even if they are statistically indistinguishable from zero. The point estimates of $\mathbf{\Psi}$ for both U.K. samples are reported in Tables 4 and 5. Lagged macro-finance variables affect fiscal variables and vice versa. Consistent with the long-run mean reversion dynamics imposed by cointegration, $\Psi_{[8,9]} < 0$ and $\Psi_{10,11]} < 0$ in both samples (and those coefficients are statistically significant). The cross-terms also have the expected sign: $\Psi_{[8,11]} > 0$ and $\Psi_{[10,9]} > 0$ for both samples. The estimates of $\Sigma^{\frac{1}{2}}$ for both samples are reported in Appendix C.1.

[13] Formally, the inclusion of the levels of spending and tax revenue relative to GDP in the VAR is motivated by a cointegration analysis; the system becomes a vector error correction model. We performs Johansen cointegration tests, and both the trace test and the max eigenvalue test support two cointegration relationships, one between log tax revenue and log GDP and one between log spending and log GDP. The coefficients estimates of the cointegration relationships tend to vary across sample periods. As a result, we take an a priori stance that the tax-to-GDP ratio $\log \tau$ and the spending-to-GDP ratio $\log g$ are stationary. That is, we assume cointegration coefficients of $(1, -1)$ for both relationships.

Table 4: VAR Estimates $\mathbf{\Psi}$: 1729 – 1946 UK Sample

	π_{t-1}	$y^{\$}_{t-1}(1)$	$y^{\$,spr}_{t-1}$	x_{t-1}	$\Delta \log d_{t-1}$	$\log d_{t-1}$	pd_{t-1}	$\Delta \log \tau_{t-1}$	$\log \tau_{t-1}$	$\Delta \log g_{t-1}$	$\log g_{t-1}$
π_t	0.37	0.09	0.66	0.23	-0.02	0.01	0.01	0.12	-0.01	0.02	0.01
$y^{\$}_t(1)$	0.01	1.15	0.50	0.05	-0.00	0.00	0.01	0.00	0.00	0.00	-0.00
$y^{\$,spr}_t$	-0.01	-0.19	0.45	-0.04	0.00	-0.00	-0.01	-0.00	-0.00	0.00	0.00
x_t	-0.05	-0.55	-0.21	-0.10	-0.00	-0.01	-0.02	-0.01	0.00	0.04	-0.01
$\Delta \log d_t$	-0.07	2.69	0.08	0.07	-0.18	-0.03	0.35	0.09	0.05	-0.09	-0.06
$\log d_t$	-0.07	2.69	0.08	0.07	-0.18	0.97	0.35	0.09	0.05	-0.09	-0.06
pd_t	-0.28	-7.05	-6.16	-0.41	0.11	-0.03	0.49	-0.21	-0.10	-0.02	0.07
$\Delta \log \tau_t$	0.13	0.29	0.59	0.33	-0.03	-0.02	-0.04	-0.03	-0.11	0.03	0.06
$\log \tau_t$	0.13	0.29	0.59	0.33	-0.03	-0.02	-0.04	-0.03	0.89	0.03	0.06
$\Delta \log g_t$	0.63	2.50	4.45	0.88	-0.02	0.07	-0.06	-0.28	0.15	0.32	-0.13
$\log g_t$	0.63	2.50	4.45	0.88	-0.02	0.07	-0.06	-0.28	0.15	0.32	0.87

Table 5: VAR Estimates $\mathbf{\Psi}$: 1947 – 2020 UK Sample

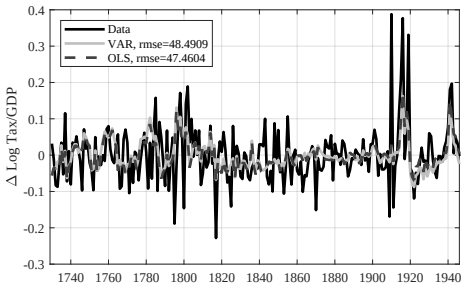
	π_{t-1}	$y^{\$}_{t-1}(1)$	$y^{\$,spr}_{t-1}$	x_{t-1}	$\Delta \log d_{t-1}$	$\log d_{t-1}$	pd_{t-1}	$\Delta \log \tau_{t-1}$	$\log \tau_{t-1}$	$\Delta \log g_{t-1}$	$\log g_{t-1}$
π_t	0.51	0.34	0.40	0.32	-0.03	0.01	-0.02	-0.08	0.06	-0.01	0.02
$y^{\$}_t(1)$	0.19	0.92	0.67	0.19	0.09	-0.01	0.03	-0.11	-0.06	0.03	-0.06
$y^{\$,spr}_t$	-0.09	-0.00	0.17	-0.10	-0.10	0.01	-0.02	-0.02	0.03	-0.03	0.06
x_t	-0.21	0.46	1.23	0.07	0.01	0.02	0.04	-0.07	0.02	-0.02	-0.05
$\Delta \log d_t$	-0.29	-0.63	0.24	1.48	0.10	-0.13	-0.11	0.26	-0.05	-0.12	-0.06
$\log d_t$	-0.29	-0.63	0.24	1.48	0.10	0.87	-0.11	0.26	-0.05	-0.12	-0.06
pd_t	-2.95	0.68	3.10	-3.76	-0.18	-0.26	0.48	1.57	0.32	-0.36	-0.65
$\Delta \log \tau_t$	0.07	-0.24	-0.93	0.13	-0.11	0.00	-0.02	0.50	-0.25	-0.21	0.13
$\log \tau_t$	0.07	-0.24	-0.93	0.13	-0.11	0.00	-0.02	0.50	0.75	-0.21	0.13
$\Delta \log g_t$	0.21	-0.66	-1.90	-0.29	-0.04	-0.05	-0.05	-0.08	0.12	0.31	-0.20
$\log g_t$	0.21	-0.66	-1.90	-0.29	-0.04	-0.05	-0.05	-0.08	0.12	0.31	0.80

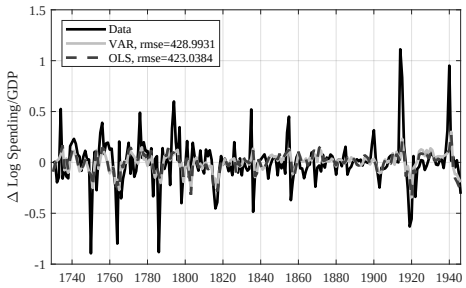
5.3 Tax and Spending Growth Forecasts

Figures 6 and 7 evaluate the forecasting performance of the VAR model. They plot expected cumulative spending and revenue growth over the next one, five, and ten years against realized future spending and revenue growth, for each of the two subsamples. To assess predictive accuracy, we compare the prediction of the benchmark annual VAR to that of the best linear forecaster at that horizon using the root mean squared error (RMSE) as our criterion. By design, the VAR prediction is the best linear forecast at the one-year horizon, but not at the five- and ten-year horizons. Overall, predictive accuracy of the VAR is similar to that of the best linear forecast at the five- and ten-year horizons. The pre-1946 sample has larger RMSEs than the post-1946 sample. This evidence leads us to conclude that the VAR implies reasonable behavior of long-run fiscal cash flows.

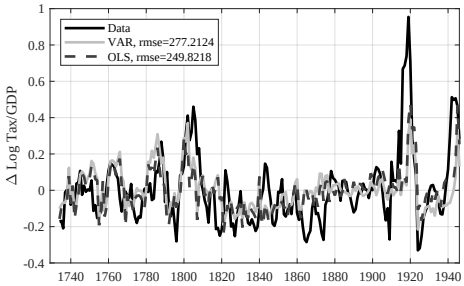
Figure 6: Cash Flow Forecasts: 1729 – 1946

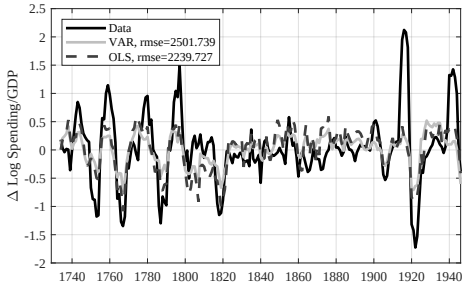
Panel A: 1Yr Forecast of $\Delta\tau$ and Δg



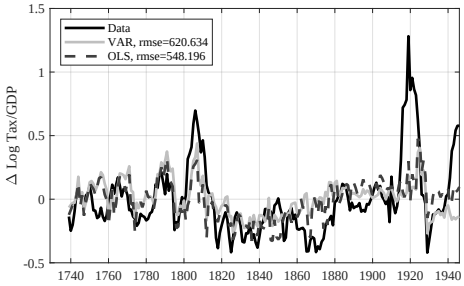


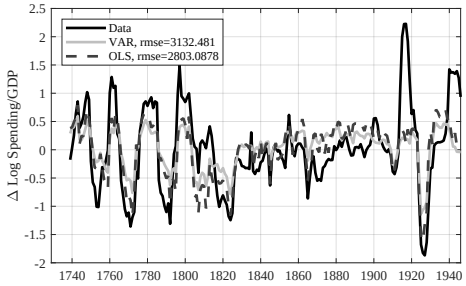
Panel B: 5Yr Forecast of $\Delta\tau$ and Δg





Panel C: 10Yr Forecast of $\Delta\tau$ and Δg

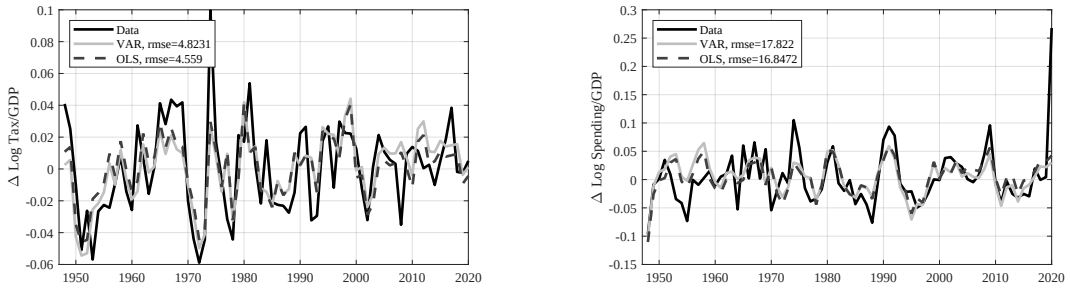




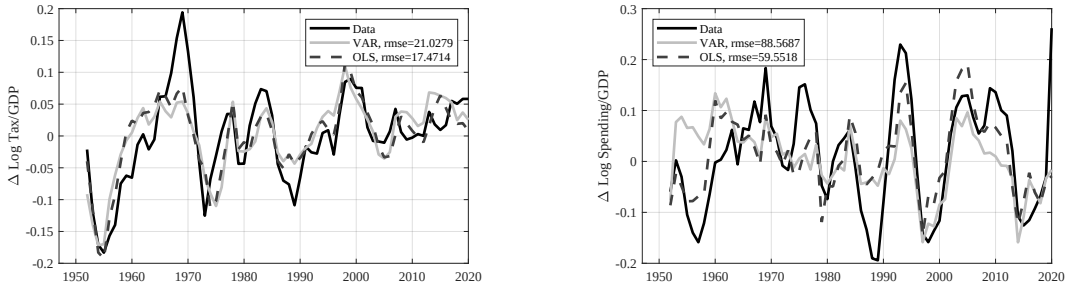
We plot the actual log tax and spending growth rates over 1-year, 5-year and 10-year rolling windows in solid black lines. The value at each year represents the k-year growth rates that end at that year. We also plot these rates as forecasted by our pre-1946 VAR model in gray lines and these rates as forecasted by the OLS model using the pre-1946 sample in dash black lines. The value at each year represents the k-year growth rates condition on the information k years ago.

