Tax Risk and Asset Prices: Evidence from Dual-class Corporate Bonds in the 19^{th} Century*

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Abstract

Little is known about how the risk of unexpected changes in tax policy is priced in financial markets. We measure how tax risk affects asset prices using a novel dataset of taxable and tax-exempt corporate bonds in the 19^{th} century, and the introduction of federal taxes as a natural experiment. Our tax risk measure is derived from bonds with a tax-exempt clause that requires firms to pay coupons to investors in full, and to pay investors' taxes on coupons. Tax risk is pro-cyclical and is priced in the cross-section of asset returns with a statistically and economically significant positive risk premium.

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1 Introduction

Investors periodically face a significant amount of uncertainty regarding how their investment income will be taxed, as tax policy changes over time. For instance, the U.S. government introduced federal income taxes in 1861, repealed them in 1872, then re-instated them in 1894, and finally deemed them unconstitutional in 1895. Since the contemporary federal income tax system was introduced in the early 1900s, several aspects of tax policy have changed frequently, generating considerable uncertainty or tax risk among investors regarding their after-tax investment cash flows (Sialm (2006)).[1] Moreover, even if tax policy does not change over time, tax risk can arise due to inconsistent implementation and enforcement of tax statutes, especially when the tax code is complex.[2]

While a large literature studies how the level of tax rates affects financial markets and asset prices, the literature on *tax risk* is more limited. With a few exceptions (Sialm (2006), Sialm (2009), and Longstaff (2011)) there is little guidance on how tax risk should be measured and the magnitude of its effect, if any, on asset prices. To the best of our knowledge, we are the first to exploit data from a natural experiment from the 19^{th} century in which many U.S. firms had issued both taxable and tax-exempt (i.e., dual-class) bonds, and when many investors faced federal income taxes for the first time to derive a novel, market-based measure of tax risk, to examine how it changes in response to tax policy, and to quantify how tax risk is priced in the cross-section of asset returns.

In the late 1800s, U.S. firms issued 'tax-exempt' bonds. Investors in these bonds were protected from federal income taxes on the bonds' coupon cash flows since the firms, not the investors, paid taxes on the coupon interest of tax-exempt bonds. That is, the firm or the issuer not only paid coupon interest in full to bondholder, but also paid the requisite taxes on such coupons (computed at the withholding tax rates specified annually by the U.S. Treasury) to the federal government.

Why would firms issue tax-exempt bonds? The origin of U.S. corporate bonds with a tax-exempt clause can be traced back to the first federal income tax of 1861, which required firms to withhold federal income taxes before paying coupons to investors. As a result, many investors withdrew from the corporate bond market, and migrated to the stock and the tax-free municipal bond markets (Osgood (1920)). When taxes were repealed in 1872, firms issued bonds with a tax-exempt clause, promising to pay withholding

[1] Sialm (2006) documents how marginal federal income tax rates for individuals vary over 1913 to 1999, and how such changes can affect asset prices.

[2] In 2010, for example, market participants faced significant uncertainty regarding whether the so-called 'Bush tax cuts' would be extended. https://waysandmeansforms.house.gov/news/documentsingle.aspx?DocumentID=204996.

taxes on coupon cash flows of the bonds, if federal income taxes were ever reinstated, most likely to attract investors back to the corporate bond markets, and to prevent future episodes of 'flight from taxes'.

By the 1890s, tax-exempt clauses had become standard in most firms' bond offerings, yet investors did not attach a special meaning to these clauses, since federal income taxes were deemed unconstitutional by the U.S. Supreme Court decision of 1894. However, this changed when in February, 1913, the 16^{th} amendment reestablished Congress' right to impose a federal income tax. As a result, bonds with tax-exemption became more valuable relative to bonds without the clause.[3] Around 30% of bond issues outstanding, many by firms that had otherwise also issued tax-exempt bonds, did not have tax-exempt clauses.[4] Moreover, there are no systematic differences in characteristics (maturity, coupon rates, outstanding amounts, or face values) between taxable and tax-exempt bonds issued by the same firms, except their tax status. The simultaneous existence of both taxable and tax-exempt corporate bonds, and the introduction of the first federal income tax in 1913 serves as a natural experiment that allows us to identify the effect of tax risk on asset prices.[5]

We find that prior to the first federal income taxes during 1910-1913, there was no substantial difference in the yields of taxable and tax-exempt bonds issued by a cross-section of nearly 708 nonfinancial firms. This suggests that investors considered the likelihood of future taxes on their bond holdings a very low probability event. That is, investors considered both taxable and tax-exempt bonds issued by the same firm to be nearly equivalent investments. In contrast, after 1913, yields on taxable bonds are approximately 108 basis points higher than those on tax-exempt bonds on average. This yield difference is not only statistically and economically significant, but it also varies significantly over time and peaks at 218 basis points. Even after accounting for the top marginal income tax rates over the 1913–1920 period, yields on taxable bonds are 36-80 basis points higher than those on comparable tax-exempt bonds. This suggests

[3] Commercial and Financial Chronicle, Volume 97, November 22, 1913, Page 1467. "It has been taken as a matter of course [by investors] that the tax-exemption feature should be in the bond – simply because the fashion had grown up to issue bonds in that way. Yet it cannot be said if any disposition existed on the part of investors to lay emphasis on this feature, or to attach any great importance to it, or even to make inquiry as to whether the bond purchased had the tax-exempt proviso or not. This apathy and indifference followed, of course, from the fact the until the passage of the new Act [16^{th} Amendment] it was the least consequence whether a bond carried a tax-exempt clause or not, since neither the owner nor the issuing corporation was called upon to pay any tax. Quite naturally, now that the duty has been imposed upon the Government to collect an income tax, the liveliest of interest is being manifested in the subject."

[4] Osgood (1920) analyzes data for all U.S. corporate bonds outstanding at the time of the passage of the income tax law of 1913. He documents that the tax-exempt clause existed in about 70 percent of the outstanding corporate bonds at that time.

[5] We examined several historical sources to determine why firms would simultaneously issue bonds with and without a tax-exempt clause. We could find no discussion of firms' motivation to issue 'dual-class' bonds. Since the tax-exempt clauses had become standard in most firms' bond offerings, we can only conjecture that the omission of the tax-exempt clause was an inadvertent mistake on the part of the issuing firms.

that investors not only require compensation for the current level of taxes, but also that investors may demand a 'tax risk premium' for the risk of holding assets whose after-tax cash flows are subject to shocks from unexpected future changes in tax rates. In this paper, we develop a new measure of tax risk and estimate the 'tax risk premium' in the cross-section of bond and stock returns.

To illustrate the intuition behind our measure, consider a firm which had issued both tax-exempt and non-exempt bonds. During the pre-1913 period taxes were deemed unconstitutional, and tax-exemption had little, if any, value to investors. Thus, bonds with and without tax-exemption clause that are otherwise identical (e.g. credit risk, coupon rates, time to maturity, call/put provisions etc.) should trade at the same prices.[6]

As a result of the change in tax laws in 1913, however, taxable bonds became less valuable relative to tax-exempt bonds, not only because their cash flows were affected by the current level of tax rates, but also because these bonds would be affected by future changes in tax rates. That is, taxation of cash flows created tax risk for investors of taxable bonds. As a result of the 'shock' from the 1913 tax law, prices of taxable bonds will reflect how investors adjusted their beliefs about the likelihood of future changes in tax policy and how these changes might impact the after-tax cash flows of their bond investments. Investors in tax-exempt bonds, however, are unaffected by tax risk as tax policy has little, if any, effect on how investors value those bonds. In other words, post 1913, investors reprice taxable bonds as they assess the likelihood and the timing of future changes in tax rates. As this information is impounded into prices, prices of taxable bonds, will be more volatile than those of otherwise identical tax-exempt bonds. This is the intuition behind our measure. Specifically, we use the degree to which prices of exempt bonds deviate from no-arbitrage prices from a term-structure model relative to the price deviations of non-exempt bonds. This approach has several advantages. First, it keeps credit risk fixed as we use only firms that had issued both tax-exempt and non-exempt bonds and the set of firms are all non-financial firms from the industrial sector. Second, by using a term structure model, we compare the relative price deviations of bonds with the same maturity and coupon cash flows. Third, we include only standard fixed-rate coupon bonds and exclude all bonds with features such as call and put provisions. Finally, by using the ratio of price deviations of non-exempt to tax-exempt bonds, we keep fixed other risk such as aggregate industry or macroeconomic risks that affect both types of dual-class bonds.

To construct our tax risk measure we compute relative price deviations of non-exempt bonds and tax-

[6] Price differences between both types of bonds are largely eliminated by arbitrageurs, especially because corporate bond markets in the 19^{th} century were remarkably liquid (as documented by Biais and Green (2007) and confirmed in this paper).

exempt bonds at the monthly frequency using the Nelson and Siegel (1987) no arbitrage term-structure model. Specifically, we first estimate the term-structure of yields on taxable and tax-exempt bonds separately. Then, we use the non-exempt and tax-exempt Nelson and Siegel (1987) yield curves to generate model-implied prices of all non-exempt and tax-exempt bonds in each month, respectively. Lastly, we compute the root mean squared price differences between market and model-implied prices of non-exempt and tax-exempt bonds. Our tax risk measure (TRM) is then simply the log ratio of the root mean squared price differences.[7]

A number of important results emerge from our analysis. First, TRM captures uncertainty about taxes in financial markets. Specifically, over the 1910–1920 period, changes in TRM are positively correlated with the number of newspaper articles in the Wall Street Journal that include the keywords 'tax' and 'bill'. In addition, during the period from 1913 to 1920, TRM is on average two standard deviations higher than it is in the period before the 1913 tax law took effect. Moreover, peaks in TRM coincide with changes in tax policy. Specifically, TRM jumps up in 1913 right after federal income taxes were imposed, and it jumps up again in 1914, when the federal government increased tax rates to fund World War I. TRM also increases substantially in 1916 when the federal government increased tax rates, introduced a federal estate tax, and levied an excess profits tax on corporations.

Second, TRM is pro-cyclical, it increases in good economic times, and is positively correlated with industrial production, the risk-free rate, and inflation. TRM is also positively correlated with components of the text-based measure of uncertainty developed by Manela and Moreira (2017) that captures natural disasters, wars, and government policy. However, the magnitude of the correlations is economically small, indicating that TRM is distinct from, and is not subsumed either by macroeconomic or general uncertainty variables.

Third, tax risk is priced in the cross-section of bond and stock returns. Using Fama-MacBeth regressions for a large set of bond and stock market indices, we find that tax risk premia are positive and economically significant. Specifically, during the period from 1913 to 1920, when many investors not only faced taxes on their bond investments for the first time but were also subject to top marginal tax rates that increased rapidly from 7% in 1913 to nearly 77% in 1919, the tax risk premium is on the order of 1.21–2.43% per month. This is an important result since it shows that investors may require a significant

[7] TRM is expressed in cents per \$100 notional value. Intuitively, a value of 100 means that tax-risk induces prices of non-exempt bonds to deviate on average by around one dollar per \$100 face value from their model-implied no-arbitrage values during the month of measurement.

risk premium to hold securities with cash flows that are more sensitive to tax risk.[8]

Fourth, we construct a tradeable tax risk mimicking portfolio and study the time-series properties of tax risk over an extended period. We find that this mimicking portfolio captures episodes of tax uncertainty over a time span of more than three-quarters of a century (1930—2016). Specifically, it increases in years in which significant tax legislations are enacted. Over 1930–2016, the average monthly return of the mimicking portfolio is 0.14% or about 1.70% annualized. We also examine if tax risk is priced in the 100 size and book-to-value sorted portfolios, and find the premium for tax risk over 1930–2016 amounts to approximately 0.34%, annualized.[9]

Fifth, our results are also important because they indicate that the impact of taxes on asset prices may be an order of magnitude higher than previously documented. For example, Ang, Bhansali, and Xing (2010) find that yields for taxable municipal bonds are 25 basis points higher than that of comparable non-taxable municipal bonds. We find that the yield difference between taxable and tax-exempt corporate bonds is nearly 4 times higher (approximately 100 basis point). Our study is also able to distinguish among competing views in the literature concerning the magnitude and the sign of the tax risk premium. While Miller and Scholes (1978) suggests that there should be no premium for bearing tax risk, Sialm (2009) argues that such risk affects prices of assets with long durations (such as equities and long-term bonds). Further, while Sialm (2006) shows that tax risk can be difficult to sign in the context of a general equilibrium model, Longstaff (2011) finds a negative tax risk premium.

We conduct several robustness checks to confirm that our results are not driven by how we measure tax risk. We find no evidence that our results are driven by time-varying bond market liquidity or by relative differences in the liquidity of taxable and tax-exempt bonds. Specifically, we derive and control for three different measures of bond market liquidity: (1) the actual end of day bid and ask prices for a sample of 100 bonds, (2) transaction costs based on the range-based estimator in Corwin and Schultz (2012), and (3) transaction costs based on the adjusted range-based estimator in Corwin and Schultz (2012) that explicitly accounts for irregularly spaced trading days. Our empirical results show that corporate bond markets between 1910–1920 were remarkably liquid with average trading costs of 20–30 basis points. This complements the results in Biais and Green (2007), who also study bond market liquidity during the early

[8]The positive tax risk premium is consistent with the fact that TRM is pro-cyclical and that tax risk increases the volatility of net, after-tax future cash flows. In an important paper, Longstaff (2011) uses data on U.S. municipal bonds during the 21st century, and finds that the risk premium associated with level of marginal tax rates can be as high as 12.58% over a 1-year horizon.

[9]Over 1910–1920, the correlation between TRM and the tradeable mimicking portfolio is just 37% which perhaps explain the lower tax risk premium over the extended sample.

20th century.[10]

While our data-set is historical, it is relevant for understanding the effect of tax risk on asset prices today for several reasons. First, the U.S. introduced the federal income tax system in 1913, and the ensuing decade was accompanied by many frequent changes in tax policy. The uncertainty associated with these changes increased tax risk substantially, which makes our sample period unique for investigating the effects of tax risk on asset prices. Second, our data allows us to compare yields of non-exempt and tax-exempt bonds while keeping other factors that could impact bond prices fixed. Specifically, we compare prices of otherwise virtually identical bonds, issued by the same firm, over the same time period of time, that differ only regarding their after-tax cash flows to investors. Third, financial markets and firms in the late 19^{th} and 20^{th} century were similar in many ways to those in modern times. In the early 1900s, firms also raised private capital using securities with features similar to modern day equity and (both secured, and unsecured) coupon-bearing debt. These instruments were actively traded in secondary markets and in some cases such the corporate debt markets, were even more liquid than their modern day counterparts (Giesecke, Longstaff, Schaefer, and Strebulaev (2011)). Thus, while the tax code, and names of the bond issuers and the industries they represent may have somewhat changed over time, how tax risk affect asset prices, and the extent to which tax risk is priced in financial market should not.

The remainder of this paper is organized as follows. In Section 2 we review the extant literature on how taxes affect financial markets. Section 3 describes the market for tax-exempt and non-exempt bonds and Section 4 describes the data. In Section 5, we develop our tax risk measure, study the time-series properties of the tax risk measure, and analyze how tax risk is priced in the cross section of asset returns. Finally, Section 6 concludes.

2 Related literature

While the notion of tax risk is not new and can be traced back to Lucas (1978), Stiglitz (1982), Auerbach and King (1983), Dybvig and Ross (1986), Dammon and Green (1987), and Bizer and Judd (1989), to date there has been little empirical work on measuring tax risk and on examining its affects on asset prices. Empirical work on how taxes affect asset prices include Sialm (2006), Sialm (2009), and Longstaff (2011). Sialm (2006) finds that tax risk affects assets with long durations such as, equities and long-term bonds,

[10] Using transaction-level prices of a sample of six bonds, Biais and Green (2007) estimate transaction costs in bond markets to be 20–220 basis points in the 1940s. Our data indicate that U.S. corporate bond markets were even more liquid in the early 1900s. One reason is that bond trading had partially migrated from the NYSE to the over-the-counter (OTC) markets by the 1940s.

and that the premium for tax risk can be difficult to sign in the context of a general equilibrium model. Sialm (2009) shows that tax risk affects returns for both risky and safe assets. More recently, Longstaff (2011) uses data for municipal swaps to show that the premium for tax risk is negative. Compared to these papers, we use data from dual-class corporate bonds and develop a direct, market-based measure of tax risk, and find that the tax risk premium is positive in our sample.

Our work also relates to the large literature on how taxes affect asset prices. Poterba (2001), Bernheim (2002), and Graham (2003) provide excellent reviews. Much of this literature relies on comparing prices of tax-exempt municipal bonds with those of taxable U.S. Treasury bonds.[11] The literature on how taxes affect other assets, such as equities and corporate bonds, is more limited, and the empirical evidence is somewhat mixed. For instance, Boyd and Jagannathan (1994), Fama and French (1998), and Erickson and Maydew (1998) find no evidence that taxes affect equity prices, and argue that this is consistent with Miller (1977)'s and Miller and Scholes (1978)'s tax irrelevance hypothesis.

Our tax risk measure is motivated by the literature on limits to arbitrage. Shleifer and Vishny (2012) suggest that prices of financial assets can deviate from their fundamental (or 'no-arbitrage') values during periods of distress in financial markets, and that these price deviations can be explained by limited capital available to arbitrageurs. Mitchell, Pulvino, and Stafford (2002) use this idea to study arbitrage mispricing in the equity markets in cases where the market value of a company is less than that of its ownership stake in a publicly traded subsidiary. Abreu and Brunnermeier (2002) study limits to arbitrage when traders face risk regarding when their peers will exploit a common arbitrage opportunity. This 'synchronization' problem can occur when there is risk related to future payoffs from the arbitrage trade because arbitrageurs' opinions about the timing of the price correction vary.

Finally, we also contribute to the literature which compares market prices of securities to their implied prices from no-arbitrage models to estimate whether securities are mispriced. This literature is extensive and too large to review comprehensively here. Specific examples in the bond markets include, Bennett, Barbade, and Kambhu (2000), Fleming (2000), and Hu, Pan, and Wang (2013). For instance, Hu, Pan, and Wang (2013) calculate the deviation of market yields from the no arbitrage model-implied yields for Treasury bonds to estimate funding liquidity of arbitrageurs.

[11] See Trzcinka (1982), Poterba (1989), Green (1993), Green and Ødegaard (1997), Chalmers (1998), and more recently Longstaff (2011).

3 Historical background on tax-exempt corporate bonds

The origin of bonds with tax-exemption can be traced back to the first federal income tax of 1861, which required firms to withhold federal income taxes before paying coupons to investors. The Revenue Act of 1861 introduced a federal income tax for the first time and required issuers to withhold taxes due on coupon payments at the source. Under the Act, corporate bond investors were required to provide ownership certificates (with names and identities) when collecting coupon payments, so that income tax on these payments could be withheld and correctly reported to the U.S. Treasury. Due to the administrative burden associated with disclosing identities and paying taxes, many investors migrated from the corporate bond markets to the stock and municipal bond markets (Osgood (1920)).[12] After income taxes were repealed in 1872, firms began issuing bonds with a tax-exemption clause to attract investors back to the corporate bond markets, and to protect investors if taxes were ever reimposed. Issuance of tax-exempt bonds again gained momentum nearly 20 years later, when Congress attempted to re-institute federal income taxes in 1894. While this attempt was blocked by the Supreme Court, it heightened investor concerns, and spurred renewed issuances of bonds with tax-free clauses.

Over time the tax-exemption became a standard clause in bond offerings. The tax-exempt clause from the 4% coupon bonds issued by Atchinson, Topeka, and Santa Fe Railroad in 1895 is a typical example:

> "...Both the principal and interest of this bond are payable without deduction for any tax or taxes which the Railway Company may be required to pay or to retain therefrom by any present or future law of the U.S., or of any State or Territory thereof, the railway company hereby agreeing to pay such tax or taxes...."

Since taxes were ruled unconstitutional by the Supreme Court in 1894, investors did not attach special importance to these clauses. For instance, an article published on November 22, 1913 in the Commercial and Financial Chronicle, a popular financial newspaper at the time, describes investor and firm behavior:

> "...It has been the practice for years to include tax-exemption clauses in new bond issues-the tax-exempt provision. Such a fixity of custom in that respect has existed that it has been taken as a matter of course that the tax-exemption feature should be in the bond – simply because the fashion had grown up to issue bonds in that way. And yet it cannot be said that

[12] Under the 1861 Act, income from municipal bonds was not taxed at the federal level, and investors in equity did not pay income tax on capital gains until the gains were realized.

any disposition existed on the part of investors to lay emphasis on this feature or to attach any great importance to it or even to make inquiry as to whether the bond purchased had the tax-exempt proviso or not. This apathy and indifference followed, of course, from the fact that until the passage of the new Act it was not of the least consequence whether a bond carried a tax-exempt clause or not, since neither the owner nor the issuing firm was called upon to pay any tax..."

When federal income taxes were reintroduced in 1913 with the ratification of the 16^{th} Amendment to the Constitution, whether bond issues contained the tax-exemption directly impacted the coupon cash flows investors would collect on their bond investments. Moreover, tax-exempt bonds not only protected investors against current taxes on coupon interest, they also protected investors from future tax changes. This means that tax-exempt bonds also had an option value that hedged against future unanticipated changes in the tax policy. The economic value of the tax-free clause was widely recognized in an article published in the Commercial and Financial Chronicle in November 1913 which stated:

> "...It seems likely that the possession by a bond of the exemption provision will in the course of time become an increasingly valuable quality. This is so for a variety of reasons. In the first place, now that the country is definitely committed to an income tax, and there is little likelihood that its constitutionality can be successfully attacked, the chances are that it will not be long before the normal rate of the tax, which is at present 1%, will be increased. An income tax [...] is a direct incentive to extravagance on the part of Congress, and hence we may expect to see the rate mounting steadily upward, rising to 1 1/2%, to 2%, 2 1/2%, to 3 1/2%, and still higher in the course of time..." (See the Commercial and Financial Chronicle, dated November, 1913, page 1468).

