The U.S. Treasury Funding Advantage Since 1860*

Clemens Lehner† Jonathan Payne‡ Jack Shurtleff§ Bálint Szőke¶

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Abstract

We estimate the historical funding cost advantage of the U.S. government, as measured by the yield spread between comparable highest-grade corporate bonds and U.S. Treasuries. We construct a new dataset with monthly prices, cash-flows, and ratings for U.S. corporate bonds over 1860-2024. We deploy a Kernel Ridge estimator to infer U.S. highest-grade corporate and Treasury yield curves making adjustments for tax treatment and time-varying embedded option values. The U.S. funding advantage emerged well before Bretton Woods with the introduction of the 1862-65 National Banking Acts. Previous estimates have mismeasured and exaggerated U.S. funding advantage in the post-WWII period. We use our yield curves to inform an asset pricing model for U.S. Treasury funding advantage, which concludes there is little connection between the market value of outstanding Treasuries and government funding advantage at long maturities.

JEL classification: E31, E43, G12, N21, N41

Key words: Corporate Yields, Treasury Yields, Convenience Yields, Government Debt Capacity, Exorbitant Privilege, Flower Bonds, Kernel Ridge Regression.

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†Columbia University, Department of Finance. Email: clehner28@gsb.columbia.edu

‡Princeton University, Department of Economics. Email: jepayne@princeton.edu

§Federal Reserve Board. Division of Monetary Affairs. Email: jack.k.shurtleff@frb.gov

¶Federal Reserve Board. Division of Monetary Affairs. Email: balint.szoke@frb.gov

1 Introduction

Many researchers have argued that the US government enjoys a funding advantage: it can issue bonds at lower interest rates than the private sector, even when the private sector issues bonds that promise the same cash flow sequence. In macroeconomic modeling this allows the government to sell debt that is not necessarily backed by future fiscal surpluses (a "convenience benefit" or "service flow" source of financing). The magnitude of the government's funding cost advantage is often measured by the spread between yields on high-grade US corporate bonds and the yields on US treasuries (e.g. Krishnamurthy and Vissing-Jorgensen (2012)). In this paper, we revisit and expand the historical evidence on US highest-grade corporate to treasury spreads. This involves the compilation of new bond datasets, the estimation of corporate and government yield curves for the period 1860-2024, and corrections to make corporate and government debt comparable (e.g. adjustments for taxes and callability). In doing so, we uncover the statistical properties of US funding advantage and show how it has evolved with major changes in monetary, financial, and fiscal policies.

We construct zero-coupon yield curves for highest-grade corporate and government bonds that promise consistent pecuniary payouts. This involves resolving three main difficulties: (i) detailed bond-level price data for corporate bonds prior to the 1970s has not previously been collected, (ii) the outstanding public and private sector coupon-bearing bonds differ in their "characteristics", which distort observed prices but do not necessarily reflect the government's funding advantage, and (iii) public and private sector discount functions must be inferred from the prices of coupon-bearing bonds. To overcome the first difficulty, we construct a new micro-level dataset with historical bond price, coupon, and maturity information from 1860-2024 that matches our existing datasets for Treasuries. This involves the digitization of records from historical newspapers, business magazines, and company financial reports.

To address the second challenge, we make adjustments to the estimated bond pricing formulas to ensure like-for-like comparison between private and public sector bonds. One set of adjustments relate to differential tax treatment. From 1913-1941 the treasuries were exempt from Federal taxation while corporate bonds were not. After 1941, all new issue treasuries and corporate bonds were subject to Federal income tax, but the persistently lower capital gains rate favored discount bonds relative to par and premium bonds, which only faced the higher income tax rate. We resolve these issues by inferring implicit tax advantages from comparing bonds with different tax treatments. Another set of adjustments relate to differential option values. Between 1918 and 1971, the Treasury issued a subclass of government bonds, known as “flower bonds”, which could be redeemed to pay the bondholder’s federal estate taxes upon their death *at par value* rather than market value. This meant that flower bonds essentially provided a tax concession *and* a put option, through the early redemption, that became more valuable during periods of high inflation when bond prices fell well below par value. That is, they provided a hedge against inflation risk. In addition, some treasuries and most corporate bonds included call options. We resolve these issues by pricing the various options embedded in the different bonds.

Finally, to address the third challenge, we estimate zero-coupon yield curves by adapting the “Kernel Ridge” estimator from Filipović et al. (2022), incorporating tax and option adjustments. This approach is attractive because it prioritizes smoothness of the fitted discount function, yet allows for more flexibility than popular parametric forms. The degree to which smoothness is allowed in the fit is calibrated to achieve strong out of sample performance, which is crucial to price the fundamental values of bonds with embedded options in our sample. For the treasury sample before the 1930s, we form a strong prior around the dynamic Nelson-Siegel estimates from Payne et al. (2025), ensuring we retain the shape of the yield curve over times where there are few price observations.

Our new estimates allow us to infer a collection of stylized facts about relative government debt prices and funding cost advantage. First, our long time series allows us to identify low frequency movements in average funding cost spreads that coincide with large changes to financial sector regulation and the Federal Reserve’s large scale bond purchase programs. The funding cost spread on US Treasuries emerged well before Bretton Woods and global dollar dominance with the introduction of the 1862-65 National Banking Acts that allowed banks to create money so long as they backed the money with holdings of government debt (referred to as a “circulation” privilege). The funding cost spread generally stayed high at around 1.5% throughout the National Banking Era (1865-1920) before dropping sharply to around 0.5% in 1920 following the elimination of the National Bank circulation privilege. It then followed a downward trend until the mid 1980s before reversing course and increasing back up to around 0.5% in the 2000s. Quantitative easing during World War II led to an increase in the funding cost spread at the short maturities while quantitative easing after the 2007-09 financial crisis led to an increase at long maturities.

Second, we find that existing work has exaggerated the size of US funding advantage, particularly during the 1970s and 1980s when inflation risk was high. The most commonly used existing measure for the US funding advantage on long-maturity securities is the spread between the Moody's Aaa corporate yield index and the Fed's long term bond index (which we refer to as the "index-based spread"). This measure was proposed by Krishnamurthy and Vissing-Jorgensen (2012) and has subsequently been used by many other papers. The indices compute the average yield-to-maturity across bonds with a wide of range of characteristics which leads to large distortions to the spread in the 1920s, 1940s, and 1970-80s.

The high inflation period in 1970-80s offers a particularly revealing contrast: the funding advantage reaches its maximum value in the late 1970s using the index-based spread ($\sim 2\%$), while it reaches its lowest value in the late 1970s using our estimates ($\sim 0\%$). A key reason for the discrepancy is that the index-based measure includes yields-to-maturity on many flower bonds and the flower put option became particularly valuable when bond prices dropped during the 1970s. In this sense, treasury flower bonds trade like "real-bonds" in the 1970s. So the index-based spread is effectively a comparison between a nominal, callable corporate bond and a "real" treasury with a put option against inflation risk. We conclude that a large portion of the 1970's variation in existing AAA Corporate-Treasury series is attributable to the (negative) inflation risk premia on flower bonds instead of a heightened funding advantage on regular US Treasuries.

In Section 6, we use our new corporate and treasury yield curve estimates to study how US funding advantage is priced. We start by revisiting the influential Krishnamurthy and Vissing-Jorgensen (2012) paper, which argues that a debt-to-GDP factor and i.i.d. demand shocks are able to forecast a large fraction of movements in the AAA Corporate to Treasury spread on long-maturity bonds. That is, debt "quantity" changes can forecast "spread" changes. We replicate their regression analysis using our new series, which enables us to correlate the weighted average spread within maturity bins to the corresponding market value of debt-to-GDP within those bins rather than comparing a long-term index-based spread to total debt-to-GDP. Our analysis shows that debt-to-GDP increases forecast large spread declines for bonds with maturity less than 1 year, small spread declines for bonds with maturity between 1-10 years, and no significant spread decline for maturities greater than 10 years. In this sense, we find some support for the Nagel (2016) hypothesis that quantity driven spreads are primarily a phenomenon for money-like short-term government bonds.

To better understand how the government funding advantage is priced, we estimate a richer factor asset pricing model that forecasts changes in the treasury and corporate discount functions while respecting no-arbitrage across time. Being able to fit this model highlights the value of having estimated the term structure of government funding advantage: we can use asset pricing tools to understand corporate-to-government bond spreads. Our model finds that quantities are explain little of the variation in spreads (approximately 5-10%), reinforcing the findings from the regressions. Instead, we find that the non-pecuniary benefit of government debt appears to have similar risk factors to standard bond pricing.

Related literature: Our work extends existing studies on the convenience yield (e.g. Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016), Choi et al. (2022), Cieslak et al. (2024)) back to the mid nineteenth century. This makes us part of a literature attempting to connect historical time series for asset prices to government financing costs (e.g. Payne et al. (2025), Jiang et al. (2022a), Chen et al. (2022), Jiang et al. (2022b), Jiang et al. (2021b), Jiang et al. (2021a), Jiang et al. (2020)).

Technically, our work is related to Nelson and Siegel (1987), Cecchetti (1988), Svensson (1995), Gürkaynak et al. (2007), Liu and Wu (2021), and Filipović et al. (2022) who estimate zero-coupon yield curves using combinations of the law of one price and some restrictions on the shape of the yield curve. We adopt and extend the Ridge regression approach proposed by Filipović et al. (2022). Our paper is related to the literature attempting to explain (at least) part of the corporate-treasury spread with technical characteristics such as tax advantages and time-varying option values: Cook and Hendershott (1978), Duffee (1996), Duffee (1998), Elton et al. (2001a).

The paper is structured as follows. Section 2 explains our conceptual framework. Section 3 examines our dataset, traces the evolution of US bond markets, and outlines the institutional details regarding the distinctions between corporate and government bonds. Section 4 summarizes our statistical methodology. Section 5 presents our estimate of the high-grade corporate yield curve and the term structure of AAA Corporate-Treasury spreads. Section 6 construct an asset pricing model for US funding advantage. Section 7 concludes.

2 Conceptual Framework

In this section we define our notion of government funding cost advantage using a stylized model. We then discuss the difficulties involved with attempting to use bond data to estimate the yield curves required to calculate funding advantage.

2.1 Defining Government Funding Advantage

Consider a discrete time, infinite horizon economy with time indexed by $t \in \{0, 1, \ldots\}$. The economy contains a representative private sector investor and a government.

The government issues bonds with different cash-flow profiles none of which are subject to default risk. Let $\mathcal{N}_t$ denote the set of government bonds outstanding at time t. Each bond $i \in \mathcal{N}_t$ promises a sequence of coupons $\{cp_{t,i}^{(j)}\}_{j=1}^{\infty}$ and principal payments $\{pr_{t,i}^{(j)}\}_{j=1}^{\infty}$, combined into the cash-flow stream $\mathsf{c}_{t,i} := \{c_{t,i}^{(j)}\}_{j=1}^{\infty}$ with $c_{t,i}^{(j)} := cp_{t,i}^{(j)} + pr_{t,i}^{(j)}$ denoting period-t promises of j-period-ahead dollars. These coupon-bearing bonds trade in a competitive market at prices $p_{t,i}$ and are in positive net supply $B_{t,i}$, where $B_{t,i}$ is the total amount (face value) of newly issued and outstanding bond i in period t. In equilibrium, the law of one price holds implying that

$$p_{t,i} = \sum_{j=1}^{\infty} q_t^{(j)} c_{t,i}^{(j)}, \qquad \forall i \in \mathcal{N}_t, \forall t \geq 0, \tag{2.1}$$

where $q_t^{(j)}$ denotes the price of a government promise to one dollar at time $t + j$ with $q_t^{(0)} = 1$. We call the sequence $\mathsf{q}_t := \{q_t^{(j)}\}_{j=0}^{\infty}$ the government's *discount function*. Using condition (2.1), we can express the period-t market value of the government debt portfolio in the following (equivalent) forms:

$$\sum_{i \in \mathcal{N}_t} p_{t,i} B_{t,i} = \sum_{i \in \mathcal{N}_t} \sum_{j=1}^{\infty} q_t^{(j)} c_{t,i}^{(j)} B_{t,i} = \sum_{j=1}^{\infty} q_t^{(j)} \sum_{i \in \mathcal{N}_t} c_{t,i}^{(j)} B_{t,i} =: \sum_{j=1}^{\infty} q_t^{(j)} b_t^{(j)},$$

where the last expression defines $b_t^{(j)} := \sum_{i \in \mathcal{N}_t} c_{t,i}^{(j)} B_{t,i}$ as the number of $t + j$ dollars that the government has at time t promised to deliver. We call the sequence $\mathsf{b}_t := \{b_t^{(j)}\}_{j \geq 1}$ the *zero-coupon equivalent* government debt portfolio and construct the panel $\{\mathsf{b}_t\}_{t \geq 0}$ from historical data by adding up all of the dollar principal-plus-coupon payments promised by the government at time t.

Each period t, the government enters with a stock of promised payments b_{t-1}, spends g_t, raises taxes τ_t and finances the resulting deficit/surplus by "restructuring" its debt portfolio in the form of new issues of zero-coupon bonds b_t. The period t government budget constraint can be written as

$$b_{t-1}^{(1)} + g_t - \tau_t = \sum_{j=1}^{\infty} q_t^{(j)} \left(b_t^{(j)} - b_{t-1}^{(j+1)} \right)$$

that is, period-t interest payments, $b_{t-1}^{(1)}$, and primary deficit, $(g_t - \tau_t)$, must be financed by refinancing the government debt portfolio at market prices $\{q_t^{(j)}\}_{j\geq 1}$. In other words, the government's borrowing costs can be fully characterized by the discount function q_t.

The basic premise of this paper is that when a private corporation issues default free debt that matches the cash-flow profile of government bonds, they may face a different discount function $\tilde{\mathsf{q}}_t$ with $\tilde{\mathsf{q}}_t \leq \mathsf{q}_t$. This means that the government can potentially sell a bond at a higher price than the private sector, even when the bond promises the same cash flow stream $\mathsf{c}_{t,i} := \{c_{t,i}^{(j)}\}_{j=1}^{\infty}$ and the same default risk. A common explanation for such a difference is because the representative investor receives a non-pecuniary benefit from holding government debt due to higher liquidity, differential regulation, market segmentation, or other reasons unrelated to the bond's cash-flow stream. Following the literature, we characterize this non-pecuniary benefit by imposing that the elements of q_t and $\tilde{\mathsf{q}}_t$ solve the investor Euler equations $\forall j \geq 1$:

$$q_t^{(j)} = \mathbb{E}_t\Big[\xi_{t,t+1}\Omega_{t,t+1} q_{t+1}^{(j-1)}\Big], \quad \tilde{q}_t^{(j)} = \mathbb{E}_t\Big[\xi_{t,t+1}\tilde{q}_{t+1}^{(j-1)}\Big], \quad \text{with} \;\; q_t^{(0)} = \tilde{q}_t^{(0)} = 1, \tag{2.2}$$

where $\xi_{t,t+1}$ is the investor's stochastic discount factor (SDF) and $\Omega_{t,t+1}$ is a government debt specific wedge capturing the non-pecuniary benefit of government debt.

Iterating the government budget constraint forward gives the lifetime budget constraint under the private sector's stochastic discount factor (see Appendix A):[1]

$$\sum_{j=1}^{\infty} q_t^{(j-1)} b_{t-1}^{(j)} = \underbrace{\mathbb{E}_t\left[\sum_{s=0}^{\infty} \xi_{t,t+s}\Big(\tau_{t+s} - g_{t+s}\Big)\right]}_{(i)} + \underbrace{\sum_{j=1}^{\infty}\Big(q_t^{(j)} - \tilde{q}_t^{(j)}\Big) b_{t-1}^{(j+1)}}_{(ii)}$$
$$+ \underbrace{\mathbb{E}_t\left[\sum_{s=0}^{\infty} \xi_{t,t+s}\left\{\sum_{j=1}^{\infty}\Big(q_{t+s}^{(j)} - \tilde{q}_{t+s}^{(j)}\Big)\Big(b_{t+s}^{(j)} - b_{t-1+s}^{(j+1)}\Big)\right\}\right]}_{(iii)}. \quad (2.3)$$

This equation implies that the market value of outstanding debt (including interest payments) can be written as a sum of three components: (i) the present discounted value of future primary surpluses, (ii) a term associated with the revaluation of the *stock* of existing long-term government debt, and (iii) the present discounted value of the "convenience revenue" the government earns from being able to issue *new* debt more cheaply than the private sector. The second term would disappear if the government only issued one-period debt.

We characterize the government's funding advantage through the term structure of the high-grade corporate to treasury yield spreads:

$$\chi_t^{(j)} := \frac{1}{j}\log\Big(q_t^{(j)}\Big) - \frac{1}{j}\log\Big(\tilde{q}_t^{(j)}\Big), \qquad \forall j \geq 1, \quad \text{with} \quad \chi_t^{(0)} = 0.$$

Evidently, holding all else equal, the portion of the market value of government debt which is unbacked by future surpluses, i.e., the last two terms on the right-hand-side of (2.3), is an increasing function of $\{\chi_t^{(j)}\}_{j\geq 1}$. In the special case of $\mathsf{q}_t = \tilde{\mathsf{q}}_t$, we obtain the result that current debt must be fully backed by future primary surpluses.

From this discussion, we can see the importance of comparing yields on government and corporate bonds that are subject to the same tax treatment. Tax exemptions on government bonds can give rise to an observed spread but only because they decrease future tax revenues. In this sense, they don't contribute to the portion of government debt that is truly unbacked by future surpluses.

[1] Why do we use the private sector's SDF? To project the future cost of debt issuance—and the associated funding advantage—we must consider the SDF of the prospective buyer, which, in this case, corresponds to the private sector.

2.2 Discount Function Estimation with Heterogeneous Bonds

Since commensurate private and public sector zero-coupon bonds are not traded in large numbers, the discount functions, q_t and $\tilde{\mathsf{q}}_t$, must be inferred from a sample of traded bonds with heterogeneous bond characteristics. The law of one price implies that:

Assumption 1. Within each period t, there is a common discount function q_t pricing all government bonds and a common discount function $\tilde{\mathsf{q}}_t$ pricing all high-grade corporate bonds.

In the finance literature, two approaches have been used to estimate discount functions (yield curves). The first approach, Homer (1968) and Salomon Brothers (1988), addresses the widespread heterogeneity in bond markets by partitioning outstanding securities into well-defined subclasses based on characteristics such as maturity, coupon rate, callability, and tax treatment and computes average yields-to-maturity for each subclass of like-for-like bonds. The main advantage of this approach is that, in some cases, it allows for the isolation of price effects associated with non-standard bond features, such as the call deferment period. Its drawback is that it restricts analysis to the maturities available at any given point in time.

The second approach, Fama and Bliss (1987), Gürkaynak et al. (2007), Filipović et al. (2022), seeks to overcome this limitation by interpolating across non-traded maturities to estimate the entire discount function. Specifically, this literature aims to identify a smooth discount function, $\mathsf{q} \in \mathcal{Q}$, from a suitably chosen set of functions $\mathcal{Q}$. The objective is to ensure that implied bond prices—given by the law of one price condition as in Equation (2.1), which states that a bond's price equals the sum of its future cash flows discounted by q—closely match observed market prices, with any residuals being regarded as noise.

A key prerequisite for the validity of this approach is the existence of a homogeneous sample of regular bonds, for which it can be reasonably assumed that price differences arise solely from variations in coupon rates and maturity. Naturally, this approach imposes strict selection criteria—for example, excluding all bonds with embedded options—and primarily focuses on the past few decades, characterized by "regular and predictable" U.S. Treasury issuance.

This paper bridges the gap between these two traditions by incorporating bond heterogeneity into the estimation of discount functions. When bonds differ in characteristics beyond their promised (before-tax) cash flows—such as tax exemptions or option-like features—the law of one price (Assumption 1) necessitates the inclusion of distortions in the pricing formula (2.1). These distortions capture the price effects associated with specific bond attributes and, for government bonds, they generalize the bond pricing formula as:[2]

$$p_{t,i} = \underbrace{\sum_{j=1}^{\infty} q_t^{(j)} z_i^{(j)}(\theta_t, p_{t,i}) c_{t,i}^{(j)}}_{\text{tax-adjusted fundamental value}} + \underbrace{v_i(\theta_t, p_{t,i})}_{\text{option value}} \tag{2.4}$$

where $\mathsf{z}_i(\theta_t, p_{t,i}) := \{z_i^{(j)}(\theta_t, p_{t,i})\}_{j\geq 1}$ represents tax distortions, such that the first term on the right hand side of (2.4) represents the bond's "fundamental value", while $v_i(\theta_t, p_{t,i})$ can be thought of as a value of embedded options. These distortions can depend on observable bond characteristics, a set of free parameters, θ_t, and potentially on the bonds price itself. We define $\mathsf{z}_{t,i}$ to capture only the bond-specific effects of tax distortions, the common component is assigned to q_t. For a par bond with standard tax treatment, $\mathsf{z}_{t,i} = 1$ and $v_{t,i} = 0$. Accordingly, q_t can be viewed as the *before-tax discount function* which is common across bonds—an object directly comparable to other before-tax yield curve estimates in the literature.

At this level of generality, the crucial point to recognize is that, in the presence of bond heterogeneity, estimating discount functions without accounting for such pricing distortions can introduce significant bias.[3] Using (2.1) instead of (2.4) effectively forces the estimator to treat all price differentials as arbitrage to be eliminated, even though some observed price discrepancies stem from tax advantages and valuable option features. By contrast, pricing formula (2.4) introduces discounting factors, composed of a common component q_t and bond-specific components $\mathsf{z}_{t,i}$ and $v_{t,i}$. Imposing structure on the bond-specific components—guided by tax legislation and option pricing theory—enables us to leverage a heterogeneous bond sample to estimate the equilibrium q_t as the common component without the influence of tax effects and option-like features.

In Section 3, we examine the historical context and institutional details to identify important tax effects and embedded options that the distortions $(\mathsf{z}_{t,i}, v_{t,i})$ can repre-

[2] A similar expression holds for high-grade corporate bonds with discount function $\widetilde{\mathsf{q}}_t$.

[3] The issue is analogous to the *omitted variable bias*: if, at a given period t, the distortions $\mathsf{z}_{t,i}$ and $v_{t,i}$ correlate with the bond price, $p'_{t,i}$, omitting them leads to biased estimates of q_t.

sent. We also analyze patterns in the implied yield differentials suggesting specific parameterizations for these distortions under Assumption 1. In Section 5, we deploy these parameterizations to estimate the common discount functions.

Throughout our estimation we restrict attention to the highest-grade corporate bonds and assume that our sample of corporate bonds and government treasuries is free of default risk. Many papers have argued that default risk on AAA-rated bonds is too small to account for the observed spread between corporate and Treasury yields in the modern period (e.g. Krishnamurthy and Vissing-Jorgensen (2012); Longstaff et al. (2005); Elton et al. (2001b)). However, it is less clear that highest grade corporate and government bonds were not subject to default risk in the 19th century. For example, if corporate bonds carried a higher default risk than treasuries, then an additional distortion would be introduced into equation (2.4) from the differential default risk premia. In Section 5.5 we test our no-default assumption by showing that our funding advantage estimates and pricing errors are orthogonal to measures of default risk.

3 Data and Institutional Details

In this section, we discuss the data and historical context, highlighting the challenges in measuring the government funding advantage. There are two key difficulties: (i) detailed bond-level price data for high-grade corporate bonds prior to the 1970s has not previously been collected, (ii) public and private sector discount functions q_t and $\widetilde{\mathsf{q}}_t$ must be inferred from a heterogeneous set of coupon-bearing bonds that differ in their characteristics, such as differential tax treatments and embedded options, which contribute to observed price differentials that do not necessarily reflect the government's funding advantage.

To overcome the first difficulty, we construct a new historical dataset with comprehensive coverage of corporate bonds going back to the 1840s. We describe our dataset in Section 3.1 and in Appendix C. To address the second challenge, we estimate zero-coupon yield curves while using pricing formula (2.4) to ensure a like-for-like comparison between private and public sector bonds with heterogeneous bond characteristics. We examine the key institutional details and technical characteristics contributing to price distortions in Section 3.2, followed by our proposed corrections and estimation strategy in Section 4.