Figure 7: Cash Flow Forecasts: 1947 – 2020

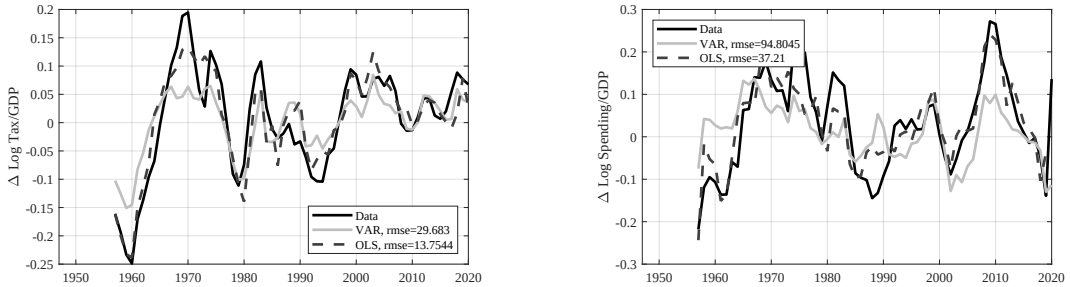
Panel A: 1Yr Forecast of $\Delta\tau$ and Δg



Panel B: 5Yr Forecast of $\Delta\tau$ and Δg



Panel C: 10Yr Forecast of $\Delta\tau$ and Δg



We plot the actual log tax and spending growth rates over 1-year, 5-year and 10-year rolling windows in solid black lines. The value at each year represents the k-year growth rates that end at that year. We also plot these rates as forecasted by our post-1946 VAR model in gray lines and these rates as forecasted by the OLS model using the post-1946 sample in dash black lines. The value at each year represents the k-year growth rates condition on the information k years ago.

5.4 Discount Rates and Valuation Ratios

Given the VAR dynamics and our assumption that the GDP risk premium is constant, the expected returns on the GDP claim is given by:

$$\mathbb{E}_t[r^i_{t+j+1}] = y^{\$}_0(1) + yspr^{\$}_0 + rp^i_0 + (\boldsymbol{e}_y + \boldsymbol{e}_{yspr})'\boldsymbol{\Psi}^{j+1}\boldsymbol{z}_t, \quad i \in \{T, G\},$$

where $\boldsymbol{e}_k$ to denote a column vector of zero with a 1 as the kth element. The dynamics in the expected nominal return on the GDP claim are driven by the dynamics in the nominal short rate and in the slope of the term structure.

The discount rate (DR) terms in equations (2) and (3) for the valuation ratios of the tax and spending claims are defined by:

$$DR_t^i = \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho_i^{j-1} r_{t+j}^i\right] = \frac{y_0^{\$}(1) + yspr_0^{\$} + rp_0^i}{1-\rho_i} + (\boldsymbol{e}_y + \boldsymbol{e}_{yspr})'\boldsymbol{\Psi}(I-\rho_i\boldsymbol{\Psi})^{-1}\boldsymbol{z}_t, \quad i \in \{T, G\}$$

The cash flow (CF) terms in equations (2) and (3) are easily computed from the VAR:

$$CF_t^i = \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho_i^{j-1}\Delta\log CF_{t+j}\right] = \frac{x_0+\pi_0}{1-\rho_i} + (\boldsymbol{e}_\pi + \boldsymbol{e}_x + \boldsymbol{e}_i)'\boldsymbol{\Psi}(I-\rho_i\boldsymbol{\Psi})^{-1}\boldsymbol{z}_t, \quad i \in \{T, G\}$$

We use $\widetilde{CF}_t^i$ and $\widetilde{DR}_t^i$ to denote the time-varying components of the cash-flow and discount rate expressions CF_t^i and DR_t^i above.

With discount rates and valuation ratios from the VAR in hand, and our assumption $rp_0^T = rp_0^G = rp_0^Y$, we can compute the valuation ratios in equations (2) and (3).

5.5 Dynamic Measure of Fiscal Capacity

Fiscal capacity without convenience yields in equation (1) as:

$$D_t = \tau_t \exp(pd_0^T + \widetilde{CF}_t^T - \widetilde{DR}_t^T) - g_t \exp(pd_0^G + \widetilde{CF}_t^G - \widetilde{DR}_t^G), \tag{9}$$

where the mean log-price dividend ratios $pd_0^T = pd_0^G = pd_0^Y$ as before.

The fiscal capacity with convenience yields adds the present value of seigniorage revenues. We continue to assume that seigniorage revenue is a constant fraction of GDP, but now discount the revenue stream using the time-varying expected return on the GDP claim.

5.6 Results for Dynamic Fiscal Capacity Pre-WW-II

U.K. Panel A of Figure 8 plots the dynamic fiscal capacity estimate for the U.K. in the pre-1946 era in red. This estimate includes the seigniorage revenue from convenience yields. Although the GDP risk premium is assumed to be constant over time, this dynamic fiscal capacity reflects the time-varying cash flow growth rates as well as time-varying discount rates arising from long-term interest rate dynamics. The grey shaded areas indicate one- (dark) and two-standard error (light) bands obtained from a bootstrap exercise.

Whenever the U.K. goes to war, the fiscal capacity estimate actually increases because the VAR correctly forecasts larger surpluses following a period of war deficits. Our fiscal capacity estimates correctly see through these short-lived deficits. So do bond market investors. The correlation between our measure of fiscal capacity and the debt/GDP ratio is 90% before 1914. This is not a mechanical result since the debt/GDP ratio is not in the VAR.

Between 1740 and 1840, our dynamic estimate of fiscal capacity gradually increases from 50 to 100% of U.K. GDP. Before 1860s, the observed market value of debt-to-GDP ratio (blue line) exceeds the fiscal capacity estimate. The debt is not fully backed by our estimate of future surpluses and seigniorage revenue. The gap briefly increases to 50% of GDP after the Napoleonic wars. However, starting in 1860, our estimate of fiscal capacity closely tracks the actual U.K. debt/GDP ratio.

As shown in the bottom panel of Table 2, the average fiscal capacity including seigniorage in the pre-WW-I period is 64.25%. This number is close to the steady-state fiscal capacity estimate from the previous section. On average, 74.32% of U.K. debt was backed by future surpluses and convenience yields before WW-I, according to our dynamic estimates. For the pre-1946 sample, the average dynamic fiscal capacity is 69.32%. This estimate is much higher than the corresponding steady-steady fiscal capacity estimate of 37.97%. This large difference arises because the dynamic estimate from the VAR reflects the mean reversion in surpluses after the wartime deficits. The steady-state measure does now.

U.S. The dynamic fiscal capacity estimates confirm that the U.S. experience was quite different from the U.K.'s before WW-II. Panel B of Figure 8 plots the dynamics of the fiscal capacity for the U.S. in red with two standard error bands. In the pre-1946 sample, the correlation between our measure of fiscal capacity and the U.S. debt/GDP ratio is 0.62, lower than in the U.K.

Before 1860, the fiscal capacity stays below 30% of GDP. Unlike for the U.K., the U.S. fiscal capacity estimate remains above the actual debt/GDP ratio throughout the pre-1946 sample, except briefly at the inception of the U.S. and during the U.S. civil war. Whenever the U.S. goes to war, the estimates of fiscal capacity increase as the VAR forecasts larger surpluses in the near future.

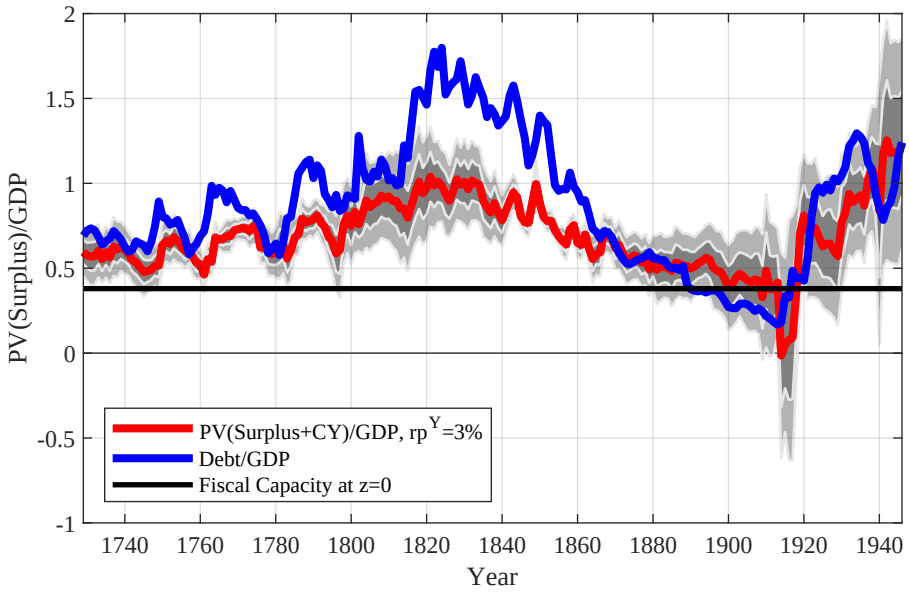
The bottom panel of Table 2 confirms that surpluses fully back the value of the debt. The average ratio of U.S. fiscal capacity to debt is 169.36%.

5.7 Results for Dynamic Fiscal Capacity Post-WW-II

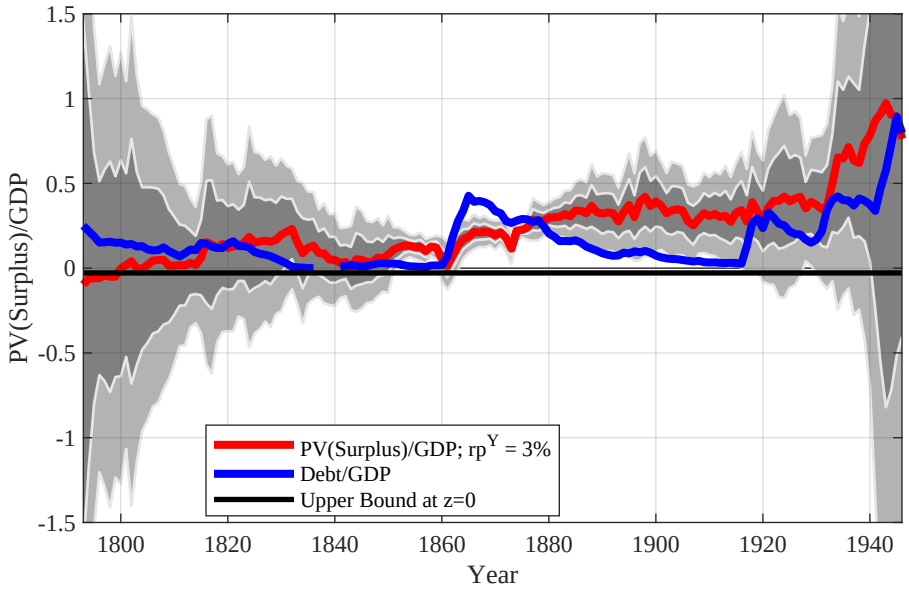
U.K. Next, we turn to the post-war sample. The top panel of Figure 9 plots the dynamic fiscal capacity estimate after WW-II. As shown in Panel A of Figure 9 , the U.K.'s dynamic fiscal capacity stays above the market value of debt-to-GDP ratio over the entire period from 1947 to 2020. The

Figure 8: Fiscal Capacity: Pre-WW-II

Panel A: U.K. 1729 – 1946



Panel B: U.S. 1793 – 1946



The top panel plots the dynamic measure of fiscal capacity for the U.K. government over the sample period from 1729 to 1947 (red line), the steady-state fiscal capacity measure (horizontal black line), and the actual debt/GDP ratio (blue line). The fiscal capacity measure for the U.K. assumes a GDP risk premium of 3% and includes the seigniorage revenue from convenience yields. The two-standard-error confidence interval around the dynamic fiscal capacity estimate is generated by bootstrapping 10,000 samples. The bottom panel plots the dynamic fiscal capacity for the U.S. government over the sample period from 1793 to 2020; it too assumes a GDP risk premium of 3%.

correlation between fiscal capacity and debt/output is still quite high (0.74) , though lower than in the pre-WW-I era.