Post 1913, the issuer paid the bond holder's tax liabilities on tax-exempt bonds, in the amount specified by the U.S. Treasury's withholding tax rate on income from the bonds. The withholding rate was published annually and usually set to the lowest marginal tax rate. Investors in tax-exempt bonds were responsible for any taxes beyond those covered by the issuers at the withholding rate (Annalist (1918)). In 1913, the withholding tax rate was 1% and the lowest and highest marginal tax rates on incomes above $20,000 ($1.10 million in 2010 dollars) and $500,000 ($11.01 million in 2010 dollars) were 1% and 7%, respectively. Thus, investors with more than $11.01 million in income (in 2010 dollars) had to pay the 6% taxes on interest income beyond that covered by the firms. Similarly, in 1916, the withholding tax rate was 2%, and the lowest and highest marginal tax rates were 2% and 15%, respectively.

An article in the Commercial and Financial Chronicle on November 1, 1913 details how income tax on taxable and tax-exempt bonds was to be withheld and paid. Investors in both taxable and tax-exempt bonds were required to provide a form declaring their name, identity, and address when collecting coupon or principal payments from the issuer. This form also specified if the investor was exempt from federal income taxes based on income limits or residence status. For investors in taxable bonds, firms withheld the appropriate income taxes using the withholding rate specified by the U.S. Treasury. For investors in tax-exempt bonds, firms covered the appropriate withholding income taxes, again using withholding rates specified by the U.S. Treasury. These withheld or covered taxes along with the forms submitted by investors was subsequently transferred to the U.S. Treasury.

Since many, but not all bonds had the tax-exempt clause, the corporate bond market was bifurcated into bonds issued with a tax-free clause, or tax-exempt bonds, and those without any reference to taxes, or taxable bonds.[13] In 1913, 70% of the U.S. corporate bond issues outstanding contained the tax-free clause, while the remaining 30% were issued without any references to taxes (Osgood (1920)).

Whether firms were indeed required to pay the withholding tax on coupon interest and to pay coupons in full to investors was all but clear. Some argued that the tax-free clause was never meant to apply to federal income taxes, and firms paying such taxes for investors would effectively penalize and double tax income of shareholders. Others argued that the language of the tax-free clause left little doubt as to the obligation of the issuing firm to assume taxes on behalf of investors (Marshall (1914)). Thus, investors initially faced considerable risk regarding their tax obligations, even on bonds issued with a tax-free clause.

The U.S. Treasury soon clarified that it did not recognize the tax-free clause, that no private contract could interfere with its ability to collect taxes, and that taxes were required to be withheld and paid even on bonds issued with a tax-free clause. However, the Treasury was silent on the question of tax incidence, and stated it was a private matter to be settled among the issuers and their bondholders. In other words, the U.S. Treasury required taxes to be paid on income from both taxable and tax-exempt corporate bonds, but did not clarify who (the investor or the firm) paid these taxes. After this ruling all but few firms agreed to cover taxes on bonds issued with a tax-free clause.[14].

[13]Taxable corporate bonds, like regular corporate bonds, required investors to pay taxes on income from the bonds.

[14]See Annalist (1918), which states "...There were firms which tried, between 1913 and 1916, to break their covenants, although such cases were few, and the tax was usually paid by them without reducing the amount of interest paid, net, to bondholders..."

4 Data

We present details regarding our data sources, followed by summary statistics for taxable and tax-exempt bonds. We also present summary statistics for macroeconomic variables, financial variables, and equity and bond market indices that we use in the empirical analysis below. Table A2 in Appendix A provides further details regarding our data-sets, variable definitions, data sources, and how our data was collected.

4.1 Taxable and tax-Exempt corporate bonds

Our primary data source is the Commercial and Financial Chronicle (henceforth, the CFC). This weekly newspaper was founded in 1865 and it was the first major national business and financial newspaper in the U.S. The CFC regularly reported on key developments in U.S. financial markets including, but not limited to market prices, aggregate volumes, interest rates, annual reports for firms, banks, trust companies, etc. The CFC also published extensive lists of the corporate bonds traded on the NYSE, all of the regional exchanges, as well as information about leading unlisted and inactive bonds. Thus, the listing of bonds in the CFC is far more extensive than simply the bonds actively traded at the major exchanges. In addition to the bond listings, the CFC also reported on key news items relating to these issuers and bonds such as annual earnings, balance sheet data, missed coupons, defaults, bondholder committees, receiverships, reorganizations, bankruptcies, etc.[15]

The starting point for our extensive data collection exercise is the categorical lists of corporate bonds in the CFC, which identify the tax status of each outstanding bond issued by U.S. firms. A total of 19 such lists were published by the CFC over November 22, 1913–April 18, 1914. Figure 1 provides a typical example of such a list published in the CFC on November 22, 1913. The list identifies the bond issuer, the month in which coupon payments are made, the maturity date for the bond, the total outstanding amount for the bonds, and whether the bonds were issued with or without the tax-free clause. The list also indicates if a particular bond issue had special features such as, call and put provisions, sinking fund features, and whether the bonds were collateralized or unsecured. We hand collect data for bonds issued by U.S. nonfinancial firms that did and did not contain the tax-free clause.

All firms in our sample had issued both taxable and tax-exempt bonds. The CFC contains no instances of firms that had exclusively issued either taxable or tax-exempt bonds. There are also no systematic

[15] Data for bonds from the CFC has been used in other studies, for instance in Giesecke, Longstaff, Schaefer, and Strebulaev (2011)

patterns based on type of issuer and dual-class bonds were issued by steam railroads, electric railroads, utilities, and other nonfinancial industrial firms.

We focus on bonds issued by U.S. nonfinancial firms, as historically the U.S. nonfinancial sector has represented a much larger share of the market for long-term corporate debts than bonds issued by the financial sector. For example, financial issuers represented zero percent of all corporate bond issuers listed in the CFC in 1870, 1.2 percent of all issuers listed in 1900, 6.9 percent of all issuers listed in 1930, and 1.8 percent of all issuers listed in 1969 (Giesecke, Longstaff, Schaefer, and Strebulaev (2011)). Many commentators at the time viewed bonds issued by non-financial firms, particular railroad bonds, as very safe investments because they were backed by safe collateral (Mundy (1907)).[16]

We obtain corresponding bond prices from the CFC's General Quotation of Bonds and Stocks section, which lists bid and ask quotes, as well as high and low prices, for each bond, for each month. We collect bond price data from January 1910 to December 1920, i.e., starting 3 years before and up to 7 years after the imposition of federal income taxes via the Revenue Act of 1913. Throughout, we use bond mid prices, computed as the average of the monthly bid and ask quotes, for all our analyses. We also use the monthly high and low prices, and monthly bid and ask prices to compute various measures of bond market liquidity. Figure 2 provides a typical example of how bond prices and quotations were published in the CFC.

Pages with bond prices and quotations from the CFC were scanned and converted to electronic datasets by Crux Solutions Inc., India.[17] Since, bond price and quotation data copied over from the CFC could suffer from minor data entry errors. To filter these we drop all observations with a bond price above \$150 per \$100 notional amount and below \$10 per \$100 notional amount. We also exclude from our analysis all observations with bonds prices below the 5^{th} and above the 95^{th} percentile in a given month. We also exclude bonds with special features such as put or call provisions, stepped coupon cash flows, bonds issued by firms in default or in receivership, and bonds that are defined as perpetual, consol, or income bonds. We also drop bonds with the following labels: called, cancelled, conversion, exchanged, matured, redeemed, sinking fund, or tendered, guaranteed, convertible, etc. Finally, we do not use bonds with prices quoted in non-U.S. Dollars. These are still issued by U.S. firms, but the data for prices is from financial markets not located in the U.S. Our final sample includes 272,513 observations for 3,637

[16] For a description of growth in securities issued by financial firms, see Philippon (2008).

[17] Crux guaranteed an accuracy rate of 99.00% in data entry operations. Research assistants in the U.S. double checked the data-set for errors, and resolved any discrepancies between the scanned copies and the electronic data-set.

bonds issued by 708 nonfinancial U.S. firms. Of these, nearly 72% (or 2,602 issues) are for bonds with a tax-exempt clause, and the remaining 28% (1,035) are for taxable bonds.[18]

Table 1 reports the summary statistics for characteristics such as, coupon rates and time to maturity, separately for taxable and tax-exempt bonds pooled across all firms. We report the mean, standard deviation, minimum, 25^{th}-percentile, median, 75^{th}-percentile, and maximum values for coupon rates and time to maturity for both taxable and tax-exempt bonds. The first row reports the summary statistics for taxable bonds, the second row reports the summary statistics for tax-exempt bonds, and the last row reports the summary statistics for all bonds. Columns 3–9 report summary statistics for the coupon rates, and columns 10–16 report summary statistics for the time to maturity. N denotes the number of bond issues. All statistics are as of the beginning of our sample, in January 1910.

Summary statistics for taxable and tax-exempt bonds are not that different, and bonds issued under either category are very similar in terms of their characteristics. The average coupon rate for taxable bonds at the start of our sample is 4.96%, while that for tax-exempt bonds is 4.85%. While the minimum average coupon rate for both types of bonds is the same at 3%, the maximum coupon rate for taxable bonds (7%) is slightly lower than that for tax-exempt bonds (10%). Since all 3,637 bonds were issued well before any federal income tax was imposed, the difference in coupon rates between taxable and tax-exempt bonds is likely not tue to tax-exempt clauses.[19]

The average time to maturity for taxable bonds is 20 years, while that for tax-exempt bonds is slightly higher at 26 years. The shortest time to maturity for taxable and tax-exempt bonds is 3 and 1.20 years, respectively. The longest time to maturity for these bonds is 88 and 99 years, respectively. Despite the high average time to maturity, our sample contains sufficient observations for both long-term and short-term bonds. Figure A1 in Appendix B plots the proportion of observations in a given year that fall in 5 distinct maturity buckets – those with maturity less than 5 years, between 5–10 years, between 10–15 years, between 15–30 years, and greater than 30 years. On average, in any given month, 60.61% of our observations are for long-term bonds with maturities greater than 15 years, and the remaining 39.39% of observations are for short-term bonds, with maturity less than 15 years. The average amount outstanding for taxable bonds is \$3.71 million and the average amount outstanding for tax-exempt bonds is \$4.85 million. The median amount outstanding for taxable and tax-exempt bonds is \$0.90 million and \$1.01

[18] We test that our choice of price filters and cutoff has no substantial affect on our results and our conclusions.

[19] If the difference in coupon rates was driven by taxes, one would expect investors to demand a higher and not a lower coupon rate for taxable bonds.

million, respectively. Thus, it seems that there are no significant differences in the outstanding dollar amount between taxable and tax-exempt bonds.

Next, we report the summary statistics for prices and yields for taxable and tax-exempt bonds in Tables 2 and 3. For each year and each month, we first compute the average price and yields separately for all taxable and tax-exempt bonds, pooled across all firms. We then compute and report the summary statistics for the time-series of monthly average prices and yields in Table 2 and the differences in prices and yields of taxable and tax-exempt bonds in Table 3. In each Table, Panel A reports the summary statistics for the full sample, while panels B and C report the summary statistics for the pre-1913 and post-1913 samples, respectively. The columns titled Prices and Yields report summary statistics for bond prices expressed in dollars per $100 notional value, and yields either expressed in percentages or in basis points.

Our sample includes nearly 275,000 observations for monthly corporate bond prices collected over 1910 to 1920. A majority of these observations (nearly 200,000) are for bonds with a tax-exempt clause. The remaining nearly 75,000 observations are for bonds issued without any reference to taxes. The fact that tax-exempt bonds, as measured by both the number of observations and the number of bond issues, comprise a bulk of our sample is consistent with the common practice among firms to issue bonds with a tax-exempt clause in the early 1900s. This is also consistent with anecdotal evidence in Osgood (1920) that nearly 70% of bond issues outstanding at any point in time in the early 1900s included the tax-exempt clause.[20]

Over the full sample, tax-exempt bonds, trade at slightly higher prices and hence slightly lower yields. The average price of a taxable bond over the full sample is approximately $89.00 per $100 notional value, and that for a tax-exempt bond is approximately $90 per $100 notional value. This difference of $1.00 per $100 in notional value translates into a difference of 86 basis points in yields.

Panels B of Tables 2 and 3 show that there is hardly any difference in average prices and yields of taxable and tax-exempt bonds issued by firms before federal income taxes are imposed in 1913. In the pre-tax era, the price in dollars per $100 notional value, for taxable and tax-exempt bonds is $96.88 and $96.80, respectively. The average yield to maturity for these bonds is 5.62% and 5.37%, respectively.

[20] Since we have only 75,000 observations for taxable bonds, but 200,000 observations for tax-exempt bonds, one concern could be that our results are driven by this imbalance in the number of observations between taxable and tax-exempt bonds. Therefore, as a robustness test, we rerun all of the analyses in this study after randomly selecting an equal number of observations for both taxable and tax-exempt bonds, and find that differences in the number of observations does not affect our results.

The difference of -\$0.08 in prices or 28 basis points in yields is small and not statistically significant. Clearly, before 1913, investors did not attach much importance to the tax status of the bond issued by the same firm since federal income tax had been ruled unconstitutional. That is, investors considered both taxable and tax-exempt bonds issued by the same firm as nearly identical investments. Note that the yield difference between taxable and tax-exempt bonds reaches a high of 148 basis points even in this pre-tax era. This is likely due to the fact that the resolution for the 16^{th} amendment to the Constitution was passed by U.S. Congress in 1909, although it had not been ratified by the states, and there was still considerable uncertainty if it would ever be ratified by the states.

After 1913, tax-exempt bonds trade at a price that is nearly \$1.50 per \$100 notional value higher than those of taxable bonds. This is nearly 18 times higher than the difference in prices in the pre-tax era. The average price for taxable and tax-exempt bonds over 1913–1920 is \$84.18 and \$85.47 per \$100 notional value, respectively. This translates into an average difference in yields of 108 basis points. Thus, post-1913, the average difference in yields between taxable and tax-exempt bonds increases by approximately 80 basis points, from an average of 28 basis points in the pre-1913 era. This represents nearly a 2-standard deviation jump in the yield difference between taxable and tax-exempt bonds after the introduction of taxes.

The average bid-ask spread for both taxable and tax-exempt bonds in our sample is \$0.02. Thus, the pre-tax spread of -\$0.08 between prices of taxable and tax-exempt bonds is within an order of magnitude of the bid-ask spread in bond prices. However, post-1913, the spread in prices of taxable and tax-exempt bonds of \$1.50 is 75 times higher than the average bid-ask spread in bond prices.

At first glance, the lower prices, and hence higher yields, for taxable bonds in the 1913-1920 sample are perhaps not surprising, and are consistent with investors reacting rationally to tax effects in asset prices. Investors require higher yields from taxable bonds to compensate them for bearing income tax liabilities associated with these bonds. But is the yield difference sufficient to compensate investors, or is it too high or too low relative to the present value of all expected future income tax liabilities? To address the question, we compute the after-tax yield on taxable bonds computed as $y^T \times (1 - \tau)$. Here, y^T is the yield to maturity on a taxable corporate bond and τ is the marginal tax rate for individual investors. If an investor in a taxable bond receives fair compensation for bearing the tax liability burden, the after-tax yield on a taxable bond should be the same as the yield on a tax-exempt bond issued by the same firm. Table 3 shows that the average difference in yields between taxable and tax-exempt bonds over 1913-1920 is 108 basis points. Setting τ to the highest marginal federal income tax rate over this period of 67%, implies that even after accounting for tax liabilities, yields on taxable corporate bonds are 36 basis points higher than those on comparable tax-exempt bonds. Setting τ to the median marginal federal income tax rate of 26% heightens the disparity and implies that the after-tax yield difference between taxable and tax-exempt bonds was 80 basis points. With τ set to the effective tax rates for the wealthiest households of 15% (Brownlee (2004)), the yield difference is nearly 92 basis points. Although after-tax yield spreads between taxable and tax-exempt bonds are narrower than the pre-tax yield spreads reported above, they are not zero on average as expected. In other words, taxable bonds seem to be trading at prices that appear to be too low, even after accounting for the value of their income tax liabilities. Part of this difference may be due to compensation for tax risk, a question we turn to in the next Section.

In addition to differences in yield spreads, the standard deviation for prices and yields for both taxable and tax-exempt bonds is higher in the post-tax sample in Panel C of Tables 2 and 3 than in the pre-tax sample in Panel B. In panel B of Table 2, the standard deviation of prices is 14.13 in the pre-tax sample, but it increases by nearly 30% to 17.86 in the post-tax sample. Similarly, the volatility of yields more than doubles from 2.67 to 5.13 in the post-tax sample. This higher volatility for prices and yields in the post-tax sample may in part also reflect the initial risk faced by investors regarding their tax obligations on either type of bond, right after the ratification of the 16^{th} amendment and the imposition of federal taxes.

Figure 3 plots the time-series of the yields of taxable and tax-exempt bonds. The top panel plots the yields of taxable bonds, the middle panel plots the yields of tax-exempt bonds, and the bottom panel plots the difference, i.e., the yields of taxable bonds in excess of yields of tax-exempt bonds. In each panel, the gray bars represent dates with significant news regarding the federal income tax law or its implementation. These dates are collected from a search of the editorial section of the Commercial and Financial Chronicle over 1910–1920 and include: August 1911 – when Wisconsin instituted a state tax and New York ratified the 16^{th} amendment; December 1912–March 1913 – when the 16^{th} amendment was ratified by the requisite two-third of the states; June 1913–September 1913 – when the Revenue Act of 1913 was passed by the House, the Senate, and signed into law by President Woodrow Wilson; July 1915–March 1916 – when an important case (Brushaber v/s Union Pacific Railroad) was argued and decided by the U.S. Supreme Court, which upheld the 16^{th} amendment and the Revenue Act of 1913; October 1917–October 1918 – when the U.S. entered World War I and passed a series of Acts to raise taxes and revenue for the war; and June 1919–July 1919, when the federal government prohibited the sale of alcohol (reducing revenue generated from excise on alcohol) and signed the World War I Armistice treaty (which reduced the expenses required for the war).

As shown, the difference in yields of taxable and tax-exempt bonds almost always spikes on days with news regarding tax policy. For example, the difference in yields between taxable and tax-exempt bonds is relatively flat at the start of the sample at approximately 23 basis points, but spikes to nearly 140 basis points in August 1911, when Wisconsin imposed a state tax and New York ratified the 16^{th} amendment. Similarly, the difference spikes again in early 1913, when the 16^{th} amendment is ratified, and again in October 1913, when the Revenue Act of 1913 is passed by Congress and signed into law. The difference in yields spikes and remains at elevated levels throughout October 1917 to October 1918, when the U.S. enters World War I, and as a result passes the Revenue Act of 1916 and 1917 which raised income tax rates, imposed a war profits, as well as an estate tax.

So far, in all our analyses, we have pooled data for taxable and tax-exempt bonds across all (i.e., the same set) of firms. One could claim that cross-sectional differences in default risk could account for at least part of the difference in yields between taxable and tax-exempt bonds. Default risk is unlikely to account for the large difference in prices and yields of taxable and tax-exempt bonds, because both types of bonds are issued by the same set of firms.[21] To show this more formally, Table 4 presents results for the difference in yields between taxable and tax-exempt bonds, after these bonds have been matched at the issuer level. Specifically, in each year, in each month, we first compute the difference in the average yields on all taxable and tax-exempt bonds issued by each firm. Thus, when computing the averages in Table 4, both taxable and tax-exempt bonds are issued by the exact same firm, and the question of any variation in default risk does not arise. We then compute the cross-sectional average of this issuer-level difference in yields between taxable and tax-exempt bonds, by pooling data across all firms.

Table 4 presents the summary statistics for this average issuer-matched yield difference between taxable and tax-exempt bonds for each year between 1910-1920, as well as for the pre-tax (1910–1913) and the post-tax (1913–1920) years. The most striking observation is that the yield difference between taxable and tax-exempt bonds is almost always positive. While the yield difference between taxable and tax-exempt corporate bonds is just about 15 basis point at the start of our sample in 1910, it increases steadily to around 35 basis points over 1911 and 1912, but then accelerates rapidly in 1913 to nearly 60 basis point.

[21] The results presented so far are based on pooled data across firms, but separately for taxable and tax-exempt bond.

The average issuer-lever yield difference between taxable and tax-exempt bonds peaks in 1915–1916 at 111 basis points, a period during which Congress enacted a large number of rapid tax policy changes, including a substantial change in the individual tax rates, levied an excess profits tax, and imposed an estate tax.

Surprisingly, the average issuer-level yield difference between taxable and tax-exempt bonds is not zero even during 1910-1913, although this period had practically no federal or state income taxes. However, Congress did enact a corporate income tax in 1909, and the 16^{th} amendment had already been proposed and passed by the Congress in July 1909. In addition, by 1910, seven states had already ratified the 16^{th} amendment, and in 1911 an additional 22 states had ratified the amendment. Savvy investors could have interpreted these events as harbingers of federal and state income taxes, causing them to drive a small wedge in the prices of taxable and tax-exempt bonds issued by firms. Thus, the difference in yields of taxable and tax-exempt bonds may have already reflected investors required compensation for tax risk to some degree even before actual taxes were ever imposed in the U.S.

Overall, even the simple summary statistics in this section suggest that taxes matter for the cross-section of asset prices. These results are consistent with evidence in other studies showing that individual investors react rationally to tax affects in other asset pricing decisions such as, asset allocation to mutual funds or to tax-deferred accounts (see e.g., Bergstresser and Poterba (2002) and Bernheim (2002)).

4.2 Macroeconomic and financial data

We supplement data on corporate bonds from the CFC with macroeconomic and financial variables. Tables A3 and A4 in Appendix B present summary statistics for these additional data. Specifically, we use data for several macroeconomic variables, financial variables, as well as measures of bond market liquidity in our analysis.