3.1 Our Dataset

High-grade Corporate Bonds: We construct a new historical dataset of US corporate bonds covering the period 1840–2024, providing monthly data on trading prices, cash flows, and bond characteristics such as maturity, credit rating, and callability. The dataset integrates several existing databases with hand-collected prices and bond characteristics from historical newspapers, business magazines, and corporate financial statements. For the early period, we gather prices primarily from the *New York Times (1851-1973)*, *Commercial & Financial Chronicle* (1886–1963) and *Barron's Magazine* (1942–1973). Credit ratings and bond characteristics are primarily obtained from *Moody's Manuals*, published since 1900. From 1974 onward, we rely on the *Lehman Brothers Fixed Income Database* (1974–1997) and the *Merrill Lynch Bond Index Database* (1998–2024). Appendix C.1 provides details on the corporate bond data sources and construction.

We limit our sample to the period 1860-2024 to have sufficient price observations and restrict to high-grade corporate bonds to minimize default risk. To classify bonds as high-grade, we primarily rely on annual Moody's credit ratings, which became available in 1909, and restrict our sample to Aaa-rated bonds. For bonds maturing before 1909, we follow Macaulay (1938) in identifying high-quality issuers, relying on the selection of railroad companies included in his high-grade railroad bond yield index. Additional details on bond selection and credit ratings are provided in Appendix C.1.3.

US Government Bonds: Our dataset on US Treasury debt combines the comprehensive monthly panel of prices and quantities for all Treasury securities from 1790–1925 constructed by Hall et al. (2018) and utilized in Payne et al. (2025), with the CRSP Treasury Database (1925-2024). We exclude the Treasury Inflation-Protected Securities (TIPS) from our sample, but we keep bonds with varying tax exemptions and bonds with embedded call and put options. Appendix C.2 provides further details on the construction of the Treasury bond sample.

3.2 Bond Characteristics with Price Effects

In this section we highlight five key bond features that create pricing differences between otherwise "equivalent" corporate and government bonds unrelated to funding advantage: tax exemptions, low coupon rates, estate tax treatments ("flower bonds"), callability and exchange privilege. Table 1 summarizes the characteristics, necessary adjustments to the pricing formula (2.4), and the periods where the issues are greatest.

	Summary	**Sample**	**Effect on Yield**	**Period**
Tax Exemption	reduced federal income tax rate on interest income	Gov	$y \downarrow p \uparrow$	'17–'41
Low Coupon	income mainly from capital gains with low tax rate	Both	$y \downarrow p \uparrow$	high y
Flower Bond	valued at par for estate taxes upon death	Gov	$y \downarrow p \uparrow$	1970s
Call Option	issuer has the right to refinance at call price	Both	$y \uparrow p \downarrow$	low y
Exchange Privilege	at maturity exchangeable for new issue premium bond	Gov	$y \downarrow p \uparrow$	1930s

Table 1: Bond Characteristics with Price Effects

Notes: This table summarizes key characteristics of US corporate and government bonds that generate systematic price effects unrelated to funding advantage. These include tax exemptions, capital gains tax advantages, and embedded options such as callability, estate tax treatment (flower bonds), and exchange privilege. For each feature, the table indicates the affected sample (government or both), the direction of the yield changes and price effect, and the period of greatest relevance.

3.2.1 Tax Advantages

Tax exemptions on US Treasuries: Before the introduction of US federal income taxation in 1913, neither corporate nor government bonds were subject to taxes.[4] Since then, income earned by both corporations and individuals from long-term securities holdings has been subject to two types of taxes.[5] Coupon payments are taxed at the relevant (holder-specific) marginal income tax rate τ^{inc}. In addition, capital gains are

[4]The Sixteenth Amendment to the Constitution was announced on February 25, 1913 and the new Federal income-tax law in pursuance of this amendment was enacted on October 3, 1913.

[5]In addition, since 1916, all bonds were subject to estate taxes except for the so called flower bonds, represented by the light marked areas in Figure 1.

taxed at the long-term capital gains tax rate τ^{cg} while capital losses can be deducted against ordinary income and are thus valued at the ordinary income tax rate τ^{inc}.

From WWI in 1918 to WWII in 1941, the Treasury also issued partially tax-exempt bonds, effectively replacing the tax rate on ordinary income with a lower rate.[6] While fully-taxable bonds were subject to normal income taxes and surtaxes (e.g. war, excess profits taxes), partially-tax exempt bonds were only subject to surtaxes. Over this period, the gap between tax rates τ^{inc} and τ^{pte} was around 5%.

Figure 1 depicts the share of outstanding marketable Treasury bonds and notes (excluding T-bills and Certificates of Indebtedness) classified by tax-treatment for the sub-period 1900-2024. From the introduction of income taxation 1913 until WWII in 1941, US federal government bonds were (either partially or wholly) exempt from federal income taxes. Because corporate bonds did not have such exemptions, this created an obvious tax advantage for US treasuries.

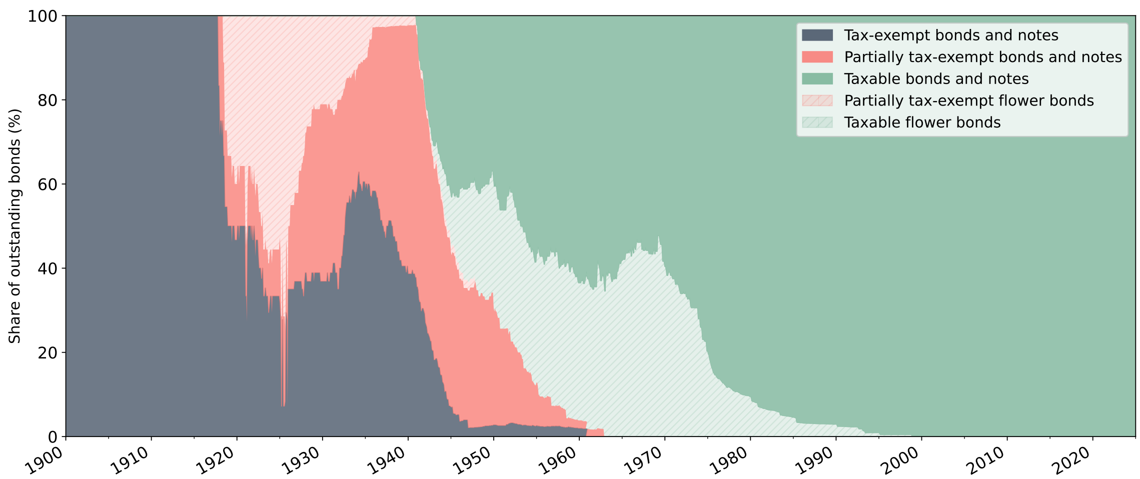

Figure 1: Share of Outstanding Treasury Bonds and Notes with Tax Exemptions.

Notes: Excluding T-Bills and Certificates of Indebtedness. Different colors represent the tax treatment of each issue.

We can gauge the approximate price impact of this exemption by analyzing the early 1940s, a period during which taxable, partially tax-exempt, and fully tax-exempt

[6]Treasury Secretary McAdoo advocated for this feature as a means of stabilizing interest rates as ever-increasing surtaxes caused long-term interest rates to rise on secondary markets. He wanted to create a class of bonds to be held by households, not banks who bought up tax-exempt debt to avoid their relatively higher tax burden.

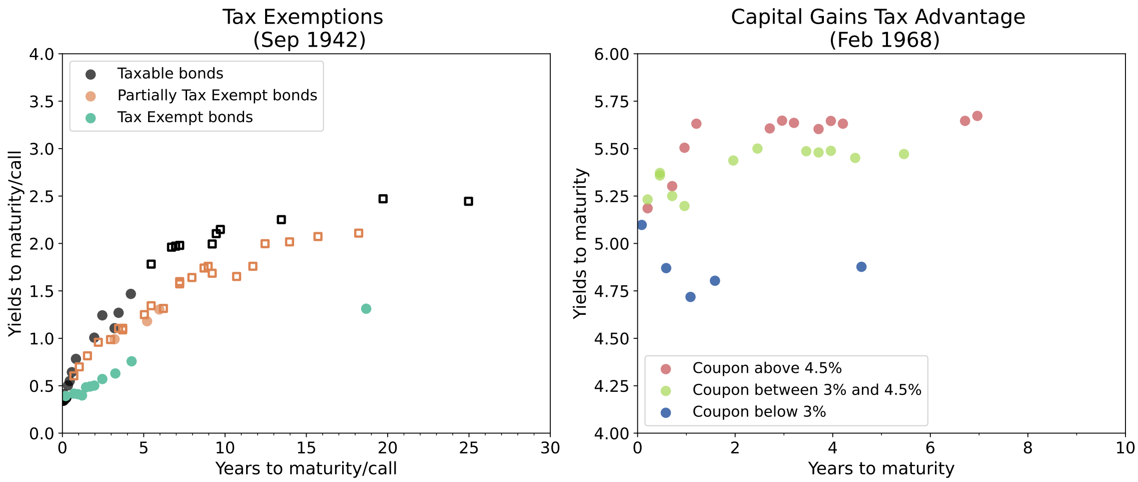

Figure 2: Price Implications of Tax Advantage.

Notes: Panels depict yields-to-maturity (y-axes) against years-to-maturity (x-axes) for different dates (panel title). Each circle/square corresponds to a separate bond outstanding in the given month. Dots show non-callable bonds, squares represent callable bonds. Green color represents tax-exempt bonds, black color represents regular taxable bonds.

bonds were traded concurrently. The left panel of Figure 2 illustrates the yields-to-maturity across various maturity horizons for taxable and fully tax-exempt government bonds outstanding in September 1942. The plot highlights that the price impact of federal income tax exemptions was substantial. Notably, at the five-year horizon, tax-exempt bonds earned yields approximately 80 basis points lower than those of taxable bonds with comparable coupon rates and maturities. For longer maturities, the effect was even bigger.

Capital Gains Tax Advantage on Low Coupon Bonds: The holding period return of a bond with coupon c_i consists of two components: the coupon yield, $c_i/p_{t,i}$, and capital gains, $p_{t+1,i}/p_{t,i}$. In equilibrium, (risk-adjusted) *after-tax* holding period returns are equalized across all outstanding bonds. For fixed-coupon bonds, this adjustment must occur through price movements, meaning that—all else equal—bonds with lower coupons tend to derive a greater share of their return from capital gains compared to high-coupon bonds. As long as the taxation of coupon income and capital gains remains symmetric, the equilibrium relationship between coupon rates and the proportion of income derived from capital gains has no direct impact on bond pricing. However, since 1921, the U.S. tax code has consistently favored long-term capital gains over interest income, i.e., $\tau^{cg} < \tau^{inc}$ to a varying degree. Consequently, low-coupon bonds—those with coupons below the prevailing equilibrium yield—were subject to a lower effective tax rate than high-coupon bonds. This tax advantage systematically contributed to lower before-tax yields for low-coupon bonds.

The price impact of this so-called "capital gains tax advantage" became particularly evident in the late 1960s, as rising interest rates caused low-coupon bonds issued in the 1950s to trade at deep discounts relative to par. The right panel of Figure 2 illustrates the significant coupon-rate effect on observed before-tax yields-to-maturities: in February 1968 bonds with the lowest coupons (blue dots) exhibited yields nearly a full percentage point lower than those with the highest coupons (red dots).

3.2.2 Embedded Options

Estate tax provisions ("flower bonds"): A notable policy between 1918 and 1971 was the issuance of a subclass of government bonds, known as "flower bonds", which could be used to pay the bondholder's federal estate taxes upon their death *at par value* (instead of market value) plus accrued interest. Moreover, prior to the Tax Reform Act of 1976, flower bonds were valued as inherited property *at their par value* on the date of the decedent's death, effectively exempting them from long-term capital gains taxes when they were redeemed early for estate tax purposes. This meant that flower bonds effectively acted as an inflation hedge: rising inflation expectations drove up interest rates, which reduced the bond's market price relative to its par value. This decline, in turn, enhanced the bond's capital gains tax advantage, helping to maintain its *after-tax* return and offering protection against inflation risk. In this way, flower bonds functioned in a manner akin to inflation-protected bonds.

According to Figure 1, flower bonds were an important subset of Treasury securities during the early decades of the post-WWII period.[7] Importantly, from 1955-1971, (almost) all outstanding treasuries with maturity greater that 10 years were flower bonds. Effective March 1971, Congress eliminated flower bond privileges on new US bond issues, ensuring a gradual reduction in their overall supply as outstanding issues used for estate tax purposes were progressively retired over time. The passage of the

[7] McCulloch (1975), Cook (1977), Cook and Hendershott (1978), and Mayers and Clifford (1987).

Tax Reform Act of 1976 in October terminated the flower bonds' exemption from capital gains taxes, which significantly reduced their appeal.

To illustrate the importance of the flower bonds, on the left panel of Figure 3, we show yields-to-maturity for flower bonds (in red) and non-flower bonds (in black) for the month of August 1976. Evidently the flower bonds had a significant price impact. For longer maturities, the flower bond yields-to-maturity are 1-3 percentage points below yields-to-maturity of comparable non-flower bonds (the black dots) and appear to follow a downward sloping yield curve. Appendix Section D.3 provides further details on the flower bond effect and it's magnitude.

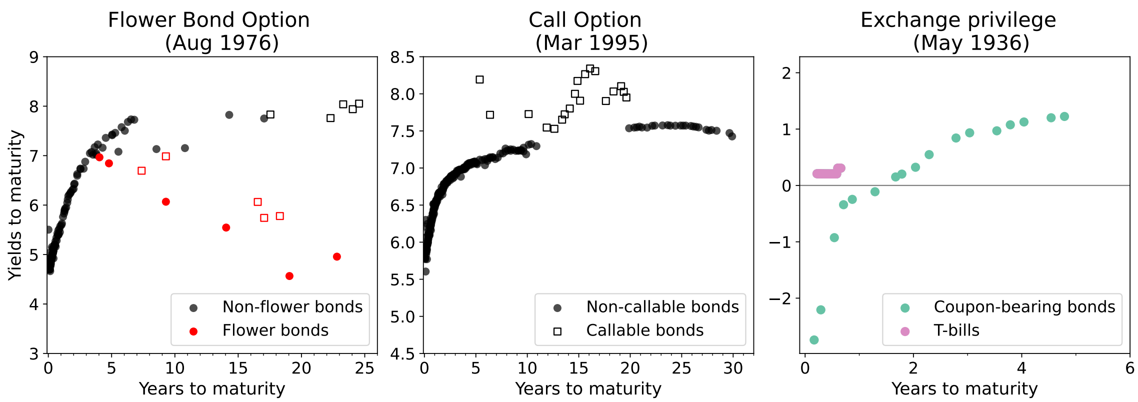

Figure 3: Price Implications of Embedded Options.

Notes: Panels depict yields-to-maturity (y-axes) against years-to-maturity (x-axes) for different dates (panel title). Each circle/square corresponds to a separate bond outstanding in the given month. Red color represents "flower bonds", black color is for regular taxable bonds. Dots show non-callable bonds, squares represent callable bonds.

Call provisions: Call provisions, which grant the issuer the right to repurchase its bond before its maturity at a prespecified "call price", introduce uncertainty to the underlying cash flows from the bondholder's perspective. Because issuers are expected to call bonds when their market price sufficiently exceeds the call price, such bonds tend to trade at a discount compared to otherwise identical non-callable bonds.[8] Call provisions are accompanied by a *call-deferment period*—a predetermined timeframe after issuance (but before maturity) during which the issuer cannot call the bond.

[8]The greater the probability of a call, and consequently the higher the value of the call option for the issuer, the larger the bondholder's required discount compared to non-callable bonds.

Intuitively, the size of the discount investors demand for holding callable bonds is inversely related to the call price and the length of the call-deferment period.

Prior to the 1960's, virtually all callable high-grade corporate bonds had very brief call-deferment periods. In particular, these bonds were usually callable on any interest payment dates, with notice periods typically ranging from 30 to 60 days. Bonds with non-zero call-deferment periods provided only limited protection, typically around five years. In contrast, a large fraction of US government bonds was non-callable. Those with call provisions typically featured 3-6-month notice periods along with long call-deferment periods often only a few years shorter than the bonds' maturity.

To illustrate the price implications of call options, the top right and bottom right panels in Figure 3 show yields-to-maturity for callable bonds (squares) and non-callable bonds (dots) across government bonds (top right) and high-grade corporate bonds (bottom right). Evidently, the value of call options were relatively large in the two months under consideration resulting in a visible decoupling of the term structures of yields-to-maturity of callable and non-callable bonds. Appendix Section D.2 provides further details on differences in call features between corporate and government bonds.

Exchange Privilege: During the 1930s, interest-bearing US debt nearly doubled, placing substantial pressure on the US Treasury to allocate newly issued securities to the private sector. This challenge was further exacerbated by legal constraints that prohibited the issuance of new government debt securities below par value.[9] In response, as explained by Cecchetti (1988), the US Treasury began issuing new bonds with coupon rates implying market prices above par value, yet these bonds were sold at par. Holders of maturing government bonds and notes received preferential treatment in the allocation of these new issues, creating a valuable ”exchange privilege”: upon maturity, coupon-bearing Treasury securities could be exchanged for new bonds at par, which subsequently traded above par.

The value of this exchange option exerted significant downward pressure on the yields of coupon-bearing government bonds. In fact, throughout the 1930s, the yields of bonds nearing maturity often turned negative. The right panel in Figure 3, depicting yields-to-maturity for outstanding government bonds in May 1936, is a rep-

[9]The Second Liberty Bond Act required that new Treasury bonds and certificates of indebtedness be issued at par and new notes issued at not less than par.

resentative example. Except for the zero-coupon T-bills (that did not have exchange option), all bonds less than 18 months to maturity appear to have offered a negative yield-to-maturity![10] According to Cecchetti (1988), the value of the exchange privilege was non-trivial throughout the early 1940s. While the practice of exchange continued beyond 1944, the terms were no longer as favorable and the value of the exchange option disappeared.

3.3 Implications for Funding Advantage Measures

The bond-specific features discussed in Subsection 3.2 lead to distortions in the estimate of government funding advantage. To illustrate this, Figure 4 plots the yields-to-maturities for both government and corporate bonds in January 1976. The figure shows three distinct spread measures that demonstrate the magnitude of these distortions. The spread between long-term non-flower bond yields and long-term corporate bond yields (20-30 year maturity) is relatively small at approximately 55 basis points. However, when comparing corporate bonds to the broader long-term government bond index (LTGOVTBD), which includes all bonds with 10+ years maturity, the spread widens to 186 basis points. This is because the LTGOVTBD series is a simple unweighted average of flower and non-flower bonds and does not correspond to any actual traded bond observation. Note that the spread between long-term corporate bonds and flower bonds is very large at approximately 297 basis points.

These observations emphasize the problem with the most widely used measure of historical government funding advantage on long-maturity bonds (initially proposed by Krishnamurthy and Vissing-Jorgensen (2012) and subsequently used in many papers), which is computed as the difference between two yield indices:

- Moody's Seasoned Aaa-rated long-maturity corporate bond index (FRED code: AAA)—constructed from a sample of industrial and utility bonds (industrial only after 2002) with more than 20 years to maturity.

- The Federal Reserve Bulletin's long-term US government bond yield index (FRED code: LTGOVTBD)—constructed as the average yield on *all* outstanding government bonds neither due nor callable in less than 10 years.[11]

[10] A comparison between the callable bonds (squares) and non-callable bonds (dots) in the bottom-left panel of Figure 3 also suggests that the value of call options was relatively high during the 1930s.

[11] More precisely, the Treasury bonds included are due or callable after 12 years for 1926–1941, 15

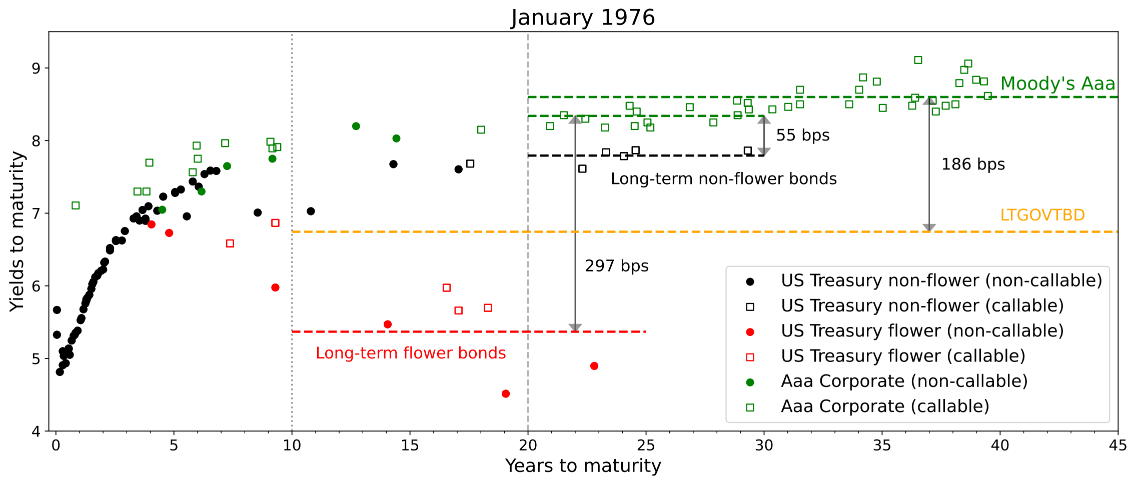

Figure 4: Calculation of Government Funding Advantage

Notes: Panel depicts yields-to-maturity (y-axes) against years-to-maturity (x-axes) for different dates (panel title). Each circle/square corresponds to a separate bond outstanding in the given month. Red color represents "flower bonds", black color is for regular taxable bonds. Dots show non-callable bonds, squares represent callable bonds.

For brevity, we will call this the *index-based* Aaa Corporate-Treasury spread. The green and orange dashed lines on Figure 4 show the Moody's index and the LTGOVTBD series values in January 1976 respectively. Evidently, the LTGOVTBD series averages over flower and non-flower bonds, which distorts the yield on government bonds down and so overstates the government's funding advantage.

4 Methodology

In this section, we outline our methodology for estimating a term structure of government funding advantage that controls for the tax and option-related distortions discussed in Section 3.

An appealing approach for addressing bond heterogeneity is to restrict the sample to a collection of "standard" bonds that are not or only minimally affected by tax and option distortions. We attempt to do this in Section 4.2 where we construct a 15+ year

years for 1941–1951, 12 years for 1952, and 10 years for 1953–1999. The series was discontinued in 2000, after which point papers in the literature use the "market yield on US Treasury Securities at 20-year constant maturity" (FRED code: GS20).

index spread between yields-to-maturity using a selected subsample of homogeneous corporate and government bonds. We view this exercise as in the spirit of Salomon Brothers (1988) and Homer and Sylla (2004), because it constructs average yields-to-maturity for a narrow range of bonds at particular maturities. We treat this series as an "anchor" or "sense-check" for our analysis because it offers a clean view of US funding advantage without the need to model the distortions in Section 3.

Although our selection-based index spread illustrates key trends for government funding advantage, it has some important limitations. First, there are many periods with insufficiently many standard bonds to directly compare yields on homogeneous bonds. This means that resolving how to incorporate heterogeneous bonds into our estimates is not only advantageous—it is essential for gaining insight into historical yield spreads. Second, we want to construct a yield curve at all maturities. This means we need to study zero-coupon yields rather than yields-to-maturity so we can use the law-of-one-price to price assets that are not traded.[12]

To address these issues, we outline an approach for estimating corporate and government zero-coupon yield curves that utilizes our heterogeneous bond sample to identify and correct for the bond characteristic distortions summarized in Table 1. To this end, in Section 4.1, we specify functional forms for $\mathsf{z}_i(\theta_t, p_{t,i})$ and $v_i(\theta_t, p_{t,i})$, informed by features of tax legislation and option pricing theory. Section 4.2 then outlines a yield curve estimation strategy that combines a selection-based index spread with model-dependent smoothing across time and maturities.

