Government Funding Advantage and Financial Repression*

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Abstract

US federal debt plays a special role in the US economy and so gives the US government a funding advantage, often summarized by the spread between the yield on high-grade US corporate bonds and comparable US treasuries. Why? One reason is that government regulation (and/or repression) of the financial sector influences asset pricing and helps make long term US federal debt an endogenously "safe-asset". We study the mechanics, limitations, and macroeconomic trade-offs involved with generating a government funding advantage through restrictions on the financial sector. We show the government cannot choose all three of: (i) high funding advantage, (ii) a well-functioning financial sector, and (iii) fiscal policy that leads to systematic debt devaluation. We relate our theories to new US historical corporate and treasury yield curve data from 1860-2024.

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

Key words: Convenience Yields, Government Debt Capacity, Financial Repression, Safe Assets.

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1 Introduction

US federal debt plays a special role in the economy and so gives the US government a funding advantage, often summarized by the spread between the yield on high-grade US corporate bonds and comparable US treasuries.[1] Macro-finance models have frequently treated US funding advantage as an immutable feature of the economic environment and encoded the "benefits" of holding US debt into agent preferences or the market structure. This means the government can easily "exploit" the funding advantage to increase spending. By contrast, historical studies suggest that the funding advantage emerged as part of a complicated collection of financial-monetary policies that have shaped financial sector demand for US treasuries. As documented in Lehner, Payne and Szőke (2024), this led to a funding advantage appearing in the late 1860s, well before Bretton-Woods, and falling to zero during the high inflation of the 1970s, despite the emergence of US dollar denominated debt as the international reserve asset. When viewed in this way, generating and exploiting a funding advantage is closely interconnected with government policy, difficult to execute, and imposes far reaching impacts on the macroeconomy. It links the stability of the financial sector to the stability of the government budget constraint. It distorts the portfolio of the financial sector, potentially increasing default and crowding out private liquidity creation and productive investment. In this paper, we study the mechanics, limitations, and trade-offs involved with creating financial sector demand for government debt and relate our analysis to historical eras.

We start by using our new dataset from Lehner et al. (2024) to study the historical statistical properties of the US high-grade corporate to treasury spread over the period from 1860-2024. To understand the equilibrium relationships between spreads and macroeconomic variables, we run the regressions from Krishnamurthy and Vissing-Jorgensen (2012) with the following changes: we use a longer sample, we include treasury return volatility as a dependent variable, and we condition the regressions by regulatory era. We find that different regulatory eras have very different relationships. First, the US high-grade corporate to treasury spread is largely uncorrelated with the US debt-to-GDP ratio during National Banking Era (1865-1913). By contrast, the relationship is negative across the overall period from 1920-2007 although there appears to be little correlation during the era of yield curve control (1942-1951), the high inflation period (1965-90), and the quantitative easing period (post 2008). Second, we find that the US high-grade corporate to treasury spread is strongly negatively correlated with treasury return volatility, particularly during the second half of

[1] This spread is sometimes referred to as the "convenience yield", "convenience spread", or "treasury premium" in the literature. However, there are also other measures of the convenience yield. So, to avoid confusion we instead use the term high-grade corporate to treasury spread to refer to the measure in our data and government funding advantage or public-private borrowing cost spread to refer to theoretical spread in our model that we are trying to approximate. We choose this terminology to emphasize that we are measuring how much more cheaply the government can raise funds than the private sector.

the twentieth century. Finally, we find that regulatory regime level effects are important for explaining the long sample. Our empirical evidence emphasizes the breadth and complexity of the interaction between government policy and convenience yields.

In Section 3, we build a structural model that endogenizes the connections between financial sector regulation, fiscal policy, and the return process on government debt. Our environment is a stochastic neoclassical growth model extended to include a morning subperiod where households need liquidity services provided by a risky banking sector (referred to as the "secondary" asset market) and an afternoon subperiod where there are no frictions (referred to as the "primary" asset market). Absent regulation, there is no special role for government debt. The economy is populated by households who need bank deposits to be able to consume in the morning sub-period. Banks issue on-demand deposits and equity to households and invest in short assets, capital, and government bonds. In this sense, banks provide both liquidity and intermediation services to households. In the morning sub-period, banks get idiosyncratic deposit withdrawal shocks, which potentially cause them to default because their resource-drawing capacity is constrained and the inter-bank asset markets are characterized by "fire-sale pricing". The combination of households' need for deposits and the possibility of costly default are the "frictions" in the economy that break Modigliani and Miller (1958) by driving a wedge between the stochastic discount factors of the household and banks. The government in our model cares about spending and household welfare but faces a constraint that taxation is determined by an exogenous political process. Instead, the government can place restrictions on the portfolios of the banks that potentially increase the price of government debt and expand their spending. We focus on restrictions that require the banks to maintain a particular ratio of weighted average assets to deposits. We interpret equal weighting on government debt and capital to be neutral regulation and a higher weighting on government debt to be financial "repression".

We characterize how repression can generate a government funding advantage by making government debt an endogenously "safe-asset" in the economy. We show that the government can choose constraints on holdings of government debt that bind more for banks in the morning in the bad state of the world and so create counter-cyclical "captive demand". This leads to an appreciation of the price of government debt in the morning market in bad states and so makes government debt a good "hedge" against both aggregate shocks and idiosyncratic withdrawal risk. Consequently, banks voluntarily increase their government debt in the afternoon market to self-insure against morning market shocks, which also leads to banks taking on higher leverage and so, in equilibrium, having more need for government bonds to hedge their risk. The end result is that the price of government debt is inflated in the primary asset market. We interpret the inflated debt price as an embedded "funding advantage", as measured by the difference between the yield on government debt and the yield on an asset issued by the private sector with the same cashflow process.

We use our model to show that the combination of financial repression and government "fiscal irresponsibility" erodes the government's funding advantage, where we interpret fiscal irresponsibility to mean the (explicit or implicit) devaluation of government debt in bad afternoon periods. This is because financial repression ties the solvency of the banking sector to the stability of the government debt prices while at the same time irresponsible fiscal policy destabilizes government debt prices. This means that the banks are left with a difficult trade-off: if they don't purchase government debt, then they violate the regulatory restrictions on backing deposits but if they purchase government debt, then the government's fiscal policy policy forces them to take losses and pay negative dividends. So the government's fiscal policy makes government debt a worse hedge at the same time that it makes banks less solvent and more concerned about finding a good hedge. Banks respond to this lose-lose situation by defaulting to depositors and effectively "exiting" the deposit market. This erodes the government's captive demand in the banking sector and so the government' funding advantage disappears. It is important to note that this decrease in funding advantage is not coming from a devaluation risk premium emerging on government debt (since that is differenced out in our definition of government funding advantage). Instead, it occurs because government debt no longer plays a special role in interbank market and so no longer provides a non-pecuniary benefit. This is in sharp contrast to models with bond-in-the-utility or bond-in-advance where the role of government debt is exogenous and its marginal usefulness increases as return volatility decreases the market value of government debt. In these models, as the government starts to run irresponsible fiscal policy, the government funding advantage increases. Or put another way, in these models the agents receive welfare from providing resources to the government so, when the government starts to devalue its debt, they feel they are providing the government too few resources and purchase more government debt. This highlights the importance of starting from a model where government is endogenously important when we study fiscal policy.

Our model leaves the government with complicated trade-offs, which we summarize as a "trilemma" that the government cannot choose all three of: (i) high funding advantage, (ii) a well-functioning financial sector (profitable and stable), and (iii) fiscal policy that leads to systematic real debt devaluation (e.g. "default", "counter-cyclical" issuance, "inflation"). For example, if the US government wants to run policy that leads to a real devaluation of its debt, then according to the trilemma it must choose between maintaining its funding advantage by forcing the financial sector to hold more government debt and maintaining financial stability by allowing the financial sector to substitute away from government debt. Alternatively, if the US government wants to generate a high funding advantage through heavy repression of the financial sector, then it must choose between a maintaining a profitable/stable financial sector and fiscal-monetary policy that would lead to the systematic devaluation of its debt.