Table A3 in Appendix B reports summary statistics for all macroeconomic variables. We collect data for the year-on-year growth in the quarterly index of industrial production (IP), the year-on-year percentage change in the consumer price index published by the U.S. Bureau of Labor Statistics (CPI), the economic policy uncertainty index from Baker, Bloom, and Davis (2016) (EPU), the news impled VIX (NVIX) and its subcomponents for the security market (SEC), government (GOV), intermediation (INTR), natural disasters (NAT), war (WAR), and other (UNCL) from Manela and Moreira (2017). Data for all these variables are available at the monthly frequency.

We report summary statistics for financial variables used in our analysis in Table A4 in Appendix B. Here, RF is the U.S. call money rate on mixed collateral and we use it as a proxy for the risk-free rate. MKT is the value-weighted return for stocks in the S&P500 index, BOND is the return on the 10-year bond issued by the U.S. Treasury, CREDIT is the spread between yields of U.S. investment grade corporate bonds and the 10-year constant maturity bond issued by the U.S. Treasury, and MKTVOL is the annualized realized volatility of the value-weighted returns for stocks in the S&P500 index.

In our analysis, we also estimate and control for various measures of bond market liquidity. Our measures of bond market liquidity include BAP – the average spread between the bid and ask prices of all bonds in our sample expressed in cents per $100 notional value, and CS and CSA – the Corwin and Schultz (2012) range-based and the adjusted-range-based estimator for transaction costs in bond markets, respectively. For computing BAP, we use the end of the month bid and ask prices available from the quotation section of the Commercial and Financial Chronical (CFC), and calculate the spreads as a percentage of the mid-point of bid and ask prices. We then equally-weight them to obtain an indication of the bond market liquidity. For computing CS and CSA, we use daily data from the Global Financial Database. While this database has data at higher frequency, the number of paired taxable and tax-exempt bonds available is more limited than those available to us from the Commercial and Financial Chronicle. Using daily data we compute the CS, and CSA for each bond in our sample. Table A4 then reports the summary statistics for these measures of bond market liquidity averaged across all bonds. Note that the original derivation of the transaction cost estimator in Corwin and Schultz (2012) uses regularly spaced daily stock market data. Appendix C shows how to adjust the original derivation in Corwin and Schultz (2012) to account for irregularly spaced trading days.

Figure 4 plots the time-series of the Corwin and Schultz (2012) range-based and the adjusted-range based estimator of liquidity (transaction costs) averaged across all bonds. In our sample, the average transaction cost for corporate bonds is between 23-38 basis points. This can be compared to estimates in Biais and Green (2007), who estimate bond market transaction costs over the years 1943–1947 on the order of 61 cents. Edwards, Harris, and Piwowar (2007) estimate bond market transaction costs in modern times on the order of 70 basis points for small trades (less than $5000).[22]. Thus, it appears that bond markets were remarkably liquid in the early 20^{th} century, with low transaction costs even for retail trades, as compared to later in the century or even in modern times. The higher liquidity of bond markets in the

[22] Edwards, Harris, and Piwowar (2007) also show that bond market transaction costs in modern times falls substantially for larger trades by institutional investors and that these can be as low as 5 basis points for such trades.

early 1900s is likely due to the fact that most bond trading occurred on organized exchanges at the time where prices were readily available to investors with higher pre- and post-trade transparency.

Finally, Tables A5 and A6 in Appendix B present the list and summary statistics for all securities used in our asset pricing tests. Since data for individual securities is not available to us over 1910–1920, we primarily use data for several bond market and stock market portfolios to test if tax policy risk is priced in the cross-section of asset prices. Table A5 lists the fixed income and equity securities used in our asset pricing regressions. Table A6 presents the summary statistics for the securities listed in Table A5, grouped by type of security. We collect data for each month from January 1910 to December 1920 from Global Financial Data.

5 Measuring tax risk

We use prices of taxable and tax-exempt bonds to derive a measure of tax risk. To illustrate the intuition behind our approach, suppose that the prices of taxable and tax-exempt bonds can be written as their fundamental values plus some 'noise'. Specifically, assume that for each date t, there are N firms, indexed by the subscript i, that have issued both taxable and tax-exempt bonds. Let $F_{i,t}^{T}$ and $F_{i,t}^{X}$ represent the fundamental value of taxable and tax-exempt bonds issued by firm i on date t, respectively. Assume that all bond issued by the firm i have a common noise component δ_i, that captures risk related to firm fundamentals. That is, δ_i relates to information that affects market prices for both taxable and tax-exempt bonds issued by firm i. In addition, risk related to future tax policy impacts only taxable bonds. Thus, all taxable bond prices issued by all firms are assumed to have an additional noise component ε, that relates to risk regarding taxes, and is orthogonal to the firm noise component δ_i.[23] To summarize, market prices for taxable and tax-exempt bonds can be expressed as:

$$
\begin{aligned}
P_{i,t}^{T} &= F_{i,t}^{T} + \delta_{i,t} + \varepsilon_t \qquad (1)\\
P_{i,t}^{X} &= F_{i,t}^{X} + \delta_{i,t}
\end{aligned}
$$

[23] The assumption that the noise component is due to tax uncertainty is an innocuous one. First, the same tax rate applies to all taxable bonds equally. Second, the firms in our sample are all industrial firms that have issued both tax-exempt and non-exempt bonds.

Assume that both δ_i and ε are random variables such that:

$$\begin{aligned} \delta_i &\sim N\left(0, \frac{\sigma_\delta}{2}\right) \\ \varepsilon &\sim N\left(0, \frac{\sigma_\varepsilon}{2}\right) \end{aligned} \tag{2}$$

Then for each date t, for taxable bonds, we can write :

$$\begin{aligned} \log\left(RMSE_t^T\right) &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(P_{i,t}^T - F_{i,t}^T\right)^2 \\ &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(F_{i,t}^T + \delta_{i,t} + \varepsilon_t - F_{i,t}^T\right)^2 \\ &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(\delta_{i,t} + \varepsilon_t\right)^2 \longrightarrow \sigma_\delta + \sigma_\varepsilon \end{aligned} \tag{3}$$

Similarly, for each date t, for tax-exempt bonds, we can write:

$$\begin{aligned} \log\left(RMSE_t^X\right) &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(P_{i,t}^X - F_{i,t}^X\right)^2 \\ &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(F^X + \delta_{i,t} - F_{i,t}^X\right)^2 \\ &= \frac{1}{2N}\sum_{i=1}^{i=N}\left(\delta_{i,t}\right)^2 \longrightarrow \sigma_\delta \end{aligned} \tag{4}$$

Hence, our tax risk measure or factor, TRM, or σ_τ equals:

$$\begin{aligned} \sigma_t^\tau &\equiv \log\left[\frac{RMSE^T}{RMSE^X}\right] \\ &\equiv \log RMSE^T - \log RMSE^X \\ &\equiv \sigma_\delta + \sigma_\varepsilon - \sigma_\delta \\ &\equiv \sigma_\varepsilon \end{aligned} \tag{5}$$

As a benchmark for measuring the fundamental prices of taxable and tax-exempt bonds we begin by constructing yield curves of taxable and tax-exempt bonds separately at the monthly frequency using the Nelson and Siegel (1987) method. Specifically, for each observed cross-section of bond prices, for both taxable and tax-exempt bonds, we separately estimate the bond yield curve using the Nelson-Siegel term-structure model. That is, for constructing the taxable yield curve we use data for all taxable bonds, and for constructing the tax-exempt yield curve we use data for all tax-exempt bonds. This structural approach ensures that benchmark prices for taxable and tax-exempt bond prices are internally consistent and free of arbitrage opportunities.

Our choice of the Nelson and Siegel (1987) term-structure model is motivated by the extensive empirical literature on the approach, and its widespread use among both academics and practitioners (e.g, see Gürkaynak, Sack, and Wright (2007)).[24] However, there are other reasons for using the Nelson-Siegel factor structure for bond yields as well. First, the Nelson-Siegel term-structure model allows us to summarize the price information for a large number of taxable and tax-exempt bonds at each point in time, while at the same time minimizing the impact of any one single bond on the estimation results. This ensures that measurement error does not impact our estimates. Second, the Nelson-Siegel model is effectively a dynamic three-factor term-structure model (Diebold and Li (2006)), and is consistent with the extensive literature that has documented that nearly all bond price information can be summarized with just a few factors (Litterman, Scheinkman, and Weiss (1991) and Cochrane and Piazzesi (2005)). In addition, the parsimonious structure of the Nelson-Siegel model generates yields that are consistent with their empirical properties (i.e., forward rates are always positive, and the discount factor approaches zero as maturity increase). While using other term-structure models, with additional factors may improve the in-sample fit, it increases the risk that our term-structure model is misspecified. For instance Diebold and Li (2006) show that term-structure model with additional factors, require the estimation of a large number of coefficients, and this often renders the model unreliable for forecasting. A final reason to prefer the Nelson-Siegel term-structure model is that it does not require any assumptions about the dynamics of the underlying yield curve factors. That is, in estimating and using the Nelson-Siegel term-structure model, we do not need to take a view on the evolution of yields over our sample. Rather the model presents a parsimonious and intuitive description of bond yields at a given point in time, which is what

[24]The Federal Reserve Bank of New York uses Nelson and Siegel (1987) to provide yield curve estimates on its web-site at https://www.federalreserve.gov/.

we need to summarize the information in the cross-section of bonds prices and yields.[25]

In robustness tests, we confirm that our results hold regardless of the choice of term structure model by separately estimating the original Nelson and Siegel (1987), the Svensson (1994), the Diebold and Li (2006), and the Christensen, Diebold, and Rudebusch (2009) term structure models. There is no noticeable difference between the tax risk measure from the Nelson-Siegel method and that derived by using these alternate no-arbitrage term-structure models.[26]

To derive a tax risk measure, we use the yield curve backed out from a monthly cross-section of bond prices to price each taxable and tax-exempt bond. That is, we use the zero-coupon taxable yields to price each taxable bond, and the zero-coupon tax-exempt yield to price each tax-exempt bond in our sample. We refer to the prices computed using the zero-coupon yields as 'model-implied' prices. Thus, we assume that model-implied yields represent the fundamental value of taxable and tax-exempt bonds. Specification or estimation error could imply that model-implied values do not reflect fundamental values. However, our measure uses the relative differences in the market and fundamental prices of taxable and tax-exempt bonds, and the model-implied prices serve only as a way to express bond prices relative to a common benchmark. This means that as long as specification or estimation error does not systematically affect values for zero-coupon yields of just one of the categories of bonds (either taxable or tax-exempt), our approach should be fairly robust to estimation error. Equation (5) is our tax risk measure (TRM) and we express TRM in cents per $100 par value.

5.1 Tax risk before and after the federal income tax of 1913

Table 5 presents the summary statistics for TRM. Prior to 1913, average TRM equals approximately 137 (cents per $100 par value). This can be compared to the average bid-ask spread of just 2 cents (Table A4 in Appendix B) for all bonds over our entire sample period. Thus, TRM is much higher than the average bid-ask spread, which suggests that it does not simply capture the cost of transacting in bond markets. Post-1913, average TRM jumps to nearly 190. Average TRM peaks in 1914 at 220, in 1918 at

[25] Note that a dynamic version of the Nelson-–Siegel model is proposed by Diebold and Li (2006), in which a time-series model is suggested to account for the evolution of the level, slope and curvature factors over time.

[26] This finding is consistent with Nyholm and Vidova-Koleva (2012), Duffee (2011a), Duffee (2011b) and Joslin, Singleton, and Zhu (2011), who find that imposing no-arbitrage conditions has no statistically significant effect on the Nelson-Siegel coefficient estimates and that therefore the Nelson-Siegel model is compatible with the no-arbitrage constraints. In particular, Duffee (2011a) analyzes the incremental impact of imposing cross-sectional no-arbitrage constraints for forecasting bond yields, and finds these cross-sectional restrictions have no effect on the estimates from the term-structure model. The results from these studies lend confidence that our estimates for the tax risk measure are not driven by measurement error in our term-structure model because we use a large cross-section of taxable and tax-exempt bonds in each month.

207, and in 1919 at nearly 200. Given its sample standard deviation of about 30, these jumps represent large deviations from the mean. For example, the peak TRM of 220 in 1914 is a 3-standard deviation increase over its pre-1913 level.

The time-series variation in the tax risk measure is plotted in Figure 5. The most striking feature of this plot is the rich information contained in our measure of tax risk. Throughout 1910–1920, TRM peaks on days with significant news regarding tax policy (gray bars). TRM spikes in 1913 at approximately 172, right after federal income taxes are imposed. TRM peaks again in 1914, when the federal government revised tax rates to fund World War I, and then again in 1916, when the federal government again increased tax rates, introduced a federal estate, and levied an excess profits tax. TRM moved substantially in the latter half of the second decade in the 20^th century and remains at elevated levels, consistent with the number of tax law and policy changes enacted during this period, which increased risk about future tax policy. Thus, it seems that TRM serves as a good measure of investors' unease about future tax policy during this period.

Next, we compare how our tax-risk measure is related to other measures developed in the literature. In present day, several market based risk measures such as, the option market implied volatility index (Whaley (2000)) and the interest rate risk measure (Cremers, Fleckenstein, and Gandhi (2018)) are available to investors. Unlike today, there were not many economically motivated risk measures covering our sample period and this significantly limits our empirical analysis. Manela and Moreira (2017) propose a news-based risk measure (NVIX) that is calibrated to modern day's VIX based on the time period over which these two indices overlap. Manela and Moreira (2017) also develop subcomponents of this index that measure risk related to government, financial intermediation, natural disaster, securities markets, war, etc. In addition, the economic policy uncertainty (EPU) index proposed by Baker, Bloom, and Davis (2016) spans part of our sample period.

In Table 6 we report the correlation between tax risk and other risk measures, as well as several financial, and macroeconomic variables. Each column reports the result for a separate univariate regression. Panel A reports the contemporaneous correlations, while Panels B–E explore the lag-lead relationships at horizons of 6 and 12 months. In Panel A, the column titled 'NVIX' shows that the correlation between TRM and $NVIX$ is small but statistically significant (coefficient 0.0246, with t-statistic 2.67). The small magnitude is perhaps not entirely surprising as $NVIX$ captures risk related to several distinct components (listed above) and we do not expect to see that tax risk significantly relates to all of these distinct components. We next report the correlation coefficient of TRM with the individual components of $NVIX$. TRM is significantly correlated with risk associated with natural disasters (NAT) and war (WAR). The coefficient on these variables are 0.025 (significant at the 10% level) and 0.1240 (significant at the 1% level), respectively. Since governments may raise taxes to meet unexpected fiscal expenditure related to natural disasters or wars, the positive correlation between TRM and NAT and WAR is plausible. Further, while TRM is also positively correlated with risk associated with government policy (GOV), the coefficient on this variable is statistically significant only in Panels D and E, which suggests that TRM leads risk regarding future general government policy.

The next three columns report the correlation between TRM and measures of bond market liquidity. Specifically, we regress TRM on the spread between bid and ask prices of corporate bonds, and the Corwin and Schultz (2012) range-based and adjusted-range-based estimate for transaction costs. TRM is weakly positively correlated with bond market liquidity as the coefficient in these regressions is positive and statistically significant at the 10% level or better at almost all horizons. The positive correlation between TRM and measures of bond market liquidity may be driven by the fact that high tax risk may deter investors from investing in the bond markets which in turn could adversely impact bond market liquidity. Thus, the positive correlation between TRM and bond market liquidity serves as a partial validation of our measure. However, it also suggests that it is important to control for bond market liquidity in our asset pricing tests below.

TRM has no significant correlation with most financial variables such as the S&P 500 index returns (MKT), the returns on the 10-year bond issued by the U.S. Treasury ($BOND$), the yield to maturity on AAA bonds issued by U.S. firms ($CREDIT$), and the annualized realized volatility of the monthly returns on the S&P 500 index ($MKTVOL$). The only financial variable that is significantly correlated with TRM is the overnight call money rate – a proxy for the risk-free rate (RF). While the coefficient on RF is almost always positive, it is statistically significant only in Panels D and E at a horizon of 6 and 12 months, such that TRM positively correlates with future increases in the risk-free rate. Since our tax risk measure is based on the relative price deviation between market and fundamental prices of taxable and tax-exempt bonds, and since both types of bonds load in a similar manner on aggregate macroeconomic and financial factors, the low correlation between TRM and financial and economic variables is plausible.

We also examine the correlation between TRM and two macroeconomic variables - an index of industrial production (IP), and an index of consumer prices (CPI). The results indicate that TRM is positively correlated with both industrial production and inflation. In Panel A, the coefficient in a regression of TRM on IP is 0.21 with a t-statistics of 1.70, indicating that this correlation is marginally statistically significant. Similarly, the coefficient in a regression of TRM on CPI is 0.47 with a t-statistic of 2.32. The last column in Table 6 examines the correlation between TRM and the economic policy uncertainty (EPU) as measured by Baker, Bloom, and Davis (2016). We note that the correlation between TRM and EPU is always positive. In addition, while the coefficient is always statistically significant at conventional levels, it is economically small and its magnitude never exceeds 0.0021.

Overall, our tax risk measure is correlated with aggregate macroeconomic factors in an economically meaningful way. Specifically, the positive correlation between TRM, RF, IP, and CPI indicates that tax risk is pro-cyclical. The pro-cyclical nature of tax risk could be driven by the fact that in bad economic times governments usually enact changes to tax laws to reduce tax risk, to encourage investment, and to stabilize the economy. Such actions typically include tax cuts and rebates which could reduce tax risk for market participants.

Finally, Figure 6 plots the annual percentage change in our tax risk measure and the annual percentage change in the number of newspaper articles that include the word 'tax bill'.[27] Figure 6 shows that peaks and troughs in the tax risk measure coincide with the number of newspaper articles that reference tax law and policy. For example, both the tax risk measure and the number of articles peak in 1919, when the federal government passed the Revenue Act of 1919 that reduced income tax rates and repealed the war profits tax. In some instances, the market-implied tax risk measure appears to lead the number of newspaper articles that reference tax policy. For instance, TRM peaks in 1913, the year federal income taxes were imposed. While the number of newspaper articles also increases in 1913, it does not peak till 1914. Similarly, TRM peaks in 1916–1917, when the federal government passed a series of laws that increased tax rates, and imposed war profits and estate taxes. Again, the number of newspaper articles also increases over this period, but it does not peak until 1919. This suggests that TRM captures the market's forward-looking assessment of future tax risk, and may outperform measures based on textual analysis.

[27] The count for newspaper articles is collected from the digital back-file of the Wall Street Journal, which provides historical coverage of business and financial markets over 1910–1920.

5.2 Tax risk and cross-section of asset returns

In this section, we estimate whether tax risk is priced in the cross-section of bond and stock returns using the standard Fama-MacBeth procedure and a cross-section of 46 test assets. This approach has an important advantage for our application, in that we have only a rather moderate number of monthly observations, but we have a reasonably large number of asset returns in the pricing tests. Our test assets include 6 portfolios of corporate and government bonds, and 39 portfolios of industry and sector equity indices. Our choice of test assets is partially guided by Lewellen, Nagel, and Shanken (2010), who advocate using industry portfolios as testing assets.[28]

To implement Fama-MacBeth, we begin by estimating the following time-series regression over two-year rolling windows for each test asset j in our sample:

$$r_t^j = \widetilde{\beta}^{j,MKT} MKT_t + \widetilde{\beta}^{j,BOND} BOND_t + \widetilde{\beta}^{j,LIQ} LIQ_t + \widetilde{\beta}^{j,TRM} TRM_t + \epsilon_{j,t} \tag{6}$$

Here, $r^{j,t}$ is the realized excess return for testing asset j in month t, MKT_t is the market excess return, $BOND_t$ is the bond market excess return, LIQ_t is the cross-sectional average bid-ask average of bond prices, and TRM_t is the tax risk measure in month t. In robustness tests we use the liquidity measures based on Corwin and Schultz (2012) and find that the results are qualitatively similar to those obtained using the specification in Equation (6). In the second stage, we estimate the following cross-sectional regression for each month t in our sample:

$$E[r_{j,t}^e] = \beta^{j,MKT} \widetilde{\lambda}^{MKT} + \beta^{j,BOND} \widetilde{\lambda}^{BOND} + \beta^{j,LIQ} \widetilde{\lambda}^{LIQ} + \beta^{j,TRM} \widetilde{\lambda}^{TRM} \tag{7}$$

Here, $\beta^{j,MKT}$, $\beta^{j,BOND}$, $\beta^{j,LIQ}$ and $\beta^{j,TRM}$ are the estimated factor loadings for the excess return on the market, the excess return on the bond market, and tax risk measure for test asset j, respectively. The left-hand-side is the average realized return on test asset j over the two-year rolling window, ending at time t. The time-series average of λs in Equation (7) provides the risk premium associated with the equity, bond, liquidity, and tax risk factors, respectively and is denoted by $\widetilde{\lambda}^{MKT}$, $\widetilde{\lambda}^{BOND}$, $\widetilde{\lambda}^{LIQ}$ and $\widetilde{\lambda}^{TRM}$, respectively.

Results from the second-stage estimation are presented in Table 7 and 8. In Table 7 we use data for all

[28]Due to the 1910–1920 sample period, we cannot readily use standard size, momentum, and book-to-market equity portfolio returns.

46 stock and bond market test portfolios, whereas in Table 8 we just use data for the test assets from the stock markets. Rows 1, 3, 5 and 7 in the table report the risk premiums associated with the tax risk, the stock market, the bond market, and the liquidity factor. Each column presents the results for a different specification for the regressions in Equations (6-7). For example, in column (1) we present the results for the univariate regressions which include TRM as the only factor. Similarly, column (2) presents the results for regressions that include TRM and MKT as risk factors. The row below the coefficient estimates reports the $t-statistics$ based on standard errors corrected for heteroscedasticity, auto-correlation using Newey-West. The second row below the coefficients estimates reports the $t-statistics$ based on the Shanken (1992) correction.