4.1 Corrections For Bond Heterogeneity

4.1.1 Tax Advantages

Consider a bond with maturity M_i, market price $p_{t,i}$, coupon rate cp_i, and yield-to-maturity $\overline{y}_{t,i}$. Let the marginal income tax rates on fully taxable, partially tax-exempt, and fully tax-exempt government bonds be τ^{inc}, τ^{pte}, and 0, respectively.

[12] This is because no-arbitrage arguments hold for (after-tax) zero-coupon yields rather than yields-to-maturity. For instance, differences in yields-to-maturity between two coupon-bearing bonds with identical maturity dates do not indicate an arbitrage opportunity. However, differences in zero-coupon yields between two zero-coupon bonds with the same maturity date signify a violation of the law of one price and the presence of profitable arbitrage opportunities. See also Elton et al. (2001a).

The relative marginal income tax advantages can be measured by

$$\sigma^{pte} := \log\left(\frac{1-\tau^{pte}}{1-\tau^{inc}}\right), \qquad \sigma^{fe} := \log\left(\frac{1}{1-\tau^{inc}}\right).$$

As discussed in Section 3.2.1, no arbitrage requires that in equilibrium, when $\overline{y}_{t,i} > cp_i/p_{t,i}$, part of the bond's return must be attributable to projected future capital gains, which are taxed more favorably than interest income. As a result, such bonds incur a lower effective tax burden than comparable high-coupon bonds. These tax advantages motivate the following functional form:

$$z^{(j)}_{t,i}(\theta_t, p_{t,i}) = \underbrace{\exp\Big(\sigma_{t,i}\Big)}_{\text{tax exemption}} \exp\Big(\eta_t \sum_{s=0}^{j} \max\{\underbrace{\overline{y}_{t,i} - cp_i/\widehat{E}_t[p_{t+s,i}]}_{\text{implied future capital-gains}}, 0\}\Big), \tag{4.1}$$

where $\sigma_{t,i} \in \{0, \sigma_t^{pte}, \sigma_t^{fe}\}$ and $\widehat{E}_t[p_{t+s,i}]$ denotes the s-period-ahead bond price implied by $\overline{y}_{t,i}$.[13] The tuple $(\sigma_t^{pte}, \sigma_t^{fe}, \eta_t)$ contains the parameters to be estimated, all subject to non-negativity constraints. We interpret $\overline{y}_{t,i} - cp_i/\widehat{E}_t[p_{t+s,i}]$ as the projected capital gains s-period ahead, representing the portion of return that cannot be explained by the expected coupon-yield path. A wider gap implies a greater implicit tax advantage, which vanishes for bonds trading at or near par. Both components of $\mathsf{z}_{t,i}$ are greater than or equal to one, implying that tax-advantaged bonds are effectively valued as if their cash flows were magnified.

The functional form (4.1) can be thought of as a generalization of the standard tax formula used by Robichek and Niebuhr (1970), McCulloch (1975), Cook and Hendershott (1978), and McCulloch and Kwon (1993) among others. Assuming that bonds are held until maturity, these papers use the following pricing formula:

$$\begin{aligned}
p_{t,i} &= \sum_{j=1}^{M_i} q_t^{(j)}(1-\tau^{inc})cp_i + q_t^{(M_i)}\left[100 - \tau^{cg}(100 - p_{t,i})\right] \\
&= \sum_{j=1}^{M_i} q_t^{(j)}\left(\frac{(1-\tau^{inc})}{1-\tau^{cg}q_t^{(M_i)}}\right)cp_i + q_t^{(M_i)}\left(\frac{(1-\tau^{cg})}{1-\tau^{cg}q_t^{(M_i)}}\right)100.
\end{aligned}$$

The terms in the parentheses can be viewed as $\mathsf{z}_{t,i}$, akin to (4.1), except that (4.1)

[13] $\widehat{E}_t[p_{t+s,i}]$ can be derived from the recursion $\widehat{E}_t[p_{t,i}] = \exp(-\overline{y}_{t,i})\left(c_i + \widehat{E}_t[p_{t+1,i}]\right)$ with boundary conditions $\widehat{E}_t[p_{t+M_i,i}] = 100$ and $\widehat{E}_t[p_{t,i}] = p_{t,i}$.

relaxes the held-to-maturity assumption, and allows the tax advantage to depend on the magnitude of projected capital gains beyond what's captured by the bond's maturity.

4.1.2 Embedded Options

Depending on the type of bond, the option value in (2.4) can be the (negative) value of the call option, the value of the inflation put option embedded in flower bonds, or the value of the exchange privilege, respectively.[14] We denote this by:

$$v_i(\theta_t, p_{t,i}) = \begin{cases} -v_i^c(\theta_t, p_{t,i}), & i = \text{callable bond} \\ v_i^f(\theta_t, p_{t,i}), & i = \text{flower bond} \\ v_i^e(\theta_t, p_{t,i}), & i = \text{exchange privileged bond} \end{cases}$$

Call Option (v_i^c): Consider a callable bond with maturity M_i, market price $p_{t,i}$, coupon rate cp_i, strike price $p_{t,i}^c$, and date from which the bond can be called, $T_{t,i}^c$. Option theory (e.g. Black and Scholes (1973)) tells us that current value of the bond's call option, $v_{t,i}^c$, should depend upon the return from exercising the option (the "moneyness" of the option), the time until the option becomes active, the window in which the option can be exercised, and the future path of macroeconomic variables (e.g. interest rates). This motivates the following functional form:[15]

$$v_i^c(\theta_t, p_{t,i}) := \beta^{(T_{i,t}^c - t)} \exp\Big(\underbrace{\phi_{t,0}}_{\substack{\text{common}\\ \text{component}}} + \phi_{t,1} \max\{\underbrace{\overline{y}_{i,t}^c - \overline{y}_{i,t}}_{\text{moneyness}}, 0\}\Big) \Big(\underbrace{M_i - T_{i,t}^c}_{\text{call window}} \Big)^{\phi_{t,2}} \quad (4.2)$$

where $(\overline{y}_{t,i}, \overline{y}_{i,t}^c)$ denotes the yields-to-maturity if the bond is purchased at the current market price and current strike price respectively and $(\beta, \phi_{t,0}, \phi_{t,1}, \phi_{t,2})$ denotes the set of parameters to be estimated subject to the restrictions that $\phi_{t,1} \geq 0$ and $\phi_{t,2} \geq 0$. We interpret $\overline{y}_{i,t}^c - \overline{y}_{i,t}$ as the "moneyness" of the option because it captures the excess return from buying the bond at strike price (exercising the call) over buying the bond at the market price. If the market price is greater than the call price,

[14] Some bonds have multiple option features. For callable bonds with the exchange privilege, we take $v_i = v_i^e - v_i^c$ additively. We drop callable flower bonds from the estimation, as they have both an embedded call and a put.

[15] A similar functional form to capture the value of call option was proposed by Thies (1985).

then yield-to-maturity from exercising the call option is greater than the yield-to-maturity from purchasing the bond and so the moneyness becomes positive.[16] This implies that β can be interpreted as the time discount factor on the option, $\phi_{t,0}$ can be interpreted as the common component of the option value, $\phi_{t,1}$ can be interpreted as the responsiveness of the option value to the moneyness of the option, and $\phi_{t,2}$ can be interpreted as the responsiveness to the size of the call window. We allow $(\phi_{t,0}, \phi_{t,1}, \phi_{t,2})$ to be time varying to capture the sensitivity of the option value the prevailing macroeconomic conditions.

Flower Bonds (v_i^f): Consider a flower bond with maturity M_i, market price $p_{t,i}$, and coupon rate cp_i. Upon their death, the holder of the flower bond could effectively redeem the bond at par value to offset their estate taxes. So, if flower bonds were able to be traded to investors near death, then the flower bond provision was potentially priced like a put option. To allow for this possibility, we specify the following functional form for the value of the flower bond privilege:

$$v_i^f(\theta_t, p_{t,i}) := \exp\Big(\underbrace{\gamma_{t,0}}_{\substack{\text{common}\\\text{component}}} + \gamma_{t,1} \max\{\underbrace{\overline{y}_{i,t} - \overline{y}_{i,t}^p}_{\text{moneyness}}, 0\}\Big) M_{i,t}^{\gamma_{t,2}} \tag{4.3}$$

where $\overline{y}_t^p$ is the par yield of bond i, and now $(\gamma_{t,0}, \gamma_{t,1}, \gamma_{t,2})$ are the parameters to be estimated subject to $\gamma_{t,1}, \gamma_{t,2} \geq 0$. For flower bonds, we refer to the "moneyness" of the flower bond privilege as $\overline{y}_{i,t} - \overline{y}_{i,t}^p$ because it represents the excess yield-to-maturity from using the flower bond privilege to redeem the bond at par value compared to selling it at market value. If the market price is less than the par value at which flower bonds can be exercised, then the yield to maturity from redemption at par is greater than the yield-to-maturity from selling at the market price and so the put option becomes "in-the-money".

Our estimates of $(\gamma_{t,0}, \gamma_{t,1}, \gamma_{t,2})$ are informative about how effectively the flower bond privilege could actually be used as a put option. If $\gamma_{t,1}$ is very large, then the value of flower bond privilege was very responsive to the excess return from redeeming the flower bonds. We interpret this as suggesting that the buyers of flower bonds were those with a relatively high death probability who could benefit the most from the

[16] For stocks following a random walk process, the moneyness for a call option is often defined as $\max\{p_{t,i} - p_{t,i}^c, 0\}$. This doesn't make sense for finite maturity bonds because bond prices necessarily drift towards par value at maturity rather than following a random walk. For this reason, we instead include the excess yield from exercising the option.

flower bond privilege.[17]

Exchange Privilege: Unlike the call or flower bond options, the exchange privilege could be exercised only at maturity. The option value can be written as

$$v^{e}_{t,i} := q_t^{(M_{t,i})} \zeta_i \tag{4.4}$$

where $\zeta^i \geq 0$ is a bond-specific parameter representing the expected payoff from exchanging the bond at maturity. Following Cecchetti (1988), we compute ζ_i directly from data for each bond i when they are three months to maturity using the formula:

$$\zeta_i = \exp\left(y_t^{T\text{-}bill} M_{t,i}\right) \widehat{p}_{t,i} - \left(cp_{t+M_{t,i}} + pr_{t+M_{t,i}}\right)$$

where $y_t^{T\text{-}bill}$ is the yield on a T-bill with the closest maturity to bond i. In general, the expected payoff at maturity fluctuates over time. However, since short-term T-bills were the only assets without the exchange privilege, estimating how expectations evolved before the bond got near maturity is infeasible. Instead, (4.4) assumes that throughout the bond's lifetime, the representative investor has perfect foresight of the expected payoff three months prior to maturity, as captured by ζ_i.

4.2 Estimation

Using bond level data on trading prices, $\widehat{p}_{t,i}$, before-tax promised cash-flows, $\mathsf{c}_{t,i}$, call price schedules, $\{p^c_{t,i}\}_{t \geq T^c_i}$ and inferred values of tax advantages $\{\sigma^{pte}_t, \sigma^{fe}_t\}$ and exchange privilege ζ_i, the task is to estimate the common discount function q_t that minimizes deviations from the law-of-one-price pricing formula, (2.4), subject to the tax and option distortions (4.1), (4.2), (4.3), and (4.4) with parameter vector:

$$\theta_t := (\eta_t,\ \phi_{t,0},\ \phi_{t,1},\ \phi_{t,2},\ \gamma_{t,0},\ \gamma_{t,1},\ \gamma_{t,2})$$

Conditional on our tax and option corrections, one could choose any popular yield-curve estimator, such as Fama and Bliss (1987), Gürkaynak et al. (2007), or Liu and Wu (2021), for the estimation of q_t, as the corrections (4.1)-(4.4) essentially

[17] This would be consistent with Mayers and Clifford (1987), which finds that the flower bonds with the deepest discount were redeemed at the fastest rate, suggesting that the most deeply discounted—and thus most in-the-money—flower bonds were concentrated in the hands of individuals with the highest death probabilities.

homogenize our bond datasets so that we are estimating on like-for-like securities.

Regardless of the estimator used, we seek to ground our analysis in a restricted, homogeneous subset of bonds that are least affected by tax- and option-induced distortions. To this end, we will write the before-tax discount function as a sum of two components:

$$q_t^{(j)} = a_t^{(j)} + h_t^{(j)}, \qquad \text{s.t.} \qquad a_t^{(0)} = 1.$$

We refer to $a_t^{(j)}$ as an "anchor" and interpret $h_t^{(j)}$ as the deviation from this anchor. This formulation allows us to incorporate external information into the estimation of discount curves. We define the anchor, $\mathsf{a}_t := \{a_t^{(j)}\}_{j\geq 0}$, as a selection-based index spread: specifically, we partition the bond sample into three maturity bins—less than 5 years, 5-15 years, and more than 15 years to maturity—and compute the average yields of non-callable, non-flower bonds traded at or above par within each bin. Although this restriction is well-suited to minimizing the distortions discussed in Section 3, it is sufficiently stringent that only the post-1990 period remains usable. Consequently, we expand our selection-based index to include option bonds that are "out-of-the-money." With this coarse term structure of yield indices serving as an anchor, estimation of q_t entails assessing the extent to which deviations from a_t are warranted by the data.[18]

To estimate q_t, we adapt the non-parametric Kernel Ridge estimator proposed by Filipović et al. (2022). The advantages of this estimator are threefold. First, the space of smooth discount functions to choose from is much larger than popular parametric forms, allowing for more flexibility, while the regularization component of the estimator preserves the smoothness of the fitted curve as desired in a parametric specification. Second, the degree of flexibility permitted in the estimator is chosen such that we obtain the strongest out-of-sample performance. Finally, this estimator is tractable and Filipović et al. (2022) show that it improves upon the out-of-sample performance of other popular yield curves models in the literature.[19,20]

The goal of the Kernel Ridge estimator is to estimate a discount function $\mathsf{q}_t \in$

[18]In this sense, the anchor functions as a "prior yield curve."

[19]Remarkably, the estimator has a simple closed-form solution, shown in Appendix E.

[20]Given the ample amount of treasuries without embedded options post-1980s and a lack of a capital gains advantage in the tax system, we expect our post-1990 government yield curve estimates not to differ much, if at all, from Filipović et al. (2022).

$\mathcal{Q}(\alpha, \delta)$, given tuning parameters $\lambda > 0, \alpha > 0, \delta \in [0, 1]$ and tax/option parameters θ_t. $\mathcal{Q}(\alpha, \delta)$ is the set of twice weakly differentiable functions with finite smoothness defined below by (α, δ). Conditional on a_t, the discount function, $\mathsf{q}_t := \mathsf{a}_t + \mathsf{h}_t$, is chosen by minimizing the weighted mean squared pricing errors while rewarding smoothness:

$$\min_{\mathsf{q}_t \in \mathcal{Q}(\alpha,\delta),\ \theta_t} \quad \sum_{i \in \mathcal{N}_t} \rho_i \underbrace{\left(\widehat{p}_{t,i} - v_i(\theta_t, p_{t,i}) - \sum_{j=1}^{M_i} q_t^{(j)} z_i^{(j)}(\theta_t, p_{t,i}) c_i^{(j)} \right)^2}_{\text{price error}} + \underbrace{\lambda ||\mathsf{h}_t||^2_{\alpha,\delta}}_{\text{regularization}} \quad (4.5)$$

where $\{\rho_i\}_{i \in \mathcal{N}_t}$ denotes a set of exogenous weights, and the smoothness norm is:

$$||\mathsf{h}||_{\alpha,\delta} = \left(\int_0^\infty \left(\delta h'(x)^2 + (1-\delta) h''(x)^2 \right) \exp(\alpha x) dx \right)^{\frac{1}{2}}. \quad (4.6)$$

This integral represents a linear trade-off in δ between the squared first and second derivatives of h, penalizing oscillations and kinks, respectively, under an exponential weighting scheme governed by α. The basis functions, which span the discount curves in $\mathcal{Q}(\alpha, \delta)$ are fully determined by the smoothness measure (4.6). The tuning parameters $(\lambda, \alpha, \delta)$ are selected via K-fold stratified cross-validation across the maturity spectrum. Following Gürkaynak et al. (2007), Payne et al. (2025), and Filipović et al. (2022), the exogenous weights ρ_i are set equal to the squared duration times price of bond i, so that the weighted mean squared error in (4.5) approximates the mean squared yield fitting error. Additional details on the estimator are provided in Appendix E.

5 Results

In this section, we show our estimates for the term structure of US funding advantage over 1860-2024. We infer a collection of stylized facts. First, there are low frequency movements in average US funding advantage that correspond to changes in financial regulation and the Fed's quantitative easing programs. Second, existing series have mismeasured long-term yield spreads in the post WWI period leading to a significant overstatment of US funding advantage in the 1920s, and 1970-80s. Third, the US lost its funding advantage during the high inflation in the 1970-80s.

5.1 Estimated Long-Term Funding Spreads

We start by inspecting spreads at long-maturities. The black lines in figure 5 show time series of the 20-year (top) and 10-year (bottom) US funding advantage, as measured by our estimate for the highest-grade corporate zero-coupon yield minus our estimate for the treasury zero-coupon yield. Evidently, US funding advantage emerged in the mid 1860s with the end of the Civil War and the introduction of the National Banking system which gave National Banks the privilege to create bank notes so long as they backed them by holding long-term debt (referred to as "circulation privilege"). It stayed high at around 1.5% until 1920 when is sharply declined to around 0.5%. This corresponds to the elimination of National Bank circulation privilege and the introduction of the Fed monopoly on money creation Funding advantage then followed a downward trend reaching zero in the late 1970s before reversing course and increasing back up to around 0.5-1.0% in the 2000s.

We compare our estimates to two other time series for long-maturity US funding advantage. First, we compare to the index spread introduced by Krishnamurthy and Vissing-Jorgensen (2012) which uses average yields-to-maturities over all bonds. This comparison highlights why our new estimates change the existing narratives about government funding advantage. Second, we compare to our selection based index spread that we use as an anchor in the estimation and attempts to only compare bonds with homogeneous characteristics. We use this comparison as a "sense-check" that our estimation is delivering meaningful results.

Moody's Aaa corporate-Long-Term-Treasuries Spread: The red line in Figure 5 depicts the Moody's Aaa corporate-long-term-treasury spread. Over the overlapping period beginning in 1920, our 20-year spread estimate follows this measure fairly closely except during the 1920s and the high inflation of the 1970's and 1980's. While the index-based measure (the red line) reaches its highest values during this period, our estimate shows the opposite: the high-grade corporate to treasury spread is close to zero. The difference occurs because we make corrections for the capital gains tax advantage, and the option value on flower bonds, suggesting that a large portion of the variation in the index-based measure is attributable to an "inflation risk premium" instead of a "specialness premium" on US treasuries.[21]

[21] This is consistent with Figure 1 in Cook and Hendershott (1978), which suggests that after adjusting for "tax effects" yield spreads between high grade corporate and government bonds stayed below 1% before 1975.

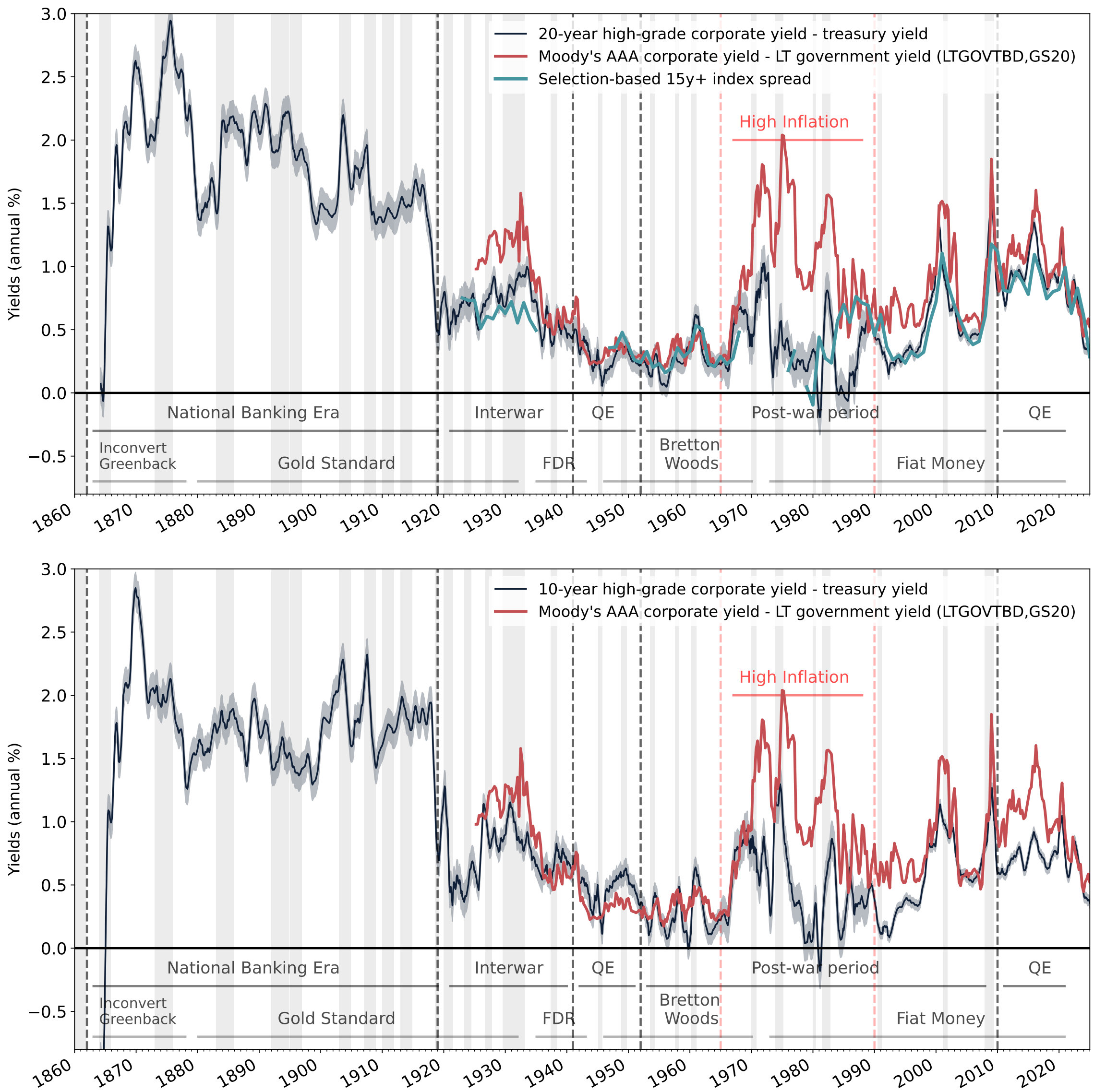

Figure 5: Highest-Grade Corporate to Treasury Spread Estimates: 1860-2024

Top panel depicts the 12-month centered moving average of the posterior median estimate of the 20-year convenience spread (black solid line) defined as the difference between 10-year zero-coupon yields on high-grade corporate debt and US Treasuries. The gray bands depict 90% posterior interquantile ranges. The red solid line shows the 12-month centered moving average of the index-based AAA Corporate-Treasury spread proposed by Krishnamurthy and Vissing-Jorgensen (2012). Bottom panel depicts the 10-year convenience spread against the index-based measure. Dashed vertical lines denote financial regulatory eras. Bottom labeling shows monetary standards. The light gray intervals depict NBER recessions.

We find more discrepancies relative to index-based measure (the red line) at shorter maturities, which are arguably more relevant for US government borrowing costs. In particular, at the 10-year horizon, which approximates the average debt maturity of US federal debt between 1860-2024 well, our estimates indicate relatively high spreads during the yield curve control period, and relatively low spreads during the decade after the Global Financial Crisis (GFC).

Selection Based Index Spread: The teal line in the top panel of Figure 5 depicts our selection-based yield index, constructed from a restricted subsample of bonds with maturities exceeding 15 years. The gap between the red and teal lines captures the total impact of distortions stemming from tax exemptions and option-like features, as detailed in Table 1. The two periods showing the most pronounced discrepancies are the 1920s—when varying degrees of tax exemption on government bonds suppressed long-term Treasury yields—and the 1970s–1980s, when high inflation and elevated interest rates amplified both the capital gains advantage and the embedded option value of flower bonds.