1.1 Related Literature

Our paper is part of a large literature studying financial and fiscal policies in non-Ricardian macroeconomic models. A recent branch of this literature studies the "fiscal-sustainability" of government debt taking fiscal policy and private sector pricing kernels as given (e.g. Jiang, Lustig, Stanford, Van Nieuwerburgh and Xiaolan (2022a); Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2022b); Chen, Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2022)) or deriving private sector pricing kernels from a model with incomplete markets that generate a premium on government debt (e.g. Reis (2021b), Reis (2021a), Brunnermeier, Merkel and Sannikov (2022)). Our paper studies the feasibility and costs of using financial regulation as a means to "choose" private sector pricing kernels that increase government fiscal capacity. Another branch of this literature studies fiscal-monetary connections (e.g. Sargent and Wallace (1981) and the "fiscal theory of the price level" papers such as Leeper (1991), Sims (1994), Woodford (1994), Cochrane (2023), Bianchi, Faccini and Melosi (2023)). Unlike in these papers, government debt in our model is partially backed by financial regulation that creates captive demand within the financial sector and so makes government debt a safe asset. Ultimately, this means that fiscal policy not only backs government debt through the surplus process but also through its effectiveness as a safe asset. In this sense, we bring the fiscal cost of generating a funding cost spread onto the equilibrium path.

Our government design problem is related to the literature studying optimal policy in economies with financial frictions and tax distortions (e.g. Calvo (1978), Bhandari, Evans, Golosov and Sargent (2017a), Bhandari, Evans, Golosov, Sargent et al. (2017b), Chari, Dovis and Kehoe (2020), Bassetto and Cui (2021), Sims (2019), Brunnermeier et al. (2022)). In this paper we take the stand that the government follows a fiscal policy rule governed by unmodeled political constraints but has flexibility in how it wants to restrict the financial sector. We believe this reflects the historical experience of many governments. We use this model to focus on microfounding the "costs" of using financial regulation to increase government fiscal capacity.

We are also part of a long literature attempting to understand how the financial sector and government can create safe assets (e.g. Holmstrom and Tirole (1997), Holmström and Tirole (1998), Gorton and Ordonez (2013), Gorton (2017), He, Krishnamurthy and Milbradt (2016), He, Krishnamurthy and Milbradt (2019), Choi, Kirpalani and Perez (2022)) and the macroeconomic implications of safe asset creation (e.g. Caballero, Farhi and Gourinchas (2008), Caballero, Farhi and Gourinchas (2017), Caballero and Farhi (2018)). Our contribution to this literature is to connect an endogenous safe asset model to a general equilibrium macroeconomy with a government that faces fiscal constraints.

Our historical comparisons extend existing studies on the convenience yield (e.g. Krishnamurthy and Vissing-Jorgensen (2012), Choi et al. (2022)) back to the mid nineteenth century. This makes us part of a literature attempting to connect historical time series for asset prices to government financing costs (e.g. Payne, Szőke, Hall and Sargent (2023b), Payne, Szőke, Hall and Sargent (2023a), Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2021b), Jiang, Krishnamurthy, Lustig and Sun (2021a), Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2020a)). Our Eurozone example adopts the approach in Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2020b). Our focus on modeling the hedging properties of government debt is complementary to the empirical work of Acharya and Laarits (2023).

Section 2 presents historical empirical evidence on the private-public borrowing cost spread. Section 3 describes and characterizes our model. Section 4 explores implications for macroeconomic policy.

2 Evidence on US Government Funding Advantage

In this section, we introduce the notion of a private-public borrowing cost spread in a stylized model and study its historical empirical properties. In the next section, we build a general equilibrium model to endogenize the emergence and fragility of this spread.

2.1 Conceptual Framework

Consider a discrete time, infinite horizon economy with time indexed by $t \in \{0, 1, \ldots\}$. The economy contains a representative household, a representative financial intermediary, and a government. The government and the household both issue bonds that pay a fraction ω of the remaining outstanding balance each period. The bonds trade in a competitive market at prices q_t^b and q_t^h respectively. The private sector bonds are in zero net supply whereas the government bonds are in positive net supply b_t.

The representative financial intermediary purchases the assets and receives a non-pecuniary benefit from holding government debt, which means that the government can sell its debt at a higher price than the private sector, $q_t^b > q_t^h$, even though the bonds promise the same cash flow stream. Following the literature, we characterize this funding advantage by imposing the following asset pricing structure. The representative financial intermediary has an exogenous stochastic discount factor (SDF) process, $\tilde{\xi}$. Government and private debt satisfy the respective Euler equations:

$$q_t^b = \mathbb{E}\Big[\tilde{\xi}_{t,t+1}\Omega_{t,t+1}\Big(\omega + (1-\omega)q_{t+1}^b\Big)\Big], \qquad q_t^h = \mathbb{E}\Big[\tilde{\xi}_{t,t+1}\Big(\omega + (1-\omega)q_{t+1}^h\Big)\Big]$$

where $\tilde{\xi}_{t,t+1}$ is the financial intermediary's exogenous stochastic discount factor from t to $t+1$ and $\Omega_{t,t+1}$ is a government debt specific wedge capturing the non-pecuniary benefit of government debt. The government's funding advantage compared to the private sector is summarized by the yield spread:

$$\chi_t := \log(q_t^b) - \log(q_t^h). \tag{2.1}$$

This spread is sometimes referred to as a "convenience yield" (e.g. Krishnamurthy and Vissing-Jorgensen (2012)), a treasury convenience premium, or a "box spread" (van Binsbergen, Diamond and Grotteria, 2022) compared to a synthetic government bond without its non-pecuniary benefits. We do not take a stand on the most appropriate name instead refer to it as the "private-public borrowing cost spread" or government "funding advantage". Rearranging equation (2.1) implies that:

$$\exp(\chi_t) = \frac{q_t^b}{q_t^h} = \mathbb{E}_t[\Omega_{t,t+1}] + \mathbb{C}\mathrm{ov}_t\Big[\tilde{\xi}_{t,t+1}\frac{1}{q_t^h}\Big(\omega + (1-\omega)q_{t+1}^b\Big);\ \Omega_{t,t+1}\Big].$$

Many models (e.g. the BIU models in Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016)) assume that Ω_t is a time invariant function of the market value of debt to gdp $q_t^b b_t/y_t$ and preference shocks ζ_t. This implies that Ω_t is adapted to period-t information, the covariance term is zero, and $\chi_t = \log(\Omega_t)$. However, in general, the non-pecuniary benefit of government debt, $\Omega_{t,t+1}$, can co-move with the risk-adjusted return on private debt, $\tilde{\xi}_{t,t+1}(\omega + (1-\omega)q_{t+1}^b)$. This means the covariance term can potentially be an important source of government funding advantage or a reason why the government could lose its funding advantage.

Each period t, the government raises taxes τ_t, spends g_t, and issues long-term debt b_t. The period t government budget constraint is given by:

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

Iterating the budget constraint forward gives the lifetime budget constraint:

$$\big(\omega + (1-\omega)q_t^b\big)b_{t-1} = \mathbb{E}_t\left[\sum_{s=0}^{\infty}\tilde{\xi}_{t,t+s}\Big(\Big(\frac{\tau_{t+s} - g_{t+s}}{y_{t+s}}\Big) + \Big(\frac{q_{t+s}^b - q_{t+s}^h}{y_{t+s}}\Big)b_{t+s}\Big)y_{t+s}\right] \tag{2.2}$$

This equation implies that the value of outstanding debt, $(\omega + (1-\omega)q_t^b)b_{t-1}$, is the present discounted value of future surpluses, $\{\tau_{t+s} - g_{t+s}\}_{s\geq 0}$, and the present discounted value of the "seigniorage" revenue the government earns from being able to issue debt more cheaply than the private sector, $\{(q_{t+s}^b - q_{t+s}^h)b_{t+s}\}_{s\geq 0}$. Following Sargent and Wallace (1981), we can express the seigniorage revenue as:

$$(q_t^b - q_t^h)b_t = q_t^b b_t(1 - \exp(-\chi_t))$$

which can be interpreted as the market value of government debt $q_t^b b_t$ multiplied by the implicit "tax" from the government's funding advantage $1 - \exp(-\chi_t)$.