U.S. The bottom panel of Figure 9 plots the dynamic fiscal capacity in the U.S. estimate after WW-II. The contrast with the U.K. could not be clearer. The correlation between fiscal capacity and the debt/output ratio is negative (-0.17). Macro fundamentals play no discernible role in the valuation of U.S. debt.

Except for a short period in the early 2000s, the U.S. dynamic fiscal capacity measure inclusive of seigniorage revenue is below the market value of debt. Future surpluses and convenience yields only cover only 32.20% of outstanding debt. The gap has grown large over the last two decades of the sample. Despite its current privileged position as the world's safe haven asset post WW-II, U.S. debt is substantially less backed then U.K. debt during its period as the global hegemon pre-WW-I. Interestingly, and in sharp contrast with the U.K. during its period of financial hegemony, the correlation between the market value of debt/GDP and our measure of fiscal capacity inclusive of convenience is -17%.

5.8 Robustness

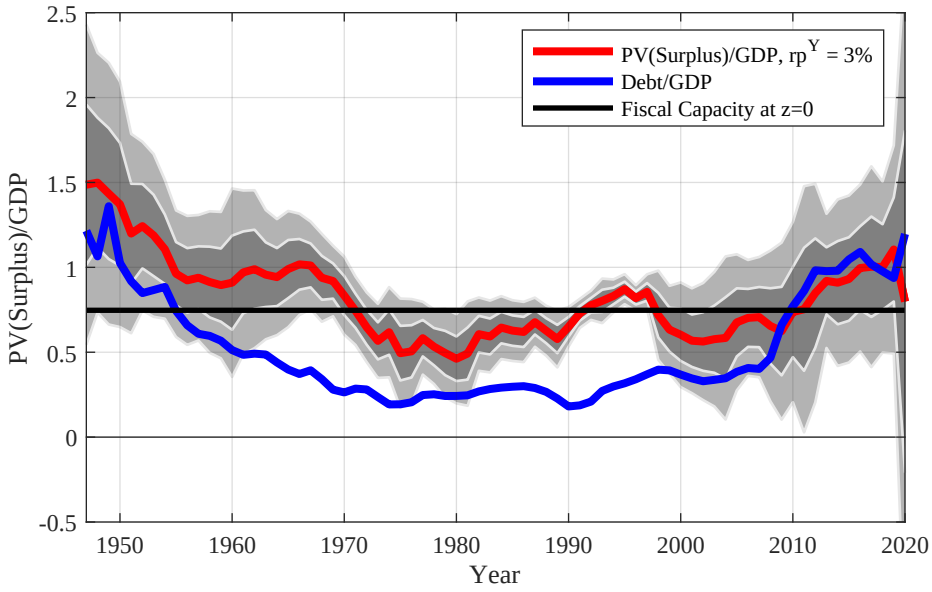
We consider three robustness checks and show that our results remain largely unchanged.

In our benchmark results, we held seigniorage revenue from convenience for the U.K. in the pre-WW-II period fixed at 0.47% of GDP. In a first robustness check, we study how sensitive results are to an alternative measure of convenience yield. We use the actual convenience yields in Figure 4 to estimate the seigniorage revenue. For the periods with missing convenience yields, we proxy them with the average value from the adjacent period. We use the average convenience yield from 1873 to 1913 (107 bps.) to proxy for the convenience yields from 1729 to 1872 and use the average convenience yield from 1925 to 1931 (61 bps.) to proxy for the convenience yields from 1914 to 1924 and from 1932 to 1946. Seigniorage revenue is obtained as the product of the convenience yield with the outstanding debt in each period. The yellow line in Panel A of Figure 10 presents the estimated dynamic fiscal capacity. The last two columns of Table 6 reports the averages of the fiscal capacity for both the pre-WWII and post-WWII samples. The steady-state fiscal capacity for the pre-WWII period is 47.04%, 10 percentage points higher than the benchmark value of 37.97%. The sample average of the dynamic fiscal capacity estimate (yellow line) for the pre-WWII period is 78.75%, compared to 69.32% in the benchmark case (red line). The correlation between these two dynamic fiscal capacity measures is high at 0.80. This alternative approach raises the fiscal capacity estimates in the pre-war era but does not change our conclusion.

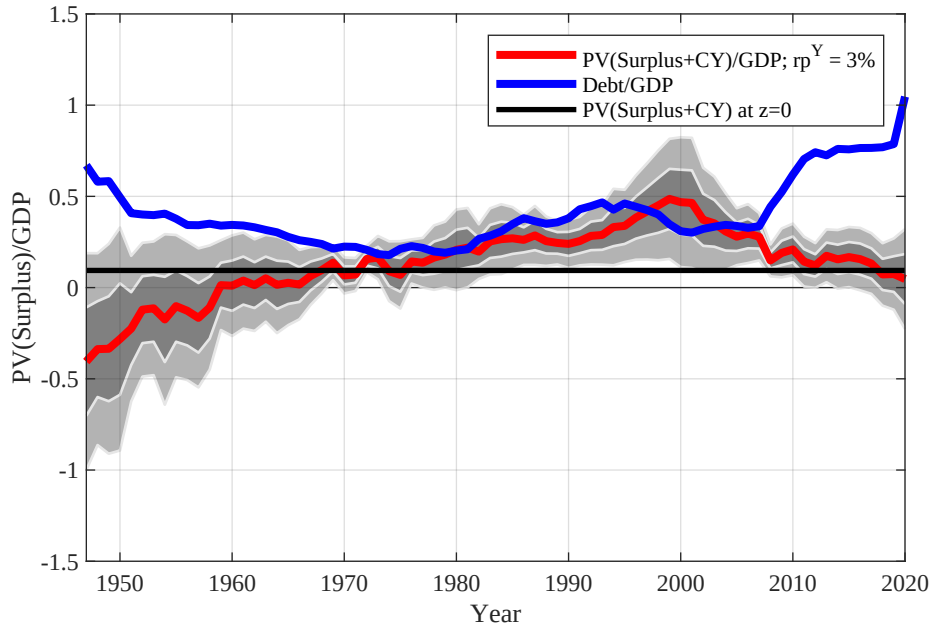
In a second robustness check, we consider a VAR model which includes the log debt-to-GDP

Figure 9: Fiscal Capacity: Post-WW-II.

Panel A: U.K. 1947 – 2020



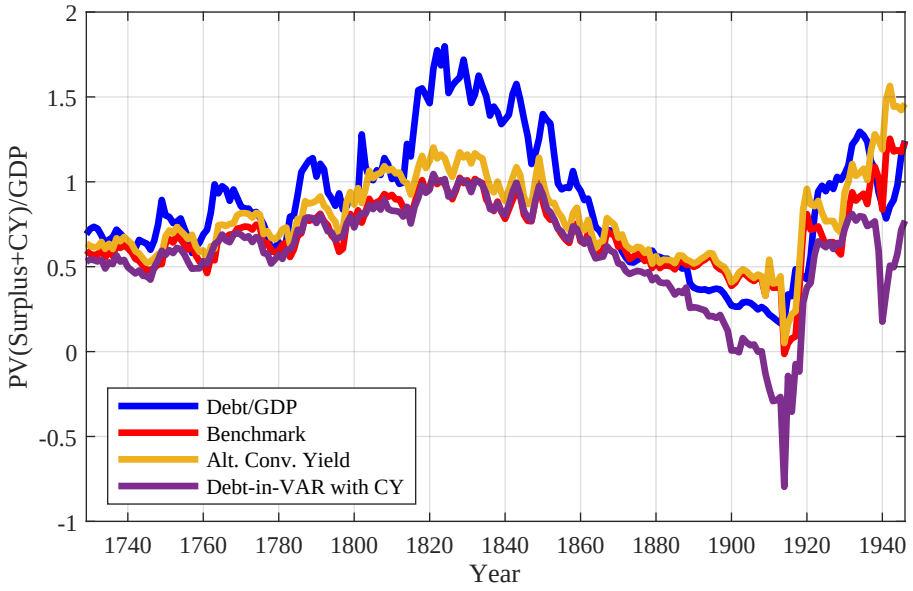
Panel B: U.S. 1947 – 2020



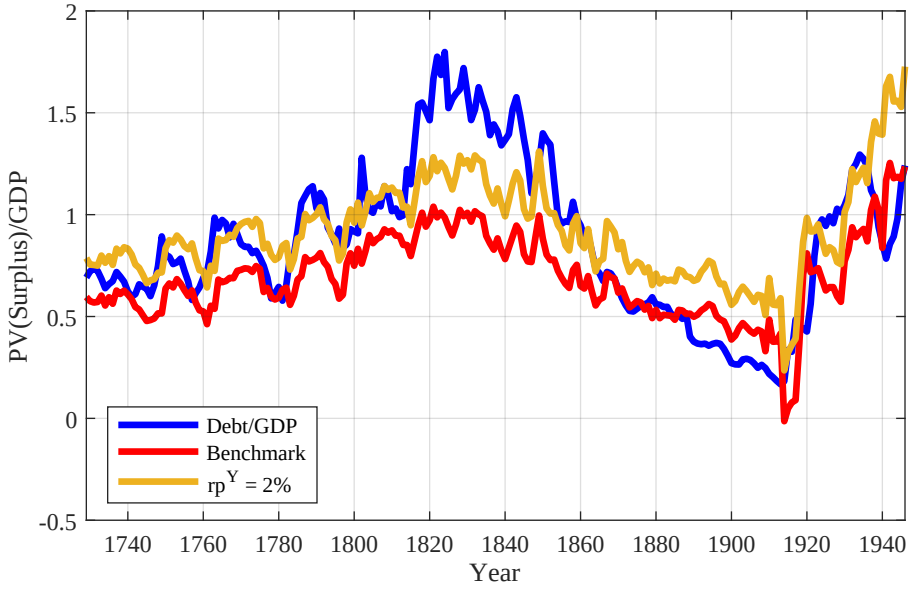
The top (bottom) panel plots U.K. (U.S.) fiscal capacity post-WW-II. In the post-WW-II U.S. period, the benchmark case includes the seigniorage revenue from convenience yields. 2-standard-error confidence intervals generated by bootstrapping 10,000 samples. We also report the steady-state upper bound evaluated at $z = 0$, and the actual debt/output ratio. We report the benchmark case with a GDP risk premium of 3%.