5.2 Term structure and quantity weighted measure

Figure 6 illustrates the spread between highest-grade corporate and U.S. Treasury yields at 5-, 10-, and 20-year maturities. While the U.S. funding advantage was, on average, relatively uniform across maturities, certain subperiods reveal a pronounced term structure with varying slopes. Specifically, our estimates show a negative slope—indicating a greater funding advantage at shorter maturities—during the yield curve control period, and a markedly positive slope—reflecting a larger advantage at the long end—throughout the decade following the Global Financial Crisis (GFC). These patterns in the term structure of funding cost spreads align with the Federal Reserve's Treasury purchase programs: in the 1940s and 1950s, the Fed focused on short-term government debt, whereas post-2008 quantitative easing (QE) emphasized acquisitions of long-term Treasuries.

The term structure in our estimates motivates the desire for one series to best capture the funding advantage of the U.S. Treasury across all periods in our sample. To do so, we construct a simple weighted average of the difference of our estimated corporate and treasury zero coupon yield curves, weighted by the quantity of debt at each maturity. Our weighted funding advantage $\chi_t^{weighted}$ is constructed to be:

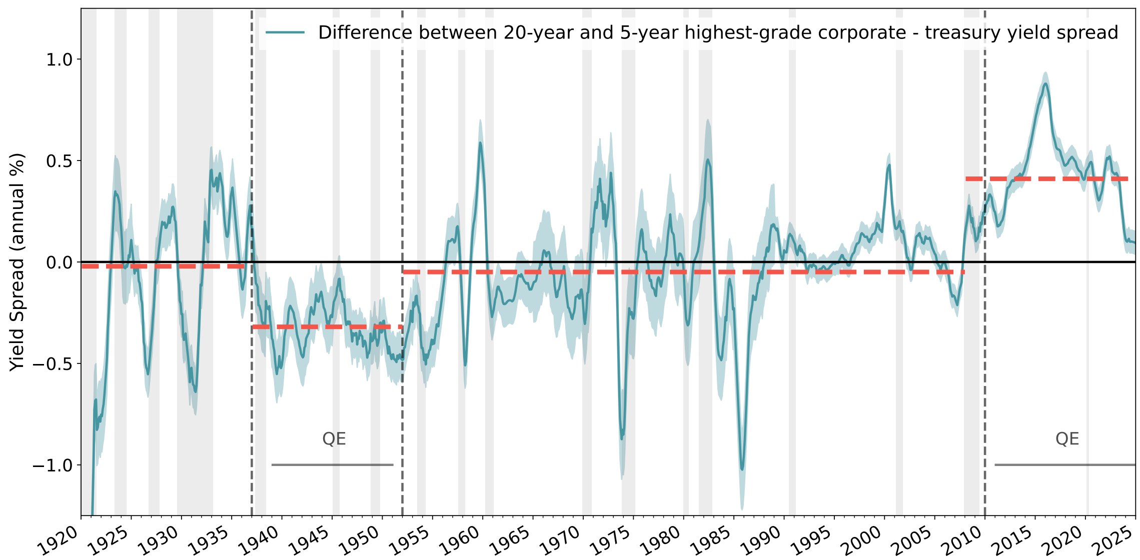

Figure 6: Term Structure of Highest-Grade Corporate to Treasury Spread: 1860-2024

Notes: The solid green line shows the posterior median estimate of the 20-year minus 5-year convenience spread estimates. The bands depict 90% posterior interquantile ranges. Dashed vertical lines denote financial regulatory eras. Bottom labeling shows two big QE episodes. The light gray intervals depict NBER recessions.

$$\chi_t^{weighted} = \frac{\sum_{j=1}^{\infty} \chi_t^{(j)} b_{t-1}^{(j)}}{\sum_{j=1}^{\infty} b_{t-1}^{(j)}} \tag{5.1}$$

For periods where we see a term structure in the funding advantage in Figure 6, the weighted funding advantage best shows the degree of influence across the maturity spectrum. During the two QE episodes when the term structure widened most, $\chi_t^{weighted}$ most closely resembles the maturity targeted by respective policy interventions: short and medium-term in WWII and long-term post-GFC.

5.3 Convenience Revenue

Figure 7 examines the ex-post ”convenience revenue” term in the government budget constraint (2.3). As this term can be viewed as a revenue source for the government, we normalize the term by total federal receipts for each year. During periods of crisis and economic revitalization (World Wars, New Deal, GFC, COVID), the convenience revenue from issuing new debt increases. This suggests that in these periods, the

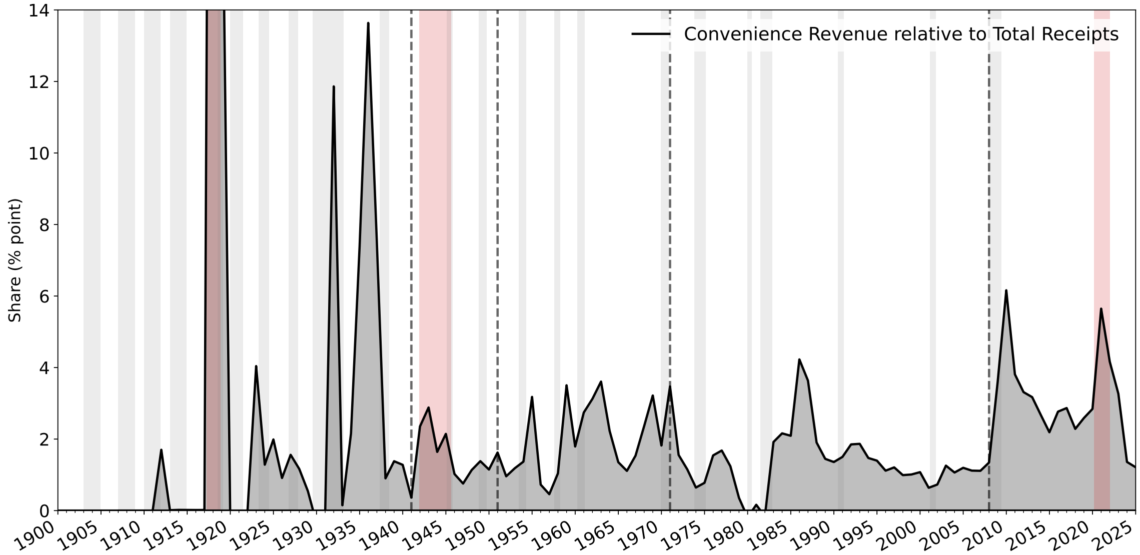

Figure 7: Convenience Revenue as percentage of Total Federal Receipts

Notes: The convenience revenue in period t is defined as $\sum_{j=1}^{\infty}\left(q_t^{(j)}-\tilde{q}_t^{(j)}\right)\left(b_t^{(j)}-b_{t-1}^{(j+1)}\right)$. The figure show the annualized convenience revenue relative to annual total federal receipts τ_t. The light gray intervals depict NBER recessions. The light red bands, from left to right, depict WW1, WW2, and COVID. The value of the series in 1917 and 1918 are 50.1 and 20, respectively.

government preferred financing expansionary measures by having the private sector hold their debt as opposed to raising taxes. In the high inflation period of the 1970s and early 1980s, the convenience revenue goes to zero.

5.4 Yield Curve Fit

Figure 8 shows properties of the fitted treasury yield curve across different dimensions of coupons, maturities, and time. The yield errors appear to appear as noise, as desired.

5.5 Default Risk

In line with the prior literature we assume that AAA-rated bonds are close to default free and that any remaining default risk is not an influential component of the AAA-Treasury Spread. In this section, investigate the plausibility of this assumption by calculating expected losses on AAA corporate bonds.

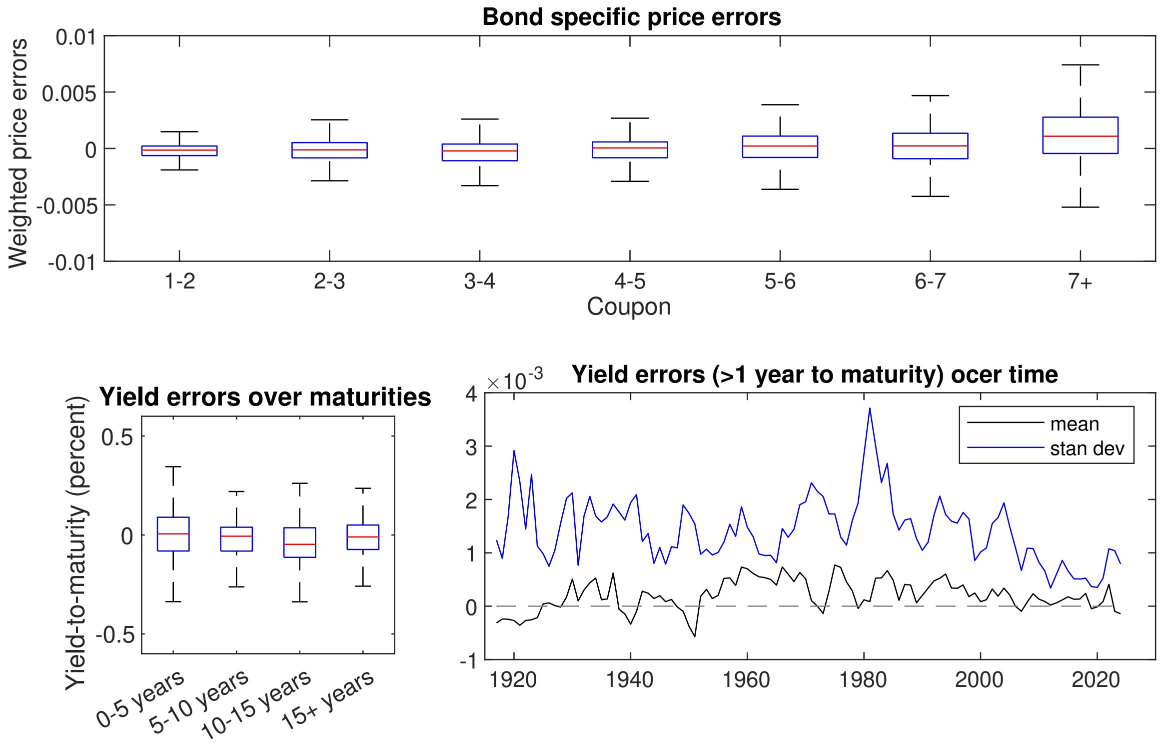

Figure 8: Statistical Fit

Notes: The top panel shows weighted price errors by coupon for the entire sample. The bottom panels show the difference of observed and model implied yield to maturities. The bottom left panel shows quartiles for these yield errors across maturity bins for the entire sample. The bottom right plot shows the time series of the mean (black line) and standard deviation (blue line) yield errors for every year in the sample starting in 1917. Pre-1917, our estimates deviate minimally from the estimates of Payne et al. (2025), thus we do not show them here. Option bonds are included in the calculations.

Default risk in corporate bonds can arise from two distinct channels: (i) actual defaults occurring between periods t and $t+1$, and (ii) changes in investors' expectations about future default probabilities, e.g. through rating downgrades. For the highest-grade corporate bonds, the probability of default over a one-year horizon is zero throughout our sample. Moody's Investors Service estimates that the cumulative default rate on Aaa-rated bonds over a 20-year horizon is only around 1.3 percent based on data from 1920–2024. As a result, nearly all of the relevant default risk stems from the second channel—i.e., changes in expected future defaults. To account for this, we estimate an expected loss measure that incorporates downgrade risk using historical corporate default rates, transition matrices and recovery rates provided by

Moody's Investor Service dating back to 1920. This approach aligns closely with the methodology of Elton et al. (2001b), who show that expected default losses explain only a small share of observed corporate to Treasury bond spreads. Moody's Investors Service estimates that the cumulative default rate on Aaa-rated bonds over a 20-year horizon is only around 1.3 percent based on data from 1920–2024. Figure 9 shows that even when incorporating downgrade risk, the expected loss on Aaa-rated bonds is close to zero and noticeably smaller than on Aa- or A-rated bonds. In line with Elton et al. (2001b), the expected loss is clearly not large enough to be able to explain the AAA treasury spread alone.

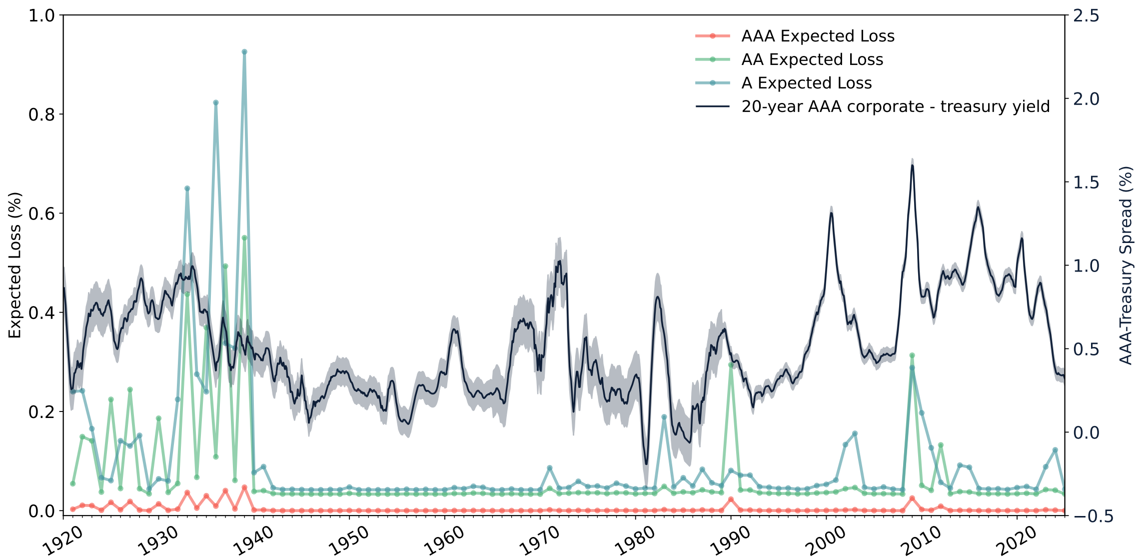

Figure 9: Expected Loss and AAA-Corporate to Treasury Spread: 1920-2024

Notes: The black solid line shows the posterior median estimate of the 20 year AAA-treasury spread. The shaded region denotes 90% posterior interquantile ranges. The orange, green and blue lines denote the expected loss on AAA, AA, A corporate bonds, respectively, as computed in Elton et al. (2001b). The expected loss on AAA corporate bonds in orange is clearly a negligible share of the AAA-treasury spread in black.

6 Funding Costs, Debt Supply, and Risk

In this section, we look for an asset pricing model that explains movements in the US government's funding advantage. Recall from equation (2.2) that the non-pecuniary benefit of j-maturity government debt is characterized by a (potentially maturity dependent) wedge $\Omega_{t,t+1}^{(j-1)}$ satisfying the investor Euler equations for the government and corporate bond discount functions respectively:

$$q_t^{(j)} = \mathbb{E}_t\Big[\xi_{t,t+1}\Omega_{t,t+1}^{(j-1)}q_{t+1}^{(j-1)}\Big], \quad \tilde{q}_t^{(j)} = \mathbb{E}_t\Big[\xi_{t,t+1}\tilde{q}_{t+1}^{(j-1)}\Big], \ \forall j \geq 1, \text{ with } q_t^{(0)} = \tilde{q}_t^{(0)} = 1,$$

Formally, our goal is to use our estimated time series of $\{\tilde{\mathsf{q}}_t, \mathsf{q}_t\}_{t\geq 0}$ to identify a factor model for the wedge $\Omega_{t,t+1}^{(j-1)}$.

We start, in Section 6.1, by revisiting the influential Krishnamurthy and Vissing-Jorgensen (2012) paper (henceforth referred to as KVJ-12), which argues that $\log(\Omega_{t,t+1}^{(j-1)})$ is well approximated by an affine function of the aggregate debt-to-GDP ratio and i.i.d. demand shocks. This proposal builds on a long literature debating whether changes in debt "quantities" can forecast a significant amount of the variation in the government funding spread (e.g. Fair and Malkiel (1971), Cook and Hendershott (1978)). We show that the historical evidence used to support this argument is influenced by the distortions in the index-based spread discussed in Section 3. Using our series for government funding advantage, both the scatter plots and the regressions in Krishnamurthy and Vissing-Jorgensen (2012) provide much less support for a clear, unconditional relationship between funding advantage and the aggregate debt-to-GDP ratio. In addition, because we have computed the term structure of funding advantage, we can also investigate the relationship at different debt maturities. We find that there is strong negative relationship between funding advantage and debt-to-GDP for maturities less than 1 year, a small negative relationship for maturities between 1-10 years, and essentially no relationship for maturities greater than 10 years. In this sense, we find some support for the Nagel (2016) hypothesis that quantity driven spreads are primarily a phenomenon for money-like short-term government bonds.

In Section 6.2, we then estimate a richer factor asset pricing model for $\Omega_{t,t+1}^{(j-1)}$ that forecasts changes in the discount functions $\{\tilde{\mathsf{q}}_t, \mathsf{q}_t\}$ for corporate and government bonds while respecting no-arbitrage across time. Being able to fit this model highlights the value of having estimated the term structure of government funding advantage in Section 5: we can use asset pricing tools to understand corporate-to-government bond spreads. Our model also finds some evidence that quantities are relevant for explaining the variation in government advantage at very short term maturities but finds little evidence that quantities can explain variation at other maturities. For long maturities, the non-pecuniary benefit of government debt appears to have similar risk factors to standard bond pricing. Or put another way, risk and asset pricing matter for understanding long-maturity funding spreads.

6.1 Revisiting Krishnamurthy and Vissing-Jorgensen (2012)

KVJ-12 and many subsequent papers argue that the wedge $\Omega_{t,t+1}^{(j-1)}$ satisfies the parametric specification:

$$\Omega_{t,t+1}^{(j-1)} = \exp\left(\beta_0 + \beta_1 \log\left(\theta_t / y_t\right) + \log(\zeta_t)\right) \tag{6.1}$$

where θ_t is the market value of all "convenience assets" that earn a non-pecuniary benefit, y_t is GDP, and $\log(\zeta_t)$ is a time-t adapted i.i.d. mean zero random variable often interpreted as a demand shock.[22] This specification rejects the competitive markets model, which assumes that $\Omega_{t,t+1}^{(j-1)} = 1$. However, it restricts the deviation from competitive markets by imposing that θ_t is the only factor that can predict the non-pecuniary component of the pricing kernel for government debt.

For 1-period government and corporate bonds without default risk, equation (6.1) implies that the funding advantage is given by:

$$\chi_t^{(1)} = \log\left(\tilde{q}_t^{(1)}\right) - \log\left(q_t^{(1)}\right) = \beta_0 + \beta_1 \log(\theta_t / y_t) + \log(\zeta_t)$$

For $j-$maturity government and corporate bonds with default risk, the funding advantage also includes additional covariance terms. To a first order approximation, this becomes (see Appendix G.2):

$$\begin{aligned}\chi_t^{(j)} \approx{}& \frac{1}{j}\left(\beta_0 + \beta_1 \log\left(\theta_t / y_t\right) + \log(\zeta_t)\right) + \frac{1}{j}\left(\log\left(\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]\right) - \log\left(\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]\right)\right) \\ &+ \frac{1}{j}\left(\frac{\operatorname{Cov}\left[\xi_{t,t+1}, \tilde{q}_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]} - \frac{\operatorname{Cov}\left[\xi_{t,t+1}, q_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]}\right)\end{aligned} \tag{6.2}$$

KVJ-12 tests specification (6.1) by looking for co-movement between the index-based spread and the ratio of the market value of publicly held government debt to GDP.

[22]This form can derived by imposing agents receive utility from holding particular assets.

Like the authors, we start by investigating the relationship visually in Figures 10 and 11. We then compute regressions in Tables 2 and 3.

Scatter plots: Figure 10 plots our estimate for the weighted average funding advantage within different maturity bins against the market value of debt to GDP within those same bins.[23] The first, second, and third plots shows the relationship for bonds with maturities less than 1 year, between 1-10 years, and more than 10 years respectively. The final plot shows the relationship for the weighted average funding advantage across all maturities (i.e. the funding advantage from equation (5.1)). Evidently, for short maturities there is a clear negative relationship, for medium maturities there is a weak relationship, and for long maturities there is no clear relationship. This suggests that debt-to-GDP changes play little role in forecasting government funding spreads on long-term debt.

Figure 11 provides a more direct comparison to the scatter plots in KVJ-12 to help show why correcting for the tax and option distortions is influential. The top panel in replicates the scatter plot in KVJ-12 using their data (the index-based spread) and time period (1920-2007). The middle panel plots the same time period as KVJ-12 but uses our estimates for the 20-year corporate-to-government funding spread and our estimates for the market value of tradable government debt. The bottom panel plots our estimates for our entire sample (1865-2024). The key periods where our estimates differ from the existing studies are highlighted with colors and lines linking consecutive years to show the direction of time. The stable unconditional negative relationship that KVJ-12 observed using the index-based spread is significantly weakened by using our new estimates. This is because the periods that identify the shape in the KVJ-12 plot (the 1920s, the 1940s, and the 1970-80s) are also the periods where the distortions discussed in Section 3 are most pronounced.

The high inflation period in the 1970-80s (the red dots and lines on the scatter plot) offers a particularly interesting example for how our new series changes our understanding of government funding advantage. Looking at the top panel, one can get the impression that the high-grade corporate-treasury spread started to increase when inflation shocks started to devalue long-term government debt after 1965. That

[23] To do this, we generalize the definition of weighted funding advantage from (5.1) to be the debt weighted average of the difference in corporate and treasury zero coupon yields for a given maturity range, instead of across all maturities.

is, it looks like the economy could be moving along a stable demand function for US treasuries. In fact, in the top panel, the spread reaches its maximum value in the sample in the midst of the high inflation in the mid 1970s. The middle panel, with our data, tells a very different story: as government debt devalued in the 1970-80s, the high-grade corporate-treasury spread dropped down to around zero, its lowest value in the sample. That is, it looks like high inflation coincided with a breakdown (or leftward shift) of the relationship between spreads and quantities.

The bottom panel with our full sample from 1860-2024 sheds light on how sharply government funding advantage has varied across financial regulatory eras. For a given level of debt-to-GDP, the spread was approximately 0.5-1.0 percentage points higher during the National Banking Era (approximately 1865-1920) compared to later periods. This is similar in size to the drop in the spread around 1920 in Figure 5 when National Banks stopped being able to use government debt to create bank notes (that is National Bank circulation privilege was eliminated). This is further suggestive evidence that the circulation privilege contributed approximately 1 percentage point to the government's funding advantage in the 19th century.

Regressions: To study the co-movement between government debt supply and funding advantage more systematically, in Table 2 we run KVJ-12 style regressions on the four maturity weighted funding advantages from Figure 10, and in Table 3 we rerun the regressions from KVJ-12 using our extended dataset. The first column in 3 uses the data from KVJ-12 for their time period 1925-2007, the second column replicates the KVJ-12 regression using our data, the third column adds in holding return volatility, and columns four to six study our entire sample from 1865-2024.