One can see that the premium on tax risk is positive, and ranges from 1.21–2.43% per month and is statistically significant at the 10% level or better. Including additional risk factors such as the MKT, $BOND$, or LIQ does not affect the key conclusion that tax risk commands an economically and statistically significant positive risk premium. Table 7 also shows that the risk premium on the MKT and $BOND$ risk factors is 0.48% and 0.15% per month, respectively. However, the risk premium for $BOND$ does not remain statistically significant once we include the MKT, LIQ, and TRM in the regression specification (Column (7)).

These results are robust to a variety of changes in the empirical specification. For example, the premium for tax risk is positive and significant even if we change the length of the rolling windows over which equations (6) and (7) are estimated. When using 3-year rolling windows, the risk premium for TRM is 2.82% per month and is statistically significant at the 1% level with a t-statistic of 2.89.

Our results also obtain if our test assets include data from just the stock market. Table 8 presents the results from the second-stage Fama-MacBeth regression using only data for the 39 stock portfolios. This allows us to investigate if tax risk is priced differentially in stock and bond markets.[29] Table 8 indicates that the coefficient on TRM in all specifications ranges from 1.21%–2.17% per month, implying an annualized tax risk premium of 14.52–26.04%. Including additional risk factors also does not affect the statistical significance of TRM, which remains statistically significant at the 10% level or better in almost all specifications. The only exception is regression specification (6), when both $BOND$ and LIQ factors are included. In this case the coefficient on TRM is not statistically significant.

Thus, over 1910–1920, the risk premium for TRM is positive and equals 14.52% (annualized). The

[29] Due to the small number of bond portfolios (only 6) over 1910–1920, we are unable to carry out Fama-MacBeth regressions just using data for bond portfolios.

high value for tax risk premium in our sample period is consistent with the notion that the introduction of a federal income tax system induced substantial risk regarding tax policy among investors. The magnitude of the tax risk premium should also be interpreted in context of the frequent changes to marginal income tax rates, which increased rapidly from a maximum of 7% in 1913 to a maximum of 67% in 1918. In addition, our results can be compared to those in Longstaff (2011), who uses data for U.S. municipal bonds during the 21^{st} century, and shows that the risk premium for changes in marginal tax rates can be as high as 12.58% over a 1-year horizon (Table IV in Longstaff (2011)).

Evidence in the extant literature suggests that the premium for the expected level of taxes can be either positive or negative. For example, Longstaff (2011) shows that the premium for tax level risk is -1.9%, although it can vary from -27.10% to 12.60% at the 1-year horizon. Similarly, Sialm (2006) shows that the tax level risk premium can be difficult to sign in the context of a general equilibrium model. In Sialm (2006), the sign for the tax level risk premium is positive if changes in tax rates are uncorrelated with changes in economic or dividend growth rates.

We find that the premium for tax risk is positive which is consistent with our finding that TRM itself is pro-cyclical. As shown in Table 6, TRM increases (decreases) in good (bad) economic times, and is positively correlated with industrial production, risk-free rates, and inflation. The risk premium for TRM can also be positive if investors require a higher return for holding securities that are more sensitive to tax risk. This is because, ceteris paribus, investors in securities with higher exposure to tax risk will demand to be compensated for the higher volatility of the after-tax cash flows of such securities. In other words, investors demand a positive risk premium for securities more sensitive to TRM, because after-tax cash flows for these securities are more volatile (less certain), when TRM is high.

5.3 Tax risk mimicking portfolio

We construct and analyze the time-series properties of a traded portfolio that mimics our tax risk measure. This approach has several advantages and provides several new insights. First, this methodology allows us to construct and analyze the time-series properties of a market-implied tax risk measure over a much longer sample, and provides an out-of-sample robustness test for our tax risk measure. Second, this analysis allows us to provide contemporary evidence regarding the relevance of tax risk, avoiding the criticism that such uncertainty only concerned investors when taxes were first introduced in the U.S., and that tax risk does not matter for investors in modern times. Third, constructing the tax risk mimicking portfolio over an extended horizon allows us to investigate how such risk is priced in frequently used testing assets such as, equity portfolios sorted by size and book-to-market, and also allows us to control for the standard risk factors in our analysis.

To construct the mimicking portfolio, we begin by projecting TRM onto the space of traded returns. Specifically, we run the following regression using data just for 1910–1920:

$$TRM_t = a + b' \times [\mathbf{R}]_t + \epsilon_t \tag{8}$$

Here, $[\mathbf{R}]_t$ is the $T \times 46$ matrix of returns for the 46 test assets used in the previous section. We define a tax risk measure mimicking portfolio, TMP, as the fitted value of the regression in equation (8). We normalize the weights, b', to sum to one. Thus, the tax risk measure mimicking portfolio is given by:

$$TMP_t = \widetilde{b'} \times [\mathbf{R}]_t \tag{9}$$

We estimate $\widetilde{b'} = \frac{b'}{\sum b'}$ via ordinary least squares using data *only* for 1910–1920.[30] We then apply the weights, $\widetilde{b'}$ to the $[\mathbf{R}]_t$, the $T \times 46$ matrix of returns over 1930–2016 to obtain the tax risk measure mimicking portfolio over an extended horizon.

We analyze how TMP loads on the 46 test assets ($\widetilde{b'}$), and find no significant pattern in the positive and negative loadings positively of TMP on the set of test assets. For example, TMP loads negatively on the returns for the S&P 500 retail composite index, the S&P 500 automobiles composite index, but positively on the returns for the S&P 500 industrials composite index. There are also no significant differences in how the TMP loads on returns for stock or bond market indices.

Over 1910–1920, the correlation between our original TRM and the mimicking portfolio TMP is 0.37, indicating that the traded tax risk measure mimicking portfolio correlates positively with TRM, derived above. Since TMP is a traded portfolio with a stable composition that does not change over time, we can simply interpret the average return on this portfolio, computed over a long-horizon, as the expected return or the premium for tax risk. The average return for TMP is 0.14% per month or 1.70% annualized. The mean is statistically significant at the 1% level with a t-statistic of 6.42. The annualized standard deviation for TMP is 0.022, indicating that TMP has an annualized Sharpe ratio of 0.76, which is higher

[30]Note that a key assumption is that error ϵ_t in Equation (8) is orthogonal to the space of returns so that the covariance of any test asset with TRM is identical to its covariance with the TMP.

than the Sharpe ratio for the market at 0.45.

Figure 7 plots the time-series variation in our tax risk measure mimicking portfolio over the extended sample from 1921–2016. We plot the 24-month backward-looking average (months $t-24$ through t) of TMP. The units are monthly returns in percentages. The gray shaded regions represent years in which significant tax legislation was enacted by U.S. Congress.[31]

Figure 7 also suggests that our measure is able to pick-up tax risk even over the extended sample, which provides a good out-of-sample robustness test for our measure. In addition, the mimicking portfolio, TMP, increases around years in which significant tax legislation is enacted by Congress. On average, during years with significant tax legislation, TMP increases by 0.03% per month or 0.38% annualized, which represents nearly 25% of the value of its in-sample mean. The performance of the TMP in detecting tax risk over 1921–2016 is particularly impressive since the weights used to construct the TMP are constant and are based on data collected over 1910–1920.

We plot the backward-looking 24-month moving average, which explains why in some instances, TMP rises just after the start of the year in which major tax legislation is enacted. In addition, in some cases it is possible that investors' face increased uncertainty about future taxes before the actual passage of new tax legislation, as Congress debates the law, and as investors assess the likelihood of a new act being actually passed by Congress and being signed into law by the President. Finally, there could also be instances, where the actual passage of new tax legislation reduces investor uncertainty regarding tax laws. An example, could be the Economic Stimulus Act of 2008, passed by the Congress in January of that year, which was intended to boost the economy via tax cuts. TPM declines during this period, perhaps, in response to reduced investor anxiety and uncertainty over taxes.

Finally, we investigate whether the mimicking portfolio, TMP, is priced in the cross-section of asset returns. For our tests, we use the 100 portfolios sorted by size and book-to-value available from Kenneth French's.[32] Table 9 presents the results. Column (1) presents the results for the univariate regression and shows that even over the extended sample, the tax risk premium is positive, ranges from 0.19–0.32% per year, and is statistically significant. Including MKT as a risk factor does not affect the result, but including additional standard risk factors such as the SMB and HML lowers the statistical significance

[31] These include the tax legislation enacted in 1921, 1924, 1926, 1928, 1932, 1934–1936, 1940–1945, 1948, 1950–1951, 1954, 1962, 1968, 1969–1971, 1975–1978, 1981–1982, 1984, 1986, 1990, 1993, 1996–1998, 2001-2006, 2008, 2009–2010, and 2012. Dates for significant tax legislation over 1921–2016 are from the Tax Policy Center at the Brookings Institute, available at https://www.taxpolicycenter.org/laws-proposals/.

[32] See data available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

for the tax risk premium.

The magnitude for the tax risk premium over the extended sample is an order of magnitude smaller than over our original sample. However, recall that over 1910–1920, the years for which both TRM and TMP lap, the correlation between the two series is just 0.37. Thus, low correlation suggests that TMP is a noisy measure for tax risk, and can account for the low economic and statistical significance of the tax risk premium over the extended sample. Over the extended sample the magnitude of the tax risk premium should also be compared to that for the market risk premium (3.48%) over the same period. Thus, over 1930–2016, tax risk premium equals nearly 10% of the value for the market risk premium. In addition, over the original and extended sample, the adjusted R^2 in univariate regressions is approximately 10%, indicating that TRM consistently explains 10% of the variation in annual returns over both samples.

6 Conclusion

Unexpected changes in tax rates affect the after-tax cash flows of investors holding taxable assets. Despite this, little is known about how tax risk is priced in financial markets. In this paper we use a unique dataset of U.S. industrial firms that had issued both taxable and tax-exempt coupon debt. Investors in tax-exempt bonds were protected from federal taxes on the bonds' coupon cash flows since the firms, not the investors, paid income taxes on 'tax-exempt' bonds. Specifically, the issuer not only paid coupon interest in full to bondholders, but also paid the requisite taxes on such interest (computed at the withholding tax rates specified annually by the U.S. Treasury) to the federal government.

We study the relative pricing of these 'dual-class' bonds during the period from 1910 to 1920, a period during which investors faced federal income taxes for the first time, and develop a new, market-implied measure of tax risk (TRM). Our approach to measure tax risk as the relative price deviations of taxable and tax-exempt bonds from a no-arbitrage pricing model is motivated by the literature on the limits to arbitrage (Shleifer and Vishny (2012)) and has parallels to Hu, Pan, and Wang (2013). We find that tax risk is pro-cyclical and that it is priced in the cross-section of asset returns with a statistically and economically significant positive risk premium.

Although, we study a period from the early 20th century, our findings on the effect of tax risk on asset prices are important for several reasons. First, in 1913, the federal government imposed income taxes for the first time after taxes had been ruled unconstitutional in 1895 by the Supreme Court. This decade was accompanied by many frequent changes in taxes. The uncertainty associated with these changes increased tax risk substantially, making our sample ideal for teasing the effect of tax risk on asset prices. Second, our dataset allows us to compare yields of non-exempt and tax-exempt bonds while keeping fixed other factors that could impact bond prices. Specifically, we compare prices of otherwise virtually identical bonds, issued by the same firm, over the same time period of time, that differ only regarding their after-tax cash flows to investors. Finally, our are also important because they indicate that the impact of taxes on asset prices may substantially larger than previously documented and they also shed light on the competing views in the literature about the magnitude and the sign of the tax risk premium.

In sum, our evidence suggests that tax risk can significantly affect asset prices, consistent with theoretical models such as (Sialm (2006)), but explored little in empirical research. We see how such risk affects corporate investment decisions as a fruitful area for further research.

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CHICAGO BURLINGTON & QUINCY RR. CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Tarkio Valley RR. 1st M. 7s	J-D	June 1 1920	$25,000
Nodaway Valley RR. 1st M. 7s	J-D	June 1 1920	22,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
General mortgage 4s ($300,000,000)	M-S	Mar. 1 1958	$61,000,000
Illinois Division 1st 3½s & 4s($85,000,000)	J-J	July 1 1949	84,427,000
Iowa Division 4s and 5s	A-O	Oct. 1 1919	7,666,000
Southwestern Division 4s	M-S	Sept. 1 1921	482,000
Denver Extension 4s	F-A	Feb. 1 1922	1,779,300
Nebraska Extension mortgage 4s	M-N	May 1 1927	22,196,000
Burl. & Mo. River RR. in Neb. Cons. 6s	J-J	July 1 1918	2,784,000
Republican Valley RR. 1st mtge. 6s	J-J	July 1 1919	119,000

CHICAGO & NORTH WESTERN RY. CO.

Issued **with** *Tax Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Gen. mtge. 3½s and 4s ($165,000,000)	M-N	Nov. 1 1987	$53,327,000
Milw. Sparta & N. W. Ry. 1st mtge. 4s	M-S	Mar. 1 1947	15,000,000
Des Plaines Valley Ry. 1st mtge. 4½s	M-S	Mar. 1 1947	2,500,000
St. Paul & East. Gr. Trk. Ry. 1st M. 4½s	J-J	Jan. 1 1947	1,120,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Consol. sinking fund mtge 7s	Q-Feb	Feb. 1 1915	$12,832,000
Extension 4s of 1886 ($20,000,000)	F-A15	Aug. 15 1926	17,670,000
Sinking fund 6% and 5% bonds of 1879	A-O	Oct. 1 1929	11,234,000
30-year debenture 5s	A-O15	Apr.15 1921	9,819,000
Sinking fund debenture 5s of 1933	M-N	May 1 1933	9,695,000
Equipment trust 4½s, Series A	J-J	To July 1 1922	2,700,000
Equipment trust 4½s, Series B	A-O	To Oct. 1 1922	2,700,000
Equipment trust 4½s, Series C	J-J	To July 1 1923	4,000,000
Mil. Lake Sh. & West. Ry. consol. 1st 6s	M-N	May 1 1921	5,000,000
Mich. Div. 1st 6s ($3,000,000)	J-J	July 1 1924	1,281,000
Ashland Div. 1st 6s	M-S	Mar. 1 1925	1,000,000
Exten. and impt. mtge. 5s ($5,000,000)	F-A	Feb. 1 1929	4,148,000
Marshfield Extension 1st 5s	A-O	Oct. 1 1922	400,000
Cedar Rap. & Mo. Riv. 3d Div. 1st M. 7s	M-N	May 1 1916	2,332,000
North Western Union Ry 1st mtge. 7s	M-S	June 1 1917	3,365,000
Winona & St. Peter 1st mtge. extens. 7s	J-D	Dec. 1 1916	4,038,500
Milwaukee & State Line 1st mtge. 3½s	J-J	Jan. 1 1941	2,500,000
Boyer Valley Ry. 1st mtge. 3½s	J-D	Dec. 1 1923	1,440,000
Minn. & Iowa Ry. 1st mtge. 3½s	J-D	June 1 1924	1,901,000
Princet. & N. W. Ry. 1st 3½s ($2,100,000)	J-J	Jan. 1 1926	1,910,000
Peoria & Northw. Ry. 1st 3½s	M-S	Mar. 1 1926	2,125,000
Sioux City Pac. RR. 1st 3½s ($4,000,000)	F-A	Aug. 1 1936	3,926,000
Minn. & So. Dak. Ry. 1st mtge. 3½s	J-J	Jan. 1 1935	528,000
Iowa Minn. & Northw. Ry. 1st mtge. 3½s	J-J	Jan. 1 1935	3,900,000
Manitowoc Green B. & N. W. 1st 3½s	J-J	Jan. 1 1941	3,750,000
Fremont Elkhorn & Mo. Valley cons. 6s	A-O	Oct. 1 1933	7,725,000
St. L. Peo.&N.W. Ry. 1st 5s($10,000,000)	J-J	July 1 1948	None
Mankato & New Ulm Ry. 1st M. 3½s	A-O	Oct. 1 1929	In skg. fd.

CHICAGO ST. PAUL MINNEAPOLIS & OMAHA RAILWAY CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Debenture 5s ($15,000,000)	M-S	Mar. 1 1930	$7,500,000

Issued **without** *reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Consol. M. 6s & 3½s ($30,000,000)	J-D	June 1 1930	$20,580,000
Chic. St. Paul & Minn. 1st M. 6s	M-N	May 1 1918	962,000
North Wisconsin Ry. 1st M. 6s	J-J	Jan. 1 1930	585,000
Superior Short Line Ry. 1st M. 5s	M-S	June 1 1930	1,500,000
St. Paul & Sioux City RR. 1st M. 6s	A-O	Apr. 1 1919	6,070,000
Sault Ste. Marie & Southwestern 1st M. 5s	M-N	Nov. 1 1915	350,000

DENVER & RIO GRANDE RAILROAD CO. AND SUBSIDIARY AND ALLIED COMPANIES.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Denver & Rio Grande RR.—			
1st consol. M. 4s & 4½s ($42,000,000)	J-J	Jan. 1 1936	$40,507,000
Improvement mortgage 5s	J-D	June 1 1928	8,335,000
First & ref. M. 5s ($150,000,000)	F-A	Aug. 1 1955	33,788,000
Cum. 7% adj. income M. ($25,000,000)	A-O	Apr. 1 1932	10,000,000
Equipment gold bonds, Series "B" (5%)	M-S	To Sept. 1917	600,000
Rio Grande Western Ry. 1st cons. M. 4s	A-O	Apr. 1 1919	15,080,000
Utah Central RR. 1st M. 4s	A-O	Jan. 1 1917	390,000
Rio Grande Jct. Ry. 1st M. 5s	J-D	Dec. 1 1939	2,000,000
Rio Grande Sou. RR. 1st M. 4s	J-J	July 1 1940	4,510,000
Western Pac. Ry. 1st M. 5s ($50,000,000)	M-S	Sept. 1 1933	49,925,000
Salt Lake City Union Depot & RR. 1st M. 30-year 5s ($1,500,000)	M-N	Nov. 1 1938	1,100,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Rio Grande Western 1st trust M. 4s	J-J	July 1 1939	$15,190,000
Utah Fuel Co. 1st M. sinking fund 5s	M-S	Mar. 1 1931	540,000
Pleasant Valley Coal 1st M. sk. fd. 5s	J-J	July 1 1928	959,000

GREAT NORTHERN RAILWAY CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
First and refunding 4¼s ($600,000,000)	J-J	July 1 1961	$35,000,000
Spokane Falls & Northern Ry. 1st 6s	J-J	July 1 1939	229,000
Gt. Nor.-Nor. Pac. C.B.&Q. coll. joint 4s	J-J	July 1 1921	107,613,500

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
St. P. M. & M. Ry.-Montana Ext. 1st 4s	J-D	June 1 1937	$10,185,000
Pacific Extension 1st 4s (£6,000,000)	J-J	July 1 1940	16,000,000
Consol. 4s, 4½s & 6s ($50,000,000)	J-J	July 1 1933	43,001,000
Minneapolis Union Ry. 1st 5s & 6s	J-J	July 1 1922	2,800,000
Eastern Ry. Co. of Minnesota-Nor. Div. 1st 4s ($9,700,000)	A-O	Apr. 1 1948	9,695,000
Montana Central Ry. 1st 5s & 6s	J-J	July 1 1937	10,000,000
Willmar & Sioux Falls Ry. 1st 5s	J-D	June 1 1938	3,625,000

LOUISVILLE & NASHVILLE RAILROAD CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
New Orl. & Mobile Div. 2d M. 6s	J-J	Jan. 1 1930	$1,000,000
Unified mortgage 4s ($75,000,000)	J-J	July 1 1940	61,871,000
Newport & Cincinnati Bridge Co. gen. 4½s	J-J	July 1 1945	1,400,000
L. & N.-Sou. Ry. (Monon) coll. joint 4s ($7,750,000)	J-J	July 1 1952	5,882,000
Pensacola & Atl. RR. 1st mtge. 6s	F-A	Aug. 1 1921	1,782,000
S. & N. Ala. RR. consol. 5s ($10,000,000)	F-A	Aug. 1 1936	7,292,000
Pad. & Memphis Div. 1st 4s ($5,000,000)	F-A	Feb. 1 1946	4,619,000
Henderson Bridge Co. 1st mtge. 6s	M-S	Sept. 1 1931	1,007,000
Southeastern & St. L. Div. 1st M. 6s	M-S	Mar. 1 1921	3,500,000
2d mortgage 3s	M-S	Mar. 1 1980	2,998,000
Mob. & Mont. Ry. 1st M. 4½s($5,000,000)	M-S	Sept. 1 1945	4,000,000
St. Louis property 1st mtge. 5s	M-S	Mar. 1 1916	617,000
Atlanta Knox. & Nor. Ry. 1st 5s	J-D	Dec. 1 1946	999,000
Atl. Knox. & Nor. Ry. 1st consol. 4s	M-S	Mar. 1 2002	500,000
Lou. Cinc. & Lex. Ry. gen. 4½s	M-N	Nov. 1 1931	3,258,000
First mortgage 5s	M-N	May 1 1937	1,749,000
Atl. Knox. & Cinc. Div. 4s ($50,000,000)	M-N	May 1 1955	24,745,000
General mortgage 6s	J-D	June 1 1930	4,136,000
Evansville Hend. & Nash. Div. 1st 6s	J-D	Dec. 1 1919	860,000
L. & N. Term. Co. 1st 4s ($3,000,000)	J-D	Dec. 1 1952	2,500,000
L. & N. equip. trust, Series A, 5s	J-D	To J'ne '23	6,500,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
New Orl. & Mobile Div. 1st M. 6s	J-J	Jan. 1 1930	$4,993,000
Kentucky Cent. Ry. 1st M. 4s($7,000,000)	J-J	July 1 1987	6,704,000
Nashv. Flor. & Sheffield Ry. 1st 5s	F-A	Aug. 1 1937	1,996,000
Lexington & Eastern Ry. gen. M. 5s	F-A	Feb. 1 1935	32,000
Pensacola Div. 1st mortgage 6s	M-S	Mar. 1 1920	225,000
First mtge. trust collateral 5s ($7,000,000)	M-N	Nov. 1 1931	4,705,000