Figure 10: Fiscal Capacity with Convenience Yields: U.K. 1729 – 1946

Panel A: Robustness with Debt in VAR



Panel B: Robustness with 2% Output Risk Premia



This figure plots the fiscal capacity with convenience yields of the U.K. government over the sample period from 1729 to 1946. The observed debt/GDP ratio is in blue in both panels. Panel A plots the benchmark model (red line), with seigniorage revenue as a constant 0.47% fraction of GDP, the case in which convenience yield is actual long-term interest rate difference in Figure 4 multiplied by the debt/GDP ratio (yellow line), and the case where the debt/GDP ratio is in the VAR model (purple line). The GDP risk premium is 3% in all three cases. Panel B plots the benchmark with 3% GDP risk premium (red line) and a case where he GDP risk premium equals 2% (yellow line).

ratio as one of the state variables. We include both the first difference and the level of the demeaned log debt/GDP ratio in the VAR and impose the cointegration for debt and output with coefficient (1, -1) as we did for tax revenue and spending. We assume that UK received the seigniorage revenue as a fixed fraction 0.47% of GDP as in our benchmark case. The purple line in Panel A of Figure 10 presents the dynamic fiscal capacity measure for the model with debt in the VAR. The first two columns of Table 6 report the sub-sample averages. The steady-state fiscal capacity is 38.00%, almost identical to that in the benchmark. The sample average of the dynamic fiscal capacity measure is 57.95%, lower than the sample average of 69.32% in the benchmark case. The correlation between these two measures is 0.89. For completeness, Appendix D.2 reports results for the model with debt in the VAR for the post-WW-II sample era. Our conclusion that debt is below the fiscal bound for the U.K. after WW-II is strengthened.

Finally, we estimate a specification that sets the GDP risk premium to 2% compared to 3% in the benchmark since some authors report lower equity premium estimates for the 19th century (Siegel, 2005). This 2% estimate of the GDP risk premium is definitely on the low end of the plausible range. With the assumed (narrow) convenience yield of 100 basis points that accrues to U.K. gilts, the true risk premium is only 1% (2%-1%) since the true risk-free rate of interest is 1% point higher. Panel B of Figure 10 presents the dynamic fiscal capacity bound in the yellow line. Fiscal capacity is higher with a lower GDP risk premium; the yellow line is above the red line for the benchmark model with a 3% GDP risk premium. The middle panel of Table 6 report the sub-sample averages. The fiscal capacity with the convenience yields is 82.00% of GDP in the pre-WW-I period and 91.31% of GDP on average in the pre-WW-II period. The ratio of fiscal capacity to debt averages 94.86% before WW-I and 104.88% before WW-II. These calculations show that a low GDP risk premium combined with a large convenience yield results in close to full backing of UK debt on average in the early period. However, we note in Panel B of Figure 10 that there remains a large deficit of 50% of GDP after the Napoleonic wars. The correlation between fiscal capacity and debt/output is 0.90 before WW-I and 0.77 before WW-II, similar to the benchmark model. After WW-II, the conclusion that there is ample fiscal capacity in the U.K is strengthened.

Table 6: Steady-state Analysis of Fiscal Capacity for the U.K.: Robustness

	Debt in VAR		$rp^Y = 2\%$			**Actual Conv. Yields**	
	1729 – 1946	1947 – 2020	1729 – 1914	1729 – 1946	1947 – 2020	1729 – 1946	1947 – 2020
	Steady State at $z = 0$						
$PV(S)/Y$	27.20	73.31	62.66	35.35	126.62	27.18	74.71
$PV(S+CY)/Y$	38.00	73.31	75.26	49.56	126.62	47.04	74.71
	Sample Averages						
$PV(S)/Y$	46.69	89.68	68.95	74.92	148.69	57.26	82.03
$PV(S+CY)/Y$	57.95	89.68	82.00	91.31	148.69	78.75	82.03
$PV(S)/D$	53.63	167.89	79.76	86.05	278.34	65.77	153.56
$PV(S+CY)/D$	66.56	167.89	94.86	104.88	278.34	90.46	153.56
$\rho(PV(S+CY)/Y, D/Y)$	0.89	0.84	0.90	0.77	0.84	0.80	0.74

The table reports estimates of fiscal capacity for the U.K. under different model specifications. All values are in percentage points, except for the correlation coefficient ρ. In three separate panels, we report the estimates of fiscal capacity in the model with the debt/GDP ratio in the VAR (left panel), the benchmark specification with an unlevered equity or output risk premium rp_0^Y of 2% (middle panel), and the actual time-varying convenience yields as in Figure 4 (right panel). D denotes the market value of debt.

6 Conclusion

Global investors seem to concentrate fiscal capacity in the world's safe asset supplier beyond what is warranted by that country's fiscal fundamentals, even when we incorporate seigniorage revenue from convenience yields into the estimate of fiscal capacity. When the country's relative fundamentals deteriorate, that extra fiscal capacity is withdrawn by bond investors who then focus only on the country's fundamentals. As the world's global safe haven asset, the U.K. benefited from this fiscal capacity prior to WW-I, but lost that privileged status to the U.S. after WW-II.

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A Data Sources

A.1 United Kingdom: 1729-2020

The main dataset we use for the UK is *A millennium of macroeconomic data* published by the bank of England. The dataset contains a broad set of macroeconomic and financial data for the UK. We also use other data sets as complementing the main dataset. Below we describe how we construct variables in our estimation procedure from the raw data set. All sheets and columns refer to the excel table *A millennium of macroeconomic data* unless described otherwise. We use *Global Financial Data* We use additional data sources to complement after 2016.

A.1.1 Government Finance

Primary Surplus: For 1729-2016, the government expenditure G is the total government expenditure (Sheet A27, Column C) plus interest payments (Sheet A27, Column N). The government revenue T is from Sheet A27, Column N. The raw source for the data is from Mitchell and Mitchell (1988) and UK Office of National Statistics. The primary surpluses are the government revenue T minus the government spending before interest payments G. For periods after 2016, we use the ONS data: We use *CG: Total current expenditure, payable: £m CPNSA'*, minus *'CG: Total Net Investment: £m CPNSA'*, plus *'Public sector finances: Central Government: Depreciation: £m: CPNSA'* and minus *CG: Current expenditure: Interest payable: £m CPNSA* for government expenditure net of interest payment. We use *'CG: Total current receipts, receivable: £m CPNSA'* for government revenue.

Debt to GDP: We compute market value of debt using aggregate number from each individial bond with the dataset from Ellison and Scott (2020). For post 2016, we first compute the growth rate of market value of debt to GDP using series **GGGDTAGBA188N** from Fred (*General government gross debt for United Kingdom, Percent of GDP, Annual, Not Seasonally Adjusted*), then using 2016 number to compute forward.

A.1.2 State Variables

GDP and Inflation: For real GDP, we use Sheet A8, Column D. For nominal GDP, we use Sheet A9, Column D. Both of the GDP series are measured based on the current definition of UK (Great Britain and Northern Ireland). We use the ratio of real GDP and nominal GDP to get the GDP deflator and the inflation series.The government finances in the raw data are for fiscal years. For years after 1854, the fiscal year ends on March 31st, so we use linear interpolation to convert fiscal year data to calendar year data. For year prior to 1854, the fiscal year ends on January 5th, so we use the fiscal year number as calendar year number as they are sufficiently close. After 1946, we use Global Financial Data series **CPIUKQ**.

Short Rate: We use *Prime Commercial Bill/Paper Rate* in Sheet A31, Column F as our 1-period interest rate in our model for 1729-2016. We use 3 month libor rate for 2017-2020.

10-year Rate: We use *United Kingdom 10-year Government Bond Yield* (series **IGGBR10D**) from *Global Financial Data* for the entire sample.

Stock Price index: We use *Share price indices* in Sheet A31, Column W as the aggregate stock price index for 1729-2016. We use FTSE All Share index for 2017-2020.

Equity Price-Dividend Ratio: We use Golez and Koudijs (2018) for 1729-1812. and 1813 – 1870, Òscar Jordà, Schularick, and Taylor (2016) for 1870 – 2015 and dividend yield from FTSE All Share index from Datastream for 2016-2020. The dividend yield for the first sample period is UK and Netherland combined.

A.2 United States:1791-2020

A.2.1 Government Finance

Expenditures and Revenue: Our historical (1791-1929) government finance data are dataset assembled by Hall and Sargent (2021), which contain detailed historical government finance information starting 1791. We use *Total ordinary expenditures* minus *Interest on public debt* as the primary spending G. We use *Gross Receipts* as the government revenue T. The data source of the government expenditures and revenues from 1791 to 1929 are from *the 1940 Annual Report of the Secretary of the Treasury on the State of the Finances*, page 642-650. The federal government expenditures and receipts from 1929 to 2020 are from NIPA Table 3.2. The government revenue is the *Current Receipts* from Table 3.2, and the government spending before net interest payment is *Current Expenditure* minus the net interest payment from Table 3.2.

Debt to GDP: The value of marketable and nonmarketable debt from 1791 to 2020 is from Hall and Sargent (2011) and CRSP Treasury Monthly Database.

A.2.2 State Variables

GDP and Inflation: Our historical real GDP data from 1791 to 1929 is from Johnston and Williamson (2022) *measuringworth.com*. Our inflation data is from Series **CPUSAM** (*United States BLS Consumer Price Index Inflation Rate NSA (with GFD Extension)*) from *Global Financial Data*. The nominal GDP from 1929 to 2020 is from NIPA Table 1.1.5, and inflation from 1929 to 2020 is the change in the GDP price index from NIPA Table 1.1.4. The real GDP growth for the period after 1929 is nominal GDP growth minus inflation.

Short Rate: We use Series **TRUSABIM** (*GFD Indices USA Total Return T-Bill Index*) from *Global Financial Data* to compute the return of T-bills to proxy for the short rate from 1791 to 1929. We use the 1-year CMT for the short rate after 1929 from Fred.

10-year Rate: We use Series **IGUSA10D** (*USA 10-year Bond Constant Maturity Yield (with GFD Extension)*) from *Global Financial Data* from 1791 to 1929. The 10-year CMT after 1929 is from Fred.

Equity Price-Dividend Ratio and Dividend Growth: We use Series **SYUSAYM** (*S&P 500 Monthly Dividend Yield (with GFD Extension)*) from *Global Financial Data* for dividend yield. We use Series **GFUS100MPM** (*GFD Indices USA Top 100 Price Index*) from *Global Financial Data* for total return index for 1791-1871 and Series **SPXTRD** (*S&P 500 Total Return Index (with GFD extension)*) from *Global Financial Data* from 1871 to 1929. We use these two series to infer dividend growth. The log-price-dividend ratio and the log real dividend growth after 1929 are computed using CRSP database.