2.2 US Government Funding Advantage in the Data

The lifetime government budget constraint (2.2) emphasizes that government borrowing capacity depends upon the joint dynamics of primary surpluses, the private-public borrowing cost spread, debt-to-GDP, the investor SDF, and other macroeconomic variables. To explore this, we study the statistical properties of the private-public borrowing cost spread. In the spirit of Krishnamurthy and Vissing-Jorgensen (2012), we measure the private-public borrowing cost empirically as the spread between the yield on high grade corporate bonds and the yield of comparable US treasuries. However, instead of using bond indexes that incorporate different maturities and tax treatments, we draw on our work in Lehner et al. (2024), which estimates zero-coupon yield curves for high grade corporate bonds and US treasuries separately and adjusts them for differential tax treatment (and other features). We then compute the term structure of private-public borrowing cost spreads as the difference between our tax-adjusted corporate and government yield curves.

Figure 1 plots our historical time series. The top panel shows the ex-post real one-period return on holding 10-year treasuries, the long run mean of the real return, and the volatility of the real return. The middle panel shows the 10-year private-public borrowing cost spread and the market value of government Debt-to-GDP. Finally, the bottom panel shows the scatter plot between the 10-year private-public borrowing cost spread and the market value of government Debt-to-GDP.

Our time series extend across many different eras of financial-fiscal-monetary policy. For the purposes of this paper, we focus on the following stylized categorization of the periods:

1. 1865-1919 ("National Banking Era"): During this period, the government tightly regulated the banking sector to create demand for Federal government debt. Between 1863-6, Congress passed a collection of National Banking Acts, which established a system of nationally charted banks that were allowed to issue bank notes up to 90% of the minimum of par and market value of qualifying US federal bonds.[2] and could only issue a narrow range of loans[3]

2. 1920-1951 ("War and Depression Financing"): During this period, the government become more directly involved in the monetary and banking systems. The Federal

[2]Technically, national banks could issue bank notes for circulation according to the following rules. Banks had to deposit certain classes of US Treasury bonds as collateral for note issuance. Permissible bonds were US federal registered bonds bearing coupons of 5% or more. Deposited bonds had to be at least one-third of the bank's capital (not less than $30,000). Banks could issue bank notes up to an amount of 90% of the maximum of the market value of the bonds and the par value of the bonds. The 90% value was changed to 100% in 1900.

[3]National banks could only operate one branch. They were restricted from making mortgages unless they were operating in rural areas, where they could make a limited range of loans collateralized by agricultural land.

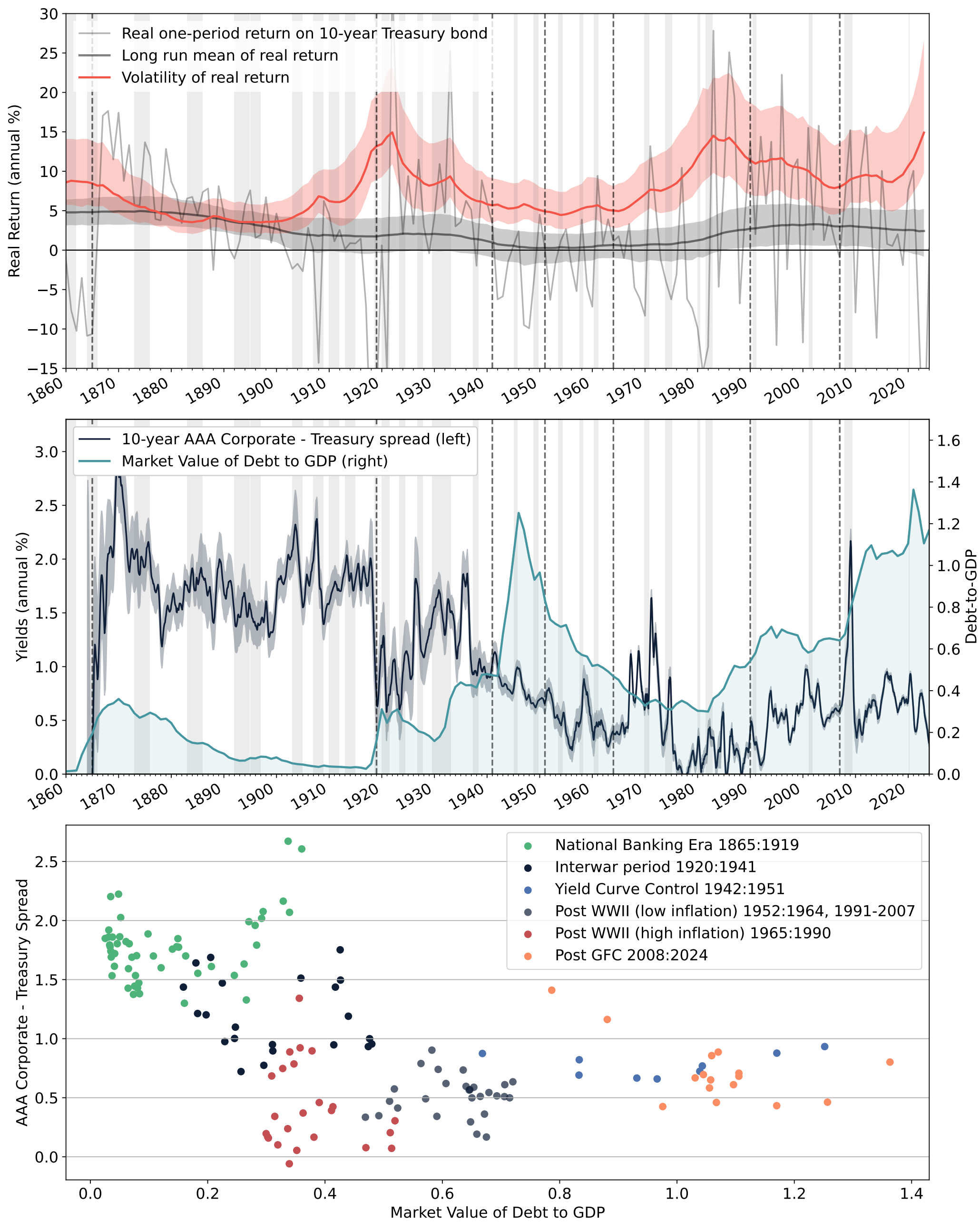

Figure 1: *Top panel:* The gray thin line is the observed real one-period (annual) return on a 10-year Treasury bond. The gray thick line and the red thick line show the posterior median estimates of the permanent component and stochastic volatility of the real holding period return, respectively, estimated using a univariate trend-cycle model of Stock and Watson (2007). The bands represent corresponding 95% interquantile ranges. *Middle panel:* The black line is the posterior median estimate of the spread between the 10 year high-grade corporate and treasury yields. The shaded bands around the line is 95% posterior intervals. The gray shaded time intervals are NBER recessions. *Bottom panel:* Scatter plot of the spread between the 10-year high-grade corporate and treasury yields against the market value of US debt to GDP.

Reserve Bank (created under the The Federal Reserve System Act in 1913) took over money creation and introduced liquid markets for short-term government debt. The 1933 Banking act introduced deposit insurance for retail banks, established the Federal Deposit Insurance Corporation (FDIC), and separated commercial and investment banking. The 1934 Gold Reserve Act ended the gold standard and prohibited private holding of gold in the US. The 1934 and 1938 household acts established the Federal National Mortgage Association (commonly known as Fannie Mae) to insure long term mortgages. The difficulties of financing World War II led to the Treasury and Fed coordinating to "fix" the yield curve from 1942-1951, with yields on long term bonds set at 2.5% (see Garbade (2020)).

3. 1952-1993 ("Business Cycle Management"): During this period, at the domestic level, the government pursued business cycle management policies that placed varying emphasis on "counter-cyclical" monetary stimulus and inflation targeting. At the international level, the 1944 Bretton Woods Agreement set up an international system of fixed exchange rate with US dollar convertible to gold. This lasted until 1971 when President Nixon ended convertibility to gold and floated the dollar.

4. 1994-2007 ("Deregulation"): Towards the end of the twentieth century, the government embarked on a program of financial deregulation. In 1994, the Riegle-Neal Interstate Banking and Branching Efficiency Act allowed banks to operate across states. In 1999, the Gramm-Leach-Bliley Act repealed the provisions of the Glass-Steagall Act that prohibited banks from holding other financial companies.

5. 2008-2024: ("Financial Crisis, Basel-III, and Dodd-Frank Act.") The 2007-9 financial crisis led to extensive new regulation on the banking sector and the Dodd-Frank Wall Street Reform and Consumer Protection Act. In addition, the Basel-III regulation introduced a large collection of portfolio constraints on the banking sector that penalized bank leverage ratios and encouraged bank government debt holding.