MISSOURI PACIFIC RAILWAY CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Pacific RR. of Missouri—			
St. Louis real estate security mtge. 5s	M-N	May 1 1938	$800,000
Second mortgage 5s	J-J	July 1 1938	2,573,000
Kansas & Col. Pacific Ry. 1st ref. 6s	F-A	Feb. 1 1938	3,972,000
Central Branch Un. Pac. Ry. 1st M. 4s	J-D	Jan. 1 1948	2,500,000
Central Branch Ry. 1st mtge. 4s	F-A	Feb. 1 1919	3,459,000
Mo. Pac. Ry. 40-yr. gold loan 4s	M-S	Mar. 1 1945	37,255,000
1st & ref. M. conv. 5s, ser. A ($150,000,000)	M-S	Sept. 1 1959	29,806,000
3-year 5% secured gold notes	J-D	June 1 1914	24,976,000
Equipment trust bonds, ser. 1, 5s	M-N	To May 1917	1,340,000
Equipment trust notes, ser. 2, 5s	M-N	To Nov. 1921	2,352,000
Boonville St. Louis & Southern 1st 5s	F-A	Aug. 1 1951	500,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Pacific RR. of Missouri 1st M. 4s	F-A	Aug. 1 1938	$6,996,000
Carondelet Branch 1st M. 4½s	A-O	Oct. 1 1938	237,500
Missouri Pacific Ry. third mtge. 4s	J-J	July 1 1938	3,828,000
Lexington Div. 1st mtge. 5s	F-A	Aug. 1 1920	650,000
Consol. first mtge. 6s ($30,000,000)	M-N	Nov. 1 1920	14,904,000
Leroy & Caney Val. Air Line RR. 1st 5s	J-J	July 1 1926	520,000
Verdigris Val. Ind. & W. RR. 1st 5s	M-S	Mar. 1 1926	806,000
Kan. City & N. W. RR. 1st M. 5s, ser. A	J-J	Jan. 1 1933	1,024,000
Missouri Pacific Ry. trust 5s	J-J	Jan. 1 1917	14,375,000
First collateral mtge. 5s ($10,000,000)	F-A	Aug. 1 1920	9,636,000

ST. LOUIS IRON MOUNTAIN & SOUTHERN RAILWAY CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Unify. & refdg. mtge. 4s ($40,000,000)	J-J	July 1 1929	$30,551,000
River & Gulf Divs. 1st M. 4s($50,000,000)	M-N	May 1 1933	34,548,000
First & ref. mtge., ser. A ($200,000,000)	J-J	July 1 1952	None.
Equipment gold bonds, Series 1, 5s	In Mch.	To June 1917	1,464,000
do do do Series 2, 5s	M-N	To Nov. 1921	2,320,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Gen. cons. ry. & land grant 5s($15,000,000)	A-O	Apr. 1 1931	$43,200,000
Little Rock Junction 1st cons. 6s	A-O	Apr. 1 1916	435,000

NEW YORK CENTRAL & HUDSON RIVER RAILROAD CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Refunding mortgage 3½s ($100,000,000)	J-J	July 1 1997	$94,000,000
Lake Shore collateral 3½s	F-A	Feb. 1 1998	90,578,400
Michigan Central collateral 3½s	F-A	Feb. 1 1998	19,336,000
30-yr. debenture 4s of 1912 ($50,000,000)	J-J	Jan. 1 1942	9,188,000
30-yr. debenture 4s of 1904 ($50,000,000)	M-N	May 1 1934	48,000,000
Mtge. on Spuyten Duyvil & Port Morris RR. 1st 3½s ($20,000,000)	J-D	June 1 1959	2,500,000
N. Y. & Harlem RR. ref. (now 1st) 3½s	M-N	May 1 2000	12,000,000
Mohawk & Malone Ry. 1st 4s	M-S	Sept. 1 1991	2,500,000
Consolidated mortgage 3½s	M-S	Mar. 1 2002	3,900,000
N. Y. & Putnam RR. 1st cons. 4s	A-O	Oct. 1 1993	3,987,000
Carthage & Adir. Ry. 1st M. 4s	J-D	Dec. 1 1981	1,100,000
Carth. Wat. & Sack. Har. RR. 1st M. 5s	J-J	July 1 1931	300,000
Beech Creek RR. 1st mortgage 4s	J-J	July 1 1936	5,000,000
Second mortgage 5s	J-J	July 1 1936	1,000,000
B'ch Cr'k Ext. RR. 1st 3½s ($4,500,000)	A-O	Apr. 1 1951	3,500,000
St. Lawrence & Adirondack Ry. 1st 5s	J-J	July 1 1996	800,000
Second mortgage 6s	A-O	Oct. 1 1996	400,000
Little Falls & Dolgeville RR. 1st 3s	J-J	July 1 1932	250,000
Pine Creek Ry. 1st M. 6s	J-D	Dec. 1 1932	3,500,000
Clearf. Bit. C'l Corp. M. 4½s($5,000,000)	M-N	Nov. 1 1932	2,500,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
N. Y. C. & H. RR. 3-yr. 4½% notes	M-S	Mar. 1 1914	$30,000,000
3-year 4½% notes ($30,000,000)	M-N	May 1 1915	20,000,000
Joint equip. trusts (B. & A.) 4½s of 1912 (due $348,000 annually)	A-O	To Oct. 1927	4,872,000
New York Central Lines—			
Joint eq. tr. 5s of '07(due$2,000,000an.)	M-N	To Nov. 1922	18,000,000
4½s, '10(due$2,000,000an.)	J-J	To Jan. 1925	24,000,000
4½s, '12(due$1,000,000an.)	J-J	To Jan. 1927	14,000,000
4½s, '13(due $836,000 an.)	J-J	To Jan. 1928	12,540,000
Rome. Wat.&Ogd.RR.1st cons.5s,4s&3½s	A-O	July 1 1922	9,995,000
Oswego RR. Bridge Co. 1st mtge. 6s	F-A	Feb. 1 1915	100,000
Oswego & Rome RR. 1st mtge. 7s	M-N	May 1 1915	350,000
Second mortgage 5s	F-A	May 1 1915	400,000
Utica & Black Riv. RR. 1st 4s	J-J	July 1 1922	1,950,000
Rome Wat. & Ogd. Term. RR. 1st 5s	M-N	May 1 1918	375,000
West Shore RR. 1st mtge. 4s	J-J	Jan. 1 2361	50,000,000
Syracuse Pheonix & Oswego RR. 1st 6s	F-A	Feb. 1 1915	175,000
Norwood & Montreal RR. 1st 5s	A-O	Apr. 1 1916	130,000
N. Y. & Northern RR. 1st 5s	A-O	Oct. 1 1927	1,200,000
Gouverneur & Oswegatchie RR. 1st 5s	J-D	June 1 1942	300,000
New Jersey Jct. RR. 1st 4s ($4,000,000)	F-A	Feb. 1 1986	1,700,000
Western Transit Co. ext. mtge. 3½s	F-A	Feb. 1 1923	1,500,000

NORTHERN PACIFIC RAILWAY CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstand'g.
Prior lien&land gr.4s($130,000,000)	Quar. Jan.1	Jan. 1 1997	$109,055,500
General lien 3s ($190,000,000)	Quar. Feb.1	Jan. 1 2047	60,000,000
St. P.-Dul. Div. pur. money 4s($20,000,000)	J-D	Dec. 1 1996	8,080,000
St. P. & Nor. Pac. Ry. gen. M. & land gr. 6s	F-A	Feb. 1 1923	7,887,000
Washington Central Ry. 1st M. 4s	Quar. Mar. 1	Mar. 1 1948	1,853,000

Issued **without** *reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
St. Paul & Dul. RR. Co. 1st mgte. 5s	F-A	Aug. 1 1931	1,000,000
Second mortgage 5s	A-O	Oct. 1 1917	2,000,000
1st consol. mtge. 4s ($5,000,000)	J-D	June 1 1968	1,000,000
Duluth Short Line Ry. Co. 1st M. 5s	M-S	Sept. 1 1916	500,000
Northern Pacific 1-year gold 6% notes	J-J	July 9 1914	10,000,000

RUTLAND RAILROAD CO.

Issued **with** *Tax-Exemption Clause.*

	Int.	Maturity Date.	Outstanding
Rutland Canadian RR. 1st Mtge. 4s	J-J	July 1 1949	$1,350,000
Bennington & Rutland 1st Mtge. 4½s	M-N	Nov. 1 1927	500,000
Second mortgage 5s	M-S	Mar. 1 1920	500,000
Ogdensburg & Lake Champ. Ry. 1st M. 4s	J-J	July 1 1948	4,400,000
Ogdensburg Terminal Co. 1st Mtg. 5s	J-J	To July 1925	100,000
Rutland RR. Equip. Trust 4½s of 1901	M-N	To Nov. 1916	59,000
Equipment Trust 4½s of 1902	A-O	To Oct. 1917	261,000

Issued **without** *Reference to Taxes.*

	Int.	Maturity Date.	Outstand'g.
Rutland RR. 1st Consol. 4½s ($3,500,000)	J-J	July 1 1941	$3,494,000
Equipment Trust 4½s of 1912	M-N	To May 1927	476,000
do do 4½s of 1913	A-O	To April 1928	210,000

Figure 1. List of taxable and tax-exempt bonds issued by U.S. firms.

Notes: This figure provides a typical example of a list published by the Commercial and Financial Chronicle over November 1913 - April 1914, identifying which bonds issued by U.S. firms did or did not contain the tax-exempt clause.

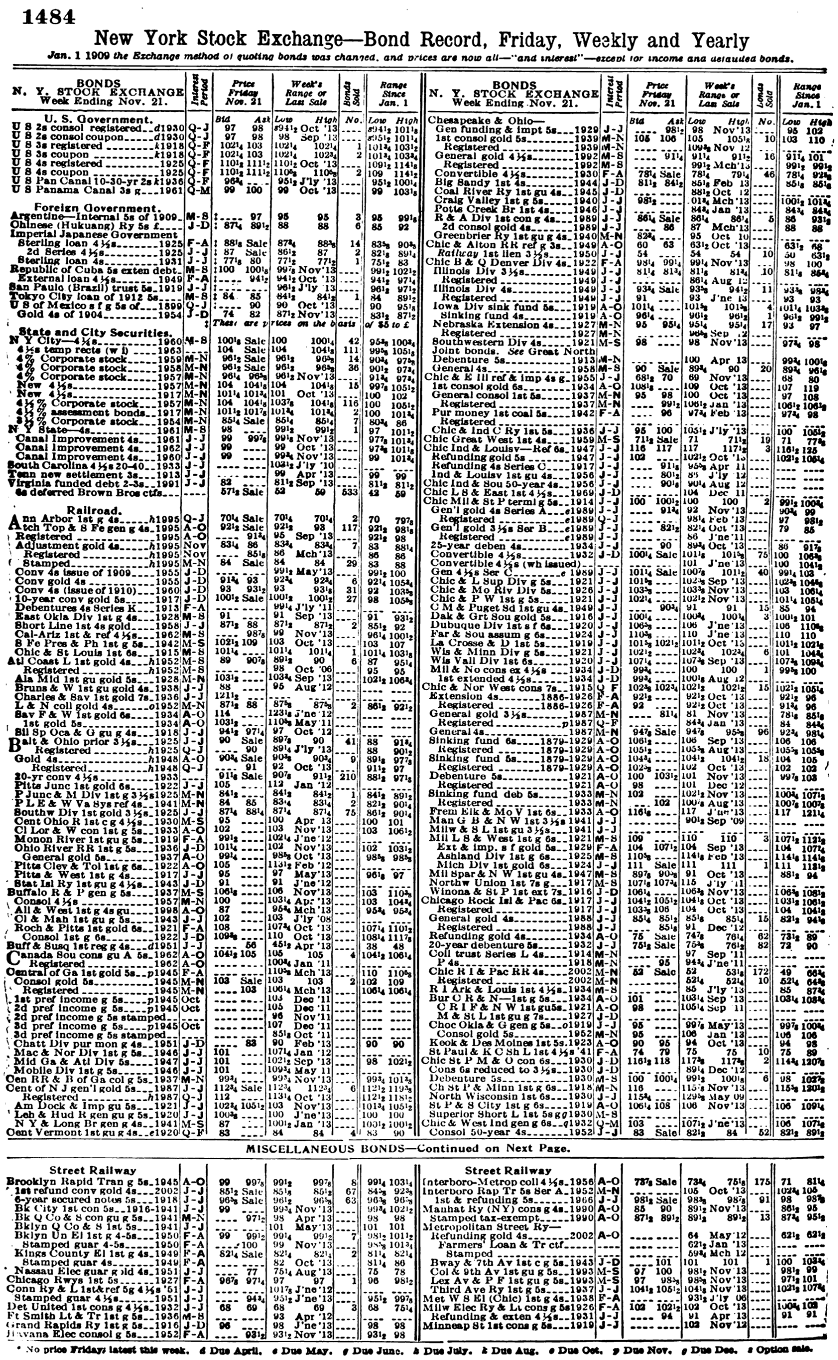

Figure 2. Table with prices and quotations for bonds issued by U.S. firms.

Notes: This figure provides a typical example of a table published in the Commercial and Financial Chronicle with prices and quotations for bonds issued by U.S. firms.

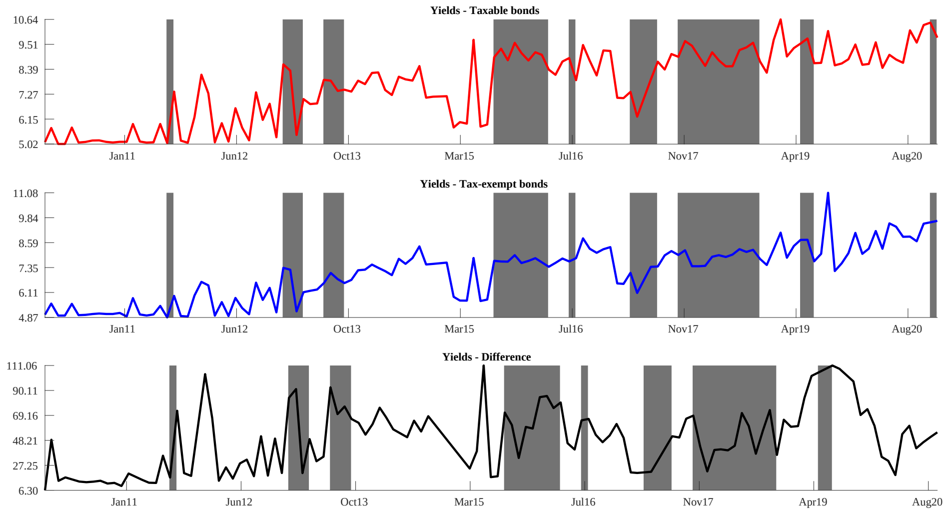

Figure 3. Time-series for yields for taxable and tax-exempt bonds.

Notes: This figure presents the yields for taxable and tax-exempt bonds. In each month, we compute the average yield, separately, for all taxable and tax-exempt bonds pooled across all maturities and all firms. The top panel plots the yields for taxable bonds, the middle panel plots the yields for tax-exempt bonds, and the bottom panel plots the yield difference, i.e. yields on taxable bonds in excess of yields on tax-exempt bonds. In each panel, the gray bars represent dates when significant news regarding federal income tax law or its implementation is published in the editorial section of the Commercial and Financial Chronicle over 1910–1920. The dates are: August 1911 (Wisconsin imposes state tax and New York ratifies 16^{th} amendment); December 1912–March 1913 (16^{th} amendment is ratified) June 1913–September 1913 (Revenue Act of 1913 is signed into law); July 1915–March 1916 (In Brushaber v/s Union Pacific Railroad U.S. Supreme Court upholds federal income taxes); October 1917–October 1918 (U.S. enters World War I and raises taxes to fund the war); and June 1919–July 1919 (federal government prohibits sale of alcohol and signs the World War I Armistice. Data are monthly from January 1910 to December 1920.

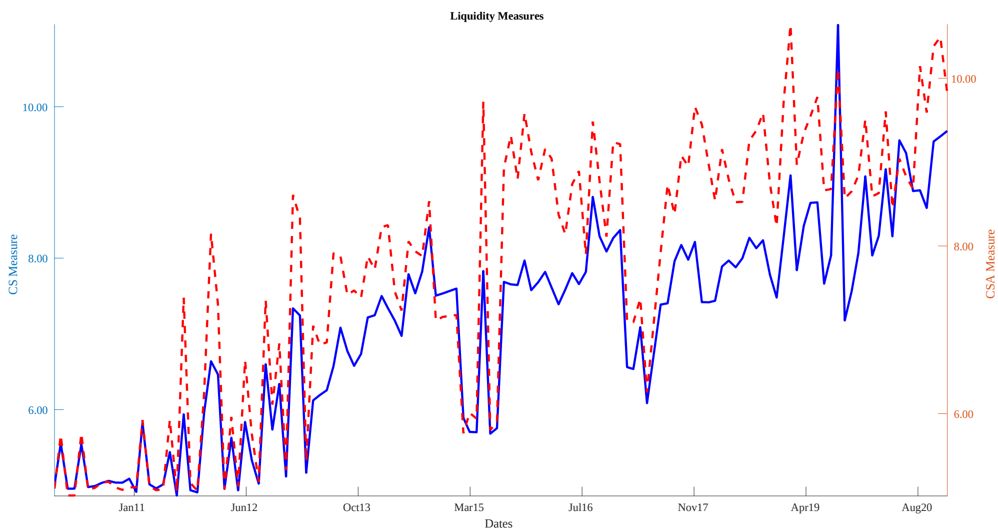

Figure 4. Time-series for bond liquidity measures.

Notes: This figure presents the Corwin and Schultz (2012) range-based (CS) and adjusted range-based (CSA) estimator for bond market liquidity (transaction costs). The blue solid line plots the CS estimator and the red dashed line plots the CSA estimator. The left and right axis reference the CS and CSA estimator, respectively. In each month, we first compute the CS and CSA estimator for each bond. We then compute the cross-sectional average of the CS and CSA estimator, by pooling data across all firms. At the firm level, data is winsorized at the 5^{th} and 95^{th} percentile levels. Months in which we have less than 50 observations to compute the cross-sectional average are excluded. We plot the time-series of the cross-sectional average CS and CSA estimator for bond market liquidity or transaction costs. Data are monthly from 1910 to December 1920.

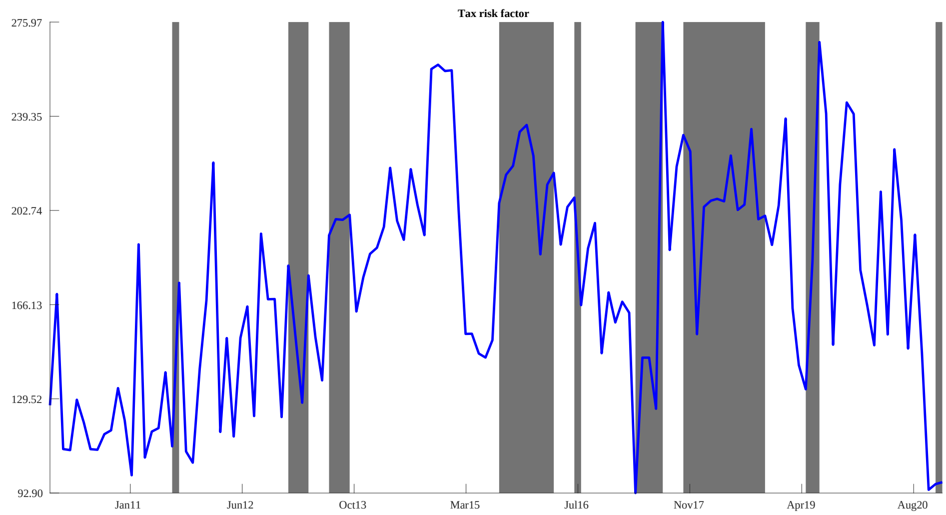

Figure 5. Time-series for the tax risk measure.

Notes: This figure presents the time-series plot for the tax risk measure. Tax risk measure equals the natural logarithm of the deviation between market and fundamental prices for taxable and tax-exempt bonds. Fundamental prices for each type of bond are computed using the no-arbitrage Nelson-Siegel term structure model. In the figure, gray bars represent dates when significant news regarding federal income tax law or its implementation is published in the editorial section of the Commercial and Financial Chronicle over 1910–1920. The dates are: August 1911 (Wisconsin imposes state tax and New York ratifies 16^{th} amendment); December 1912–March 1913 (16^{th} amendment is ratified) June 1913–September 1913 (Revenue Act of 1913 is signed into law); July 1915–March 1916 (In Brushaber v/s Union Pacific Railroad U.S. Supreme Court upholds federal income taxes); October 1917–October 1918 (U.S. enters World War I and raises taxes to fund the war); and June 1919–July 1919 (federal government prohibits sale of alcohol and signs the World War I Armistice). Data are monthly from January 1910 to December 1920.

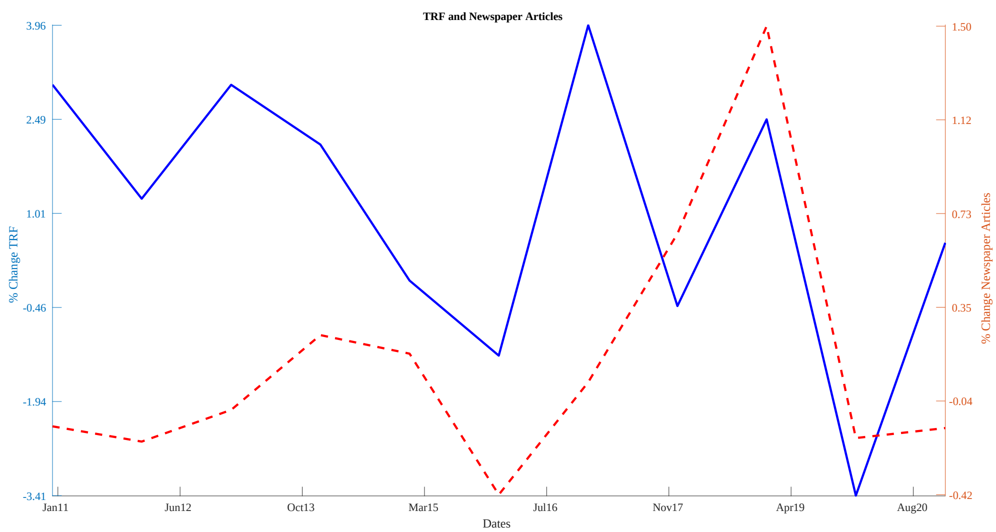

Figure 6. Tax risk measure and newspaper articles on tax law and policy.