B GDP Growth and Return Betas

Before WW-I, spending and taxes were largely a-cyclical. The government's spending decisions were driven by war and peace. Before WW-II, if anything, government spending seems riskier at short to medium horizons than tax revenue, because the government increases spending when the U.K. goes to war, which coincides with larger GDP growth. But wars are presumably not low marginal utility growth states for the stand-in U.K. investor. In fact, when we look at return betas, we see that spending looks safer than taxes over short to medium horizons.

Figure A.1 and A.2 report the GDP growth betas obtained by regressing the accumulated log tax revenue and government spending on the accumulated log GDP growth. The GDP growth beta for government spending from 1729 to 1946 is higher than tax revenue. One reason for the extra sensitivity of government spending to the GDP risk is the frequent war episodes in the pre-WW-II sample (see Panel B in Figure 1), as we see similar patterns for both the U.K. and the U.S.

In the post-WW-II sample of the U.K., taxes are much riskier than spending, especially in the U.S. the GDP growth beta for government spending remains below zero over the 1-year to 5-year horizon, as governments increase transfer spending as a fraction of GDP in recessions. On the other hand, the tax revenue is riskier in the post-war period. For both the U.K. and the U.S. sample, the GDP growth betas for tax revenue are positive and larger than the spending growth beta across all horizons.

Figure A.3 plots the return betas. In the U.K., the return betas of spending growth converge to -1.5 at short to medium horizons, whereas the return betas of tax growth are close to zero.

Cyclicality of U.S. and U.K. Government Cash Flows Table A.1 reports the regression results. The first two columns report the regressions of the change in the log of τ on GDP growth. The next two columns report the same for results for the change in the log of g. In the pre-WW-II era, the slope coefficient is negative, consistent with a-cyclical or even counter-cyclical surpluses.

Table A.1: Cyclicality of US and UK Government Finance

Panel A: 1729-1946

	$\Delta \log \tau_{us}$	$\Delta \log \tau_{uk}$	$\Delta \log g_{us}$	$\Delta \log g_{uk}$	Δs_{us}	Δs_{uk}
	(1)	(2)	(3)	(4)	(5)	(6)
const	0.01	0.02***	-0.02	0.00	0.01**	0.01*
	(0.03)	(0.01)	(0.03)	(0.02)	(0.00)	(0.00)
real gdp growth	0.01	-0.64***	1.12**	0.52	-0.14***	-0.36***
	(0.44)	(0.16)	(0.55)	(0.47)	(0.04)	(0.08)
Observations	154	218	154	218	154	218
R^2	0.00	0.07	0.03	0.01	0.08	0.08
Adjusted R^2	-0.01	0.07	0.02	0.00	0.08	0.08
Residual Std. Error	0.27	0.08	0.34	0.23	0.02	0.04
F Statistic	0.00	16.11***	4.16**	1.20	13.64***	19.32***

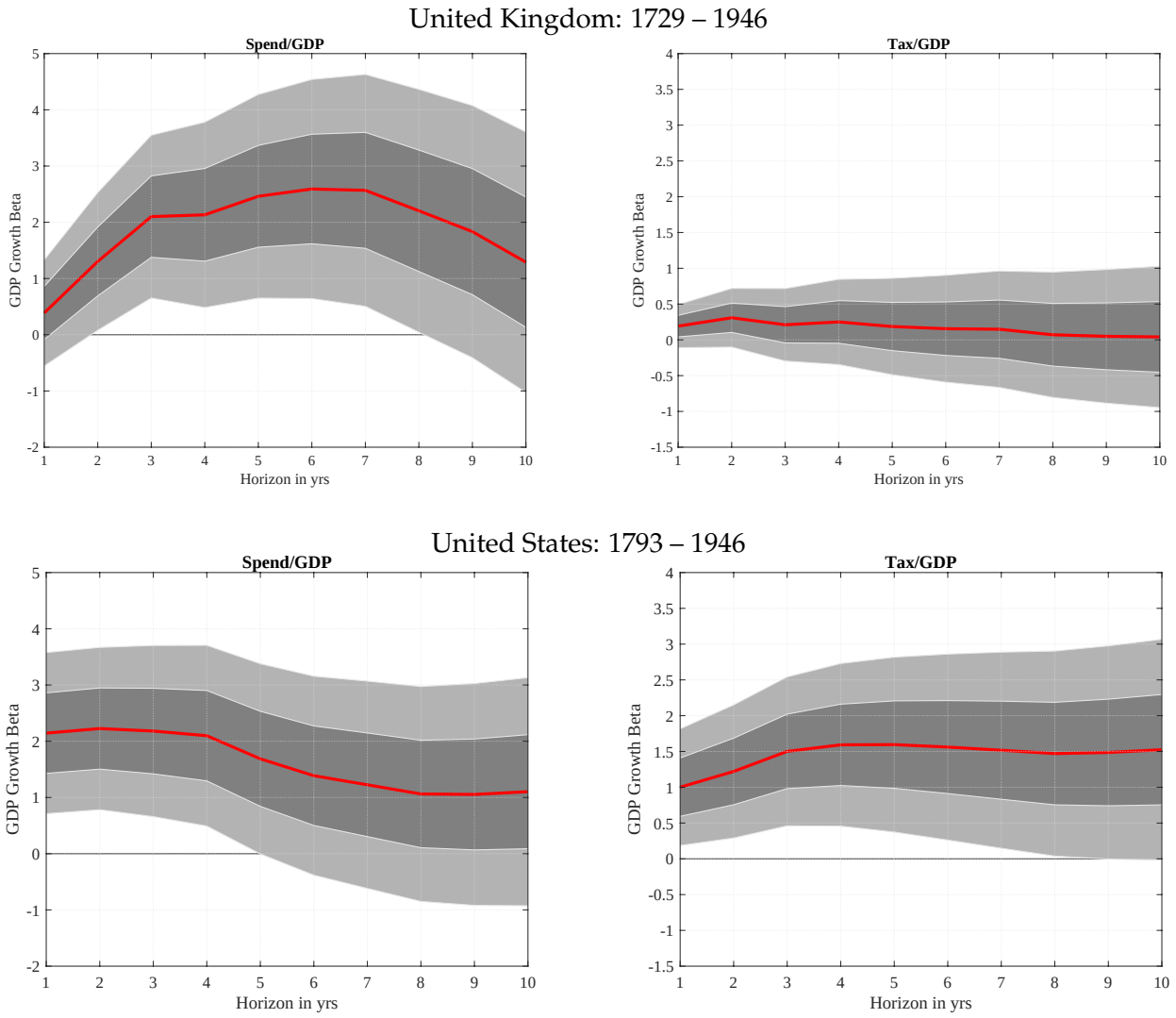
Note: *p<0.1; **p<0.05; ***p<0.01

Panel B: 1947-2020

	$\Delta \log \tau_{us}$	$\Delta \log \tau_{uk}$	$\Delta \log g_{us}$	$\Delta \log g_{uk}$	Δs_{us}	Δs_{uk}
	(1)	(2)	(3)	(4)	(5)	(6)
const	-0.03***	0.01**	0.04***	0.03***	-0.01***	-0.01***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
real gdp growth	1.10***	-0.38***	-1.27***	-1.30***	0.45***	0.36***
	(0.21)	(0.13)	(0.34)	(0.26)	(0.07)	(0.09)
Observations	74	74	74	74	74	74
R^2	0.28	0.10	0.17	0.26	0.34	0.17
Adjusted R^2	0.27	0.09	0.15	0.25	0.33	0.16
Residual Std. Error	0.04	0.03	0.07	0.05	0.02	0.02
F Statistic	27.67***	8.25***	14.24***	25.85***	36.60***	15.17***

Note: *p<0.1; **p<0.05; ***p<0.01

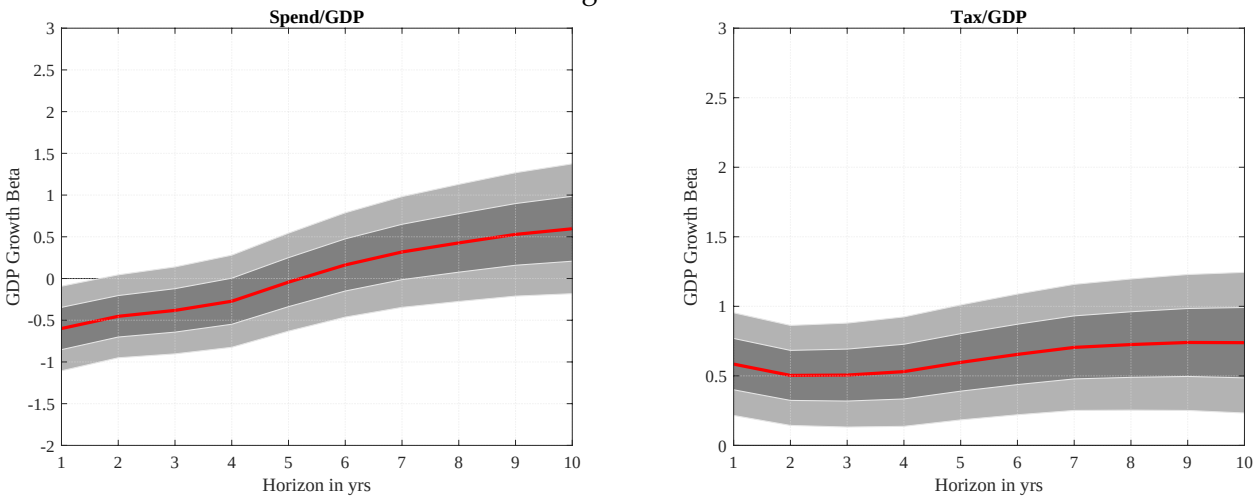
Figure A.1: GDP Growth Beta: Pre – 1946



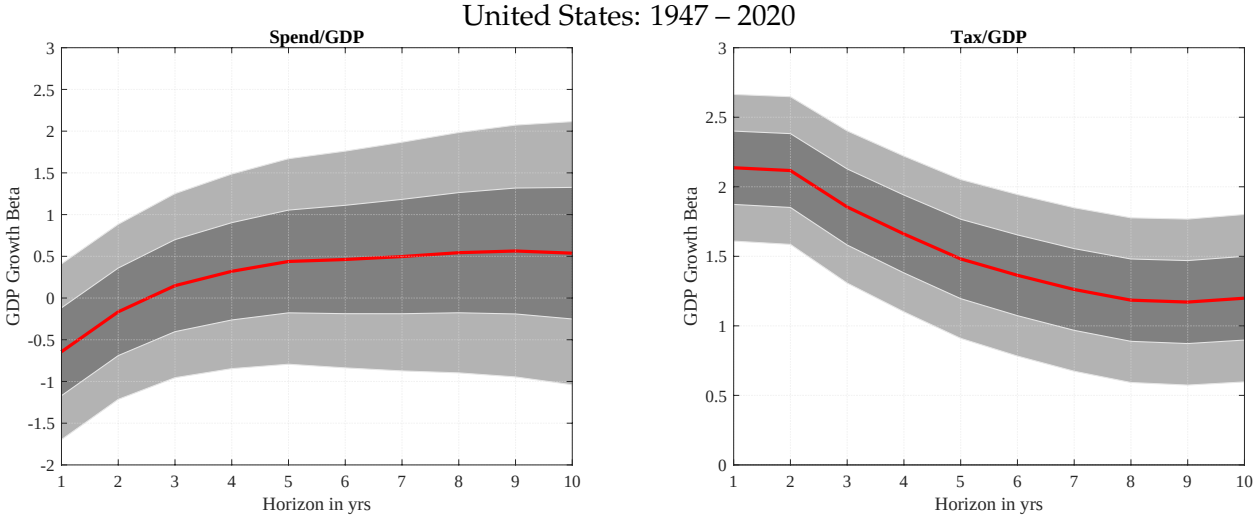
The figure plots the GDP growth betas of log government spending and log tax revenue against the horizon (in years) for the U.K. and the U.S., computed by the following regression: $\sum_{t=1}^{h} \log(CF_t) = \alpha + \beta_h \sum_{t=1}^{h} \log(\Delta GDP_t) + \epsilon_t$, where CF_t is the government spending G or tax revenue T. Plotted with 1- and 2-standard error bands. Standard errors generated by bootstrapping 10,000 times from time-series model with cointegration for taxes (spending) and output. The log of spending/output, the log of taxes/output and the log GDP growth are AR-processes. Spending growth and tax revenue growth generated by bootstrapping with replacement from joint residuals.