We depict the different policy eras in Figure 1 using dashed vertical lines on the time series plots and colors on the scatter plot. The mean, volatility, and cyclicality of key variables during each policy era are summarized in Table 1.

Figure 1 and Table 1 suggest a collection of stylized facts about government funding advantage. First, the private-public funding cost spread exhibits low frequency variation that relates to different policy eras. The spread peaked during the National Banking Era (1862-1916) with an average level of 1.73% and generally stayed high until the end of gold standard in the 1930s. It underwent a trend decline after the Great Depression before dropping close to zero during the 1970s-80s and recovering to an average value of 0.72% in the post-GFC period (2008-24). Second, the private-public funding cost spread negatively co-moves with increases in Treasury return volatility. We can see that during the two large

	1870-1919	1920-1951	1952-1993	1994-2007	2008-2025
Private-public borrowing cost spread: (χ_t)					
mean	1.734	1.066	0.431	0.663	0.717
vol	0.277	0.302	0.269	0.228	0.247
corr$(\cdot, \Delta y)$	-0.142	-0.121	-0.128	-0.557	-0.529
Debt-to-GDP: $(q_t^b b_t / y_t)$					
mean	0.126	0.512	0.477	0.655	1.07
vol	0.065	0.174	0.137	0.047	0.084
corr$(\cdot, \Delta y)$	0.044	-0.24	-0.049	-0.374	-0.079
Real return: $((\omega + (1-\omega) q_{t+1}^b)/q_t^b - 1)$					
mean	2.338	2.262	1.818	3.004	1.057
vol	4.71	7.68	8.61	9.57	10.09
corr$(\cdot, \Delta y)$	-0.206	-0.295	-0.14	-0.414	0.131
Surplus-to-GDP: $(g_t - \tau_t)/y_t$					
mean	0.071	-3.794	-1.956	-1.168	-6.153
vol	2.611	7.298	1.067	1.763	3.554
corr$(\cdot, \Delta y)$	-0.083	-0.221	-0.261	0.137	0.356

Table 1: Summary statistics for different policy eras.

increases in long-run return volatility in the third panel of Figure 1: the increase to 15% following WWI and the increase to 14% in 1981. Both correspond to sharp decreases in the spread in the second panel of Figure 1. There are many potential reasons for the changes in bond return volatility in our sample. One potential reason is changes to the co-movement between surpluses and the business cycle (which we study using our model in Section 4). Other potential reasons are higher volatility in government spending or monetary policy shocks. The stylized facts are also reflected in the scatter plot in panel 2 of Figure 1, where we can observe novel patterns in the relationship between the private-public funding cost spread and the debt-to-GDP ratio. In particular, the relationship appears mostly flat (with period specific intercepts) during the National Banking Era (1865-1919), during the era of yield curve control (1942-1951), and the quantitative easing period (post 2008). We can also see that the convenience yield drops to zero during the high inflation period (1965-1990) disrupting the pattern in the equilibrium relationship between the private-public borrowing cost spread and the debt-to-GDP ratio.

To formalize our analysis, we run the regressions from Krishnamurthy and Vissing-Jorgensen (2012) (and subsequent papers) using our new yield curve series with a longer sample and including treasury return volatility, σ_t^R, as an additional dependent variable. The results are shown in Table 2. The first two columns show the results for the National Banking Era period (1870-1919) and the period from World War I to the GFC. The remaining columns show smaller samples that have less robust statistical properties but we none-the-less believe help to tell a story. Evidently, the average level and the relationship to Debt-to-GDP ratio varies significantly across the sample. Throughout the nineteenth century there is little relationship to the Debt-to-GDP ratio while throughout the twentieth century there is typically a negative relationship to Debt-to-GDP (although the value of the coefficient has substantial variation across the subsamples). Throughout the twentieth century, there also a persistent negative relationship with volatility of the return on government. In particular, during the Great Inflation, when government debt returns became highly unstable, there is little relationship between AAA Corporate-Treasury spreads and Debt-to-GDP but a strongly negative relationship to return volatility.

	10-year AAA Corporate-Treasury spread					
	1870-1919	1920-2007	1920-1941	1952-2007	1965-1994	2008-2025
const	1.850***	0.934***	0.656	0.852***	1.903***	2.511***
	(0.330)	(0.223)	(0.482)	(0.133)	(0.382)	(0.492)
$\log(q_t^b b_t/y_t)$	0.079	-0.310***	-0.925***	-0.115*	-0.053	0.447
	(0.066)	(0.102)	(0.203)	(0.069)	(0.132)	(0.306)
σ_t^R	0.097	-0.376***	-0.467*	-0.273***	-0.686***	-0.737***
	(0.154)	(0.116)	(0.228)	(0.063)	(0.126)	(0.181)
slope	-0.046	-0.007	0.137**	-0.002	0.022	-0.069**
	(0.043)	(0.039)	(0.064)	(0.020)	(0.032)	(0.030)
VIX	-0.178	1.870***	0.710	1.007	-0.395	2.186***
	(0.447)	(0.519)	(0.576)	(0.786)	(1.163)	(0.516)
Obs	51 (A)	88 (A)	22 (A)	221 (Q)	113 (Q)	53 (Q)
Adj R^2	-0.043	0.262	0.448	0.080	0.247	0.448
F Stat	0.490	8.721***	5.263***	5.778***	10.181***	11.532***

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

Table 2: Regression of the 10-year AAA Corporate-Treasury spread on the dependent variables: the log of debt-to-GDP ($\log(q_t^b b_t/y_t)$), the volatility of government debt returns (σ^R), the 10-2 year slope of the yield curve, and the volatility of equity returns.

2.3 Private-Public Borrowing Spreads and Government Policy

The empirical evidence shows that, in equilibrium, the private-public borrowing spread co-moves with the debt-to-GDP ratio, stock market volatility, government debt return volatility, and financial regulation policy. This suggests that a non-structural, stylized representation of the private-public borrowing spread might take the form:

$$\chi_t = f\left(\frac{q_t^b b_t}{y_t}, \sigma_t^R, \sigma_t^S;\ \kappa\right) \tag{2.3}$$

where the private-public borrowing spread function f is decreasing in the ratio of the market value of debt-to-GDP $q_t^b b_t/y_t$, decreasing in the volatility of the return on government debt σ_t^R, increasing in market volatility σ_t^S, and increasing in any financial regulatory parameters κ that force the financial sector to hold government debt. By contrast, the BIU models frequently used in the literature impose a narrower stylized functional form where χ_t only depends upon the debt-to-GDP ratio $q_t^b b_t/y_t$ and potentially exogenous, independent "preference" shocks ζ_t:

$$\chi_t = \widetilde{f}\left(\frac{q_t^b b_t}{y_t}, \zeta_t\right) \tag{2.4}$$

The form of the private-public borrowing spread representation has important policy implications because it determines the suite of government policies that affect seigniorage revenue and, by extension, the government ability to issue debt not backed by surpluses. In particular, under the more general specification (2.3), the seigniorage revenue relative to GDP can be expressed as:

$$\frac{(q_t^b - q_t^h)b_t}{y_t} = \frac{q_t^b b_t}{y_t}\left(1 - \exp\left(-f\left(\frac{q_t^b b_t}{y_t}, \sigma_t^R, \sigma_t^z;\ \kappa\right)\right)\right),$$

which implies that government policy not only affects seigniorage revenue by changing the market value of government debt $q_t^b b_t/y_t$ but also by changing the price process for government debt σ_t^R and/or the regulatory regime. By contrast, the BIU specification (2.4), leads to the seigniorage revenue expression:

$$\frac{(q_t^b - q_t^h)b_t}{y_t} = \frac{q_t^b b_t}{y_t}\left(1 - \exp\left(-\widetilde{f}\left(\frac{q_t^b b_t}{y_t}, \zeta_t\right)\right)\right)$$

which implies that the seigniorage maximizing value of the debt-to-GDP ratio $q_t^b b_t/y_t$ is independent of other government policies.