Notes: This figure presents the annual percentage chance in the tax risk measure along with the annual percentage change in the number of newspaper articles that include the word 'tax and bill'. The blue solid line plots TRM and the red dashed line plots the newspaper articles. The left and right axis reference TRM and newspaper articles estimator, respectively. Newspaper articles are collected from the digital back-file of the Wall Street Journal. Tax risk measure equals the natural logarithm of the deviation between market and fundamental prices for taxable and tax-exempt bonds. Fundamental prices for each type of bond are computed use the no-arbitrage Nelson-Siegel term structure model. Taxable bonds are bonds issued by U.S. corporations without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by U.S. corporations with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Data is annual, January 1910 to December 1920.

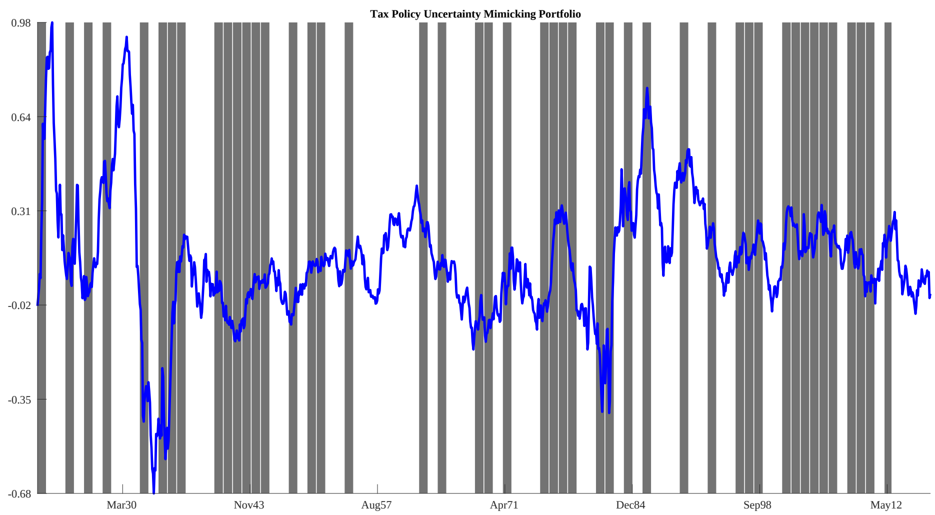

Figure 7. Tax risk measure mimicking portfolio.

Notes: This figure presents the 24-month (backward-looking) moving average (months $t-24$ through t) of the time-series of the tax risk measure mimicking portfolio. The tax risk measure mimicking portfolio is the linear combination of the returns on the 46 test assets listed in Table A5. The weights for the linear combination are given by the coefficients estimated using ordinary least squares of the TRM on the 46 test assets over 1910–1920, and normalized so as to sum to one. The gray-shaded regions represent years in which significant tax legislation was enacted by the U.S. Congress. These include the tax legislation enacted in 1921, 1924, 1926, 1928, 1932, 1934–1936, 1940–1945, 1948, 1950–1951, 1954, 1962, 1968, 1969–1971, 1975–1978, 1981–1982, 1984, 1986, 1990, 1993, 1996–1998, 2001-2006, 2008, 2009–2010, and 2012. Dates for significant tax legislation over 1921–2016 are from the Tax Policy Center at the Brookings Institute, available at https://www.taxpolicycenter.org/laws-proposals/. Data is monthly, January 1910 to December 2016.

Table 1. Summary statistics for characteristics of taxable and tax-exempt bonds.

Notes: This table reports summary statistics of characteristics of taxable and tax-exempt bonds pooled across all firms. The columns titled Coupon and Time to Maturity show summary statistics for coupon rates and time to maturity as of the beginning of the sample, respectively. Taxable bonds are bonds issued by firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. N denotes the number of bond issues. Data are monthly for January 1910.

		Coupon							Time to Maturity						
Tax status	N	Mean	σ	Min	25^{th}	Med	75^{th}	Max	Mean	SD	Min	25^{th}	Med	75^{th}	Max
Taxable	1,035	4.96	0.77	3.00	4.50	5.00	5.00	7.00	19.74	13.57	2.96	10.06	16.57	27.56	87.67
Tax-exempt	2,602	4.85	0.63	3.00	4.50	5.00	5.00	10.00	25.77	16.71	1.20	12.51	23.17	35.34	99.69
All	3,637	4.88	0.68	3.00	4.50	5.00	5.00	10.00	24.05	16.11	1.20	11.44	21.31	32.63	99.69

Table 2. Summary statistics for prices and yields of taxable and tax-exempt bonds.

Notes: This table reports summary statistics for prices and yields for taxable and tax-exempt bonds pooled across all firms. The columns titled Price and Yields show summary statistics for prices and yields, respectively. In each month, we compute the average price and yields, separately, for all taxable and tax-exempt bonds. We then compute and report the summary statistics for the time-series of average prices and yields for both taxable and tax-exempt bonds. Panel A reports the summary statistics for the full sample, Panel B for the period before federal income taxes, and Panel C for the period after federal income tax. Taxable bonds are bonds issued by firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. N denotes the number of observations. Data are monthly from January 1910 to December 1920.

		Price							Yields						
Tax status	N	Mean	σ	Min	25^{th}	Med	75^{th}	Max	Mean	SD	Min	25^{th}	Med	75^{th}	Max
Panel A: Full Sample, 1910–1920															
Taxable	73,938	89.60	18.11	50.06	82.50	95.06	101.00	142.88	7.17	5.26	0.00	4.60	5.46	7.45	50.00
Tax-exempt	198,575	90.04	17.14	50.06	83.25	95.06	100.50	147.63	6.51	4.05	0.00	4.62	5.33	6.87	49.97
All	272,513	89.92	17.41	50.06	83.00	95.06	100.50	147.63	6.69	4.42	0.00	4.62	5.36	7.00	50.00
Panel B: Pre-Tariff Bill, 1910–1913															
Taxable	31,524	96.88	14.66	50.13	94.00	99.50	105.00	142.88	5.62	3.23	0.00	4.25	4.95	5.90	49.55
Tax-exempt	80,155	96.80	13.91	50.06	93.75	99.38	103.88	147.63	5.37	2.41	0.00	4.27	4.99	5.63	49.76
All	111,679	96.83	14.13	50.06	94.00	99.50	104.00	147.63	5.44	2.67	0.00	4.27	4.98	5.71	49.76
Panel C: Post-Tariff Bill, 1913–1920															
Taxable	42,414	84.18	18.52	50.06	72.00	90.50	98.88	134.94	8.33	6.12	0.00	5.00	6.12	9.41	50.00
Tax-exempt	118,420	85.47	17.61	50.06	75.00	91.44	98.81	135.75	7.29	4.70	0.00	4.95	5.81	7.97	49.97
All	160,834	85.13	17.86	50.06	74.00	91.00	98.88	135.75	7.56	5.13	0.00	4.96	5.88	8.24	50.00

Table 3. Summary statistics for differences in prices and yields of taxable and tax-exempt bonds.

Notes: This table reports summary statistics for the first difference in prices and yields for taxable and tax-exempt bonds (i.e., taxable - tax-exempt) pooled across all firms. The columns titled Price and Yields show summary statistics for prices and yields, respectively. In each month, we compute the average price and yields, separately, for all taxable and tax-exempt bonds. We then compute and report the summary statistics for the time-series of average prices and yields for both taxable and tax-exempt bonds. Panel A reports the summary statistics for the full sample, Panel B for the period before federal income taxes, and Panel C for the period after federal income tax. Taxable bonds are bonds issued by firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. N denotes the number of observations. Data are monthly from January 1910 to December 1920.

Price							Yields						
Mean	σ	Min	25^{th}	Med	75^{th}	Max	Mean	SD	Min	25^{th}	Med	75^{th}	Max
Panel A: Full Sample, 1910–1920													
-1.00	1.96	-5.89	-2.36	-0.80	0.61	6.32	86.05	61.91	-110.52	29.39	95.69	133.40	217.81
Panel B: Pre-Tariff Bill, 1910–1913													
0.08	1.60	-4.39	-0.70	0.63	0.93	2.95	28.54	43.15	-5.70	1.70	4.52	43.99	148.19
Panel C: Post-Tariff Bill, 1913–1920													
-1.42	1.92	-5.89	-2.45	-1.47	-0.19	6.32	107.85	53.40	-110.52	73.01	113.83	143.70	217.81

Table 4. Summary statistics for differences in yields of taxable and tax-exempt bonds at the issuer level.

Notes: This table reports summary statistics for the first difference in yields for taxable and tax-exempt bonds (i.e., taxable - tax-exempt) pooled at the issuer level. In each month, we first compute the difference in average yields for all taxable and tax-exempt bonds issued by the same firm. Next, we compute the cross-sectional average of this issuer-level difference in yields of taxable and tax-exempt bonds by pooling data across all firms. At the issuer level, yield differences between taxable and tax-exempt bonds are winsorized at the 5^{th} and 95^{th} percentile respectively. Months in which we have less than 50 observations to compute the cross-sectional average are excluded. We report summary statistics for each year between 1910–1920, and also report summary statistics for the period before federal income taxes were imposed, and for the period after imposition of federal income tax. Taxable bonds are bonds issued by firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. Data are monthly from January 1910 to December 1920.

Year	Mean	σ	Min	25^{th}	Med	75^{th}	Max
1910	15.90	10.24	6.30	12.25	13.59	14.83	48.74
1911	33.93	28.18	12.48	16.04	19.37	47.87	103.82
1912	35.56	21.58	14.29	18.36	27.21	50.72	83.98
1913	59.18	21.77	20.75	41.91	62.40	73.45	92.73
1914	57.91	9.83	38.89	52.27	56.56	66.18	75.66
1915	50.81	27.58	17.36	27.97	48.63	66.34	111.06
1916	60.21	13.89	40.52	48.44	57.45	70.78	85.47
1917	39.07	17.84	20.85	21.47	41.61	51.40	68.98
1918	52.01	13.34	36.00	40.00	50.13	62.91	73.65
1919	90.32	18.67	60.19	71.96	100.00	106.68	111.06
1920	43.62	12.57	19.10	33.54	46.63	53.84	60.49
1910–1913	28.46	23.12	6.30	13.93	18.00	33.70	103.82
1913–1920	57.26	23.06	17.36	40.60	56.12	69.24	111.06
1910–1920	49.16	26.46	6.30	22.00	50.42	66.20	111.06

Table 5. Summary statistics for the tax risk measure.

Notes: This table reports summary statistics of the tax risk measure. Tax risk measure equals the natural logarithm of the deviation between market and fundamental prices for taxable and tax-exempt bonds. Fundamental prices for each type of bond are computed using the no-arbitrage Nelson-Siegel term structure model. Taxable bonds are bonds issued by firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. N denotes the number of observations. Data are monthly from January 1910 to December 1920.

Year	Mean	σ	Min	25^{th}	Med	75^{th}	Max
1910	122.82	16.31	109.59	109.97	118.82	128.08	170.25
1911	131.60	29.38	99.81	107.88	117.46	154.47	189.56
1912	156.78	31.88	114.88	122.63	159.29	174.79	221.34
1913	172.40	24.01	128.01	154.01	177.11	196.09	201.04
1914	220.16	28.16	188.24	194.76	211.83	257.07	259.38
1915	191.07	35.19	145.56	153.55	204.20	222.02	235.96
1916	187.18	21.39	147.25	168.41	188.73	205.91	217.34
1917	177.94	49.67	92.90	145.52	165.12	222.72	275.97
1918	207.05	11.13	189.34	201.80	204.83	206.88	234.38
1919	199.88	44.42	133.24	157.64	197.97	240.28	268.18
1920	156.95	43.02	94.17	122.28	152.44	196.13	226.49
1910–1913	137.07	30.37	99.81	112.97	122.63	166.59	221.34
1913–1920	189.08	39.25	92.90	154.79	194.83	214.73	275.97
1910–1920	174.90	43.69	92.90	144.08	177.11	205.30	275.97

Table 6. Correlation of tax risk measure with uncertainty, financial, and macroeconomic variables.

Notes: This table reports the estimates from a regression of the tax risk measure on economic uncertainty, financial, and macroeconomic variables. Tax risk measure equals the natural logarithm of the deviation between market and fundamental prices for taxable and tax-exempt bonds. Fundamental prices for each type of bond are computed use the no-arbitrage Nelson-Siegel term structure model. Taxable bonds are bonds issued by U.S. firms without any clauses with reference to taxes, and any tax liability on these bonds is the responsibility of the investor. Tax-exempt bonds are bonds issued by U.S. firms with the tax-free clause, and any tax liability on these bonds is the responsibility of the issuer. NVIX, SEC, GOV, INTR, NAT, WAR, and UNCL are the news impled VIX and its subcomponents for the security market, government, intermediation, natural disasters, war, and unclassified from Manela and Moreira (2017). BAP is the average spread between the bid and ask prices of all corporate bonds. CS and CSA denote the Corwin and Schultz (2012) is the range-based and adjusted-range-based estimate for transaction costs averaged across all bonds, respectively. RF is the U.S. call money rates for mixed collateral. MKT is the return on the S&P500 index. BOND is the return on the 10-year bond issued by the U.S. Treasury. CREDIT is the spread between yields of U.S. investment grade corporate bonds and the 10-year constant maturity Treasury bond. MKTVOL is the annualized realized volatility of the monthly returns on the S&P 500. IP is the annualized percentage growth rate of industrial production. CPI is the annualized percentage change in the consumer price index published by the U.S. Bureau of Labor Statistics. EPU is the economic policy uncertainty index from Baker, Bloom, and Davis (2016). Panel A reports the results of contemporaneous regressions. Panels B–E explore the lag-lead relationships between TRM and uncertainty, financial and macroeconomic variables. Each column references a separate univariate regression specification. We report the estimates for the coefficient and its t statistic. Statistical significance is indicated by *, **, and *** at the 10%, 5%, and 1% levels, respectively. Data are monthly from January 1910 to December 1920.

Variable	NVIX	SEC	GOV	INTR	NAT	WAR	UNCL	BAP	CSA	CS	RF	MKT	BOND	CREDIT	MKTVOL	IP	CPI	EPU
Panel A: $\rho(TRM_t, VAR_t)$																		
Coeff	0.0246***	0.1013	0.0103	-1.9756	0.0258*	0.1240***	0.0150	0.0016***	0.0021*	0.0014***	1.1343	0.4703	0.4734	-0.0016	-0.1837	0.2056*	0.4710**	0.0021***
$t-stat$	(2.67)	(1.57)	(0.20)	(-1.53)	(1.67)	(3.81)	(1.10)	(3.79)	(1.65)	(2.64)	(1.06)	(0.91)	(0.35)	(-0.95)	(-0.15)	(1.70)	(2.32)	(4.66)
$R^2-adj(\%)$	6.59	1.25	0.69	0.98	1.72	12.40	0.53	11.07	2.26	5.76	1.28	0.12	0.69	0.21	0.75	3.27	5.56	19.52
Panel B: $\rho(TRM_t, VAR_{t-12})$																		
Coeff	0.0371***	0.2349	0.0187	0.1561	0.0275*	0.1002***	0.0463***	0.0011***	0.0002	0.0015***	-0.0566	-0.0503	0.3550	0.0011	0.8509	0.1763*	0.3385*	0.0010***
$t-stat$	(5.69)	(1.04)	(0.38)	(0.15)	(1.74)	(3.24)	(3.68)	(2.61)	(0.11)	(3.36)	(-0.03)	(-0.11)	(0.23)	(0.59)	(0.66)	(1.73)	(1.85)	(2.61)
$R^2-adj(\%)$	16.53	11.45	0.57	0.84	1.50	9.30	10.51	5.59	0.83	6.52	0.84	0.84	0.81	0.57	0.50	2.12	2.51	4.55
Panel C: $\rho(TRM_t, VAR_{t-6})$																		
Coeff	0.0071	0.0831	0.0500	-1.0941	0.0339*	0.1240***	-0.0080	0.0013***	0.0016	0.0006	-0.8029	0.2337	0.0708	-0.0002	-0.9163	0.1834**	0.2518	0.0017***
$t-stat$	(0.74)	(1.61)	(1.37)	(-0.90)	(1.85)	(3.74)	(-0.45)	(2.46)	(1.29)	(0.89)	(-0.74)	(0.45)	(0.04)	(-0.14)	(-0.81)	(2.14)	(0.95)	(4.16)
$R^2-adj(\%)$	0.21	0.62	1.04	0.23	3.63	13.18	0.44	7.47	0.99	0.42	0.13	0.59	0.80	0.79	0.42	2.26	1.09	13.37
Panel D: $\rho(TRM_t, VAR_{t+6})$																		
Coeff	0.0076	-0.0112	0.0805*	0.4716	0.0318**	0.1396***	-0.0148	0.0025***	0.0020	0.0012**	1.6889**	0.3413	-1.6148	-0.0024*	2.0926*	-0.0169	0.6759***	0.0015***
$t-stat$	(0.90)	(-0.21)	(1.84)	(0.48)	(2.19)	(3.74)	(-1.10)	(6.91)	(1.56)	(1.99)	(2.14)	(0.71)	(-1.53)	(-1.92)	(1.69)	(-0.15)	(3.19)	(3.72)
$R^2-adj(\%)$	0.05	0.78	4.29	0.70	3.33	17.01	0.53	30.18	2.29	4.35	4.19	0.31	0.25	0.74	1.40	0.78	13.63	10.10
Panel E: $\rho(TRM_t, VAR_{t+12})$																		
Coeff	0.0008	-0.1427	0.0914***	-1.7016	0.0144	0.1068**	-0.0102	0.0021***	0.0033***	0.0013**	1.6005*	0.5134	1.9209	-0.0012	0.2984	0.1132	0.6693***	0.0012***
$t-stat$	(0.09)	(-1.05)	(2.50)	(-1.29)	(0.95)	(2.26)	(-0.71)	(4.42)	(2.51)	(2.12)	(1.77)	(1.17)	(1.62)	(-0.67)	(0.22)	(0.85)	(3.16)	(2.63)
$R^2-adj(\%)$	0.84	3.59	5.50	0.56	0.00	9.27	0.21	20.66	7.60	4.77	3.62	0.26	0.66	0.47	0.80	0.47	12.69	6.83

Table 7. Risk premium estimates for tax risk using stock and bond market indices

Notes: This table reports the estimates from the Fama-MacBeth regression for stock and bond market indices. In each month, we regress the excess return on each test asset on the excess return to the stock market index, the excess return on the bond market index, the cross-sectional average bid-ask price for all bonds, and the tax risk measure. We then regress the monthly coefficients from this regression on the average monthly excess return for the test asset, and report the estimates from this cross-sectional regression in the table below. The table reports the coefficients from this second-stage regression and the *t*-statistics based on standard errors corrected for heteroscedasticity and autocorrelation (HAC) as well as standard errors accounting for the Shanken (1992) correction. Statistical significance is indicated by *, **, and *** at the 10%, 5%, and 1% levels, respectively. Data are monthly from January 1910 to December 1920.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
γ^{TRM}	0.0137	0.0243	0.0149	0.0121	0.0232	0.0145	0.0242
	(1.73)*	(2.60)***	(1.69)*	(1.73)*	(2.74)***	(1.75)*	(2.76)***
	(4.23)***	(9.90)***	(5.21)***	(3.45)***	(9.11)***	(4.86)***	(10.38)***
γ^{MKT}		0.0048			0.0051		0.0040
		(2.61)***			(2.67)***		(2.11)**
		(0.37)			(0.38)		(0.32)
γ^{BOND}			0.0015			0.0014	-0.0004
			(2.41)**			(2.28)**	(-1.04)
			(0.04)			(0.04)	(-0.01)
γ^{LIQ}				0.0610	0.0473	0.0277	0.0306
				(2.52)***	(2.64)***	(1.34)	(1.96)**
				(5.60)***	(2.93)***	(6.18)***	(9.11)***
$R^2 - adj(\%)$	8.20	31.32	15.69	13.00	35.08	19.60	32.72
	(5.43)***	(8.34)***	(7.31)***	(7.58)***	(8.70)***	(9.59)***	(7.77)***

Table 8. Risk premium estimates for tax risk using stock market indices

Notes: This table reports the estimates from the Fama-MacBeth regression for stock market indices. In each month, we regress the excess return on each test asset on the excess return to the stock market index, the excess return on the bond market index, the cross-sectional average bid-ask price for all bonds, and the tax risk measure. We then regress the monthly coefficients from this regression on the average monthly excess return for the test asset, and report the estimates from this cross-sectional regression in the table below. The table reports the coefficients from this second-stage regression and the t-statistics based on standard errors corrected for heteroscedasticity and autocorrelation (HAC) as well as standard errors accounting for the Shanken (1992) correction. Statistical significance is indicated by *, **, and *** at the 10%, 5%, and 1% levels, respectively. Data are monthly from January 1910 to December 1920.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
γ^{TRM}	0.0139	0.0217	0.0149	0.0121	0.0192	0.0140	0.0208
	(1.67)*	(2.37)***	(1.59)	(1.68)*	(2.44)***	(1.61)	(2.68)***
	(4.50)***	(7.93)***	(5.49)***	(3.63)***	(6.51)***	(4.97)***	(7.74)***
γ^{MKT}		0.0055			0.0057		0.0045
		(3.00)***			(2.90)***		(2.35)***
		(0.40)			(0.45)		(0.39)
γ^{BOND}			0.0014			0.0013	-0.0008
			(2.05)**			(1.91)*	(-1.98)**
			(0.04)			(0.04)	(-0.02)
γ^{LIQ}				0.0364	0.0235	-0.0099	0.0023
				(1.20)	(1.21)	(-0.37)	(0.12)
				(9.61)***	(5.43)***	(-5.57)***	(1.57)
$R^2 - adj(\%)$	9.20	32.37	18.17	14.75	36.79	22.48	34.48
	(5.76)***	(8.77)***	(8.27)***	(6.71)***	(9.00)***	(9.62)***	(7.98)***

Table 9. Risk premium estimates for mimicking portfolio using stock market portfolios

Notes: This table reports the estimates from the Fama-MacBeth regression for the 100 stock portfolios sorted by size and book-to-value. In each month, we regress the excess return on each test asset on the excess return to the three Fama-French factors (MKT, SMB, HML), and the returns to the tax risk measure mimicking portfolio. We then regress the monthly coefficients from this regression on the average monthly excess return for the test asset, and report the estimates from this cross-sectional regression in the table below. The table reports the coefficients from this second-stage regression and the t-statistics based on standard errors corrected for heteroscedasticity and autocorrelation (HAC) as well as standard errors accounting for the Shanken (1992) correction. Coefficients are annualized by multiply by 12 and are expressed in percentage. Statistical significance is indicated by *, **, and *** at the 10%, 5%, and 1% levels, respectively. Data are monthly from January 1930 to December 2016.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
γ^{Tax}	0.3214	0.2330	0.1149	0.0580	0.1889	0.0665	0.1312
	(2.35)***	(2.05)**	(0.87)	(0.52)	(1.81)*	(0.63)	(1.35)
	(0.05)	(0.03)	(0.02)	(0.01)	(0.03)	(0.01)	(0.02)
γ^{MKT}		3.4790			1.0496		1.1684
		(3.25)***			(1.21)		(1.54)
		(3.88)***			(0.93)		(0.98)
γ^{SMB}			1.7713			2.0063	2.1299
			(3.67)***			(2.43)***	(4.40)***
			(1.16)			(1.88)*	(1.29)
γ^{HML}				3.8017	1.8772	3.9356	3.5589
				(6.61)***	(3.98)***	(6.87)***	(6.95)***
				(2.90)***	(1.10)	(2.87)***	(2.41)***
$R^2 - adj(\%)$	9.31	20.15	23.29	21.62	27.93	27.80	31.44
	(3.12)***	(9.11)***	(2.03)**	(3.57)***	(4.34)***	(7.05)***	(7.31)***

Internet Appendix

Tax Risk and Asset Prices: Evidence from Dual-class Corporate Bonds in the 19^{th} Century

A Data sources

U.S. federal tax system in the early 20^{th} century Table A1 lists the chronology of major events related to changes in the federal income tax code during the late 19^{th} and early 20^{th} century. We briefly discuss these events below.