Figure A.2: GDP Growth Beta: Post – 1946

United Kingdom: 1947 – 2020

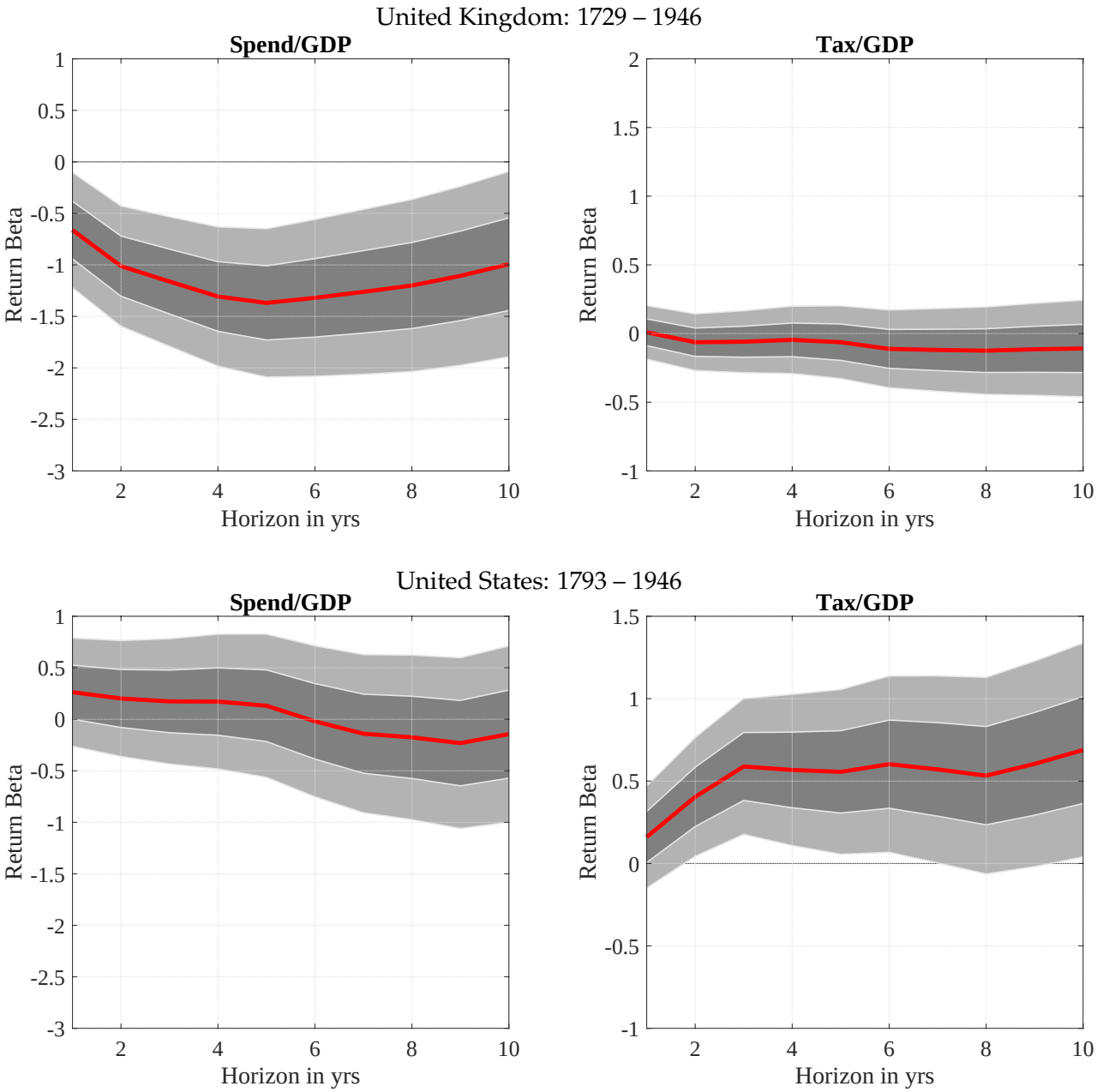


United States: 1947 – 2020



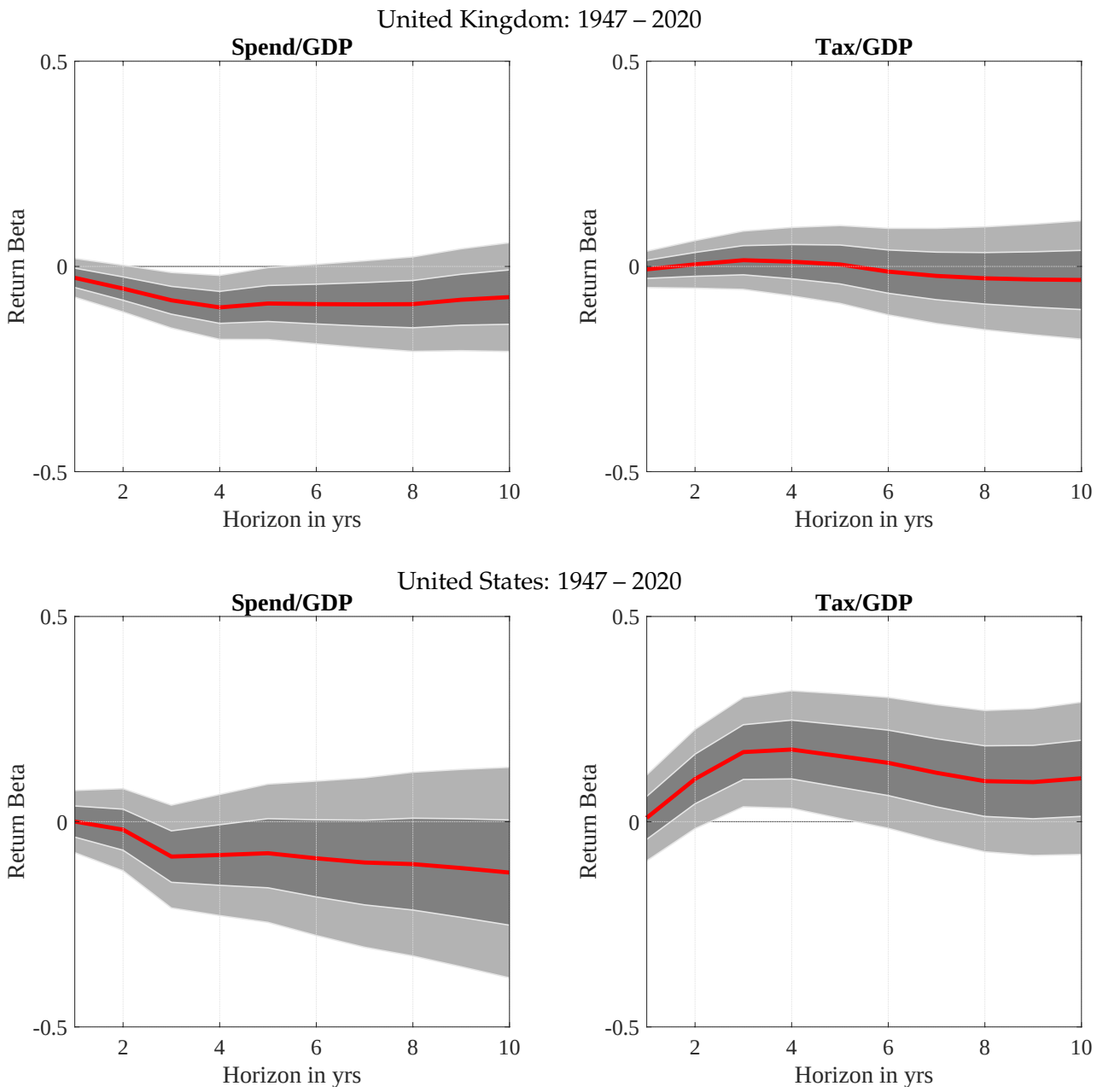
The figure plots the GDP growth betas of log government spending and log tax revenue against the horizon (in years) for the U.K. and the U.S., computed by the following regression: $\sum_{t=1}^{h} \log(CF_t) = \alpha + \beta_h \sum_{t=1}^{h} \log(\Delta GDP_t) + \epsilon_t$, where CF_t is the government spending G or tax revenue T. Plotted with 1- and 2-standard error bands. Standard errors generated by bootstrapping 10,000 times from time-series model with cointegration for taxes (spending) and output. The log of spending/output, the log of taxes/output and the log GDP growth are AR-processes. Spending growth and tax revenue growth generated by bootstrapping with replacement from joint residuals.

Figure A.3: Return Beta: Pre – 1946



The figure plots the return betas of log government spending and log tax revenue against the horizon (in years) for the U.K. and the U.S., computed by the following regression: $\sum_{t=1}^{h} \log(CF_t) = \alpha + \beta_h \sum_{t=1}^{h} \log(RET_t) + \epsilon_t$, where CF_t is the government spending G or tax revenue T, and RET is the cum-dividend return of the stock market. Plotted with 1- and 2-standard error bands. Standard errors generated by bootstrapping 10,000 times from time-series model with cointegration for taxes (spending) and output. The log of spending/output, the log of taxes/output and the log equity return are AR-processes. Spending growth and tax revenue growth generated by bootstrapping with replacement from joint residuals.

Figure A.4: Return Beta: Post – 1946



The figure plots the return betas of log government spending and log tax revenue against the horizon (in years) for the U.K. and the U.S., computed by the following regression: $\sum_{t=1}^{h} \log(CF_t) = \alpha + \beta_h \sum_{t=1}^{h} \log(RET_t) + \epsilon_t$, where CF_t is the government spending G or tax revenue T, and RET is the cum-dividend return of the stock market. Plotted with 1- and 2-standard error bands. Standard errors generated by bootstrapping 10,000 times from time-series model with cointegration for taxes (spending) and output. The log of spending/output, the log of taxes/output and the log equity return are AR-processes. Spending growth and tax revenue growth generated by bootstrapping with replacement from joint residuals.