To illustrate the relevance of these arguments, we consider the impact of policies that generate return risk (an increase in σ^R) and so a devaluation of government debt (a decrease in q_t^b). Figure 2 shows the impact on the private-public borrowing spread and seigniorage revenue under the BIU specification (2.4) with the red arrows and the more general specification from equation (2) with the blue arrows. Evidently, under the BIU model, increasing return risk moves the economy up along the private-public borrowing spread curve and the seigniorage revenue curve. In this sense, return risk does not change the seigniorage revenue

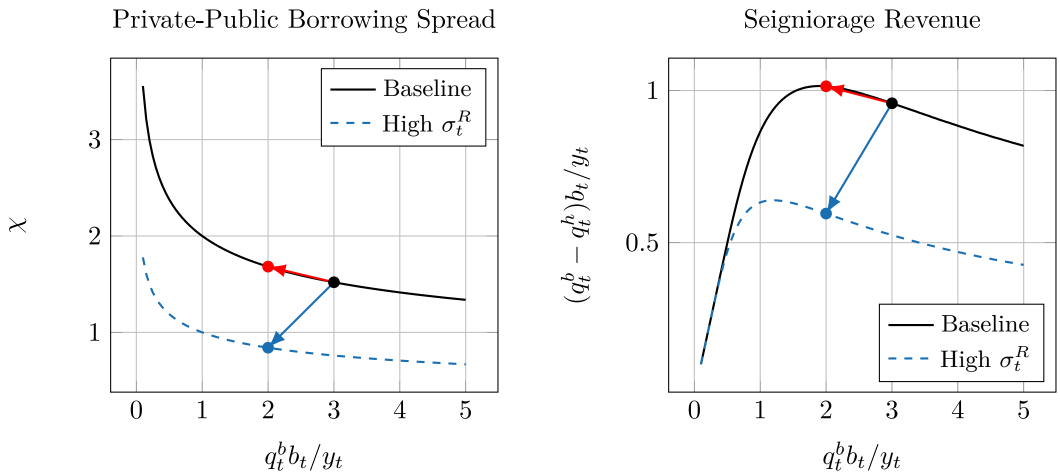

Figure 2: Impact of Return Volatility. Left plot shows the convenience yield. Right plot shows seigniorage revenue. The black lines show baseline curves. The blue dashed line and blue arrow indicate the response to an increase in return volatility under the general specification (2.3). The red arrow indicates the response to an increase in return volatility under the BIU (2.4) while the blue dashed lines show the response to repression suggested by formulation.

trade-off but rather provides another way of moving to the seigniorage revenue maximizing value of $q_t^b b_t/y_t$. By contrast, under the more general specification (2), the return risk shifts the private-public borrowing spread curve down, which is consistent with what we see empirically during the high return volatility periods in the 1920s and the 1970s-80s. This contracts the seigniorage revenue curve and so the government budget constraint. We can interpret these difference in terms of decreases in the quantity (b_t) and quality (σ_t^R) of government debt. In the BIU model, changes to quantity and quality both enter the private-public borrowing spread formula in the same way by decreasing $q_t^b b_t$ and increasing private-public borrowing spread. By contrast, in the data and the more general model, decreases in quality shift the private-public borrowing spread to Debt-to-GDP relationship, which leads to a decrease in the private-public borrowing spread.

To further illustrate the policy–spread connections, consider a government policy that forces the financial sector to hold government debt (such as the National Banking Era regulation). As shown in Figure 3, this shifts up the equilibrium relationship between the private-public borrowing spread and debt-to-GDP and skews the seigniorage revenue trade-off to right. In this sense, the level and slope parameters in the BIU formulation can be viewed as implicit functions of the financial regulatory regime.

The empirical evidence in this section emphasizes the breadth and complexity of the interaction between government policy and convenience yields. Our non-structural, illustrative examples highlight that these interactions have important implications for the government budget constraint. However, to make progress, we need a structural model that endogenizes

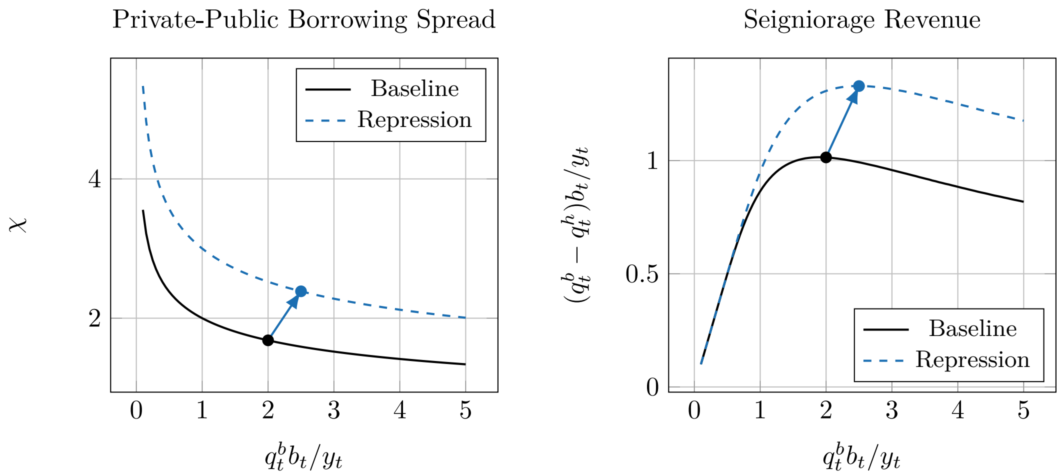

Figure 3: Impact of Financial Repression. Left plot shows the private-public borrowing spread. Right plot shows seigniorage revenue. The black lines show baseline curves while the blue dashed lines show the response to repression suggested by formulation (2.3).

the connections between financial sector regulation, fiscal policy, and the return process on government debt. We take up this challenge in the remaining sections of the paper.

3 A Model of Government Funding Advantage

Our model is a stochastic neoclassical growth model extended to include a morning sub-period where households need liquidity services. Financial intermediaries provide these services but this exposes them to frictions in the secondary asset markets (in the morning sub-period) that may force asset sales and/or costly default in bad states of the world. These frictions make our environment a “second-best” world with two interconnected asset pricing distortions: a “liquidity spread” on financial sector liabilities and a “hedging spread” on assets that can help financial intermediaries to self insure risks in the secondary asset markets. Both of these spreads are higher in bad states of the world, reflecting counter-cyclical household demand for liquid assets and counter-cyclical financial sector demand for hedging assets. Absent financial regulation and government default, government debt and productive capital are equally useful for hedging risks in the secondary market. That is, government debt does not have an immutable, special role in the economy.

We study a government facing exogenous surplus shocks that can raise financing by imposing restrictions on financial sector portfolios. This introduces additional asset-specific regulatory pricing distortions, which change the equilibrium co-movement between government debt prices and aggregate shocks. In particular, the regulatory restrictions can induce crowding into the secondary government debt market in bad times. This can make government debt a good hedging asset, which in turn generates a government funding advantage. In this sense, the funding advantage emerges endogenously through counter-cyclical captive demand rather than through an immutable, exogenous preference, as in BIU models discussed in Section 2. This means that our endogenous funding advantage becomes policy variant. In particular, systematic devaluation of government debt erodes financial sector profitability, which leads to bank default and exit from the deposit market. This limits the government's ability to create regulatory captive demand and so, in turn, erodes its funding advantage.

3.1 Environment

Setting: The economy is in discrete time with infinite horizon: $t = 0, 1, 2, \ldots$. Each period has morning and afternoon sub-periods. We interpret the afternoon sub-period as a primary asset market and the morning sub-period as a secondary (inter-bank) asset market. We denote variables in the morning market with a breve, $\breve{v}$, and in the afternoon market without a breve, v. There is one consumption good. There is a family of households and a continuum of islands, each with a representative competitive bank. There is a government that issues debt, b_t, in the primary asset market and raises taxes τ_t from the family in the afternoon.

Production technologies: There are two linear production technologies. One is a "morning" short term production technology that transforms m_t goods in the afternoon market at time t into $\breve{y}_{t+1} = \breve{z}_{t+1} m_t$ goods in the morning market at time $t + 1$. Banks can store these goods without cost between morning and afternoon. The other is an "afternoon" production technology that transforms k_t units of capital into $y_{t+1} = z_{t+1} k_t$ units of consumption goods in the afternoon of $t+1$. Capital investment involves an adjustment cost so investment i_t at time t yields $\Phi(\iota_t) k_{t-1}$ additional units of capital at the end of period t, where $\iota_t := i_t / k_{t-1}$ is the investment rate as a proportion of capital available at time t. Capital depreciates at rate $\delta > 0$ so the evolution of physical capital follows:

$$k_t = (1 - \delta) k_{t-1} + \Phi(\iota_t) k_{t-1}.$$

The productivities $(\breve{z}_t, z_t) = (\breve{z}(\varepsilon_t^z), z(\varepsilon_t^z))$ depend upon an exogenous state ε_t^z that is realized at the start of the morning market and follows a Markov Chain with transition matrix Π^z.