U.S. federal tax system before 1913: Historically, the U.S. has passed through two distinct regimes of income taxes at the federal level. In the first regime, lasting from its very beginnings until 1913, the federal government hardly ever imposed income taxes. In this era, the U.S. Constitution prohibited the federal government from levying income taxes unless all tax revenues were distributed among the states. The federal government was funded by tariffs on imports and excise taxes on alcohol, tobacco, and refined sugars. These duties and taxes accounted for approximately 80% of federal government revenues in any given year (annual report of the Secretary of the Treasury 1890-1900).

There are two exceptions to this long era without any federal income taxes. In 1861, Congress imposed a 3% tax on incomes above $800 to fund its Civil War efforts. Income tax rates were increased in 1862 (to 3% and 5% on incomes above $600 and $10,000, respectively), and again in 1864 (to 5%, 7.5%, and 10% on incomes above $600, $5,000, and $10,000). However, in 1872 Congress repealed all income taxes, because the system was onerous to implement, and the revenue collected was small compared to the cost of collection.

In 1894, Congress again attempted to impose a federal income tax. This was the first attempt by the federal government to levy an income tax in times of peace. The main motivation was to reduce the federal government's reliance on import duties and excise taxes for revenue. Proponents of the income tax believed that such taxes were progressive than import duties and excise taxes, which imposed a heavier burden on lower income groups. Congress eliminated import duties and replaced them with a 2% income tax on all incomes above $4,000. However, since the taxes collected were not distributed among the states, as mandated by the U.S. Constitution, the Act was ruled to be unconstitutional by the Supreme Court in 1895 (Brownlee (2004)).

During the late 1800s to the early 1900s, state taxation of income was also practically non-existent. Wisconsin, was the first to levy an income tax, but did not do so until 1911. Five other states – Massachusetts, North Carolina, Oklahoma, South Carolina, and Virginia – followed Wisconsin (Comstock (1921)). However, most state tax systems were irregularly and unevenly enforced, were ineffective, and did not generate any substantial revenues (Wallis (2000)). There was also no corporate income taxes until 1909. Between 1909 and 1913, all publicly-traded corporations were subjected to an income tax of 1% on all income above $5,000.

The Revenue Act of 1913: In July 1909, U.S. Congress passed the 16^{th} amendment to the Constitution, allowing it to collect income taxes without requiring that such taxes be apportioned among the states. This amendment was ratified by the requisite two-thirds of the states in February 1913. In October Congress passed the Revenue Act of 1913, which laid the groundwork for the federal income tax system that prevails even today.

The Act established a progressive income tax system with 6 brackets. The first $3,000 ($4,000) of income for single-filers (married couples) was exempt. The lowest marginal income tax rate of 1% applied to all income up to $20,000. Thereafter, marginal rates increased by 1% at income levels of $20,000, $50,000, $75,000, $100,000, $250,000 and $500,000, respectively. The top marginal income tax rate of 7% applied to all incomes above $500,000. Thus, the ratio of the top-to-bottom marginal income tax rate was 3.5:1 (Interestingly, a similar ratio holds even today (37%:10%)). The Act exempted all income from municipal bonds from federal income taxes. Dividends were also not taxed.

The federal income tax raised widespread concern among investors. Shortly after October 1913, the U.S. Treasury was flooded with inquiries regarding how income was to be computed, how such taxes were to be paid, and who was or was not subject to taxes. To clarify these issues the U.S. Treasury issued more than 250 clarification over a short period of time. Many of these clarifications were themselves required further explanations and additional rulings.

Several court cases were filed to challenge the constitutionality of the federal income taxes, and this added to the uncertainty among investors. In a prominent case (Brushaber v/s Union Pacific Railroad Company, 240 U.S. 1, at 20 (1916)), the plaintiff argued that federal income taxes violated the 5^{th} amendment's requirement for due process. In a unanimous decision, the U.S. Supreme Court ruled that the U.S. Constitution no longer restricted the ability of federal government to tax incomes. In a prescient warning, many legal experts warned that the federal government would soon raise income tax rates.

Income taxes over 1913–1920: The U.S. entry into World War I, prompted a change in the federal income tax code. The Revenue Act of 1916 raised the lowest marginal income tax rate from 1% to 3% and the top marginal income tax rate from 7% to 15%. Corporate income tax also doubled from 1% to 2%. The Act introduced an excess profits tax on munitions manufacturers and established a federal estate tax. Exemption of dividends from personal taxes was eliminated, essentially imposing a double-tax on corporate earnings.

Mounting war time expenditures caused Congress to again increase taxes in 1917. The lowest and highest individual marginal income tax rate increased to 4% and 67%, respectively. The top rate applied to taxpayers with income above $2 million. Exemption limits were lowered, corporate income taxes were increased, and the excess profits tax was imposed on all firms, not just munitions manufacturers (Bargeron, Denis, and Lehn (2015)). The excess profits tax also applied on professionals and educated taxpayers earning more than $6,000, prompting critics to label it a 'tax on brains'.

Another round of changes were implemented in 1918, when Congress increased both the corporate income tax and the excess profits tax rates. The Revenue Act of 1918 also raised the top individual tax rate from 67% to 77%. This top rate applied to all earnings in excess of $1 million (down from $2 million in 1917). Tax laws changed yet again in 1919, with the signing of the World War I armistice. This time, Congress voted to eliminate the excess profits tax, reduce corporate income tax rates, and lower individual income tax rates. These rates remained in place until 1921.

As a result of frequent changes, federal tax revenues grew substantially over 1916–1920. By 1918, 15% of households paid income taxes, and taxes from the wealthiest 1% of households accounted for 80% of all federal tax revenues. The average effective tax rate for the wealthiest households was 15% in 1918, compared to 3% just a year ago (Brownlee (2004)). The excess-profits tax alone accounted for 66% of all federal tax revenues (Bargeron, Denis, and Lehn (2015)).

In summary, over 1910–1920, taxpayers contended with frequent changes to the income tax code. The 'rapid-fire' manner in which these changes were introduced, which required frequent clarifications from the Treasury, meant that market participants faced enormous risk regarding tax policy, specifically how incomes from labor and investments would be taxed, during this period.

U.S. Bond Markets in the Early 20th Century In the late 19th century economic activity and productivity in the U.S. picked up markedly. The size of U.S. debt markets grew significantly, driven by growth in the economy, the national banking system, and the national transportation system. The growth in the U.S. debt market was accompanied by a rapid expansion of the corporate bond market. For example, the number of bond issuers listed in a national business and financial newspaper of the time – the Commercial and Financial Chronicle – was 158 in 1866, but surged to 421 by 1872.[33]

The way corporate bonds were traded in the earlier 20th century were differed dramatically from how corporate bonds are traded today. Specifically, in the early 1900s, corporate bonds traded on organized exchanges such as, the New York Stock Exchange (NYSE), rather than in over-the-counter (OTC) markets that we see today. In fact, corporate bond trading originally took place in the same location as stock trading in the so-called 'bond corner' of the Exchange. Bond trading at that time was 'order-driven' and the exchange collected, posted, and matched public customer orders. Bond investors paid commissions to brokers who could observe the book of available orders and recent trades, and passed this information along to their customers. In the 1940s, corporate bond trading migrated to the over-the-counter (OTC) market that still dominates today. Biais and Green (2007) give an excellent account of the corporate

[33] For detailed accounts of these developments, see Hickman (1953), Hickman (1958), Hickman (1960), Friedman and Schwartz (1963) and Homer and Sylla (1991).

and municipal bond markets in the early 20th century.

Bond investors had access to a wide range of reputable sources of information such as, national business and financial newspapers. These newspapers published weekly and monthly bulletins of all recorded prices on major exchanges, and quarterly or semi-annual supplements which listed all the major companies and their securities. Periodicals such as, the Henry Poor's annual railroad manual, contained detailed information about all large companies and provided balance sheets, income statements, and details on collateral for most bond issues. As the number of investors in financial markets grew, so did the number of financial analysts publishing advice on financial markets and investments. Already by the 1860s, the NYSE closely resembled its 20^{th} century counterpart in many important features (Giesecke, Longstaff, Schaefer, and Strebulaev (2011)).

The NYSE itself was quick to adopt innovations in trading technologies – as early as September 1882 the NYSE introduced stock tickers, telephones were installed in 1879, and the NYSE set up an electric annunciator in 1881 – which led to a substantial increase in trading volume, liquidity, and a high level of 'pre-trade transparency' and 'post-trade transparency'.[34]

In summary, the U.S. financial markets for stocks and bonds were already highly developed during the period from 1910 to 1920. This is important because it indicates that our sample of NYSE bond prices should accurately reflect actual trading conditions and information that investors had at the time.

List of data sources: Table A2 provides details regarding the data-sets and data sources used in this study.

B Additional summary statistics

Distribution of bonds by maturity: We classify bonds into five buckets, those with maturity: less than 5 years, between 5–10 years, between 10–15 years, between 15–30 years, and greater than 30 years. Figure A1 plots the average proportion of observations in a given year that fall in these 5 distinct maturity buckets.

Macroeconomic variables: Table A3 presents summary statistics for macroeconomic variables used in our analysis. Here, IP is the year-on-year growth rate in quarterly industrial production, CPI is the year-on-year percentage change in the consumer price index published by the U.S. Bureau of Labor Statistics, EPU is the economic policy uncertainty index from Baker, Bloom, and Davis (2016), NVIX, SEC, GOV, INTR, NAT, WAR, and UNCL is the news implied VIX and its subcomponents for the security market, government, intermediation, natural disasters, war, and other, respectively from Manela and Moreira (2017).

Financial variables: Table A4 presents summary statistics for financial variables and measures of bond liquidity used in our analysis. RF is U.S. call money rate on mixed collateral, and proxies for the risk-free rate. MKT is the value-weighted return for the stocks in the S&P500 index, BOND is the return on the 10-year bond issued by the U.S. Treasury, CREDIT is the spread between yields of U.S. investment grade corporate bonds and the 10-year constant maturity bond issued by the U.S. Treasury, and MKTVOL is the annualized realized volatility of the value-weighted monthly return for stocks in the S&P500 index. BAP is the average spread between the bid and ask prices of all bonds and is expressed in cents per $100 notional value. CS and CSA denote the Corwin and Schultz (2012) range-based and adjusted-range-based estimate for transaction costs averaged across all bonds, respectively.

[34] Pre-trade transparency refers to the dissemination of information about trading interests and includes price (bid and ask) and depth quotations, as well as limit order prices, and sizes. Post-trade transparency refers to the dissemination of information about past trades and includes transaction prices, trade execution times, and volumes. Post-trade transparency in the bond markets is sometimes referred to simply as 'price transparency'. Madhavan (2000) discusses the different dimensions of transparency in more detail.

Asset pricing tests assets Tables A5 and A6 present the list and summary statistics for securities used in asset pricing tests.

C The adjusted Corwin-Schultz liquidity measure

Corwin and Schultz (2012) derive a liquidity (transaction cost) measure from the high-low spread defined as the difference in the highest and lowest stock price within a given trading day. Their measure is quite intuitive. It is based on the assumption that high prices are a result of a buy order and that low prices correspond to a sell order. Corwin and Schultz (2012) show that the high-low spread during a day equals the daily variance plus the bid-ask spread. As the variance is proportional to the return interval, the high-low spread over two consecutive days (i.e., the difference in the highest and the lowest price over two days) equals the bid-ask spread over those two days plus two times the daily variance. Thus, one can solve for the bid-ask spread over two consecutive days using the high-low spread over two consecutive single days and twice the daily variance.

The liquidity measure in Corwin and Schultz (2012) is developed under the assumption that trading is frequent. While this is a reasonable assumption for stock markets, it is less applicable to bond markets, where trading is less frequent and several intervening days can occur without any trading in particular bonds. Therefore, we cannot just ignore the absence of consecutive days without any trading activity and simply adopt for the bond market the liquidity measure developed by Corwin and Schultz (2012) for the stock market. The modified Corwin and Schultz (2012) (CS) measure is given by the following set of equations. Its derivation is presented below:

$$
\begin{aligned}
S &= \frac{2\left(e^{\bar{\alpha}}-1\right)}{1+e^{\bar{\alpha}}} \\
\bar{\alpha} &= \frac{\sqrt{\beta/T}-\sqrt{\gamma}}{\sqrt{T}-1} \\
\beta &= \mathbf{E}\left[\sum_{j=0}^{T-1}\left[\ln\left(\frac{H^0_{t+j}}{L^0_{t+j}}\right)\right]^2\right] \\
\gamma &= \mathbf{E}\left[\left[\ln\left(\frac{H^0_{t,t+T-1}}{L^0_{t,t+T-1}}\right)\right]^2\right]
\end{aligned}
\tag{10}
$$

Here, $H_{t,t+T-1}$ and $L_{t,t+1-1}$ are the highest and lowest prices, respectively, over T days from $t, t+1, \dots t+T-1$. The monthly adjusted CS measure is the average of the daily estimated CS measure. Note that as in Corwin and Schultz (2012), expectation of high-low spread equals the average observed high-low spread over a given period. To adjust for the irregular timing of observations in bond markets, we closely follow the procedure in CS, and assume that bond price follows a diffusion process and that the bid-ask spread of $S\%$ is constant over the estimation period of T days. Also, we assume that the daily high price is buyer-initiated and inflated by half the spread, and that the daily low price is seller-initiated and thus discounted by half the spread. Hence:

$$
\left[\ln\left(\frac{H^0_t}{L^0_t}\right)\right]^2 = \left[\ln\left(\frac{H^A_t(1+S/2)}{L^A_t(1-S/2)}\right)\right]^2 \tag{11}
$$

where H^0_t and L^0_t are the observed high and low bond prices for day t, and H^A_t and L^A_t denote the actual high and low bond price for day t, respectively. Expanding the expression, we get:

$$
\left[\ln\left(\frac{H^0_t}{L^0_t}\right)\right]^2 = \left[\ln\left(\frac{H^A_t}{L^A_t)}\right)\right]^2 + 2\left[\ln\left(\frac{H^A_t}{L^A_t)}\right)\right]\left[\ln\left(\frac{2+S}{2-S}\right)\right] + \left[\ln\left(\frac{2+S}{2-S}\right)\right]^2 \tag{12}
$$

If bond prices follow a geometric Brownian motion and are observed continuously over a relatively small period of time, Parkinson

(1980) and Garman and Klass (1980) provide the solution for the expectation of the natural logarithm of the ratio of high to low bond prices:

$$\mathbf{E}\left[\frac{1}{T}\sum_{t=1}^{T}\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2\right] = k_1\sigma_{HL}^2 \tag{13}$$

Here, H_t and L_t denote the high and low bond prices for day t and $k_1 = 4\ln(2)$. Parkinson (1980) also shows that for a non-squared ratio:

$$\mathbf{E}\left[\frac{1}{\sqrt{T}}\sum_{t=1}^{T}\left[\ln\left(\frac{H_t}{L_t}\right)\right]\right] = k_2\sigma_{HL} \tag{14}$$

Here, H_t and L_t denote the high and low bond prices for day t and $k_2 = \sqrt{8/\pi}$. Taking expectations and substituting the results in, we get:

$$\mathbf{E}\left[\left[\ln\left(\frac{H_t^0}{L_t^0}\right)\right]^2\right] = k_1\sigma_{HL}^2 + 2k_2\sigma_{HL}\left[\ln\left(\frac{2+S}{2-S}\right)\right] + \left[\ln\left(\frac{2+S}{2-S}\right)\right]^2 \tag{15}$$

The expectation of the sum over T trading days is given by:

$$\mathbf{E}\left[\sum_{j=0}^{T-1}\left[\ln\left(\frac{H_{t+j}^0}{L_{t+j}^0}\right)\right]^2\right] = Tk_1\sigma_{HL}^2 + 2Tk_2\sigma_{HL}\left[\ln\left(\frac{2+S}{2-S}\right)\right] + T\left[\ln\left(\frac{2+S}{2-S}\right)\right]^2 \tag{16}$$

To shorten the notation, we define:

$$\alpha = \left[\ln\left(\frac{2+S}{2-S}\right)\right] \tag{17}$$

which leads to:

$$\mathbf{E}\left[\sum_{j=0}^{T-1}\left[\ln\left(\frac{H_{t+j}^0}{L_{t+j}^0}\right)\right]^2\right] = Tk_1\sigma_{HL}^2 + 2Tk_2\sigma_{HL}\alpha + T\alpha^2 \tag{18}$$

Also, define:

$$\beta = \mathbf{E}\left[\sum_{j=0}^{T-1}\left[\ln\left(\frac{H_{t+j}^0}{L_{t+j}^0}\right)\right]^2\right] \tag{19}$$

which then leads to:

$$0 = Tk_1\sigma_{HL}^2 + 2Tk_2\sigma_{HL}\alpha + T\alpha^2 - \beta \tag{20}$$

Next, as in Corwin and Schultz (2012), we take the square of the equation for the high-low ratio from the T-day period:

$$\left[\ln\left(\frac{H_{t,t+T-1}^0}{L_{t,t+T-1}^0}\right)\right]^2 = \left[\ln\left(\frac{H_{t,t+T-1}^A}{L_{t,t+T-1}^A}\right)\right]^2 + 2\alpha\left[\ln\left(\frac{H_{t,t+T-1}^A}{L_{t,t+T-1}^A}\right)\right] + \alpha^2 \tag{21}$$

where $H_{t,t+T-1}$ and $L_{t,t+T-1}$ are the high and low prices, respectively, over the T days $t, t+1, \ldots, t+T-1$. To further shorten notation, define:

$$\gamma = \mathbf{E}\left[\left[\ln\left(\frac{H_{t,t+T-1}^0}{L_{t,t+T-1}^0}\right)\right]^2\right] \tag{22}$$

$$\mathbf{E}\left[\ln\left(\frac{H_{t,t+T-1}^0}{L_{t,t+T-1}^0}\right)\right]^2 = \mathbf{E}\left[\frac{1}{T}\sum_{t=1}^{T}\ln\left(\frac{H_t}{L_t}\right)\right]^2 = k_1\sigma_{HL}^2 \tag{23}$$

$$\mathbf{E}\left[\ln\left(\frac{H_{t,t+T-1}^0}{L_{t,t+T-1}^0}\right)\right] = \mathbf{E}\left[\frac{1}{\sqrt{T}}\sum_{t=1}^{T}\ln\left(\frac{H_t}{L_t}\right)\right] = k_2\sigma_{HL} \tag{24}$$

which then results in:

$$0 = Tk_1\sigma_{HL}^2 + 2\sqrt{T}k_2\sigma_{HL}\alpha + \alpha^2 - \gamma \tag{25}$$

Solving 20 for α:

$$\alpha = -k_2\sigma_{HL} + \sqrt{\sigma_{HL}^2\left(k_2^2 - k_1\right) + \beta/T} \tag{26}$$

Next, using 25:

$$\begin{aligned} Tk_1\sigma_{HL}^2 \quad + \quad & 2\sqrt{T}k_2\sigma_{HL}\left(-k_2\sigma_{HL} + \sqrt{\sigma_{HL}^2\left(k_2^2 - k_1\right) + \beta/T}\right) \\ & + \left(-k_2\sigma_{HL} + \sqrt{\sigma_{HL}^2\left(k_2^2 - k_1\right) + \beta/T}\right) - \gamma = 0 \end{aligned} \tag{27}$$