C Coefficient Estimates

We perform a Johansen cointegration test by first estimating the vector error correction model :

$$\Delta w_t \quad = \quad A(B'w_{t-1} + c) + D\Delta w_{t-1} + \varepsilon_t, \quad \text{where } w_t = \begin{pmatrix} \log T_t \\ \log G_t \\ \log GDP_t \end{pmatrix}.$$

Both the trace test and the max eigenvalue test do not reject the null of cointegration rank 2 (with p-values of 0.15), but reject the null of cointegration rank 0 and 1 (with p-values lower than 0.01). These results are in favor of two cointegration relationships between variables in w_t.

C.1 The VAR System for the U.K.

The Cholesky decomposition of the residual variance-covariance matrix, $\Sigma^{\frac{1}{2}}$, multiplied by 100 for readability is given by:

Pre-1946 Sample:

$$100 \times \Sigma^{\frac{1}{2}} = \begin{pmatrix} 3.71 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.14 & 0.74 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.12 & -0.67 & 0.26 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.22 & 0.13 & -0.21 & 2.95 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -4.87 & 2.07 & 1.29 & -1.52 & 13.43 & 0 & 0 & 0 & 0 & 0 & 0 \\ -4.87 & 2.07 & 1.29 & -1.52 & 13.43 & 0.00 & 0 & 0 & 0 & 0 & 0 \\ 0.77 & -3.52 & -3.70 & 0.30 & -12.11 & 0.00 & 6.86 & 0 & 0 & 0 & 0 \\ -1.78 & -0.40 & 0.33 & -2.06 & -0.60 & 0.00 & -0.10 & 6.26 & 0 & 0 & 0 \\ -1.78 & -0.40 & 0.33 & -2.06 & -0.60 & 0.00 & -0.10 & 6.26 & 0.00 & 0 & 0 \\ -0.74 & -0.68 & 2.92 & -0.59 & -1.50 & 0.00 & -5.02 & 4.46 & 0.00 & 19.42 & 0 \\ -0.74 & -0.68 & 2.92 & -0.59 & -1.50 & 0.00 & -5.02 & 4.46 & 0.00 & 19.42 & 0.00 \end{pmatrix}$$

Post-1946 Sample:

$$100 \times \Sigma^{\frac{1}{2}} = \begin{pmatrix} 2.36 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.40 & 1.40 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.03 & -0.81 & 0.72 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.30 & 0.35 & -0.11 & 1.77 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1.34 & 0.04 & 0.03 & -0.90 & 4.91 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1.34 & 0.04 & 0.03 & -0.90 & 4.91 & 0.00 & 0 & 0 & 0 & 0 & 0 \\ -5.11 & -2.41 & -2.86 & 3.65 & -4.89 & 0.00 & 13.71 & 0 & 0 & 0 & 0 \\ 0.76 & 0.49 & 0.53 & -0.55 & -0.25 & 0.00 & -0.12 & 1.78 & 0 & 0 & 0 \\ 0.76 & 0.49 & 0.53 & -0.55 & -0.25 & 0.00 & -0.12 & 1.78 & 0.00 & 0 & 0 \\ 0.55 & -0.25 & 0.61 & -3.18 & -0.31 & 0.00 & 0.04 & 0.35 & 0.00 & 2.34 & 0 \\ 0.55 & -0.25 & 0.61 & -3.18 & -0.31 & 0.00 & 0.04 & 0.35 & 0.00 & 2.34 & 0.00 \end{pmatrix}$$

In this matrix, the last two columns are all zero. This is because the dependent variables $\log \tau_t - \log \tau_0$ and $\log g_t -$

$\log g_0$ do not have independent shocks. For example, $\log \tau_t - \log \tau_0$ can be expressed as

$$\begin{aligned} \log \tau_t - \log \tau_0 &= \Delta \log \tau_t + (\log \tau_{t-1} - \log \tau_0) \\ &= (e'_{\Delta\tau} \mathbf{\Psi} + e'_{\tau}) \boldsymbol{z}_{t-1} + e'_{\Delta\tau} \mathbf{\Sigma}^{\frac{1}{2}} \boldsymbol{\varepsilon}_t, \end{aligned}$$

which loads on the first eight shocks in the same way as $\Delta \log \tau_t - \mu_0^{\tau}$.

C.2 The VAR System for the U.S.

Table A.2: VAR Estimates $\mathbf{\Psi}$: 1793 – 1946 US Sample

	π_{t-1}	$y^{\$}_{t-1}(1)$	$y^{\$,spr}_{t-1}$	x_{t-1}	$\Delta \log d_{t-1}$	$\log d_{t-1}$	pd_{t-1}	$\Delta \log \tau_{t-1}$	$\log \tau_{t-1}$	$\Delta \log g_{t-1}$	$\log g_{t-1}$
π_t	0.23	0.28	0.87	0.21	0.06	0.01	0.05	0.03	-0.02	0.04	0.00
$y^{\$}_t(1)$	0.04	1.29	0.92	0.02	0.01	0.00	0.02	0.00	0.00	0.00	-0.00
$y^{\$,spr}_t$	-0.03	-0.44	-0.11	-0.03	-0.01	0.00	-0.02	-0.00	-0.01	-0.00	0.00
x_t	0.03	1.27	2.38	0.32	0.03	0.00	0.06	-0.00	0.03	0.02	-0.02
$\Delta \log d_t$	-0.37	7.76	6.73	0.16	-0.08	-0.03	0.42	-0.05	-0.03	-0.07	0.06
$\log d_t$	-0.37	7.76	6.73	0.16	-0.08	0.97	0.42	-0.05	-0.03	-0.07	0.06
pd_t	-0.25	-7.12	-7.47	-0.62	-0.09	-0.00	0.46	0.13	0.03	0.03	-0.04
$\Delta \log \tau_t$	-0.01	-9.46	-9.71	0.90	0.17	0.03	-0.28	-0.06	-0.33	-0.13	0.27
$\log \tau_t$	-0.01	-9.46	-9.71	0.90	0.17	0.03	-0.28	-0.06	0.67	-0.13	0.27
$\Delta \log g_t$	1.05	-4.78	-0.33	0.45	-0.18	0.08	-0.38	-0.03	0.02	0.13	-0.26
$\log g_t$	1.05	-4.78	-0.33	0.45	-0.18	0.08	-0.38	-0.03	0.02	0.13	0.74

Table A.3: VAR Estimates $\mathbf{\Psi}$: 1947 – 2020 US Sample

	π_{t-1}	$y^{\$}_{t-1}(1)$	$y^{\$,spr}_{t-1}$	x_{t-1}	$\Delta \log d_{t-1}$	$\log d_{t-1}$	pd_{t-1}	$\Delta \log \tau_{t-1}$	$\log \tau_{t-1}$	$\Delta \log g_{t-1}$	$\log g_{t-1}$
π_t	0.49	0.17	-0.39	-0.03	0.03	0.01	0.00	0.11	-0.07	-0.01	0.05
$y^{\$}_t(1)$	0.03	0.83	-0.13	0.15	0.07	-0.01	0.00	-0.03	-0.01	0.01	0.07
$y^{\$,spr}_t$	-0.07	-0.06	0.43	-0.16	-0.05	-0.01	-0.01	0.02	0.02	0.00	-0.03
x_t	-0.21	0.42	0.72	0.21	0.08	0.03	0.02	-0.08	-0.09	-0.02	0.07
$\Delta \log d_t$	-0.08	-0.93	-1.85	0.35	0.30	-0.13	-0.00	-0.29	-0.23	-0.18	0.19
$\log d_t$	-0.08	-0.93	-1.85	0.35	0.30	0.87	-0.00	-0.29	-0.23	-0.18	0.19
pd_t	-2.73	-0.64	-0.97	-1.38	-0.35	-0.13	0.68	0.06	0.40	0.32	-0.51
$\Delta \log \tau_t$	-0.69	0.72	-0.71	0.02	0.12	-0.03	0.04	0.36	-0.62	0.09	0.11
$\log \tau_t$	-0.69	0.72	-0.71	0.02	0.12	-0.03	0.04	0.36	0.38	0.09	0.11
$\Delta \log g_t$	1.08	-0.14	0.48	-0.17	-0.31	0.07	-0.04	0.36	-0.20	0.38	-0.62
$\log g_t$	1.08	-0.14	0.48	-0.17	-0.31	0.07	-0.04	0.36	-0.20	0.38	0.38

Pre-1946 Sample:

$$100 \times \Sigma^{\frac{1}{2}} = \begin{pmatrix} 5.90 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.11 & 1.12 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.05 & -1.03 & 0.29 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1.00 & 0.45 & -0.55 & 4.27 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -4.56 & -1.52 & -2.14 & -1.71 & 13.64 & 0 & 0 & 0 & 0 & 0 & 0 \\ -4.56 & -1.52 & -2.14 & -1.71 & 13.64 & 0.00 & 0 & 0 & 0 & 0 & 0 \\ -1.02 & -0.60 & -3.09 & 1.00 & -10.47 & 0.00 & 13.45 & 0 & 0 & 0 & 0 \\ 3.39 & 2.23 & -2.95 & 0.10 & 2.78 & 0.00 & -0.11 & 21.68 & 0 & 0 & 0 \\ 3.39 & 2.23 & -2.95 & 0.10 & 2.78 & 0.00 & -0.11 & 21.68 & 0.00 & 0 & 0 \\ 7.67 & -2.17 & -2.46 & 2.53 & 0.19 & 0.00 & 1.37 & 4.95 & 0.00 & 28.01 & 0 \\ 7.67 & -2.17 & -2.46 & 2.53 & 0.19 & 0.00 & 1.37 & 4.95 & 0.00 & 28.01 & 0.00 \end{pmatrix}$$

Post-1946 Sample:

$$100 \times \Sigma^{\frac{1}{2}} = \begin{pmatrix} 1.07 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.33 & 1.21 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.07 & -0.50 & 0.47 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.15 & 0.83 & -0.17 & 1.84 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1.49 & 0.29 & -0.68 & -0.71 & 4.58 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1.49 & 0.29 & -0.68 & -0.71 & 4.58 & 0.00 & 0 & 0 & 0 & 0 & 0 \\ -2.55 & 0.25 & -0.14 & -2.65 & -4.06 & 0.00 & 14.09 & 0 & 0 & 0 & 0 \\ 0.36 & 0.75 & -0.18 & 1.52 & 0.69 & 0.00 & 0.36 & 2.94 & 0 & 0 & 0 \\ 0.36 & 0.75 & -0.18 & 1.52 & 0.69 & 0.00 & 0.36 & 2.94 & 0.00 & 0 & 0 \\ 0.34 & -1.35 & 0.36 & -2.95 & -1.19 & 0.00 & 0.21 & 0.56 & 0.00 & 4.11 & 0 \\ 0.34 & -1.35 & 0.36 & -2.95 & -1.19 & 0.00 & 0.21 & 0.56 & 0.00 & 4.11 & 0.00 \end{pmatrix}$$