The regressions confirm what can be seen visually in the scatter plots. The maturity specific regression in Table 3 confirms that the negative elasticity is largest for short-maturity treasuries and non-existent for long-maturity treasuries. For the non-maturity weighted regressions in Table 3, for the original KVJ-12 sample, once we correct for tax and option distortions, there is a less pronounced statistical relationship between spreads and quantities. For our extended sample, column three of Table 3 shows a negative relationship. However, this relationship weakens once we control for the National Banking Era in columns four and five, which also have a significantly higher R^2. This indicates that the low frequency negative relationship between quantities spreads in the long sample is almost entirely accounted for by the change in financial regime. Indeed, if we subtract our estimate for the circulation

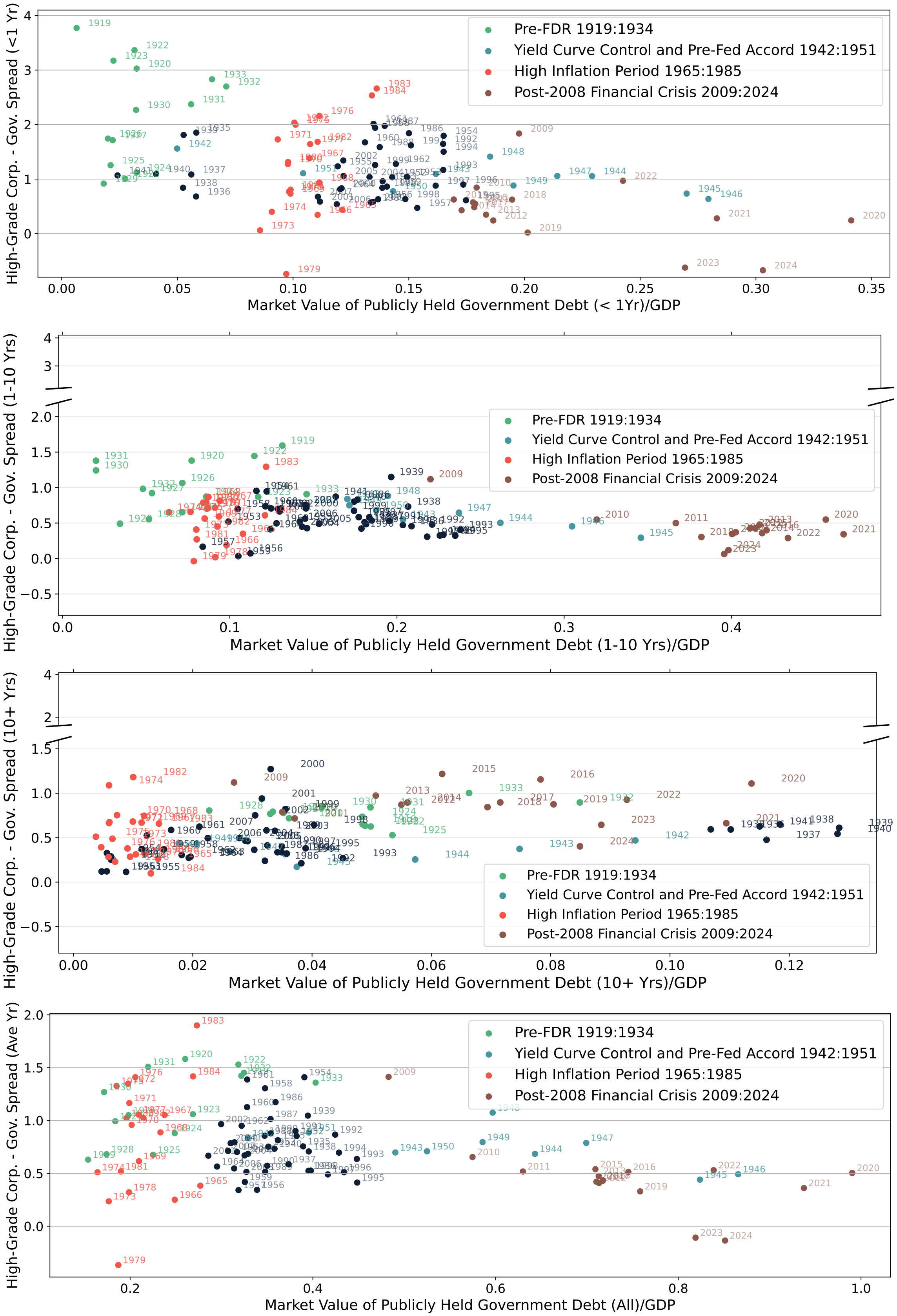

Figure 10: Spreads versus Debt-to-GDP for 1919 to 2024. (a) The top panel has maturities < 1 year. (b) The second panel has maturities from 1-10 years (c) The third panel has maturities for 10+ years. (d) The final panel has weighted average spread across all maturities.

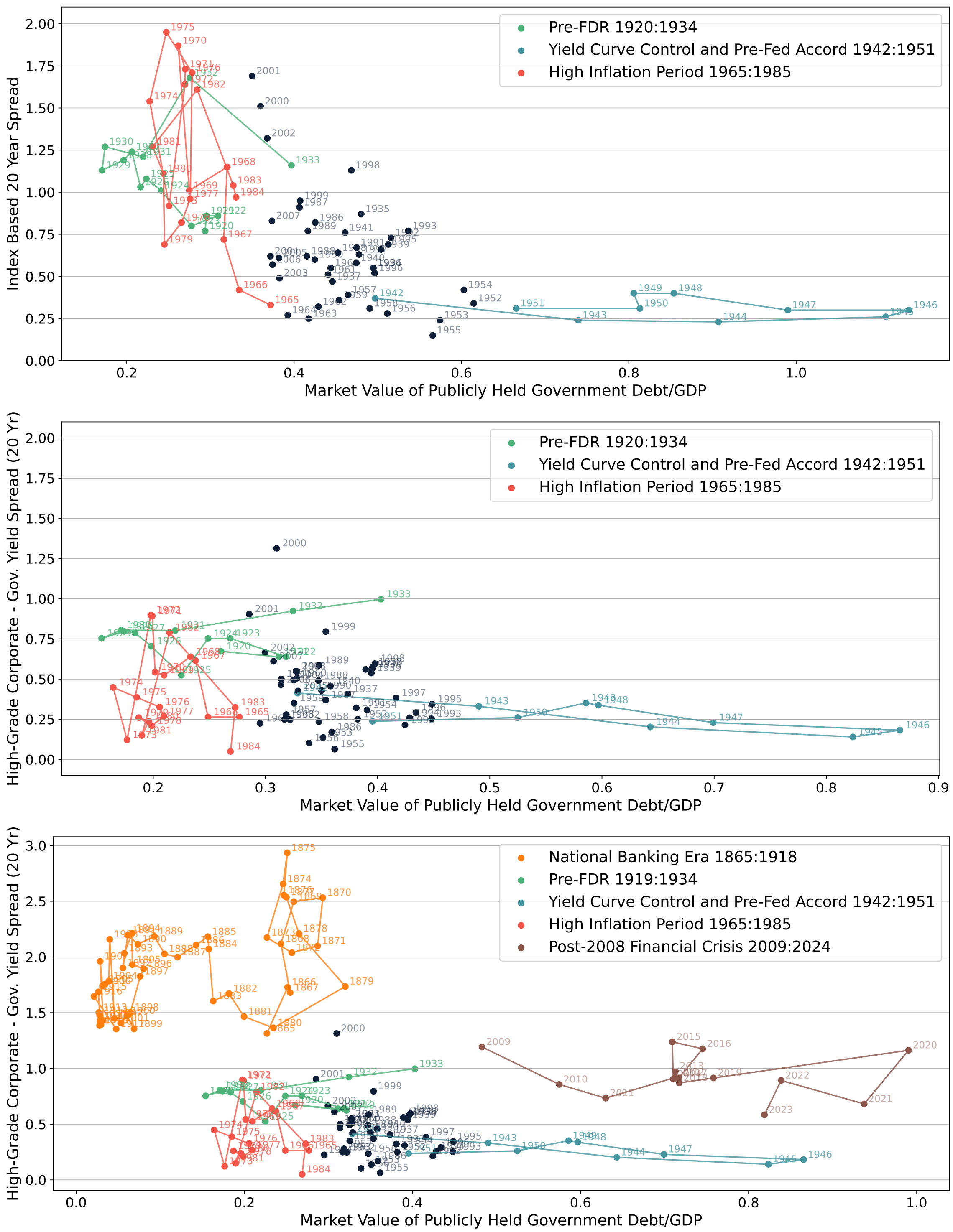

Figure 11: (a) The top panel replicates Krishnamurthy and Vissing-Jorgensen (2012) using their data and time period from 1920-2007. (b) The middle panel uses our estimate of the spread to replicate the top panel. (c) The middle panel uses our estimate for our full sample from 1865-2024.

privilege that government debt enjoyed from 1865-1918 (approximately 1 percentage point), then the orange dots would drop down further the relationship.

Period:	1920-2024	1920-2024	1920-2024	1920-2024
	Maturity 0-1	Maturity 1-10	Maturity 10+	Weighted Ave.
	(1)	(2)	(3)	(4)
log(Debt/GDP)[0-1 Yrs]	-0.526***			
	(0.093)			
log(Debt/GDP)[1-10 Yrs]		-0.234***		
		(0.040)		
log(Debt/GDP)[10+ Yrs]			0.080***	
			(0.030)	
log(Debt/GDP)[All]				-0.417***
				(0.072)
Volatility	0.549	0.698***	0.960***	0.648**
	(0.616)	(0.248)	(0.276)	(0.323)
Slope	0.384***	0.125***	-0.020	0.206***
	(0.059)	(0.025)	(0.026)	(0.032)
Constant	-0.447*	-0.079	0.718***	0.045
	(0.238)	(0.099)	(0.147)	(0.115)
Significance:	* $p<0.1$	** $p<0.05$	*** $p<0.01$	
Observations	104	104	104	104
Adjusted R^2	0.406	0.346	0.215	0.364

Table 2: Regression Results: Funding Advantage Analysis

Period:	1925-2007	1925-2007	1865-2024	1865-2024	1865-2024
	KVJ	LPSS	LPSS	LPSS	LPSS
	(1)	(2)	(3)	(4)	(5)
log(Debt/GDP)[KVJ]	-0.649***				
	(0.089)				
log(Debt/GDP)[LPSS]		-0.182***	-0.438***		0.091
		(0.069)	(0.052)		(0.076)
Volatility	0.779	1.694***	2.354***	1.020***	0.872***
	(0.508)	(0.319)	(0.389)	(0.260)	(0.261)
Slope	0.011				
	(0.037)				
Slope		-0.020	0.116***	0.035	0.002
		(0.029)	(0.040)	(0.024)	(0.026)
Pre-1920 Dummy				1.231***	1.526***
				(0.061)	(0.167)
Pre-1920 Dummy × log(Debt/GDP)					0.069
					(0.091)
Constant	0.164	-0.013	-0.267**	0.320***	0.474***
	(0.100)	(0.098)	(0.125)	(0.060)	(0.109)
Significance:	* p<0.1	** p<0.05	*** p<0.01		
Observations	83	82	157	157	157
Adjusted R^2	0.462	0.313	0.433	0.771	0.779

Table 3: Regression Results: Each column regresses the 10-year funding advantage on the listed variables. (1) Replicates the regression from KVJ-12 using their data for the period 1925–2007. (2) Replicates (1) using our estimated spread and market value series. (3) Replicates (2) with our full sample. (4) Excludes log(Debt/GDP) and includes a dummy for the end of the National Banking Era. (5) Includes all controls for the full sample.

6.2 An Asset Pricing Model of Funding Advantage

The scatter plots and regressions from the previous section are not a direct test for the specification of Ω for long-maturity bonds because spreads on long-maturity bonds also contain additional terms, as illustrated by equation (6.2). However, it has previously not been possible to estimate a pricing kernel for the spread because we have lacked historical estimates of the corporate yield curve. We now exploit our new yield curve estimates to resolve these difficulties and fit an affine Gaussian model for the treasury wedge.

6.2.1 Model

State space: Let $\tilde{x}_t$ denote a vector with the first K_C principal components of the corporate yield curve. We breakup the market value of debt into N maturity bins and let $b_t = [b_t^{(n)} : 1 \leq n \leq N]$ denote a vector with the log of the market value of total debt in each bin divided by GDP. Let x_t denote the first K_G the principle components of the government yield curve. Let v_t denote the residuals in the projection of x_t onto $[\tilde{x}_t^T, b_t^T]$. Let $X = [x_t^T, v_t^T, w_t^T]$ denote the state space for the model. We impose the law of motion on the state space:

$$
\begin{aligned}
X_t &= \mu_X + \Phi_X X_{t-1} + \ \Sigma\epsilon_t, \\
\epsilon_t &\sim N(0, I_{n_\epsilon})
\end{aligned}
$$

Corporate bond pricing kernel: We estimate a standard affine asset pricing model for the corporate pricing kernel. Formally, we impose that the corporate pricing kernel takes the form:

$$
\begin{aligned}
\xi_{t,t+1} &= \ \exp\left(-r_t - 0.5\lambda_t^T \Sigma\Sigma^T \lambda_t - \lambda_t^T \Sigma\epsilon_{t+1}\right) \\
r_t &= \delta_0 + \delta_1^T X_t \\
\lambda_t &= \lambda_0 + \lambda_1 X
\end{aligned}
$$

and satisfies the corporate bond Euler equation:

$$
\widetilde{q}_t^{(j)} = \mathbb{E}_t\left[\xi_{t,t+1}\widetilde{q}_{t+1}^{(j-1)}\right], \ \forall j \geq 1, \text{ with } \widetilde{q}_t^{(0)} = 1,
$$

Treasury wedge: We impose that the wedge on n-maturity bonds takes the form:

$$\begin{aligned}
\Omega_{t,t+1}^{(n-1)} &= \exp\left(-\mu_t^{(n-1)} - 0.5(\omega_t^{(n-1)})^T \Sigma\Sigma^T \omega_t^{(n-1)} - (\omega_t^{(n-1)})^T \Sigma\epsilon_{t+1}\right) \\
\mu_t^{(n-1)} &= \mu_0^{(n-1)} \\
\omega_t^{(n-1)} &:= \omega_0^{(n-1)} + \omega_1^{(n-1)} X_t
\end{aligned}$$

and satisfies the treasury Euler equation:

$$q_t^{(j)} = \mathbb{E}_t\left[\xi_{t,t+1}\Omega_{t,t+1}^{(j-1)} q_{t+1}^{(j-1)}\right]$$

Here, we can interpret the "risk factor" $\omega_t^{(n-1)}$ for the different components of b_t as the elasticity of the n-maturity wedge to debt supply shocks. In this sense, we can think of the equation as nesting a version of the KVJ-12 form but with time varying elasticity of demand and forecastable level shocks.

6.2.2 Estimation

We estimate the state, corporate pricing kernel, and treasury pricing kernel model parameters $(\mu_X, \Phi_X, \Sigma, \delta_0, \delta_1, \lambda_0, \lambda_1, \mu_0^{(n-1)}, \omega_0^{(n-1)}, \omega_1^{(n-1)}$ by adapting standard indirect inference techniques (e.g. Adrian et al. (2013a)). We discuss estimation in more detail in Appendix G.3.

6.2.3 Results

Figure 12 shows the variance decomposition how much different shocks contribute to explaining the variation in the spread. The different colors denote the contribution from all the debt-to-GDP factors, the corporate principal components, and the residuals when the treasury principal components are projected onto the the other states. Evidently, the residualized principal components of the treasury yield curve explain the majority of the variation while the debt-to-GDP factors explain very little. In this sense, it is the treasury risk factors that primarily explain movements in government funding advantage.

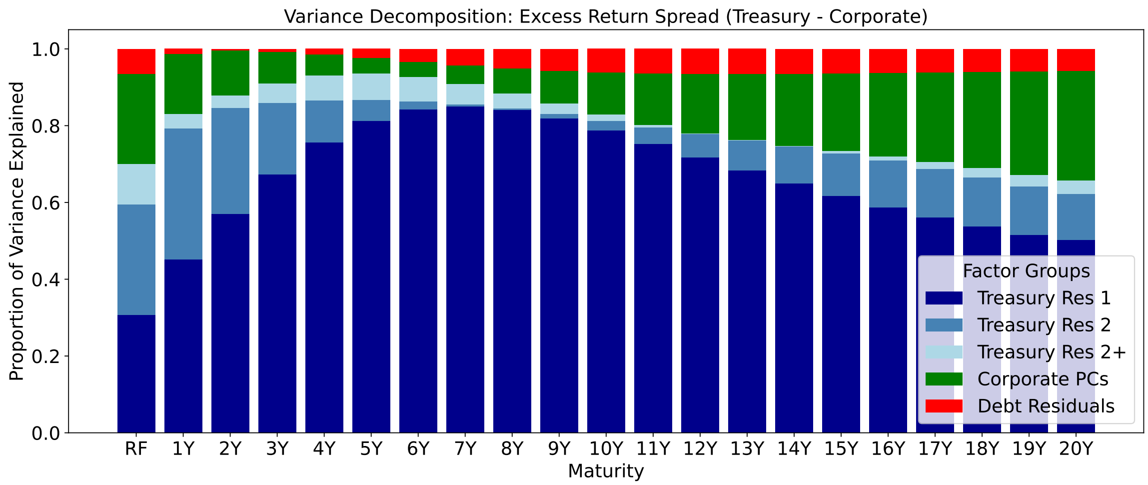

Figure 12: Variance Decomposition

7 Conclusion

In this paper, we construct new estimates for historical high-grade corporate and nominal treasury yield curves and use them to compute a term structure of Aaa-rated corporate to US Treasury spreads. We use our estimates to document how the long-run mean of the US funding cost advantage, as measured by the AAA Corporate-Treasury spread, has fluctuated in response to financial sector regulation and monetary-fiscal policies, thereby challenging prevailing narratives about the predictability and stability of demand function for US treasuries.

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A Government Budget Constraint Arithmetic

The market value of the portfolio of coupon-bearing government bonds in period t is:

$$\mathcal{B}_t := \sum_{i \in \mathcal{N}_t} q_{t,i} B_{t,i}$$

where $B_{t,i}$ is the face value of bond i at date t, $q_{t,i}$ is the market price of bond i at date t and $\mathcal{N}_t$ is the set of bonds outstanding at date t. Each bond i is characterized by a triple (c_i, p_i, T_i), where c_i is the coupon rate, p_i is the principal, and T_i is the maturity date. We can turn the maturity date into a time-to-maturity variable, $J_{t,i} = T_i - t$.

Suppose that the usual asset pricing equation holds for all bonds:

$$q_{t,i} = \sum_{n=1}^{\infty} q_t^{(n)} \mathsf{c}_{t,i}^{(n)} \qquad \forall i \in \mathcal{M}_t$$

where $q_t^{(n)}$ is a discount function which is independent of i and only depends on (t, n). By definition, $q_t^{(0)} = 1$.

That said, we can re-express the market value of the government debt portfolio (of coupon-bearing bonds) in terms of a portfolio of zero-coupon bonds:

$$\begin{aligned}\mathcal{B}_t := \sum_{i \in \mathcal{M}_t} q_{t,i} B_{t,i} &= \sum_{i \in \mathcal{M}_t} \sum_{n=1}^{\infty} q_t^{(n)} \mathsf{c}_{t,i}^{(n)} B_{t,i} \\ &= \sum_{n=1}^{\infty} q_t^{(n)} \sum_{i \in \mathcal{M}_t} \mathsf{c}_{t,i}^{(n)} B_{t,i} = \sum_{n=1}^{\infty} q_t^{(n)} b_t^{(n)}\end{aligned}$$

where $b_t^{(n)}$ denotes the number of $t+n$ dollars that the government has at time t promised to deliver. To construct the panel $\{\{b_t^{(n)}\}_{n=1}^{\infty}\}_{t\geq 1}$ from historical data, we add up all of the dollar principal-plus-coupon payments, $\mathsf{c}_{t,i}^{(n)}$, that the government has at time t promised to deliver at date $t+n$. Let the total (face value of) outstanding debt in period t be $b_t := \sum_{n=1}^{\infty} b_t^{(n)}$ and the "portfolio shares" are $b_t^{(n)}/b_t$.

A.1 Government Budget Constraint and Bond Returns

In any period t, the government enters with a stock of promised payments $\{b_{t-1}^{(n)}\}_{n\geq 1}$ and issues new (zero-coupon) bonds $\{b_t^{(n)}\}_{n\geq 1}$, where $b_t^{(n)}$ is the amount of bond of maturity n issued in period t.[24] The government budget constraint can be written as

$$\begin{aligned}\sum_{n=1}^{\infty} q_t^{(n)} b_t^{(n)} &= \sum_{n=1}^{\infty} q_t^{(n-1)} b_{t-1}^{(n)} + g_t - \tau_t \\ &= b_{t-1}^{(1)} + \sum_{n=1}^{\infty} q_t^{(n)} b_{t-1}^{(n+1)} + g_t - \tau_t\end{aligned}$$

where g_t is government spending and τ_t is tax revenues. Let Δ_t be the net amount of dollars that the government raises in period t from "refinancing" its debt:

$$\Delta_t := \sum_{n=1}^{\infty} q_t^{(n)} \left[b_t^{(n)} - b_{t-1}^{(n+1)} \right]$$

so that the budget constraint becomes

$$g_t + b_{t-1}^{(1)} = \tau_t + \Delta_t.$$

The role of the yield curve for government financing can be summarized by the Δ_t term. The government's total deficit (including interest payments) is $g_t + b_{t-1}^{(1)} - \tau_t$, while its primary deficit is $def_t := g_t - \tau_t$.

As a result, the difference between Δ_t and $\widetilde{\Delta}_t$ can be viewed as the contribution of the borrowing cost spread to period t surplus. Alternatively, we can also write the budget constraint in terms of holding period returns:

$$\begin{aligned}\mathcal{B}_t = \sum_{n=1}^{\infty} q_t^{(n)} b_t^{(n)} &= \sum_{n=1}^{\infty} q_t^{(n-1)} b_{t-1}^{(n)} + def_t \\ &= \sum_{n=1}^{\infty} \left(\frac{q_t^{(n-1)}}{q_{t-1}^{(n)}} \right) q_{t-1}^{(n)} b_{t-1}^{(n)} + def_t \\ &= \sum_{n=1}^{\infty} R_t^{(n)} q_{t-1}^{(n)} b_{t-1}^{(n)} + def_t = \underbrace{\frac{\sum_{n=1}^{\infty} R_t^{(n)} q_{t-1}^{(n)} b_{t-1}^{(n)}}{\sum_{n=1}^{\infty} q_{t-1}^{(n)} b_{t-1}^{(n)}}}_{=\mathcal{R}_t} \sum_{n=1}^{\infty} q_{t-1}^{(n)} b_{t-1}^{(n)} + def_t \\ &= \mathcal{R}_t \mathcal{B}_{t-1} + def_t\end{aligned}$$

where $\mathcal{R}_t$ denotes the holding period return on the government debt portfolio which defined by the weighted average of the one-period holding period returns (of n-period

[24] For instance, one period bond issued in period t and maturing in $t+1$ is $b_t^{(1)}$. Similarly, $b_{t-1}^{(n)}$ is the amount of n-period bond issued in period $t-1$ coming due in period $t-1+n$.

zero coupon bonds): $r_{t+1}^{(n)} := \log R_{t+1}^{(n)} = \log q_{t+1}^{(n-1)} - \log q_t^{(n)}$. The log holding period returns $\{r_{t+1}^{(n)}\}_{n\geq 1}$ can be easily computed as

$$r_{t+1}^{(n)} = -(n-1)y_{t+1}^{(n-1)} + ny_t^{(n)}$$

from the time-series of zero-coupon yield curves $\{y_t^{(n)}\}_{n\geq 1}$. Yet another way to write the budget constraint is

$$\sum_{n=1}^{\infty}(q_t^{(n)} - \tilde{q}_t^{(n)})b_t^{(n)} + \sum_{n=1}^{\infty}\tilde{q}_t^{(n)}b_t^{(n)} = \sum_{n=1}^{\infty}(q_t^{(n-1)} - \tilde{q}_t^{(n-1)})b_{t-1}^{(n)} + \sum_{n=1}^{\infty}\tilde{q}_t^{(n-1)}b_{t-1}^{(n)} + def_t$$
$$\widetilde{\mathcal{B}}_t = \widetilde{\Delta}_t - \Delta_t + \widetilde{R}_t\widetilde{\mathcal{B}}_{t-1} + def_t$$

where $\widetilde{R}_t$ denotes the holding period return on the government debt portfolio under the high-grade corporate yield curve.