Simplification yields:

$$\begin{aligned} & \sigma_{HL}^2\left[k_2\left(2 - 2\sqrt{T}\right) + k_1\left(T - 1\right)\right] \\ & + \sigma_{HL}k_2\left(2\sqrt{T} - 2\right)\sqrt{\sigma_{HL}^2\left(k_2^2 - k_1\right) + \beta/T} + \beta/T - \gamma = 0 \end{aligned} \tag{28}$$

Although this equation can be solved numerically for σ_{HL}, it can be further simplified by following Corwin and Schultz (2012) and ignoring Jensen's inqualtiy in 11:

$$\mathbf{E}\left[\frac{1}{T}\sum_{t=1}^{T}\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2\right] = \sqrt{\mathbf{E}\left[\frac{1}{T}\sum_{t=1}^{T}\left[\ln\left(\frac{H_t}{L_t}\right)\right]^2\right]^2} = \sqrt{k_1}\sigma_{HL} \tag{29}$$

Thus, $k_2^2 = k_1$ which when used in 26 and denoting the use of the approximation by $\bar{\alpha}$ results in:

$$\bar{\alpha} = -k_2\sigma_{HL} + \sqrt{\beta/T} \tag{30}$$

and using 29:

$$\sigma_{HL}^2k_2^2\left(\sqrt{T} - 1\right)^2 + 2\sigma_{HL}k_2\left(sqrtT - 1\right)\sqrt{\beta/T} + \beta/T - \gamma = 0 \tag{31}$$

Dividing both sides by $k_2\left(\sqrt{T} - 1\right)^2 \neq 0$:

$$\sigma_{HL}^2 + \frac{2\sqrt{\beta/T}}{k_2\left(\sqrt{T} - 1\right)}\sigma_{HL} + \frac{\beta/T}{k_2\left(\sqrt{T} - 1\right)^2} = \frac{\gamma}{k_2\left(\sqrt{T} - 1\right)^2} \tag{32}$$

Next, rewriting:

$$\left(\sigma_{HL} + \frac{2\sqrt{\beta/T}}{k_2\left(\sqrt{T} - 1\right)}\right)^2 = \frac{\gamma}{k_2\left(\sqrt{T} - 1\right)^2} \tag{33}$$

Solving for σ_{HL}:

$$\sigma_{HL} = \frac{\sqrt{\gamma} - \sqrt{\beta/T}}{k_2\left(\sqrt{T} - 1\right)} \tag{34}$$

Next, using 30:

$$\bar{\alpha} = \frac{\sqrt{\beta/T} - \sqrt{\gamma}}{\sqrt{T} - 1} + \sqrt{\beta/T} \tag{35}$$

which simplifies to:

$$\bar{\alpha} = \frac{\sqrt{\beta/T} - \sqrt{\gamma}}{\sqrt{T} - 1} \tag{36}$$

and thus, $\bar{\alpha}$ is the generalized high-low spread estimate, so that:

$$S = \frac{2\left(e^{\bar{\alpha}} - 1\right))}{1 + e^{\bar{\alpha}}} \tag{37}$$

Note, we use averages of observed high-low ratios to calculate the spread proxy. Since the variance and bid-ask spread are non-linear functions of the high-low spread, the average spread estimates are biased. As pointed out by Corwin and Schultz (2012) this does not affect the outcome of their estimator to a large extent. Another characteristic of bond prices it the pull-to-par effect, which is the notion that a bond's price approaches its par value over time. This effect, however, is negligible because our sample includes long-term bonds for which the pull-to-par effect is insignificant relative to the short time periods we use to calculate the CS liquidity measure.

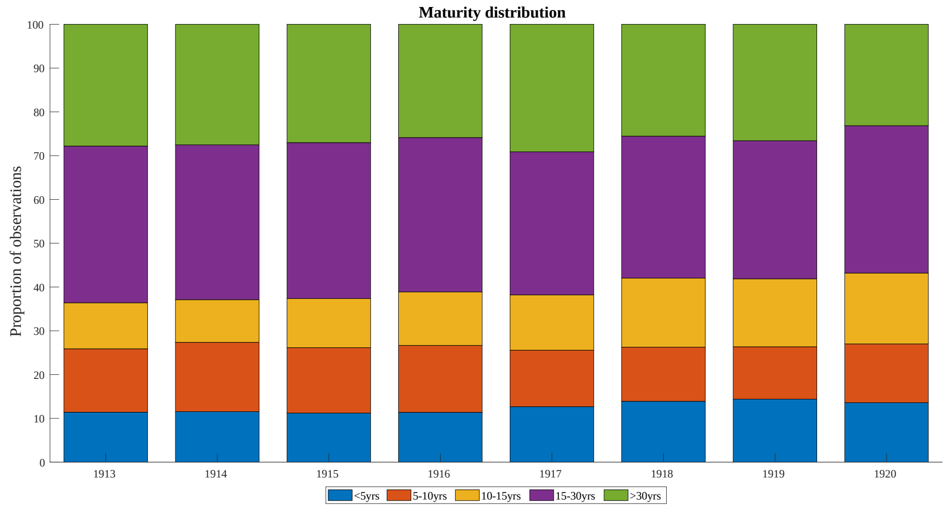

Figure A1. Distribution of bonds by maturity.

Notes: This figure plots the average proportion of observations in a given year that fall into 5 distinct maturity buckets. We classify bonds into 5 buckets based on time to maturity: less than 5 years, between 5–10 years, between 10–15 years, between 15–30 years, and longer than 30 years. Data are monthly from January 1910 to December 1920.

Table A1. Chronology of major events surrounding the introduction of U.S. federal income taxes.

Notes: This table presents the chronology of major events surrounding the introduction of U.S. federal income taxes over 1895–1920. For each event, we provide the month and the year of the event (column titled Date), and the major provisions enacted (column titled Law changes). Data is from historical records of the Internal Revenue Service.

Date	Law changes
April 1895	In Pollock v/s Farmers' Loan & Trust Co. (157 U.S. 429, 15 S. Ct. 673, 39 L. Ed. 759), the U.S. Supreme Court declares the Wilson-Gorman Tariff Act of 1894 (which imposed a 2% federal income tax on all incomes above $4,000) to be unconstitutional.
July 1909	Progressives in Congress attach a provision for an income tax to a tariff bill. Conservatives, instead propose a constitutional amendment allowing Congress to levy an income tax without apportioning it among the states on the basis of population.
August 1909	The Senate passes the Corporate Tax Act, which imposes an annual special excise tax of 1% on net income above $5,000 for all firms.
July 1911	Wisconsin becomes the first state to impose an income tax on individuals and firms located in the state. The income tax also applies to nonresidents and foreign firms as long as they derive income from within the state.
February 1913	The 16^{th} Amendment to the Constitution is ratified as Delaware becomes the 36^{th} state to authorize the amendment. The 16^{th} Amendment allows Congress to lay and collect taxes to pay the debts and provide for the common defense and general welfare of the U.S., without requiring that such taxes be apportioned among the states on the basis of population.
April 1913	President Woodrow Wilson appears before a Joint Session of Congress to read his message on a revenue bill that reduces tariffs and import duties, and replaces the lost revenue with an income tax imposed on all individuals and firms.
May 1913	The House of Representatives passes the Revenue Act of 1913, sponsored by Alabama representative Oscar Underwood. The Act lowers tariffs, bringing the average tariff rate down to 26%. The Act is also the first to impose an income tax since the end of the Civil War.
September 1913	Special interest groups attempt to add numerous increases in tariff rates to the Revenue Act of 1913 as passed by the House of Representatives. President Woodrow Wilson becomes personally involved, visiting the Capitol to argue for tariff reduction and imposition of income taxes. The Senate finally passes the Revenue Act of 1913 in September 1913.
October 1913	President Woodrow Wilson signs the 1913 Tariff Act into law, thus formally establishing the first progressive federal income tax of 1-7% on all income above $3,000-$500,000.
September 1916	The Revenue Act of 1916 is ratified which raises the lowest marginal income tax rate on individuals from 1% to 2% (on income above $20,000), and the top marginal income tax rate on individuals from 7% to 15% (on income above $2 million). The Act also doubles the tax on firms to 2%.
March 1917	The March Revenue Bill raises the lowest and top marginal income tax rate on individuals to 4% and 67% respectively. The corporate tax rate increases to 6%. The act also establishes a war profits tax, levying an 80% tax on all manufacturers of munitions.
October 1917	The October Revenue Bill replaces the war profits tax with an excess profits applicable to all firms. The Act levies a set of graduated tax rates of 20%–60% on net income of a firm in excess of its peacetime income. The bill also raises capital gains tax rate from 7% to 15%.
February 1919	The revenue act of 1918 again raises income tax rates over those established in the previous year. The lowest marginal income tax rate was increased to 6% and the top marginal income tax rate increased to 77%.
November 1920	Republican party wins the 1920 general elections, after promising to lower taxes to spur economic expansion and restore prosperity. Congress soon reduces the top marginal income tax rate for both individuals and firms and also eliminates the war profits tax.

Data	Frequency	Description and source
Taxable and tax-exempt corporate bond prices	Monthly	Mid-Price of taxable and tax-exempt U.S. corporate bonds from 1910–1920. This data is available for 3,731 bond issues. Source: Hand-collected from the Commercial and Financial Chronicle, available online at the HathiTrust Digital Library at https://catalog.hathitrust.org/Record/000548353.
Taxable and tax-exempt corporate bond prices	Monthly	Mid-Price of taxable and tax-exempt U.S. corporate bonds from 1910–1920. This data is available for 3,731 bond issues. Source: Hand-collected from the Commercial and Financial Chronicle, available online at the HathiTrust Digital Library at https://catalog.hathitrust.org/Record/000548353.
Taxable and tax-exempt corporate bond prices	Monthly	Bid and ask prices of taxable and tax-exempt U.S. corporate bonds over 1910–1920. This data is available for just 102 of the 3,731 bond issues for which data was hand collected from the Commercial and Financial Chronicle. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/.
Interest rates	Monthly	Rates on the one-year as well as the long-term bonds issues by the U.S. Treasury. Source: Shiller (2005), available online at http://www.econ.yale.edu/~shiller/data.htm..
Industrial production	Quarterly	Year-on-year growth rate of quarterly U.S. industrial production. Source: Miron and Romer (1990), available online at https://eml.berkeley.edu/~cromer/Data/Miron-Romer/mrip.xls..
Inflation	Monthly	Year-on-year percent changes in the U.S. Bureau of Labor Statistics consumer price index. Source: Shiller (2005), available online at http://www.econ.yale.edu/~shiller/data.htm..
Economic policy uncertainty index	Monthly	Historical U.S. economic policy uncertainty index. Source: Baker, Bloom, and Davis (2016), available online at http://www.policyuncertainty.com.

Data Sources–Continued

Data	Frequency	Description and Source
News-implied volatility index	Monthly	Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
Security markets news-implied volatility index	Monthly	Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
Government news-implied volatility index	Monthly	This index captures news with headlines including the words tax, money, rates, government, and plan. Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
Financial intermediation news-implied volatility index	Monthly	This index captures news with headlines including the words banks, financial, business, bank, credit. Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
Natural disaster news-implied volatility index	Monthly	This index captures news with headlines including the words fire, storm, happenings, and shock. Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
War news-implied volatility index	Monthly	This index captures news with headlines including the words war, military, action, world war, and violence. Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..
Un-classified news-implied volatility index	Monthly	This index captures news with headlines including ‘US’ ‘special’, ‘Washington’, ‘Treasury’, and ‘gold’. Source: Manela and Moreira (2017), available online at http://apps.olin.wustl.edu/faculty/manela/mm/nvix/nvix_and_categories_timeseries_mar2016.xlsx..

Data Sources–Continued

Data	Frequency	Description and Source
Investment grade corporate bond index	Monthly	Yield to maturity for investment grade U.S. corporate bonds. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: MOCAAAD.
Volatility	Monthly	The annualized volatility of monthly stock market returns calculated over twelve-month rolling windows using the S&P500 composite price index. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: SPXD.
Stock market index return	Monthly	Monthly returns on the S&P 500 composite price index. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: SPX.
Risk-free rates	Monthly	Monthly U.S. call money rates for mixed collateral. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: NBM13001USM156N.
Government bond returns	Monthly	Monthly total return index for the 10-year bond issued by the U.S. Treasury. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: TRUSG10M.
Credit spread	Monthly	Spread between the yield to maturity for investment grade U.S. corporate bonds and the 10-year constant maturity bond issued by the U.S. Treasury. Source: Downloaded from Global Financial Data, available online at https://www.globalfinancialdata.com/, Series identifier: IGUSA10D, and MOCAAAD.

Table A3. Summary statistics for macroeconomic variables.

Notes: This table reports the summary statistics for macroeconomic variables used in our analysis. IP is the year-on-year growth rate of quarterly industrial production, CPI is the year-on-year percentage change in the consumer price index published by the U.S. Bureau of Labor Statistics, EPU is the economic policy uncertainty index from Baker, Bloom, and Davis (2016). NVIX, SEC, GOV, INTR, NAT, WAR, and UNCL are the news impled VIX and its subcomponents for the security market, government, intermediation, natural disasters, war, and unclassified, respectively from Manela and Moreira (2017). Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. Data are monthly from January 1910 to December 1920.

Year	Mean	σ	Min	25^{th}	Med	75^{th}	Max
IP	6.01	17.35	-33.79	-4.76	3.58	12.49	69.11
CPI	9.89	7.57	-0.98	2.03	10.36	17.45	23.67
GDP	9.29	21.16	-57.29	-1.17	8.29	21.12	57.89
CON	0.60	3.61	-3.40	-3.13	0.44	3.01	7.50
EPU	123.12	34.88	61.77	101.60	118.93	138.55	256.49
NVIX	26.27	1.92	21.76	25.16	26.32	27.51	31.08
SEC	4.28	1.07	2.34	3.50	4.29	4.77	9.07
GOV	0.65	0.25	0.21	0.46	0.62	0.79	1.40
INTR	0.89	0.45	0.12	0.52	0.81	1.12	2.30
NAT	-0.01	0.01	-0.05	-0.01	-0.00	0.00	0.01
WAR	0.66	0.47	0.02	0.26	0.56	0.96	1.90
UNCL	7.01	1.30	3.86	6.12	7.14	8.04	9.72

Table A4. Summary statistics for financial variables.

Notes: This table reports the summary statistics for the financial variables and measures of bond liquidity used in our analysis. RF is the U.S. call money rates for mixed collateral, MKT is the value-weighted return for the stocks in the S&P500 index, BOND is the return on the 10-year bond issued by the U.S. Treasury, CREDIT is the spread between yields of U.S. investment grade corporate bonds and the 10-year constant maturity bond issued by the U.S. Treasury, and MKTVOL is the annualized realized volatility of the value-weighted return for stocks in the S&P500 index. All of these are expressed in percentages. BAP is the average spread between the bid and ask prices of all bonds and is expressed in cents per $100 notional value. CS and CSA denote the Corwin and Schultz (2012) is the range-based and adjusted-range-based estimate for transaction costs averaged across all bonds, respectively. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. Data are monthly from January 1910 to December 1920.

Year	Mean	σ	Min	25^{th}	Med	75^{th}	Max
RF	4.26	2.20	1.76	2.26	3.88	5.81	11.06
MKT	-0.27	3.44	-8.96	-2.47	-0.13	2.42	7.53
BOND	0.11	1.10	-3.12	-0.65	0.00	0.88	3.48
CREDIT	0.96	0.23	0.63	0.83	0.88	1.02	1.65
MKTVOL	11.74	3.95	5.55	8.28	10.50	14.48	22.05
BAP	2.16	0.55	1.10	1.73	2.22	2.61	3.32
CS	37.92	30.35	2.21	13.30	30.65	55.03	139.76
CSA	22.79	14.76	0.16	11.10	18.57	32.65	59.50

Table A5. List of securities used in asset pricing tests.

Notes: This table lists the securities used in asset pricing tests. Column titled GFD identifier indicates the mnemonic used by Global Financial Data to identify a particular time-series. Column titled Description provides a brief description of the series, column titled Class indicates if a security is a fixed income or an equity security, and the column titled Type identifies the type or sector for the security. Panel A presents the list of fixed income securities and Panel B presents the list of equity securities. Data is from Global Financial Data and is monthly over January 1910 to December 1920.

GFD Identifier	Description	Class	Type
	Panel A: Fixed income securities		
SPBAAAIW	S&P AAA rated corporate bond price index	Bonds	Composites
TRUSACOM	U.S. AAA rated corporate bond total return index	Bonds	Composites
IGUSABBW	U.S. Bond buyer municipal bond index	Bonds	Government
SPBIMUNW	S&P municipal bond price index	Bonds	Government
TRUSAMUM	U.S. AAA rated municipal bond total return index	Bonds	Government
TRUSG10M	U.S. 10-year government bond total return index	Bonds	Government
NBM11016–USM052N	U.S. high grade railroad bond prices	Bonds	Transport
	Panel B: Equity securities		
SPXD	S&P500 composite price index	Stocks	Composites
SPXTRD	S&P500 total return index	Stocks	Composites
NBM11007–USM322N	NYSE common stock price index	Stocks	Composites
NBM11008–USM322N	NYSE preferred stock price index	Stocks	Composites
SPPREFEW	S&P500 preferred stock price index	Stocks	Composites
TRSPID	S&P500 industrials total return index	Stocks	Composites
RLXD	S&P500 retail composite index	Stocks	Consumer discretionary
SPAUTOD	S&P500 automobiles composite index	Stocks	Consumer discretionary
5SP25203010	S&P500 apparel, accessories & luxury goods index	Stocks	Consumer discretionary
SPRETDD	S&P500 retail and department stores index	stocks	Consumer discretionary
SPSHOED	S&P500 footwear composite index	Stocks	Consumer discretionary
SPAUXGMW	S&P500 automobiles excluding General Motors index	Stocks	Consumer discretionary
SPHOPSW	S&P500 household products and supplies index	Stocks	Consumer discretionary
SPRETMAW	S&P500 retail and mail order index	Stocks	Consumer discretionary
SPRETTOM	S&P500 retail and tobacco stores index	Stocks	Consumer discretionary
SPRETVAW	S&P500 retail and variety 5 cent and 10 cent stores index	Stocks	Consumer discretionary
SPWOOLEW	S&P500 woolen goods composite index	Stocks	Consumer discretionary
5SP302030	S&P500 tobacco composite index	Stocks	Consumer staples
SPCIGARW	S&P500 tobacco and cigar manufacturers index	Stocks	Consumer staples
SPSUGARW	S&P500 sugar composite index	Stocks	Consumer staples
5SP101020	S&P500 oil, gas and consumable fuels index	Stocks	Energy
SPINDD	S&P500 industrials composite index	Stocks	Industrials
5SP201060	S&P500 machinery composite index	Stocks	Industrials
SPELEQW	S&P500 electrical equipment composite index	Stocks	Industrials
SPMANUMW	S&P500 miscellaneous manufacturing index	Stocks	Industrials
SPCOMPD	S&P500 computer hardware composite index	Stocks	Information technology
5SP151010	S&P500 chemicals composite index	Stocks	Materials
5SP15104050	S&P500 steel composite index	Stocks	Materials
SPPAPRD	S&P500 paper and forests composite index	Stocks	Materials
SPLEADZW	S&P500 lead and zinc composite index	Stocks	Materials
SPLEATHW	S&P500 leather composite index	Stocks	Materials
SPMINSMW	S&P500 mining and smelting composite index	Stocks	Materials
5SP50101020	S&P500 integrated telecommunication services composite index	Stocks	Telecommunications
5SP20304010	S&P500 road and rail composite index	Stocks	Transport
TRGSPTRN	S&P500 transportation total return index	Stocks	Transport
NBM1105AUS–M505N	U.S. railroad stock prices value-weighted by number of outstanding shares	Stocks	Transport
5SP55	S&P500 utilities composite index	Stocks	Utilities
TRGSPUD	S&P500 utilities total return index	Stocks	Utilities

Table A6. Summary statistics for securities used in asset pricing tests.

Notes: This table reports the summary statistics for securities used in asset pricing tests. Panel A reports the summary statistics for fixed income securities and Panel B reports the summary statistics for equity securities. We report summary statistics for an equal weighted index of all securities grouped by type as identified and listed in Table A5. All statistics are expressed in percentages. Mean, σ, Min, 25^{th}, Med, 75^{th}, and Max denote the mean, the standard deviation, the minimum, 25^{th}-percentile, the median, 75^{th}-percentile, and the maximum, values respectively. Data are monthly from January 1910 to December 1920.

Type	Mean	σ	Min	25^{th}	Median	75^{th}	Max
Panel A: Fixed income securities							
Composites	0.05	0.65	-1.71	-0.25	0.05	0.40	3.03
Government	0.63	1.61	-2.48	-0.74	0.70	1.59	4.39
All	0.34	1.16	-2.43	-0.46	0.37	1.01	3.50
Panel B: Equity securities							
Composites	0.05	2.49	-5.45	-1.80	0.14	1.91	7.87
Consumer discretionary	0.64	4.65	-9.50	-2.68	0.49	3.72	17.61
Consumer staples	-0.07	3.57	-12.86	-2.36	0.19	2.03	8.18
Energy	0.31	5.65	-18.46	-3.34	0.31	3.08	20.90
Industrials	-0.16	5.04	-9.54	-3.65	-0.38	2.66	24.95
Information technology	-0.30	3.86	-12.95	-2.42	-0.08	1.77	14.56
Materials	-0.04	6.88	-17.61	-4.86	-0.40	4.43	20.88
Transports	-0.25	1.82	-5.53	-1.50	-0.16	1.10	4.10
Utilities	-0.04	2.21	-6.43	-1.43	-0.17	1.56	5.76
All	0.13	3.86	-9.05	-2.53	0.07	2.83	13.67