Households: We model intra-period heterogeneity in the spirit of Lucas (1990) by using a family of households that separate across islands in the morning sub-periods and pool resources in the afternoon sub-periods. In each afternoon, the family pools after-tax unspent wealth and chooses consumption and a portfolio of bank deposits and equity evenly across the islands. At the start of each morning, the members of the family are separated evenly across the continuum of islands. During separation, households have access to the family's bank deposit on their own island but are excluded from financial markets on other islands. Households on each island are uncertain about their own preferences, in the manner of Diamond and Dybvig (1983) and Allen and Gale (1994). There are two "layers" of uncertainty: household- and island-specific, both of which are resolved immediately after the family is separated in the morning sub-period. First, on each island, in the morning of each time t, a random fraction λ_t of households get utility $u(\breve{c}_t)$ from consuming $\breve{c}_t$, and then die. Second, the fraction λ_t is a random variable following a distribution $\lambda_t \sim \pi(\lambda_t)$ with mean Λ. In the afternoon, surviving members—of fraction $(1-\Lambda)$—return to the family and a fraction Λ of new members are born keeping the afternoon size of the family unchanged. All family members get utility $u(c_t)$ from consuming c_t in the afternoon. Since λ_t characterizes the heterogeneity across islands we refer to islands by λ_t.

Banks: In the afternoon of each period t, on each island, a one period lived representative bank is set up and issues demand deposits, d_t, and equity, e_t, to the family. The following period $t+1$, households on island λ_{t+1} can withdraw deposits for resources $\breve{x}^d_{t+1}(\lambda_{t+1}) \leq 1$ either in the morning or in the afternoon of period $t+1$. Banks face a penalty $\Psi(1-\breve{x}^d_{t+1})$ for deviating from full repayment of deposits that captures the household need for deposit certainty. In the morning, banks cannot pay or issue dividends. In the afternoon, banks sell their remaining assets to the newly formed banks, pay out dividends $x^e_{t+1}(\lambda_{t+1})$ per share, and then exit.[4]

Markets: We use goods as the numeraire. In the afternoon, government bonds, capital, bank deposits, and bank equity are traded in competitive markets at prices $(q^b_t, q^k_t, q^d_t, q^e_t)$ respectively.[5] In the morning, after the shocks are realized, banks can trade government bonds, at price $\breve{q}^b_t$, and claims on capital, at price $\breve{q}^k_t$, in the secondary asset markets. However, they cannot issue equity or short-sell during the morning market.

Government: In the afternoon of period t, the government purchases consumption goods g_t, raises lump-sum taxes τ_t on the household, and issues long-term bonds in the primary asset market that repay a fraction ω of the outstanding balance in consumption goods at time t. The government's one-period budget constraint in the afternoon is:

$$(\omega + (1-\omega)q^b_t)B_{t-1} \leq \tau_t - g_t + q^b_t B_t. \tag{3.1}$$

[4]We use bank exit for expositional simplicity. Equivalently, we could model the banks recapitalizing in the afternoon by issuing new equity.

[5]The deposit and equity prices are the same on each island because islands are ex-ante identical.

The government faces an exogenous stochastic fiscal rule. Taxes are an exogenous function of output: $\tau_t = \tau y_t$, where $\tau \in [0, 1]$ is a scalar. The government's primary deficit follows an exogenous stochastic process:

$$g_t - \tau y_t = -\eta\omega\Big(B_{t-1} - \bar{b}y_t\Big) + y_t\Big(\sigma^z(\varepsilon_t^z) + \sigma^g\varepsilon_t^g\Big) \tag{3.2}$$

where $\bar{b}$ is a "target level" of debt-to-output ratio and $\eta \geq 0$ measures the sensitivity of primary deficit-to-output to deviations from the target level of outstanding debt-to-output, and ε_t^g is an exogenous state that is realized at the start of the morning market and follows a Markov Chain with transition matrix Π^g. The budget constraint (3.1) and the fiscal rule (3.2) imply an issuance rule for b_t, which is potentially exposed to both TFP shocks through σ^z and government spending shocks through σ^g.

The government can also impose restrictions on banks' portfolios after re-trading in the secondary asset markets, which we model with the constraint:

$$\begin{aligned} \varrho^{\frac{1}{\alpha}}(1-\lambda_t)\breve{x}_t^d(\lambda_t)d_{t-1} &\leq \Upsilon\Big(\breve{q}_t^b\breve{b}_t(\lambda_t),\ \breve{q}_t^k\breve{k}_t(\lambda_t)\Big) \\ &:= \Big(\kappa\big(\breve{q}_t^b\breve{b}_t(\lambda_t)\big)^\alpha + (1-\kappa)\big(\breve{q}_t^k\breve{k}_t(\lambda_t)\big)^\alpha\Big)^{\frac{1}{\alpha}} \end{aligned} \tag{3.3}$$

where $(1-\lambda_t)d_{t-1}$ is bank λ_t's remaining share of deposits at the end of the morning of period t, and $\big(\breve{b}_t(\lambda_t), \breve{k}_t(\lambda_t)\big)$ denote bank λ's post-trade holdings of government debt and claims on capital, respectively. The pair (ϱ, κ) is a set of regulatory parameters: $\varrho \in [0, 1]$ is a leverage constraint that restricts the bank's ability to back its deposit with long term assets, while $\kappa \in [0, 1]$ is the relative "weight" on government debt in the calculation of regulatory asset value. We refer to $\kappa = 0.5$ as a "neutral" regulatory regime and $\kappa > 0.5$ as a "repression" regime.[6]

Parametric forms: For numerical exercises, we impose the following parametric forms. We let $u(c) = c^{1-\gamma}/(1-\gamma)$, $\Phi(\iota) =$, and $\Psi(1-\breve{x}^d) = \psi(1-\breve{x}^d)$.

3.1.1 A Broader Interpretation

We have written the model to focus on how portfolio restrictions on the banking sector change the price process for government debt. This because banks have historically been large holders of government debt. However, the forces in the model generalize to other environments.

[6] $\kappa = 0.5$ refers to a regulatory regime that treats government debt and capital symmetrically and just restricts bank risk taking through $\varrho > 0$. Since, absent regulation, government debt and capital have the same return process, we refer to this as a "neutral" regime. $\kappa > 0.5$ is a regime that incentivizes the holding of government debt over capital as regulatory collateral, while $\kappa < 0.5$ corresponds to the opposite case.

Alternative regulations: We have interpreted κ as the weight in explicit macroprudential regulation. One alternative is that it could reflect implicit pressure on the banking sector to purchase government debt (e.g. in the US during WWII). Another alternative is that it could reflect collateral requirements at a government discount window (e.g. in the US after the introduction of the FED). For the latter case, the regulatory requirement is only faced by banks that take significant losses in the morning market rather than by all banks in the economy.

Alternative financial intermediaries: At a more abstract level, the key features of the model that we require are: (i) there is a financial intermediary that provides a service to households that exposes the intermediary to risk, (ii) the financial intermediary faces frictions that generate a wedge in the intermediary Euler equations, (iii) the government restricts the portfolio that the financial intermediary. In this sense, the forces in our model could also apply to insurance companies, pension funds, and other financial intermediaries.

3.2 Equilibrium

We set up the equilibrium recursively using the notation that $(\check{v}, v)$ denotes a variable in the morning and afternoon of the current period respectively and $(\check{v}', v')$ denotes a variable in the morning and afternoon of the next period respectively. The aggregate state vector each period is $\mathbf{s} := (\boldsymbol{\varepsilon}, k, b, m, d)$, where $\boldsymbol{\varepsilon} := (\varepsilon^z, \varepsilon^g)$ is the vector of exogenous aggregate states, k is aggregate capital stock, b is government debt outstanding. The endogenous state variables k and b evolve according to:

$$k' = (1-\delta)k + \Phi(\iota)k \tag{3.4}$$

$$q^b(\mathbf{s})b' = \big(\eta\omega\bar{b} + \sigma^z(\varepsilon^z) + \sigma^g\varepsilon^g\big)zk + \big(\omega(1-\eta) + (1-\omega)q^b(\mathbf{s})\big)b. \tag{3.5}$$

We guess and verify that afternoon prices are functions $(q^d(\mathbf{s}), q^e(\mathbf{s}), q^k(\mathbf{s}), q^b(\mathbf{s}))$ and the follow period morning prices are functions $\big(\check{q}^k(\mathbf{s}'), \check{q}^b(\mathbf{s}')\big)$.