With these notations, the two versions of the budget constraint can be expressed as

$$\begin{aligned}\mathcal{B}_{t-1} &= \mathcal{R}_t^{-1}\Big(-def_t + \mathcal{B}_t\Big)\\ &= \sum_{s=0}\left(\prod_{h=0}^{s}\mathcal{R}_{t+h}^{-1}\right)(-def_{t+s})\end{aligned}$$

and

$$\begin{aligned}\widetilde{\mathcal{B}}_{t-1} &= \widetilde{\mathcal{R}}_t^{-1}\Big(-def_t + \Delta_t - \widetilde{\Delta}_t + \widetilde{\mathcal{B}}_t\Big)\\ &= \sum_{s=0}\left(\prod_{h=0}^{s}\widetilde{\mathcal{R}}_{t+h}^{-1}\right)\Big(-def_{t+s} + \widetilde{\Delta}_{t+s} - \Delta_{t+s}\Big)\\ \Leftrightarrow \quad \widetilde{\mathcal{R}}_t\widetilde{\mathcal{B}}_{t-1} &= -def_t + \Delta_t - \widetilde{\Delta}_t + \sum_{s=1}\left(\prod_{h=1}^{s}\widetilde{\mathcal{R}}_{t+h}^{-1}\right)\Big(-def_{t+s} + \Delta_{t+s} - \widetilde{\Delta}_{t+s}\Big)\end{aligned}$$

A.2 Models with representative long-term debt

The *admissible set of portfolios* is restricted to follow an exponential rule, i.e. $\forall t,\ \exists\,(b_t, \omega_t)$ s.t.

$$b_t^{(n)} = b_t\omega_t\,(1-\omega_t)^{n-1}$$

In other words, the assumption is that we can summarize/proxy the $\{b_t^{(n)}\}_{n=1}^{\infty}$ with a pair of scalars (b_t, ω_t). The variable Δ_t can be written as:

$$\Delta(b_t, \omega_t; b_{t-1}, \omega_{t-1}) := \sum_{n=1}^{\infty} q_t^{(n)} \Big[\underbrace{(1-\omega_t)^{n-1}\,\omega_t b_t}_{=b_t^{(n)}} - \underbrace{(1-\omega_{t-1})^{n}\,\omega_{t-1} b_{t-1}}_{=b_{t-1}^{(n+1)}} \Big]$$

In the above expression, if the government enters the period with a portfolio (b_{t-1}, ω_{t-1}) and wants to exit it with a portfolio (b_t, ω_t), then for each maturity $n \geq 1$ it must issue/buy back $b_t^{(n)} - b_{t-1}^{(n+1)}$ many bonds at price $q_t^{(n)}$.

Suppose for now that ω_t is not a choice variable and it's fixed over time, i.e. $\omega_t = \omega$. We can then write

$$\Delta_t := \underbrace{\left(\sum_{n=1}^{\infty} q_t^{(n)} \,(1-\omega)^{n-1}\,\omega \right)}_{=:q_t^b(\omega)} \Big(b_t - (1-\omega)\, b_{t-1} \Big) = q_t^b \Big(b_t - (1-\omega) b_{t-1} \Big)$$

where q_t^b denotes the market price of a "unit" of government debt portfolio (at face value) with average maturity $1/\omega$. From the definition of Δ_t we can write the law of motion of (the face value of) debt as

$$b_t = (1-\omega) b_{t-1} + \frac{\Delta_t}{q_t^b}$$

so if $\omega < 1$ and q_t^b depends on (b_t, b_{t-1}), q_t^b will behave as an (endogenous) debt adjustment cost. In this case, the government budget constraint is

$$g_t + \omega b_{t-1} = \tau_t + q_t^b \Big(b_t - (1-\omega) b_{t-1} \Big).$$

B Historical Context

This appendix provides historical and institutional context for interpreting the long-run data on US corporate and government bond markets, highlighting key developments in issuance practices, regulation, and market structure over time.

Brief History of the US Bond Market: The US corporate bond market traces its origins to the early 19th century, driven by the need to finance large infrastructure projects. The first corporate bonds were issued by banks and canal companies, but the market truly expanded with the rise of the railroad industry. By the 1850s, railroad companies were expanding into the "wild west" at a scale and level of uncertainty that they could no longer raise sufficient capital from the local and fragmented banks of the time. The solution was to issue bonded debt to a broader pool of investors, which created what is considered the world's first corporate bond market (Sylla et al., 2006). Essentially a railroad bond market in its early decades, by the early 1900s, the corporate bond market was several times larger than that of the UK or US sovereign debt markets.[25] By the late 19th and early 20th centuries, the market matured, with securities becoming more standardized, and industrial corporations and utilities also began issuing bonds.

Concurrently, the federal government initially issued bonds infrequently, as Congress was responsible for debt management, leading to long-maturity issuances with significant variations in maturities, coupon rates, denominations, and units of account (Payne et al., 2025). The expansion and standardization of federal debt issuance occurred gradually over time, with Congress delegating more autonomy in designing and issuing securities to the Treasury Department between 1917 and 1939. Both markets continued to expand throughout the 20th century and by the mid-20th century, US Treasury securities had become the world's largest and most liquid debt market, with a standardized set of securities at various maturities.

Treasuries dominated in scale but both corporate and Treasury bonds traded actively on major exchanges like the New York Stock Exchange (NYSE) and were held by similar investors, including banks, insurers, and wealthy individuals. Both corporate and government bonds shared similar features, such as fixed coupon payments and typically long maturities and exhibited relatively high liquidity compared

[25] The US actually paid off its entire national debt in 1836.

to other asset classes. On the corporate side, railroad bonds declined in importance as industrials and utilities became the dominant issuers in the 20th century, increasingly offering high-grade bonds.

Denomination: The denomination of both Treasury and corporate bonds has evolved similarly throughout American financial history. From 1800 to 1933, the US adhered to a gold standard except from 1861 to 1878 when it temporarily suspended gold convertibility and issued a paper currency known as "greenbacks". During this period, both federal and corporate bonds were typically denominated in gold (or greenbacks during the suspension). Following the Gold Reserve Act of 1933, which prohibited private US citizens from holding gold coins, both markets transitioned to nominal dollar denomination. The Bretton Woods Agreement (1944-1971) reintroduced a type of gold standard by establishing an international system of fixed exchange rates with the US dollar convertible to gold until its collapse in 1971 when the dollar was floated. Since then, both Treasury and corporate bonds have been issued exclusively in nominal terms until the introduction of Treasury Inflation-Protected Securities (TIPS) in 1997, which provide explicit inflation protection.

Credit ratings: The rise of corporate bonds was accompanied by the development of credit ratings. Beginning in 1832, the "American Railroad Journal" published detailed assessments of railroad companies, covering physical descriptions of the railroads, their assets, liabilities, and earnings. In 1868, its former editor Henry V. Poor published the first volume of "Poor's Manual of the Railroads of the United States", a comprehensive resource detailing financial statements, operational statistics, and the capital structure of their securities. In 1909, John Moody in his "Moody's Manual of Railroads and Corporation Securities" first introduced a structured rating system for these securities that established the foundation for modern credit ratings.

Default Risk: In the early 1900s, Moody's Investors Service began assigning credit ratings to bonds and other financial assets, with "Aaa" denoting the highest level of creditworthiness. This rating was based on factors such as physical capital, debt levels relative to assets and revenue, profitability, and liquidity. To qualify for an "Aaa" rating, bonds needed a long-term track record of exceptionally strong interest coverage and substantial physical assets backing the issue, ensuring minimal investment risk. Most bonds were either first mortgages or well protected underlying mortgages. Moody's argued that even in changing economic conditions, the fundamental strength of these securities would remain intact. As Hickman (1958) found, credit ratings offered investors valuable insights into bond quality and default probabilities. However, their performance was not significantly better than the bond market's own assessment, as reflected in interest rate spreads.

Policy Interventions: Corporate and government bond markets have historically been subject to different regulatory frameworks, evolving in response to financial and economic pressures. In the decades before the Civil War, only state-chartered banks existed, which were not incentivized to hold Treasuries.[26] This changed with the National Banking Acts of 1863–1866, which established a system of nationally chartered single-branch banks. These banks were permitted to issue banknotes up to 90% of the lower of the par or market value of qualifying US federal bonds, effectively tying their balance sheets to government debt. However, national banks were prohibited from using railroad bonds as backing for their notes and faced strict limitations on the types of loans they could issue.

World War II brought further regulatory intervention, as concerns over war financing led to the government "fixing" the yield curve from 1942 to 1951, with the T-bill rate set to 3/8% and the long-term bond yield capped at 2.5% (see Garbade (2020) and Rose (2021)). This policy was implemented through coordination between the Treasury and the Federal Reserve, with the Fed agreeing to absorb excess bond supply at the fixed price, and implicit coordination with the banking system, which ended up predominantly holding government debt. The arrangement ended with the 1951 Treasury-Fed Accord, establishing official Fed independence from the Treasury.

The 2007–2009 financial crisis triggered extensive regulatory reforms, including the Dodd-Frank Wall Street Reform and Consumer Protection Act, which introduced new oversight for financial institutions. Additionally, the Basel III regulations imposed stricter capital requirements and portfolio constraints on banks, penalizing excessive leverage and encouraging the holding of government debt over assets like corporate bonds. In response to the crisis, the Federal Reserve also launched a quantitative

[26] These banks, chartered by state legislatures, could issue their own banknotes and were subject to diverse balance sheet regulations, often requiring them to hold gold and state bonds. However, no state banks could operate nationally.

easing (QE) program, purchasing long-term government bonds to lower interest rates and stabilize financial markets.

C The Corporate and Government Bond Datasets

We construct a new historical dataset of high-grade US corporate bonds, providing monthly data on trading prices and cash-flows as well as bond characteristics and credit ratings from 1840-2024. Monthly prices and cash-flows date back to 1840, along with detailed bond characteristics such as maturity, denomination and callability. Annual Moody's credit ratings date back to their earliest availability: 1909 for railroads and 1914 for public utilities and industrials. Our dataset integrates existing databases with hand-collected prices and bond characteristics from historical newspapers, business magazines, and financial releases by companies. We complement the corporate bond data with a comprehensive panel of prices and quantities for all US Treasury securities from 1776 to 2024.

C.1 Corporate Bond Data

C.1.1 Bond Prices

To compile end-of-month trading prices from 1840-2024 we rely on six main data sources: *Global Financial Data (GFD)*, the *New York Times (NYT)*, the *Commercial & Financial Chronicle (CFC)*, *Barron's Magazine*, the *Lehman Brothers Fixed Income Database*, and the *Merrill Lynch Bond Index Database*. From 1840-1884 we take bond price data from *Global Financial Data (GFD)*. The GFD dataset covers nearly 800 corporate bonds from 1791 to 1884, almost all of which are railroad bonds, reflecting their dominance in the bond market during that period. The price data is particularly rich between 1870-1884, featuring both daily time series of trading prices and bond characteristics such as the bonds name, coupon, and company information. The data does not include further bond characteristics such as maturity date or denomination. From 1886 to 1963, we collect end-of-month trading prices from the *Commercial & Financial Chronicle*. The *Commercial & Financial Chronicle* was a weekly business newspaper published from 1865 to 1987.[27] We use bond quotations from the New York

[27] Scanned digital copies of the Chronicle are available from the Federal Reserve Archival System for Economic Research (FRASER) from July 1865 to December 1963.

Stock Exchange, focusing on actual sale prices, as reported in the "Stock Exchange Quotation / Bond Record" section. From 1884 to 1918, we collect only railroad bond prices. Beginning in January 1918, we expand the collection to include all corporate bonds, reflecting the growing importance of utility and industrial securities in the corporate bond market during the early 20th century. From 1964 to 1973, we collect bond closing prices from *Barron's Magazine*. *Barron's* is a weekly financial newspaper founded in 1921, providing coverage of closing prices for actively traded corporate bonds in their "Listed Bond Quotations" section. From 1973 to 1997 we rely on the *Lehman Brothers Fixed Income Database* distributed by Hong and Warga (2000) which provides comprehensive monthly bond-specific information from January 1973 to December 1997, including bond price, ratings and coupons. After 1997 we use the *Merrill Lynch Bond Index Database* which provides a similar level of detail. We use daily closing prices from the New York Stock Exchange as reported in *The New York Times (NYT)* to fill in any gaps in our sample between 1840 and 1973.

C.1.2 Bond Characteristics

A major challenge in estimating yield curves is that we need accurate information about bond maturity, coupon payments, and embedded options (e.g., call features). For the period after 1972, we are able to rely on detailed bond information from the *Lehman Brothers Fixed Income Database* and the *Merrill Lynch Bond Index Database*. For bonds maturing between 1900 to 1972, we extract the maturity, coupon and call features (i.e., call window, call date and call price) from various *Moody's Manuals* which were first published in 1900. Initially titled *Moody's Manual of Industrial and Miscellaneous Securities*, it was later replaced by *Moody's Manual of Railroads and Corporation Securities*, and subsequently by *Moody's Analyses of Investments*. These manuals provide comprehensive information on outstanding bonds, including the issue and maturity dates, coupon rates and schedules. For the pre-1900 period, we draw maturity, coupon and callability information from a variety of sources. These include the *Investors' Supplement of the Commercial and Financial Chronicle*, the *American Railroad Journal*, *Poor's Manual of Railroads*, the *Catalogue of Railroad Mortgages*, various publications by Joseph G. Martins on the Boston stock market, and annual reports to stockholders of various railroad companies.

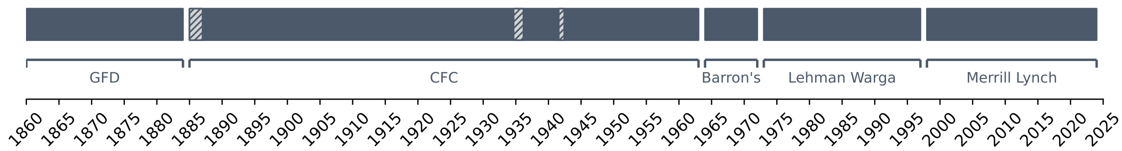

Figure 13: Corporate Bond Price Data Sources

Data sources for bond prices from 1860-2024. GFD, Lehman Warga, and Merrill Lynch are existing datasets, while bond price data from the CFC and Barron's was manually collected using scans from digital archives. Light gray areas indicate gaps in the current sample.

C.1.3 Credit Ratings

To classify high-grade bonds, we mainly rely on Moody's credit ratings which are readily available from the *Lehman Brothers Fixed Income Database* and the *Merrill Lynch Bond Index Database*. Prior to the availability of these datasets, we collect annual bond ratings from the *Moody's Manuals*. Moody's first issued credit ratings in 1909 for railroads, expanding to public utilities and industrial companies in 1914.[28] For bonds maturing before 1909, we follow Macaulay (1938) in identifying high-quality issuers, relying on the selection of railroad companies included in his high-grade railroad bond yield index. Specifically, we include companies from which Macaulay selected at least one bond for his index. Macaulay carefully selected companies based on their financial strength and excluded them before they encountered financial trouble, to ensure that his index reflected only the most creditworthy issuers. However, as pointed out in Homer and Sylla (2004), constructing an index equivalent to a modern Aaa-bond-index prior to 1900 presents challenges due to the limited number of true high-grade issuers and even Macaulay's "high-grade" sample exhibits some variation in credit quality. Hence, these classifications should be treated with some caution. In addition, the introduction of credit ratings may have changed market risk assessment, as detailed in Bernstein et al. (2025).

[28]We focus on Moody's ratings since they are the earliest available, whereas Poor's ratings began in 1922 and Fitch's in 1924.

C.2 Treasury Data

We use a comprehensive panel of prices and quantities of all US Treasury securities from 1776 to 1925, compiled by Hall et al. (2018) and used in Payne et al. (2025). We complement this historical panel with the CRSP US Treasury database after 1925. Quantities outstanding are quarterly from 1776 to 1871 and monthly thereafter. Prices are monthly, using end-of-month closing price when available. If no closing price is available, either the average of high and low prices or the average of bid and ask quotes are used. We restrict our sample to bonds with more than one year to maturity, excluding short-term debt due to liquidity premia and omitting bonds with ambiguous currency denomination. We also exclude Treasury Inflation-Protected Securities (TIPS), but keep bonds with varying tax exemptions and bonds with embedded call and put options. Details on data sources and construction of the historical Treasury panel can be found in Appendix A of Payne et al. (2025).

D Bond Characteristics

This section provides further details on differences in bond characteristics and institutional treatment between US government and corporate debt that present challenges for measuring the funding advantage of the US government.

D.1 Interest Rate Ceiling on Government Bonds

A key legislation that unexpectedly gained prominence in the late 1960s and early 1970s was the Congressional mandate, established in 1917, which imposed a 4-1/4 percent interest rate ceiling on new long-term Treasury bonds.[29] Consequently, when interest rates surpassed the 4-1/4 percent ceiling in the 1960s, the US Treasury was unable to issue new bonds with maturities exceeding 5 years (extended to 7 years in 1967) and so the average maturity of outstanding US debt declined significantly, and the government bond portfolio became heavily concentrated in seasoned discount bonds—benefiting from substantial "capital gains tax advantage". The ceiling on

[29] As explained in Department of the Treasury (1976), the primary rationale for setting a ceiling rate of 4-1/4 percent on long-term government bonds was to minimize borrowing costs tied to the United States' involvement in WWI. This ceiling was intentionally set 25 basis points below prevailing market yields, reflecting the belief that the American public would buy Liberty Bonds for reasons beyond comparative yield considerations.

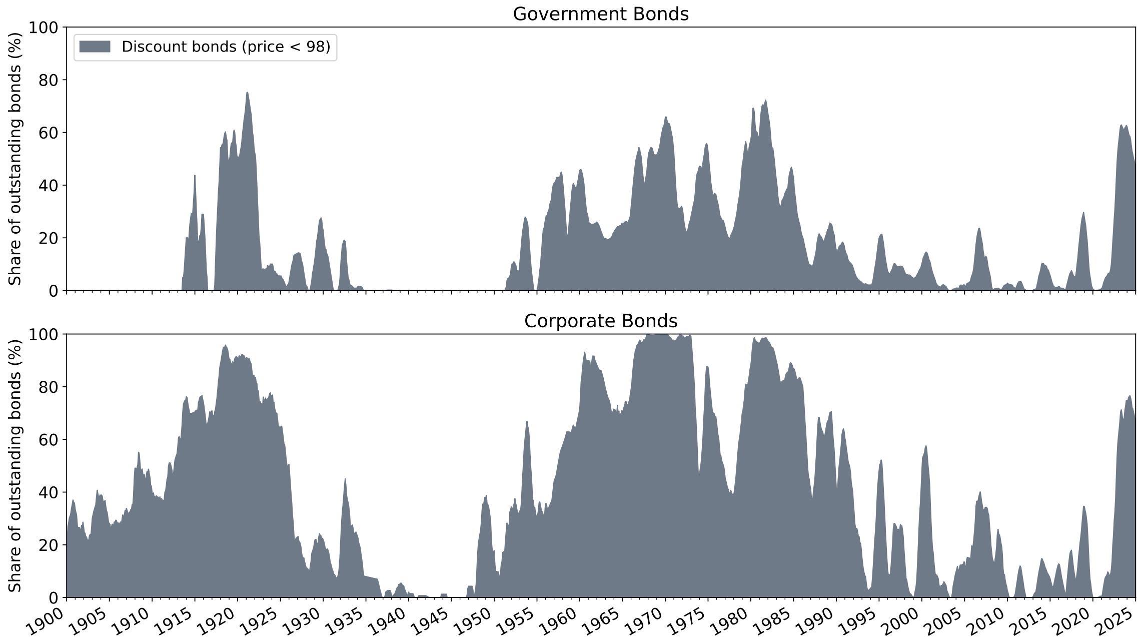

Figure 14: Composition of Government & Corporate Debt by Discount: This figure shows the share of bonds trading below par among outstanding US government and corporate debt from 1900 to 2025.

long-term U.S. Treasury bonds was effectively lifted in 1971, when $10 billion worth of bonds were authorized without regard to the ceiling. Since then, the bond authorization limit has been raised multiple times, and the issuance of long-term bonds has become a regular component of the Treasury's refunding operations.

D.2 Callability

Call provisions, which grant the issuer the right to repay the bond's principal ("call" the security) before its maturity, introduce uncertainty to the underlying cash flows from the bondholder's perspective. Because issuers are likely to call bonds when their market price sufficiently exceeds the call price to offset the costs of refinancing and administering the call, such bonds are typically expected to trade at a discount compared to otherwise identical non-callable bonds. Call provisions are accompanied by a *call-deferment period*—a predetermined timeframe after issuance (but before maturity) during which the issuer cannot call the bond. Non-callable bonds, by comparison, can be regarded as having a call-deferment period that extends to their maturity. Intuitively, the size of the discount investors demand for holding callable bonds is inversely related to the length of the call-deferment period. Prior to the late 1980's, virtually all corporate bonds had some kind of call provision with very brief call-deferment periods. In particular, these bonds were usually callable on any interest payment dates, with notice periods typically ranging from 30 to 60 days. The call price usually started at a premium (reflecting a refinancing penalty) and gradually declined to par over time, often following a structured schedule. Some bonds allowed partial redemptions, while others required full redemption, and only a small number included a non-zero (typically 5 year) call-deferment period.

In contrast, most US government bonds were non-callable. Those with call provisions typically featured long call-deferment periods, often only a few years shorter than the bonds' maturity. This pronounced difference in typical call-deferment periods between corporate and government bonds likely contributed to the observed corporate–treasury yield spreads. However, this does not reflect the government's funding advantage. This is because the losses resulting from the government's need to always refinance its debt at prevailing market rates, rather than a lower preset call price (often at par), ultimately must be offset by future revenues. Figure 15 shows the composition of callable and non-callable bonds among outstanding US government and corporate debt.

D.3 Flower Bonds

As discussed in Section 3.2.2, before 1971, the US Federal government issued "flower bonds" which bondholders could use to pay federal estate taxes upon their death *at par value* plus accrued interest (see Cook (1977), Mayers and Clifford (1987)). In addition, before 1976, flower bonds were *valued as inherited property at their par value* on the date of the decedent's death, effectively exempting them from capital gains tax and acting as an effective inflation hedge.

Figure 16 depicts the number of treasuries outstanding over the period 1960-1990 for different maturity categories and broken down into flower and non-flower bonds. Evidently, the flower bonds made up a significant fraction of the long-maturity treasuries until the 1980s. In particular, for the period from 1962-1971 all bonds with

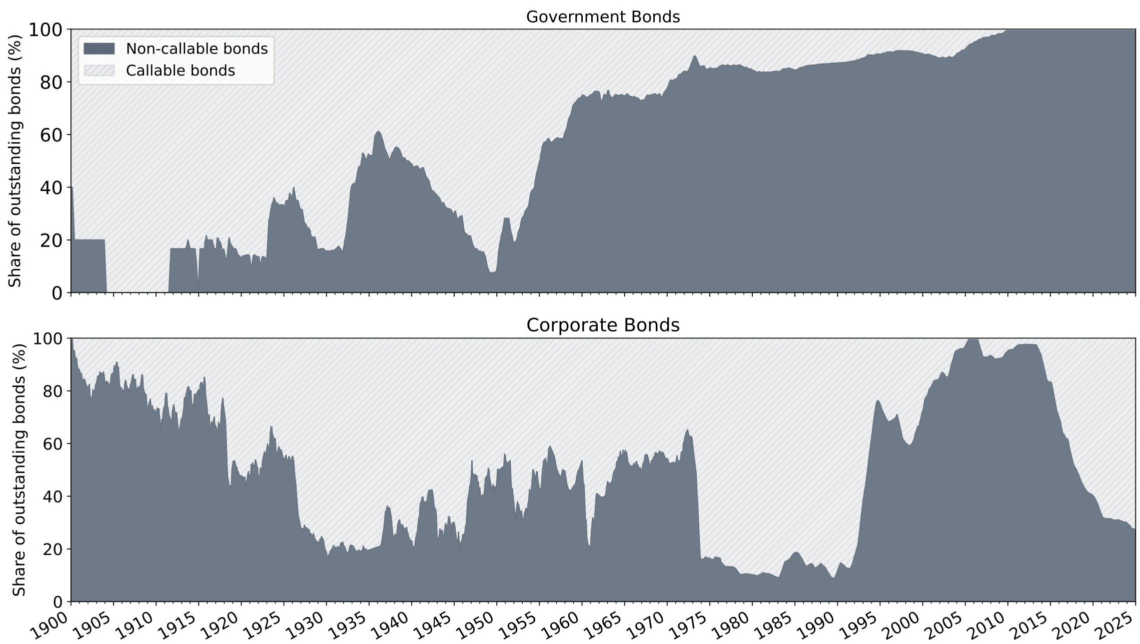

Figure 15: Composition of Government & Corporate Debt by Callability: This figure shows the share of callable and non-callable bonds among outstanding US government and corporate debt from 1900 to 2025.