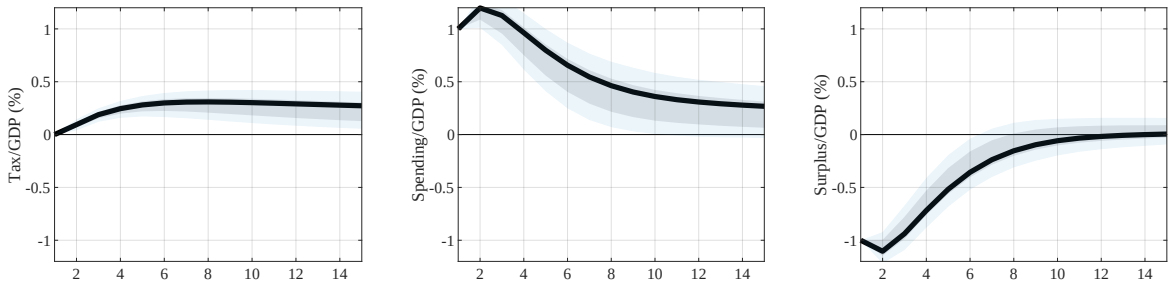
D Additional Tables and Figures

D.1 Fiscal Impulse Responses

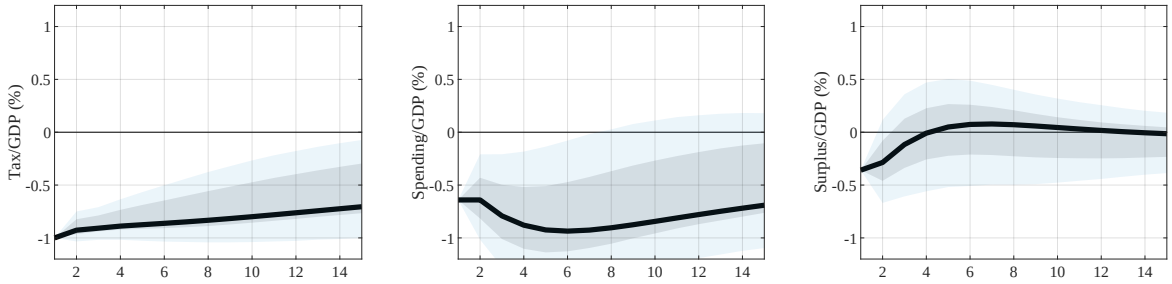
Figures A.5 and A.6 show impulse-response functions for the pre-1946 and post-1946 samples, respectively. They show the response of Tax/GDP, Spending/GDP, and Surplus/GDP to a 1% point increase in spending/GDP (panel A), a 1% point decrease in tax revenues/GDP (panel A), and a 1% point increase in GDP growth (panel C).

Figure A.5: Impulse Response: 1729 – 1946 United Kingdom

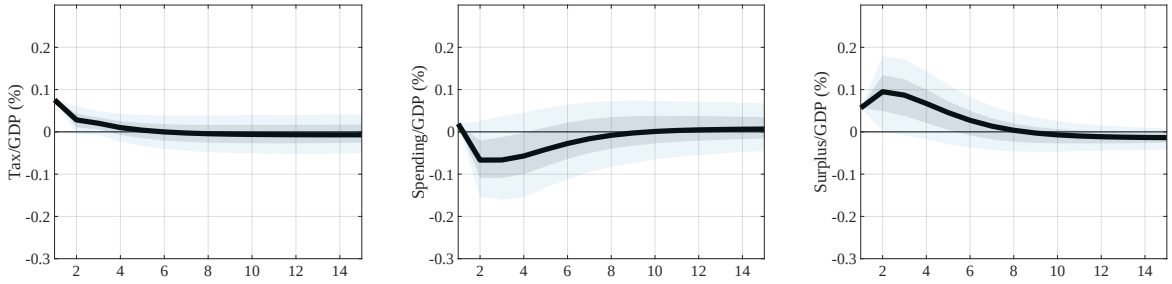
Panel A: +1% Shock to Spending-to-GDP



Panel B: -1% Shock to Tax-to-GDP



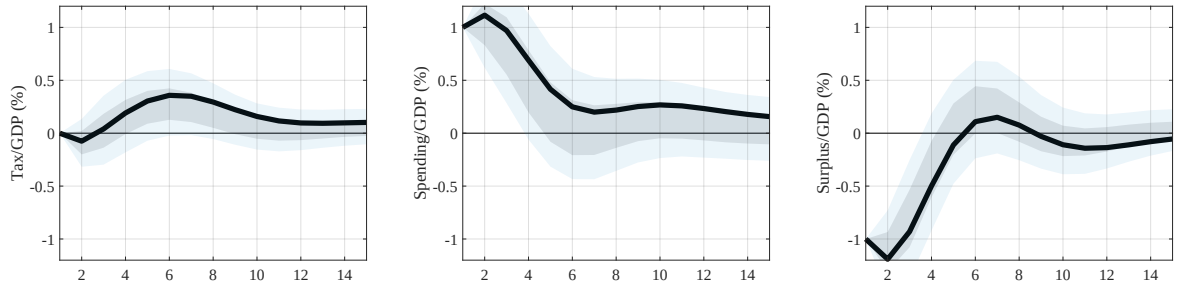
Panel C: -1% Shock to GDP Growth



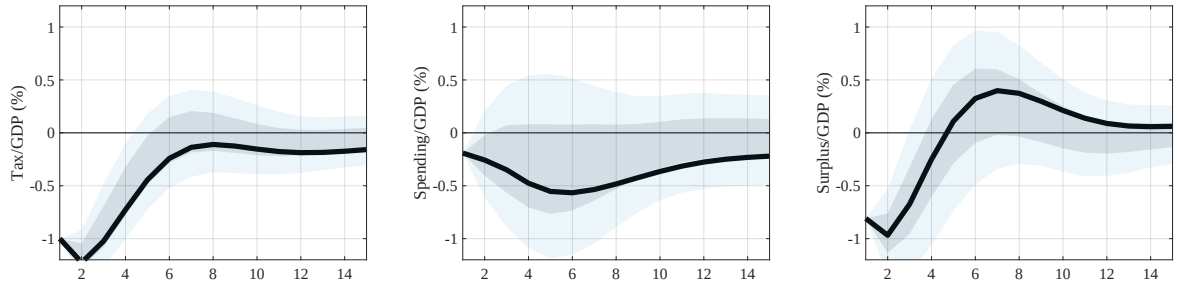
The solid black line shows the impulse responses for the benchmark VAR. The impulse in the top row is a +1 percentage point shock to spending growth. The impulse in the middle row is a -1 percentage point shock to tax revenues. The impulse in the bottom row is a -1 percentage point shock to GDP growth x_t. We plot the one- and two-standard-deviation confidence intervals based on bootstrapping over 10,000 rounds.

Figure A.6: Impulse Response: 1947 – 2020 United Kingdom

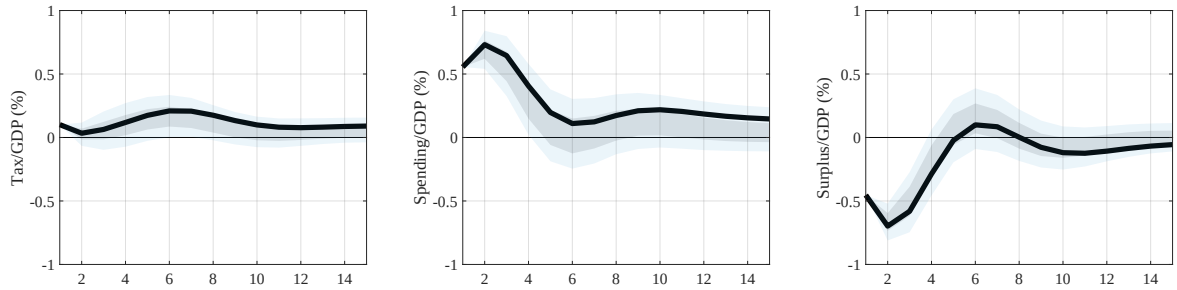
Panel A: +1% Shock to Spending-to-GDP



Panel B: -1% Shock to Tax-to-GDP



Panel C: -1% Shock to GDP Growth



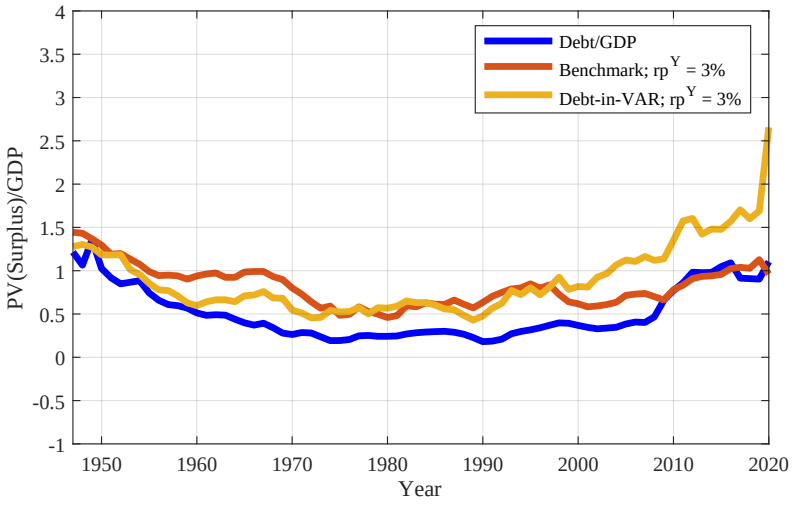
The solid black line shows the impulse responses for the benchmark VAR. The impulse in the top row is a +1 percentage point shock to spending growth. The impulse in the middle row is a -1 percentage point shock to tax revenues. The impulse in the bottom row is a -1 percentage point shock to GDP growth x_t. We plot the one- and two-standard-deviation confidence intervals based on bootstrapping over 10,000 rounds.

D.2 Dynamic Fiscal Capacity: Robustness

This section shows the results obtained for the model with the debt/gdp ratio as an extra state variable in the VAR for the U.K. in the post-war sample. We include both the first difference and the level of the demeaned log debt/GDP ratio in the VAR and impose the cointegration for debt and output with coefficient (1, -1) as we did for tax revenue and spending. For the post-war U.K. sample, we find an eigenvalue greater than 1 for the VAR companion matrix when we include the debt/output ratio in the VAR. Therefore, we remove the unit root in the debt/GDP series by removing a separate sub-sample mean pre- and post-2007 from the log debt/GDP ratio. This procedure posits a structural break in the log debt/output ratio in 2007.

The dynamic fiscal capacity measure for this model is shown as the yellow line in Figure A.7. The orange line plots the benchmark case (no debt in the VAR) and the blue line is the observed debt/GDP ratio. The yellow and orange lines are very close until about the year 2000. After 2000, the fiscal capacity increases faster for the model with debt in the VAR. This occurs because the model with debt in the VAR and a structural break in the debt/GDP ratio in 2007 generates higher surplus predictability once the low-frequency component in debt/GDP is removed. The high debt/GDP ratio at the end of the sample coincides with higher future surpluses creating extra fiscal capacity relative to the benchmark model. The estimates for the fiscal capacity under this model specification is reported in Table 6. Our main conclusion that the observed debt/GDP ratio is below the fiscal capacity bound in the post-WW-II period for the U.K. is strengthened.

Figure A.7: Fiscal Capacity: U.K. (Robustness)



The figure plots the fiscal capacity of the U.K. government over the sample period from 1947 to 2020 over three different model specifications. In all specifications, we let the GDP risk premium be 3%. The orange line plots the benchmark case. The yellow line plots the fiscal capacity estimated using the VAR with debt/GDP ratio. The blue line is the observed debt/GDP ratio in the data.