Family problem: At the start of the afternoon sub-period, suppose the family has unspent wealth a. The family's budget constraint in the afternoon sub-period at time t is:

$$c + q^d(\mathbf{s})d' + q^e(\mathbf{s})e' \leq a - \tau(\mathbf{s}) \tag{3.6}$$

where c denotes goods consumed by the family in the afternoon sub-period, (d', e') denote the family portfolio of bank deposits and equity on each island,[7] and $\tau(\mathbf{s})$ denotes the individual lump sum tax in the afternoon sub-period.

[7] The islands are symmetric in the afternoon market so the family allocates resources equally across them.

In the following morning sub-period, the household members of the family separate across islands. The new exogenous aggregate states $(\boldsymbol{\varepsilon}', b')$ are realized and each island receives its idiosyncratic shock draw $\lambda' \sim \pi(\lambda')$ for the fraction of households who have morning consumption needs (we refer to an island with a draw λ' as a "λ'-island"). Households only have access to the deposits held in the bank on their island so, for a given $\mathbf{s}$, a household on an λ'-island consumes $\breve{x}^d(\lambda', \mathbf{s}')d'$, where $\breve{x}^d(\cdot)$ denotes the function for deposit repayment. Household financial wealth not used for consumption in the morning market is returned to the family in the afternoon so, for a given $\mathbf{s}$, the evolution of family wealth between afternoon sub-periods is:

$$a' = \sum_{\lambda'} \Big(x^e(\lambda', \mathbf{s}')e' + (1 - \lambda')\breve{x}^d(\lambda', \mathbf{s}')d' \Big) \pi(\lambda') \tag{3.7}$$

where $x^e(\cdot)$ is the dividend per equity share function.

Let $V(a, \mathbf{s})$ denote the value of the household with unspent wealth a at the start of the afternoon. Then, taking as given the law of motion for the aggregate states (3.4) and (3.5), the value function $V(a, \mathbf{s})$ satisfies the Bellman equation (3.8) below:

$$\begin{aligned} V(a, \mathbf{s}) = \max_{\{c,e,d\}} & \left\{ u(c) + \beta \mathbb{E}\left[\sum_{\lambda'} \lambda' u\big(\breve{x}^d(\lambda', \mathbf{s}')d'\big)\pi(\lambda') + (1 - \Lambda)V(a', \mathbf{s}') \mid \mathbf{s} \right] \right\} \\ s.t. \qquad & (3.6), (3.7). \end{aligned} \tag{3.8}$$

This leads to the first-order-conditions (FOCs) after imposing the Envelope condition:

$$q^d(\mathbf{s}) = \mathbb{E}\Big[\xi(\mathbf{s}'; \mathbf{s})\breve{N}(\mathbf{s}') \mid \mathbf{s}\Big] \tag{3.9}$$

$$q^e(\mathbf{s}) = \mathbb{E}\Big[\xi(\mathbf{s}'; \mathbf{s}) \sum_{\lambda'} x^e(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\Big] \tag{3.10}$$

where the stochastic discount factor (SDF) and the "liquidity wedge" for a given $(\lambda', \mathbf{s}')$ are defined by:

$$\begin{aligned} \xi(\mathbf{s}'; \mathbf{s}) &:= \beta(1 - \Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))}, \\ \breve{N}(\mathbf{s}') &:= \sum_{\lambda'} \left(\left(1 - \lambda' + \lambda' \frac{\partial_c u(\breve{x}^d(\lambda', \mathbf{s}')d')}{(1 - \Lambda)\partial_c u(c(\mathbf{s}'))} \right) \breve{x}^d(\lambda', \mathbf{s}') \right) \pi(\lambda'). \end{aligned} \tag{3.11}$$

The liquidity wedge, $\breve{N}(\lambda', \mathbf{s}')$, appears because demand deposits provide liquidity services to the households by allowing them to insure consumption shocks in the morning sub-period. The presence of this asset-specific wedge implies that households are willing to hold demand deposits at a discount.

Bank problem: In the afternoon a new bank is created[8], it chooses a portfolio (m', b', k') of reserve assets, government bonds, and capital. In the following morning, given $\mathbf{s}'$, banks on a λ'-island face the withdrawal constraint $\forall(\lambda', \mathbf{s}')$:

$$\lambda' \breve{x}^d(\lambda', \mathbf{s}')d' \leq \breve{z}' m' + \breve{q}^b(\mathbf{s}')\big(b' - \breve{b}(\lambda', \mathbf{s}')\big) + \breve{q}^k(\mathbf{s}')\big(k' - \breve{k}(\lambda', \mathbf{s}')\big), \tag{3.12}$$

where $\big(\breve{b}(\lambda', \mathbf{s}'), \breve{k}(\lambda', \mathbf{s}')\big)$ denote the bank's portfolios of government bonds and capital chosen in the morning and so $\big(b' - \breve{b}(\lambda', \mathbf{s}'),\ k' - \breve{k}(\lambda', \mathbf{s}')\big)$ denotes the sale of government bonds and capital to finance deposit withdrawals. In the following afternoon, the bank repays equity and deposit holders subject to the budget constraint $\forall(\lambda', \mathbf{s}')$:

$$x^e(\lambda', \mathbf{s}') + (1 - \lambda')\breve{x}^d(\lambda', \mathbf{s}')d' \leq x^k(\lambda', \mathbf{s}')\breve{k}(\lambda', \mathbf{s}') + x^b(\lambda', \mathbf{s}')\breve{b}(\lambda', \mathbf{s}'). \tag{3.13}$$

where $x^k(\lambda', \mathbf{s}')$ and $x^b(\lambda', \mathbf{s}')$ are the afternoon payoffs from capital and government debt:

$$\begin{aligned} x^k(\lambda', \mathbf{s}') &:= z' - \iota(\lambda', \mathbf{s}') + q^k(\mathbf{s}')\big[(1 - \delta) + \Phi(\iota(\lambda', \mathbf{s}')\big] \\ x^b(\lambda', \mathbf{s}') &:= \omega + (1 - \omega)q^b(\mathbf{s}'). \end{aligned}$$

Taking as given the law of motion for the aggregate states, (3.4) and (3.5), the representative bank solves the problem (3.14) below:

$$\begin{aligned} \max_{\substack{m', k', b', d', \breve{x}^d(\cdot), \\ x^e(\cdot), \breve{b}(\cdot), \breve{k}(\cdot), \iota(\cdot)}} \quad & \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s}) \sum_{\lambda'} \{x^e(\lambda', \mathbf{s}') - \Psi(\cdot)d'\}\pi(\lambda')\Big] + q^d(\mathbf{s})d' - m' - q^k(\mathbf{s})k' - q^b(\mathbf{s})b' \\ s.t. \quad & (3.12), (3.13), (3.3), \quad \Psi(\lambda', \mathbf{s}') = \psi(1 - \breve{x}^d(\lambda', \mathbf{s}')) \\ & 0 \leq b',\ k',\ m',\ d',\ \breve{b}(\lambda', \mathbf{s}'),\ \breve{k}(\lambda', \mathbf{s}'),\ 1 - \breve{x}^d(\lambda', \mathbf{s}'), \quad \forall(\lambda', \mathbf{s}') \end{aligned} \tag{3.14}$$

where ξ is the household's stochastic discount factor and Ψ is the default penalty. The first order conditions for the portfolio choice in the afternoon market are (dropping the short selling constraints which don't bind):

$$[m']: \qquad 1 = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s})\breve{M}(\mathbf{s}')\breve{z}'\Big] \tag{3.15}$$

$$[k']: \qquad q^k(\mathbf{s}) = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^k(\mathbf{s}')\Big] \tag{3.16}$$

$$[b']: \qquad q^b(\mathbf{s}) = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^b(\mathbf{s}')\Big] \tag{3.17}$$

$$\begin{aligned} [d']: \qquad q^d(\mathbf{s}) = {} & \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s}) \sum_{\lambda'} \Big((1 - \lambda')\big[1 + \breve{\mu}^r(\lambda', \mathbf{s}')\big]\Big)\breve{x}^d(\lambda', \mathbf{s}')\pi(\lambda')\Big] \\ & + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}'; \mathbf{s}) \sum_{\lambda'} \Big(\lambda' \breve{\mu}^e(\lambda', \mathbf{s}')\breve{x}^d(\lambda', \mathbf{s}') + \Psi(\lambda', \mathbf{s}')\Big)\pi(\lambda')\Big] \end{aligned} \tag{3.18}$$