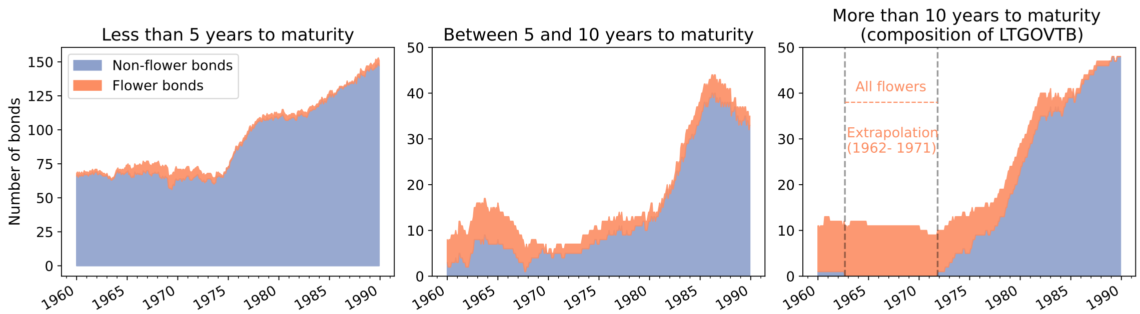

Figure 16: Composition Treasuries: 1960-1990. The left subplot shows the number of bonds with less than 5 years to maturity. The middle subplot shows the number of bonds with 5-10 years to maturity. The right subplot shows the number of bonds with more than 10 years to maturity.

maturity greater than 10 years were flower bonds.

To get a sense of the magnitude of the "flower bond effect", we estimate our yield curve model from Section 5 using a sample that includes only flower bonds and a sample that excludes all flower bonds. The results are depicted in Figure 17. The black line shows the posterior median estimate of the 10-year zero-coupon yield without flower bonds. The green line shows the posterior median estimate of the 10-year zero-coupon yield using only flower bonds. Evidently, before the end of 1965, the two yields are indistinguishable. This implies that the average long-term government yield index, represented by the red line in Figure 17, is a good approximation of long-term treasury yields.

However, from 1966 onward, a gap opens up between the black and green lines due to the slow increase in the flower bond premium which affected mainly the lowest-coupon issues.[30] 1971 brought two important changes in the US treasury market. First, the 4-1/4% ceiling on new US bond issues was lifted and so long-term bonds without flower bond provisions started to reappear (with higher coupons). Second, effective March 1971, Congress eliminated flower bond privileges on new US bond

[30]Among the outstanding flower bonds, the ones actually purchased because of the estate-tax feature tended to be the lowest coupon bonds, such as the 3's of 1995 and the 3-1/2 of 1998, which were selling at the largest discounts. Evidence of this can be seen in the amount outstanding, with the net decline from year to year measuring the amount redeemed for estate tax purposes. See Cook (1977).

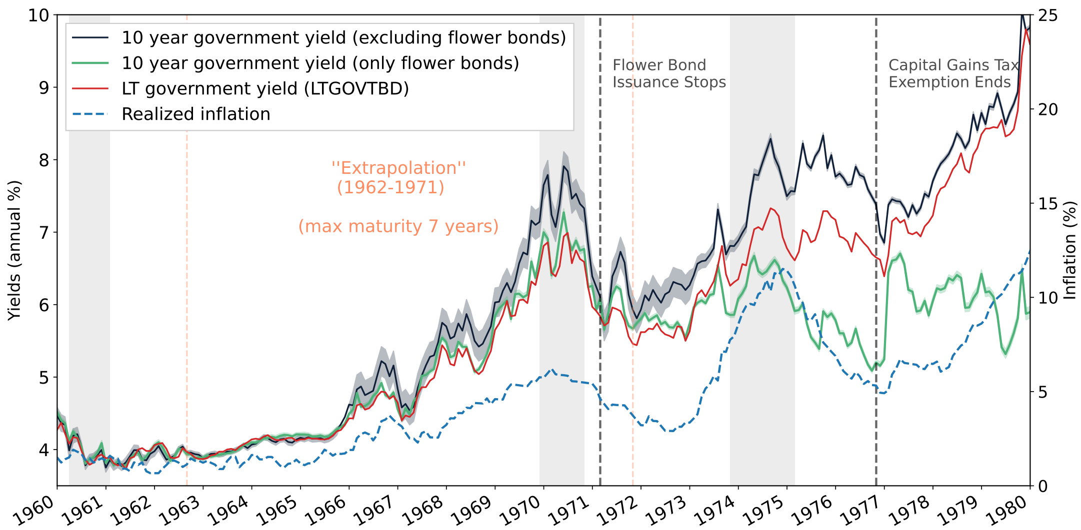

Figure 17: Long Term Government Yields With and Without Flower Bonds

Black solid line is the posterior median estimate of the 10-year zero-coupon yield on US Treasuries excluding all flower bonds from the sample. Green solid line is the posterior median estimate of the 10-year zero-coupon yield on flower bonds only. Bands denote 90% posterior interquantile ranges. Red solid line is the average long-term government yield index (LTGOVBD).

issues, thereby ensuring a steadily declining stock as outstanding issues purchased for estate tax purposes were retired over time. The flower bond premium started to increase sharply on all flower bonds, which can be attributed to the combination of (1) the steady decline in the supply of flower bonds and (2) increased demand for flower bonds as rapid inflation drove up the value of estates, but tax laws were not adjusted in a timely manner to correct for the impact on the level of estate taxes. We can see these effects reflected in the decrease in the green line between 1973-1976 in Figure 17. The next big regulatory change was the Tax Reform Act of 1976, passed in October, which effectively terminated the flower bonds' exemption from capital gains taxes. Figure 17 demonstrates that the Tax Reform Act of 1976 had a major impact on the pricing of flower bonds. The 20-year zero-coupon yield on flower bonds jumped from around 5% to almost 7% in the two months following the passage of the Act.

Ultimately, because the value of flower bond provisions was inversely related to market prices of bonds, flower bonds implicitly hedged inflation and/or interest rate risk. As a result, these bonds were not priced as regular nominal bonds but instead like real bonds. In fact, to a first approximation, the spread between the black and green lines in Figure 17 can be interpreted as a compensation for inflation risk, which is highest between 1971-1976. In this sense, the yield on flower bonds is not comparable to the yield on corporate bonds: one uses tax revenue to provide an inflation protected return while the other does not.

D.4 Circulation Privilege

During the National Banking Era (1863–1913), US federal bonds held a special regulatory status known as *circulation privilege*, which allowed federally chartered banks to issue national bank notes backed by eligible US Treasury bonds. This privilege created a strong institutional demand for long-term government securities, as banks could profitably convert them into currency liabilities. Crucially, corporate bonds were not eligible for this privilege, so the resulting yield suppression applied exclusively to US government debt. As a result, the circulation privilege helped support bond prices and depress long-term yields of government bonds, contributing to a widening of the AAA–Treasury spread during this period.

D.5 Default Risk

To account for time-varying changes in default risk we calculate an expected default probability and expected loss on corporate bonds by rating including downgrade risk over a one-year horizon. Let: $P_{r\to j}$ be the probability that a bond rated r migrates to rating j over one year (from the transition matrix); $d_j(t)$ the empirical one-year default probability for rating j in year t (from annual default rates); and R_j the average recovery rate for rating j over the sample period.

Then the expected loss for a bond rated r in year t is:

$$\text{Expected Loss}_r(t) = \sum_{j\in\mathcal{R}} P_{r\to j} \cdot d_j(t) \cdot (1 - R_j) + P_{r\to\text{Def}} \cdot (1 - R_r)$$

where $\mathcal{R}$ is the set of non-default ratings (e.g., Aaa, Aa, A, Baa, etc.). The first term captures the indirect default risk via downgrade (i.e., migrate to a worse rating j, and then default). The second term captures the direct default risk from rating r. The default probability is calculated analogously assuming that recovery rates R_j

are zero for all ratings. Figure 18 shows the expected default probability over a one year-horizon.

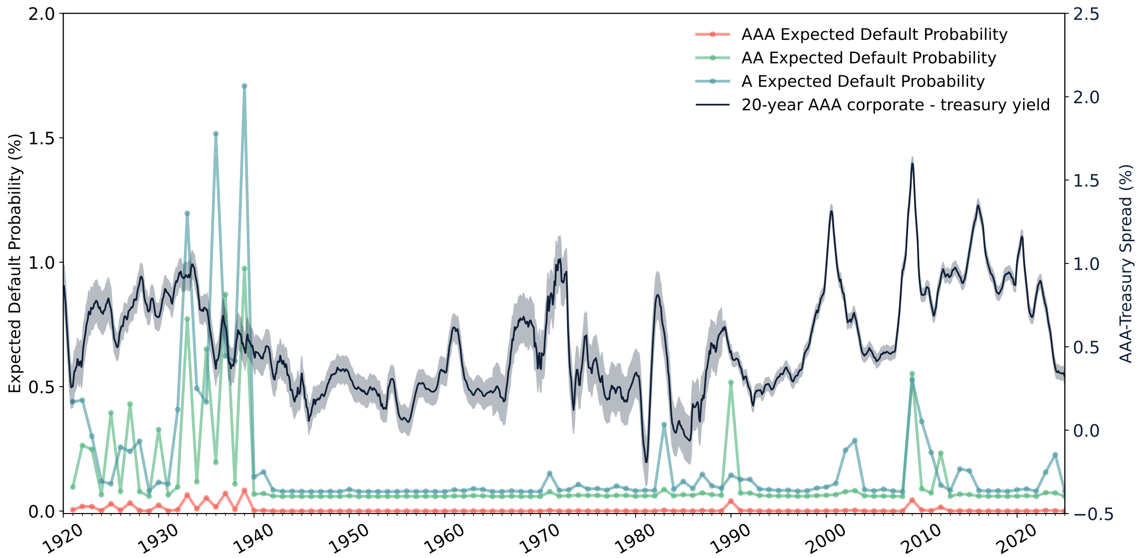

Figure 18: Expected Default Probability and AAA-Corporate to Treasury Spread: 1920-2024

E Additional Details on Yield Curve Estimation

E.1 High Level Strategy

We seek to find yield curves that price one dollar of ordinarily taxed cash flow from a straight bond at a given time in the future. Accordingly, we need machinery that makes the appropriate "corrections" from the tax-distorted, option-contaminated space to the option and tax-adjusted cash flow space. An itemized list of the steps we take to achieve this on a given date is as follows:

- Obtain a matrix C_t^{bt} of before-tax cash flows for bonds with observed prices P_t. C_{ij}^{bt} corresponds to the before-tax cash flow of bond i at time j in the future. For bonds with embedded options, the cash flows at this stage are entered as if option is not exercised.
- For every bond i, apply $z_{t,i}^j$ to each cash flow C_{ij}^{bt}, as necessary.
- For bonds with embedded options, we insert the option wedge at this stage. This is done as prescribed in Section 4.1.
- Fit the discount function q. This process is detailed in section E.2 If there are embedded options in the sample for a given date, a nested minimization is performed to find the optimal option wedges that minimize the Filipović et al. (2022) objective function given their closed form q.

E.2 Yield Curve Fitting

We observe prices $P_1, \ldots, P_N$ of N coupon bonds with cash flows summarized in the $N \times M$ matrix C, where M spans the observed maturity spectrum. Entries $C_{i,j}$ correspond to the cash flow of bond $1 \leq i \leq N$ occurring at time $1 \leq j \leq M$ in the future. We seek to estimate the vectorized discount function $q(\mathbf{x})$, where $\mathbf{x}$ is the vector spanning the maturity spectrum M periods in the future. The law of one price dictates that the fitted price of the bond be:

$$P_i(q) = \sum_{j=1}^{N} C_{i,j} q(x_j)$$

In order to impose structure on the estimates and penalize overfitting, we follow FPY and define a measure of smoothness as a weighted average of the first and second derivatives of the discount function:

$$||q||_{\alpha,\delta} = \left(\int_0^\infty \left(\delta q'(x)^2 + (1-\delta) q''(x)^2 \right) e^{\alpha x} dx \right)^{\frac{1}{2}} \tag{E.1}$$

for maturity weight parameter $\alpha \geq 0$ and shape parameter $\delta \in [0,1]$. δ closer to 0 forces the curve to be tense, avoiding oscillations, while δ closer to 1 forces the curve to be straight, avoiding kinks. The weighting term $e^{\alpha x}$ allows the smoothness term to be maturity dependent. Increasing α gives way to more flexibility at the shorter end while enforcing the longer end of the curve to be smooth.

Define $\mathcal{Q}_{\alpha,\delta}$ to be the set of twice weakly differentiable discount curves q with finite smoothness (i.e. the integral in (E.1) is convergent). Then the convex optimization problem to solve for q is:

$$\min_{q \in \mathcal{Q}_{\alpha,\delta}} \sum_{i=1}^{M} \omega_i (P_i - \hat{P}_i(q))^2 + \lambda ||q||^2_{\alpha,\delta} \tag{E.2}$$

for exogenous weights ω_i and smoothness parameter λ. FPY show that (E.2) has a unique close-form solution for any tuple of $(\lambda, \alpha, \delta)$, except in the ill-defined case $\alpha = \delta = 0$. Toward a discussion on the distributional aspect of the estimator, we may define q to be made up of an exogenous prior curve p with $p(0) = 1$ plus a deviation from prior h, $q(\mathbf{x}) = p(\mathbf{x}) + h(\mathbf{x})$. The objective function decomposes into the following:

$$\min_{h \in \mathcal{H}_{\alpha,\delta}} \sum_{i=1}^{M} \omega_i \Big(P_i - C_i(p(\mathbf{x}) + h(\mathbf{x})) \Big)^2 + \lambda ||h||^2_{\alpha,\delta} \tag{E.3}$$

where C_i is a row vector of cash flows over the maturity spectrum for bond i, or equivalently, the i-th row of C. $\mathcal{H}$ is a *reproducing kernel Hilbert space* of functions h with initial condition $h(0) = 0$. See FPY for further discussion.

Problem (E.3) can be decomposed in terms of β given an $M \times M$ kernel matrix $\mathbf{K}$. The entries of $\mathbf{K}$ are determined by the parameters α and δ in five cases. (See FPY for details). With this formulation, the optimization problem simplifies further to:

$$\min_{\beta} \sum_{i=1}^{M} \omega_i \left(P_i - C_i p(\mathbf{x}) - C_i \mathbf{K}\beta\right)^2 + \lambda \beta^T \mathbf{K} \beta$$

which emits a unique solution:

$$\hat{\beta} = C^T \left(C\mathbf{K}C^T + \Lambda\right)^{-1} \left(P - Cp(\mathbf{x})\right)$$

where P is the vector of observed prices and Λ is defined by:

$$\Lambda = \mathrm{diag}\Big(\frac{\lambda}{\omega_1}, \dots, \frac{\lambda}{\omega_M}\Big)$$

The fitted discount function $\hat{q}(\mathbf{x})$ is therefore

$$\hat{q}(\mathbf{x}) = p(\mathbf{x}) + \mathbf{K}\hat{\beta}$$

We obtain a fitted zero-coupon yield curve, which we denote $\hat{y}(\mathbf{x})$, by taking;

$$\hat{y}(\mathbf{x}) = -\log\left(\hat{q}(\mathbf{x})\right)/\mathbf{x}$$

To summarize the estimation process, we obtain a flexible closed-form estimator assuming that the estimated discount function is twice weakly differentiable and obeys some level of smoothness for a given tuple $(\lambda, \alpha, \delta)$. To choose an optimal tuple, we adopt the same cross-validation strategy as FPY, discussed in Section 3.2. This ensures that the parameters we choose best minimize the out-of-sample error.

E.3 Distributional Aspects

A feature of the Kernel Ridge estimator is that assuming a normally distributed prior curve, we obtain a normally distributed posterior distribution for the estimated curve $\hat{q}$. Specifically, assume a Gaussian distribution for q:

$$q(\mathbf{x}) \sim \mathcal{N}(p(\mathbf{x}), \mathbf{K})$$

emits a normal posterior distribution with mean function m and covariance function v for scalars y, z:

$$m^{post}(z) = p(z) + k(z, \mathbf{x^T})\hat{\beta}$$
$$v^{post}(y, z) = k(y, z) - k(y, \mathbf{x^T})C^T(C\mathbf{K}C^T + \Lambda)^{-1}Ck(\mathbf{x}, z)$$

where $k(y, z) = \mathbf{K}_{yz}$ and we assume that the price errors have variance $\Sigma_\epsilon = \Lambda$. We can therefore easily obtain confidence bounds on the fitted discount function $\hat{q}$. The posterior distribution additionally provides information on extrapolated discount functions when we have periods with only short-term bonds outstanding. As expected, the confidence intervals tend to expand dramatically as we extrapolate past the maximum observed maturity in a given period.

F Additional Results on Yield Curve Estimates

In this section, we describe the key outputs from our estimation: the high-grade corporate bond yield curve, the treasury yield curve, and the Aaa Corporate-Treasury spread curve for the period 1860-2024. We show that our spread estimate differs significantly from existing series, especially during the Great Inflation period (1965-1980) where the implicit inflation protection embedded in the "flower-bonds" was very valuable.

F.1 High-Grade Corporate Bond Yield Curves

The top panel of Figure 19 depicts selected long term nominal yields on high-grade US corporate bonds. The solid black line represents the median of our 20-year zero coupon yield estimates. Bands around the posterior median depict the 90% interquantile range. Between 1860-1900, long term high-grade corporate yields trended downward from around 8% to around 4% (the "great bond bull market"), then climbed slowly back to 5% by World War I. During the war and the subsequent 1920 recession long term corporate yields reached more than 7% before they began their renewed downward decline (interrupted briefly by the Great Depression). During World War II and the 1950s, the 20-year high-grade corporate yield exhibited surprising stability up until the late 1960s when, in tandem with increasing inflation, it reached its peak of 18% during the 1981-1982 recession.

The blue dashed line in the top panel of Figure 19 depicts the high-grade railroad bond index from Macaulay (1938) computed as the average yield-to-maturity on selected long term bonds issued by reputable railroad companies between 1857-1937. The red solid line is Moody's Seasoned Aaa Corporate Bond Yield index computed as the average yield-to-maturity on bonds with maturity 20 years and above. This index is available from 1919 onward. While yields-to-maturity are different from the notion of a zero-coupon yield, we find it reassuring that our estimates broadly align with Macaulay's high-grade railroad and Moody's Aaa indexes.[31]

One of the main advantages of estimating the whole yield curve is to observe shorter maturity private borrowing costs. The middle panel of Figure 19 depicts

[31] Yield-to-maturity is computed under the assumption of a flat yield curve. In this sense, yield-to-maturity of a particular bond can be considered as the weighted average of zero-coupon yields with the bond's cash-flows acting as weights.

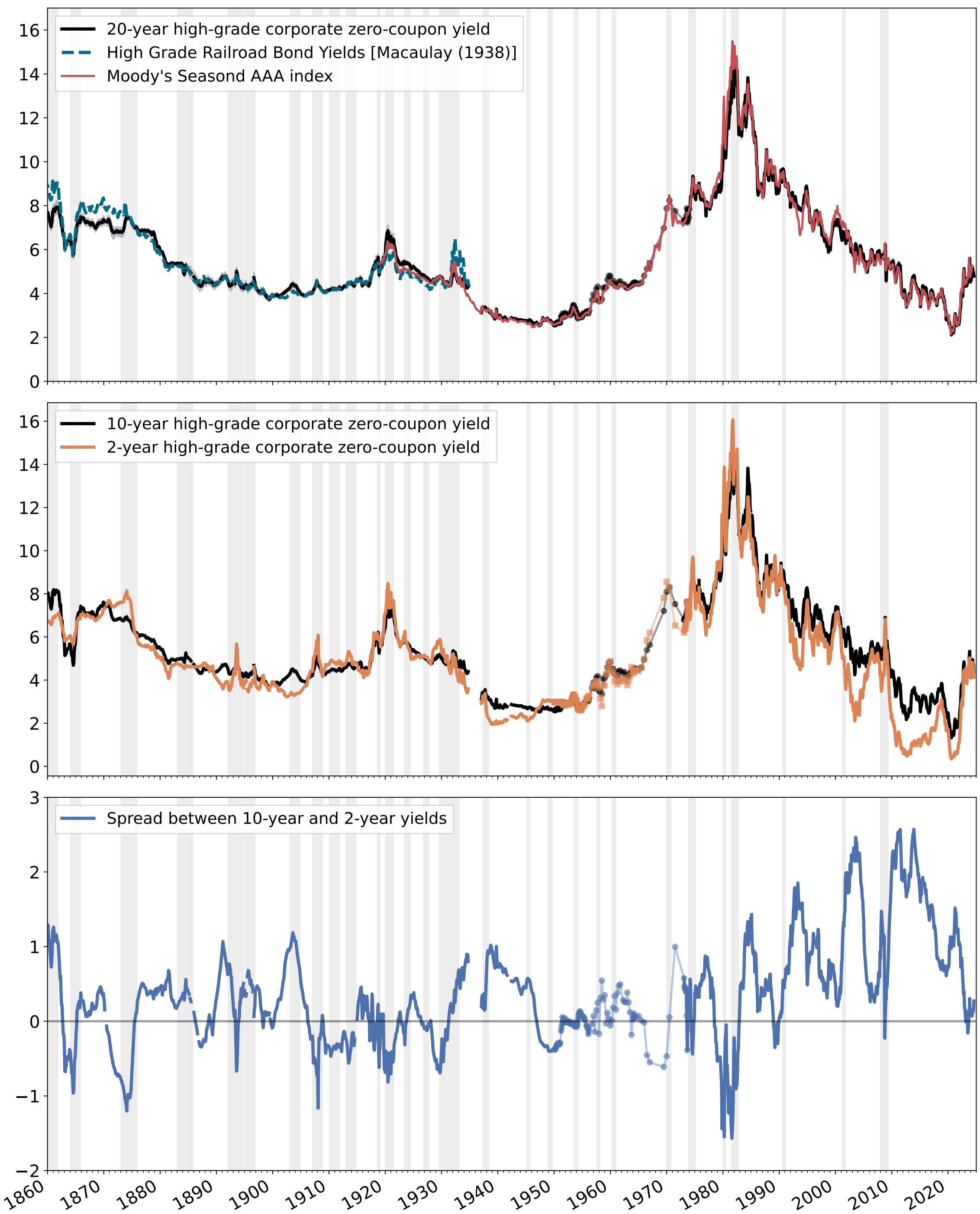

Figure 19: High-grade Nominal Corporate Zero-Coupon Yields 1860-2024

Top panel depicts our posterior median estimate of the 20-year high-grade corporate zero-coupon yield (black). The blue dashed line depicts the High Grade Railroad Bond Index from Macaulay (1938). The red solid line is Moody's Seasoned Aaa bond index. Middle panel depicts posterior median estimates of the 10- (black) and 2-year (orange) high-grade corporate yields. Bottom panel depicts the spread between the 10-year and 2-year yields. The light gray intervals depict NBER recessions.

our posterior median estimates of the 10-year and 2-year zero-coupon yields on high-grade corporate bonds. The bottom panel shows the corresponding spread. Evidently, short- and medium-term yields follow the same trend as the 20-year yield, but they are more volatile, especially in the post WWII period. Before the 1980s, the spread between the 10-year and 2-year zero-coupon yields is close to zero, suggesting that for about 100 years, the average yield curve on high-grade corporate bonds was flat on average.

F.2 Treasury Yield Curves

In previous work, we estimated historical zero-coupon yield curves on US Treasuries from 1790-1933 (see Payne et al. (2025)). For this paper, we extend our estimation to 1934-2024 and make the adjustments for taxes and embedded options described in Section 5 to provide a consistent comparison to the corporate yield curve. Here we explore these estimates. In subsection F.2, we highlight importance of adjusting for the flower bonds. In subsection F.2.1 we then discuss the overall time series for the Treasury yield curve.

F.2.1 Treasury Yields

Before we turn to the construction of high-grade corporate-Treasury yield spreads, it is instructive to see the extent to which the Treasury and Corporate yield curves co-move with each other. The top panel of Figure 20 depicts the 10-year high-grade corporate yield against the 10-year zero-coupon Treasury yields from Payne et al. (2025) combined with our estimates for the modern period. Evidently, the two yields follow similar trend dynamics, but long term treasury yields are persistently lower than high-grade corporate yields throughout our sample. In addition, despite the similar trend, short- and medium-term fluctuations of the two yield curves around their respective trends are very different in the early part of the sample. We can see this reflected in the middle and bottom panels of Figure 20. The middle panel depicts yield curve slopes defined as the spreads between the 10 year and 2 year zero-coupon yields on high-grade corporate bonds (blue) and on US treasuries (orange). The bottom panel shows the 10 year centered rolling correlation between the long end of the yield curves (blue) and the 2-year yields (orange). The corporate and treasury yield curves are only weakly correlated between 1860-1950 and then became highly synchronized after the late 1950s. Despite this convergence, the two yield curves seemed to decouple during the yield curve control period (1942-1951), the Great Inflation, and the post 2008 period.

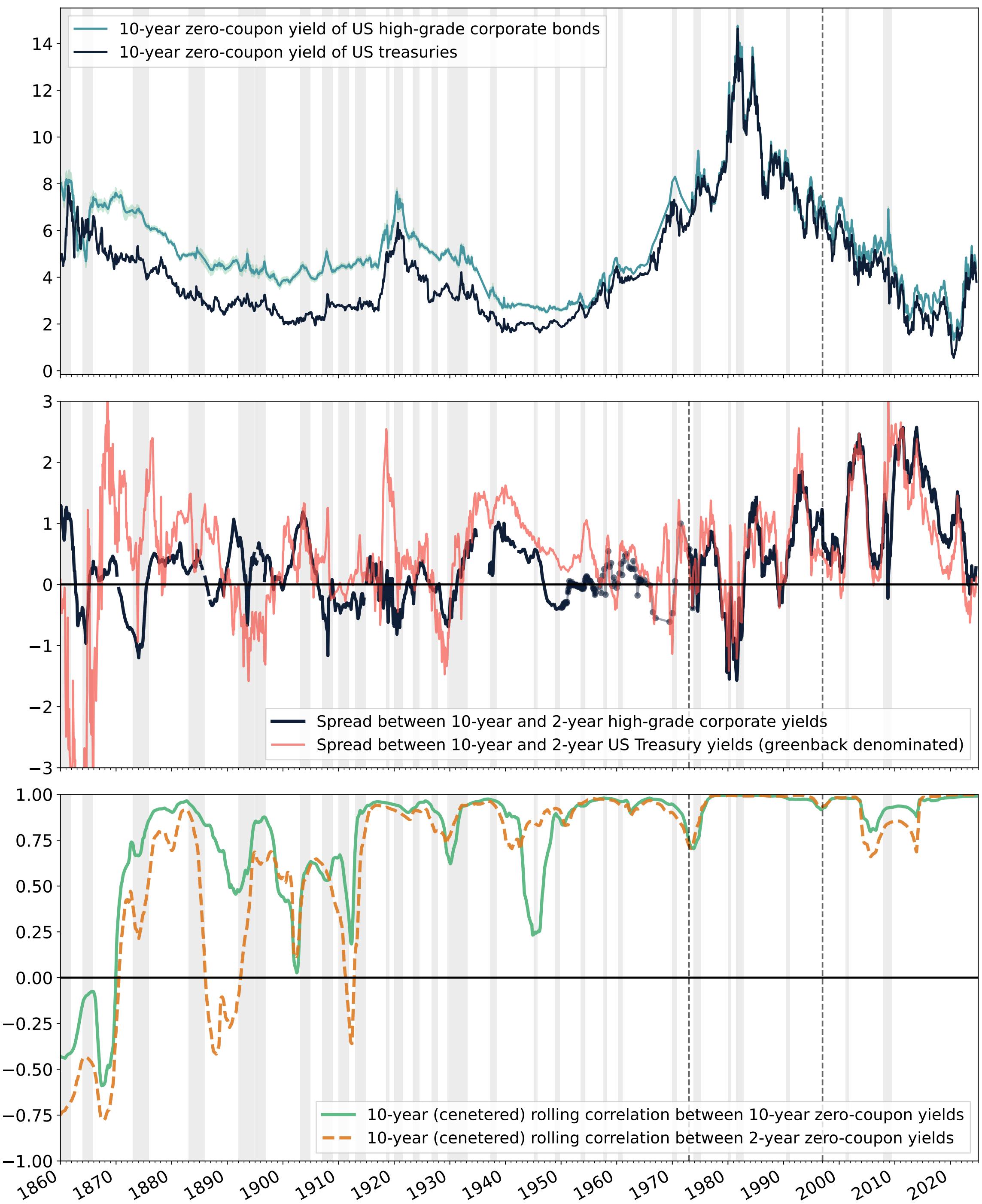

Figure 20: Difference Between Private and Public Borrowing Costs

Top panel depicts posterior median estimates of the 10-year zero-coupon yields on high-grade corporate debt (blue) and US Treasuries (black). Middle panel depicts spreads between 10-year and 2-year yields for high-grade corporate debt (black) and US Treasuries (red). Bottom panel depicts 10-year (centered) rolling correlations computed from the monthly series of posterior median estimates of 10-year (green solid) and 2-year (orange dashed) zero-coupon yields.

G Additional Details on Section 6

G.1 Additional Proofs

In this section of the Appendix, we derive additional results on the asset pricing model.

Theorem 1. *To a first order approximation, the spread takes the form:*

$$\chi_t^{(j)} \approx \frac{1}{j}\left(\beta_0 + \beta_1 \log\left(\frac{\theta_t}{y_t}\right) + \log(\zeta_t)\right) + \frac{1}{j}\left(\log\left(\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]\right) - \log\left(\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]\right)\right)$$
$$+ \frac{1}{j}\left(\frac{Cov\left[\xi_{t,t+1}, \tilde{q}_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]} - \frac{Cov\left[\xi_{t,t+1}, q_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]}\right)$$

Proof. Because $\Omega_{t,t+1}$ is time t adapted it can be taken out of the expectation in the asset pricing equations. Thus, we have:

$$\begin{aligned} q_t^{(j)} &= \exp\left(\beta_0 + \beta_1 \log\left(\frac{\theta_t}{y_t}\right) + \log(\zeta_t)\right)\mathbb{E}_t\left[\xi_{t,t+1} q_{t+1}^{(j-1)}\right] \\ &= \exp\left(\beta_0 + \beta_1 \log\left(\frac{\theta_t}{y_t}\right) + \log(\zeta_t)\right)\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]\left(1 + \frac{\text{Cov}\left[\xi_{t,t+1}, q_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]}\right) \end{aligned}$$

$$\begin{aligned} \tilde{q}_t^{(j)} &= \mathbb{E}_t\left[\xi_{t,t+1}\tilde{q}_{t+1}^{(j-1)}\right] \\ &= \mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]\left(1 + \frac{\text{Cov}\left[\xi_{t,t+1}, \tilde{q}_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]}\right) \end{aligned}$$

So, the funding advantage is:

$$\begin{aligned} \chi_t^{(j)} &= \frac{1}{j}\log\left(q_t^{(j)}\right) - \frac{1}{j}\log\left(\tilde{q}_t^{(j)}\right) \\ &= \frac{1}{j}\left(\beta_0 + \beta_1 \log\left(\frac{\theta_t}{y_t}\right) + \log(\zeta_t)\right) \\ &\quad + \frac{1}{j}\log\left(\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]\right) + \frac{1}{j}\log\left(1 + \frac{\text{Cov}\left[\xi_{t,t+1}, \tilde{q}_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]}\right) \\ &\quad - \frac{1}{j}\log\left(\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]\right) - \frac{1}{j}\log\left(1 + \frac{\text{Cov}\left[\xi_{t,t+1}, q_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]}\right) \end{aligned}$$

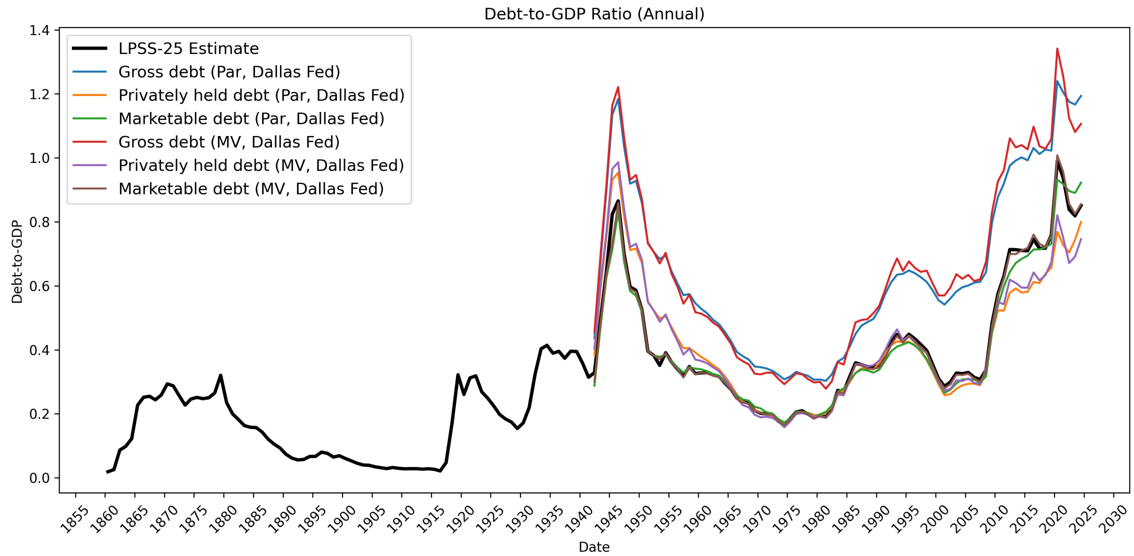

Figure 21: Convenience Spread vs Realized CPI Inflation: 1870-2024, Annual

Black line depicts our estimate for Debt-to-GDP.

To a first order approximation, this becomes:

$$\chi_t^{(j)} \approx \frac{1}{j}\left(\beta_0 + \beta_1 \log\left(\frac{\theta_t}{y_t}\right) + \log(\zeta_t)\right) + \frac{1}{j}\left(\log\left(\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]\right) - \log\left(\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]\right)\right)$$
$$+ \frac{1}{j}\left(\frac{\text{Cov}\left[\xi_{t,t+1}, \tilde{q}_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[\tilde{q}_{t+1}^{(j-1)}\right]} - \frac{\text{Cov}\left[\xi_{t,t+1}, q_{t+1}^{(j-1)}\right]}{\mathbb{E}_t\left[\xi_{t,t+1}\right]\mathbb{E}_t\left[q_{t+1}^{(j-1)}\right]}\right)$$

□

G.2 Debt-to-GDP

We compute the market value of government debt by reconstructing the term structure of cash flows promised at each month by all outstanding government liabilities. We then use our estimated Treasury discount function to calculate the market value of all promised cash flows. We plot the series in Figure 21

G.3 Estimation Approach

We fit all pricing kernel parameters using indirect inference in the style of Adrian et al. (2013b). We outline the key steps for estimating the corporate pricing kernel below.

Step 1: Estimate the state space evolution. Fit a VAR (or other time series model) to estimate the evolution of the state variables:

$$X_{t+1} = \hat{\mu}_X + \hat{\Phi}_X X_t + \hat{\Sigma}\hat{\epsilon}_{t+1}$$

where the hats refer to fitted parameters. Let $\hat{v}_t := \hat{\Sigma}\hat{\epsilon}_{t+1}$ denote the fitted innovations.

Step 2: Fit excess holding period returns. Regress the short corporate rate and excess corporate bond holding period returns on states and estimated innovations:

$$\begin{aligned} rf_t &= \hat{\delta}_0 + \hat{\delta}_1^T X_t \\ rx_{t+1}^{(n-1)} &= \hat{\alpha}_{n-1} + \hat{\beta}_{n-1}^T \hat{v}_t + \hat{\gamma}_{n-1} X_t + \hat{e}_{t+1}^{(n-1)} \end{aligned}$$

where $rx_{t+1}^{(n-1)}$ is the holding period return by:

$$rx_{t+1}^{(n-1)} := \log\left(q_{t+1}^{(n-1)}\right) - \log\left(q_t^{(n)}\right) - rf_t$$

and $\hat{e}_{t+1}^{(n-1)}$ denotes bond maturity specific measurement error. We can stack the excess holding period return regression across n and t to get:

$$rx = \hat{\alpha}\iota_T^T + \hat{\beta}^T \hat{\Sigma}\hat{\epsilon} + \hat{\gamma} X_- + \hat{E}$$

Step 3: Recover kernel parameters. We can infer the pricing kernel parameters from the excess holding period return regressions using:

$$\begin{aligned} \hat{\alpha}\iota_T^T &= \beta^T \Sigma\Sigma^T \lambda_0 \iota_T^T - 0.5(B^* vec(\Sigma\Sigma^T) + \sigma^2 \iota_N)\iota_T^T \\ \hat{\beta} &= \beta \\ \hat{\gamma} &= \beta^T \Sigma\Sigma^T \lambda_1 \end{aligned}$$

which implies:

$$\lambda_1 = (\beta\beta^T\Sigma\Sigma^T)^{-1}\beta\hat{\gamma}$$
$$\lambda_0 = (\beta\beta^T\Sigma\Sigma^T)^{-1}\beta(\hat{a} + 0.5(B^* vec(\Sigma\Sigma^T) + \sigma^2\iota_N))$$

Step 4: Recover bond pricing parameters. We can set up a recursion for the bond pricing parameters. Equating the different expressions for the excess returns:

$$\begin{aligned} A_{n-1} + B_{n-1}^T\mu_X - A_n + A_1 &= \beta_{n-1}^T\Sigma\Sigma^T\lambda_0 - 0.5\beta_{n-1}^T\Sigma\Sigma^T\beta_{n-1} - 0.5\sigma^2 \\ B_{n-1}^T\Phi_X - B_n^T + B_1^T &= \beta_{n-1}^T\Sigma\Sigma^T\lambda_1 \end{aligned}$$

Rearranging we get:

$$\begin{aligned} A_n &= A_{n-1} + B_{n-1}^T\mu_X + A_1 - \beta_{n-1}^T\Sigma\Sigma^T\lambda_0 + 0.5\beta_{n-1}^T\Sigma\Sigma^T\beta_{n-1} + 0.5\sigma^2 \\ B_n^T &= B_{n-1}^T\Phi_X + B_1^T - \beta_{n-1}^T\Sigma\Sigma^T\lambda_1 \\ A_1 &= -\delta_0, \quad B_1 = -\delta_1 \\ A_0 &= 0, \quad B_0 = 0 \end{aligned}$$

We estimate the wedge Ω parameters an analogous way although we allow all the parameters of Ω to be maturity dependent.

G.4 Yield Curve Fit

In this section we show selected results from the fit of the corporate yield curve.

H Implications for the Macro-Finance Literature

We conclude the paper by discussing how our estimate of the high-grade corporate to treasury spread relates to some recent narratives in the literature. In particular, we argue that many of the relationships identified in the current research rely on the behavior of the index-based measure during the high-inflation period of 1965–1985 and lose identification using our series.

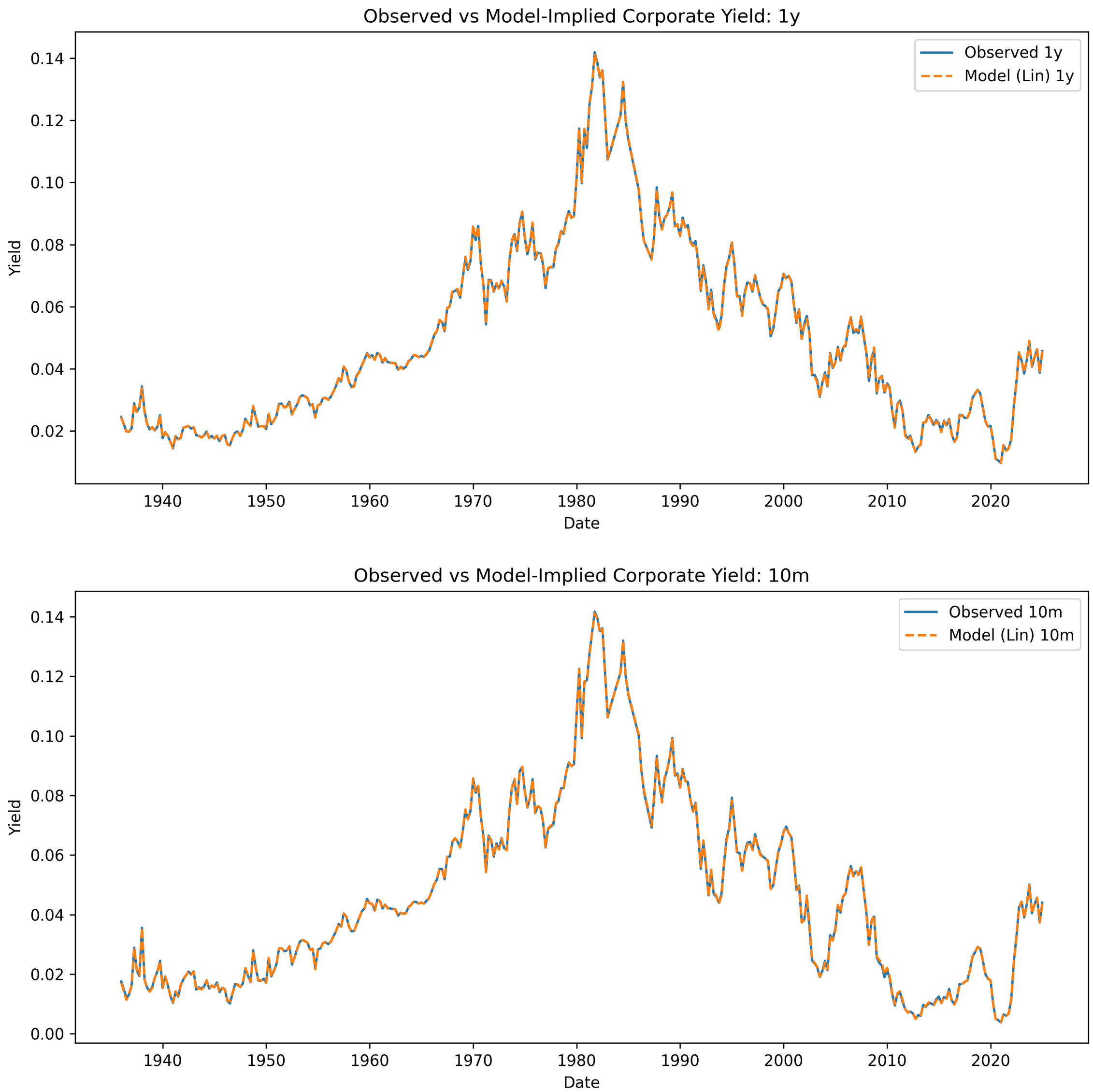

Figure 22: Observed and fitted corporate yields at maturities 1 and 10.

H.1 Treasury Demand and US Government Market Power

There has been recent interest in finding instruments for US Treasury demand and estimating the US government's market power. In this section, we investigate one such instrument that has been used in the literature: foreign volatility shocks as rotators for US debt demand.

Figure 23 depicts the relationship between the AAA Corporate-Treasury spread and debt issuance for maturities less than one year (the left panel) and for maturities greater than one year (the right panel). The red dots depict periods with high foreign volatility while the blue dots depict periods with low volatility in returns on UK equities. Changes to the shape of the equilibrium relationship in periods of high volatility have been interpreted as evidence of rotation in US debt demand (e.g. by Choi et al. (2022)). Contrary to the literature, we find little evidence that the foreign volatility acts as a rotator, except for very short term maturities.

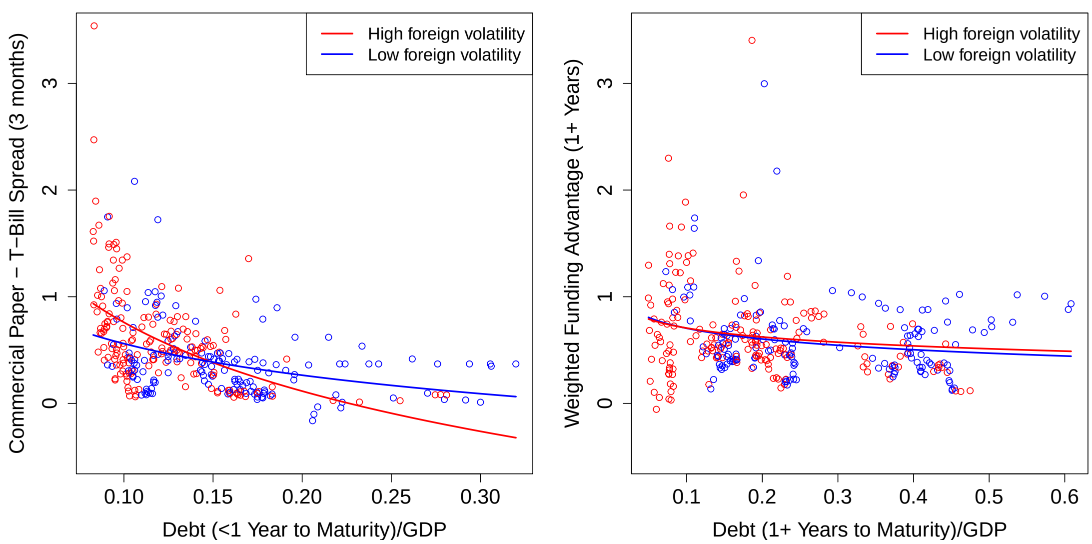

Figure 23: Convenience Spread vs Debt/GDP: 1919-2008, Annual, High and Low Foreign Volatility

Our findings have implications for estimation of US treasury market power. Following Choi et al. (2022), we impose a log linearized government issuance policy rule:

$$\lambda \log(q_t^b B_t/Y_t) = \log(\chi_t) + \log(1 - \xi \epsilon_t^{-1}(\sigma_t)) - \omega_t$$

where $q_t^b B_t/Y_t$ is the market value of debt-to-GDP ratio, χ_t is the AAA Corporate-Treasury spread, ξ is an indicator function whether debt issuance reacts systematically to elasticity, $\epsilon_t^{-1}(\sigma_t)$ is the inverse elasticity, $\sigma_t \in \{\sigma_L, \sigma_H\}$ is foreign volatility, and ω_t is an iid policy shock. We then estimate the price elasticity ϵ_t in high and low foreign volatility periods $\sigma \in \{\sigma_L, \sigma_H\}$. Finally, we test if $\xi = 1$ (debt issuance reacts systematically to elasticity) or $\xi = 0$ (debt issuance does not react systematically to elasticity) is a better fit. The results are shown in Table 4. Contrary to Choi et al. (2022), we find little evidence that US government issuance reacts systematically to elasticity shocks at maturities greater than 1 year. In other words, using the framework of Choi et al. (2022), our results suggest that the US hasn't been exploiting its market power in the bond market for maturities above 1 year. However, we do find evidence for systematic reaction at maturities < 1 year. Since inflation and volatility are correlated, this may reflect monetary policy adjustments rather than exploitation of safe-asset monopoly power.

Cost elasticity	$\lambda = 0$	$\lambda = 1$	$\lambda = 2$
< 1 Year to Maturity	-2.630^{***}	-2.712^{***}	-2.281^{**}
1+ Year to Maturity	0.575	-1.439	-1.585

Table 4: Null hypothesis: US debt issuance does not react to elasticity ($\xi = 0$)