[8] Or equivalently, the existing banks raise equity in a frictionless market.

where $\breve{M}(\mathbf{s}')$ is the average marginal value of wealth in the morning conditional on the aggregate state $\mathbf{s}'$:

$$\breve{M}(\mathbf{s}') := \sum_{\lambda'} \breve{\mu}^e(\lambda', \mathbf{s}')\pi(\lambda') \tag{3.19}$$

We can see that equations (3.15), (3.16), and (3.17), are the standard portfolio choice equations augmented with the wedge $\breve{M}(\mathbf{s}')$ reflecting how the interbank market frictions in the morning market distort the bank's portfolio. Equation (3.18) equates the deposit price to the risk-weighted average marginal cost of servicing a unit of deposits in the morning and afternoon.

The first order conditions for the morning market choices and other λ' dependent choices are (dropping the short selling constraints which don't bind):

$$[\breve{x}^d(\cdot)] : \qquad \partial\Psi\Big(1 - \breve{x}^d(\lambda', \mathbf{s}')\Big) = \lambda'\breve{\mu}^e(\lambda', \mathbf{s}') + (1-\lambda')\Big(1 + \breve{\mu}^r(\lambda', \mathbf{s}')\Big) \tag{3.20}$$

$$[\breve{k}(\cdot)] : \qquad \breve{\mu}^r(\lambda', \mathbf{s}')\partial_{\breve{q}^k\breve{k}}\Upsilon(\lambda', \mathbf{s}') = \breve{\mu}^e(\lambda', \mathbf{s}') - \underline{\breve{\mu}}^k(\lambda', \mathbf{s}') - \breve{R}^k(\mathbf{s}') \tag{3.21}$$

$$[\breve{b}(\cdot)] : \qquad \breve{\mu}^r(\lambda', \mathbf{s}')\partial_{\breve{q}^b\breve{b}}\Upsilon(\lambda', \mathbf{s}') = \breve{\mu}^e(\lambda', \mathbf{s}') - \underline{\breve{\mu}}^b(\lambda', \mathbf{s}') - \breve{R}^b(\mathbf{s}') \tag{3.22}$$

$$[\iota(\cdot)] : \qquad q^k(\mathbf{s}') = \Big(\partial\Phi_\iota(\iota(\lambda', \mathbf{s}'))\Big)^{-1} \tag{3.23}$$

where $\breve{R}^k$ and $\breve{R}^b$ are the morning to afternoon returns:

$$\breve{R}^k(\mathbf{s}') = \frac{z' - \iota(\mathbf{s}') + q^k(\mathbf{s}')\big[(1-\delta) + \Phi(\iota(\mathbf{s}'))\big]}{\breve{q}^k(\mathbf{s}')} \qquad \breve{R}^b(\mathbf{s}') = \frac{\omega + (1-\omega)q^b(\mathbf{s}')}{\breve{q}^b(\mathbf{s}')}$$

Equation (3.20) equates the marginal cost of defaulting on a deposit to the marginal benefit of relaxing the budget and regulatory constraints through deposit default. Equations (3.21) and (3.22) equate the marginal value of relaxing the regulatory constraint with the opportunity cost of foregone investment. Equation (3.23) equates the marginal cost of investment to the price of capital, which implies that ι (and therefore x^k and $\breve{R}^k$) is independent of λ'.

We can now set up a competitive equilibrium. Given a fiscal rule (3.2) and bond price function $q^b(\cdot)$, a budget-feasible government issuance rule $B'(\mathbf{s})$ satisfies (3.1).

Definition 1 (Budget-feasible Competitive Equilibrium)**.** Given regulation parameters (ϱ, κ), and a budget-feasible government policy $\{\tau(\cdot), g(\cdot), B'(\cdot)\}$, a competitive equilibrium is a collection of functions for prices $\{q^d(\cdot), q^e(\cdot), q^k(\cdot), q^b(\cdot), \breve{q}^k(\cdot), \breve{q}^b(\cdot)\}$, payoffs $\{\breve{x}^d(\cdot), x^e(\cdot)\}$, household policies $\{d^h(\cdot), e'(\cdot), c(\cdot)\}$, and bank policies $\{d'(\cdot), m'(\cdot), k'(\cdot), \iota(\cdot), b'(\cdot), \breve{k}(\cdot), \breve{b}(\cdot)\}$, such that

- Taking prices as given, the family solves (3.8),
- Taking prices as given, banks solve (3.14),

- Afternoon and morning goods markets clear:

$$c(\mathbf{s}) + m'(\mathbf{s}) + \iota(\mathbf{s})k + g(\mathbf{s}) = zk, \tag{3.24}$$

$$\sum_{\lambda} \big(\lambda \breve{x}^d(\lambda, \mathbf{s})d\big)\pi(\lambda) = \breve{z}m, \tag{3.25}$$

morning asset markets clear:

$$\sum_{\lambda} \breve{b}(\lambda, \mathbf{s})\pi(\lambda) = b, \qquad \sum_{\lambda} \breve{k}(\lambda, \mathbf{s})\pi(\lambda) = k, \tag{3.26}$$

and afternoon asset markets clear:

$$d^h(\mathbf{s}) = d'(\mathbf{s}), \qquad e'(\mathbf{s}) = 1, \qquad b'(\mathbf{s}) = B'(\mathbf{s}) \qquad k'(\mathbf{s}) = [1 - \delta + \Phi(\iota(\mathbf{s}))]k.$$

The afternoon market is the standard neoclassical growth model augmented with morning market frictions summarized by the liquidity distortion $\breve{N}(\mathbf{s}) \neq 1$ (equation (3.11) and the interbank market distortion $\breve{M}(\mathbf{s}) \neq 1$ (equation (3.19)). We can see this formally by observing that the afternoon market functions $(c(\mathbf{s}), g(\mathbf{s}), \iota(\mathbf{s}), m'(\mathbf{s}), d'(\mathbf{s}), q^d(\mathbf{s}), q^e(\mathbf{s}), q^k(\mathbf{s}), q^b(\mathbf{s}))$ solve equations (3.9), (3.10), (3.15), (3.16), (3.17), (3.18), (3.23), (3.24), and (3.2).

The novel features of our model appear in the morning market, which generate the liquidity and interbank market distortions. We characterize the equilibrium in the morning market in Proposition (1) below. In the next section, we study how government policies affect the functioning of the morning market.

Proposition 1. *Suppose the short-selling constraints don't bind.*[9] *Then given the state* $\mathbf{s}$*, morning price functions* $\big(\breve{q}^k(\cdot), \breve{q}^b(\cdot)\big)$ *and afternoon payout functions* $\big(x^b(\cdot), x^k(\cdot)\big)$*, the morning choice functions* $\big(\breve{x}^d(\cdot),\ \breve{b}(\cdot),\ \breve{k}(\cdot),\ \breve{\mu}^r(\cdot),\ \breve{\mu}^e(\cdot)\big)$ *satisfy the equations:*

$$\begin{aligned}
\breve{x}^d(\lambda, \mathbf{s}) &= 1 - [\partial_{\breve{x}^d}\Psi]^{-1}\Big(\lambda\breve{\mu}^e(\lambda, \mathbf{s}) + (1-\lambda)\Big(1 + \breve{\mu}^r(\lambda, \mathbf{s})\Big)\Big) \\
\frac{x^k(\mathbf{s})}{\breve{q}^k(\mathbf{s})} &= \breve{\mu}^e(\lambda, \mathbf{s}) - \breve{\mu}^r(\lambda, \mathbf{s})\partial_{\breve{q}^k\breve{k}}\Upsilon(\lambda, \mathbf{s}) \\
\frac{x^b(\mathbf{s})}{\breve{q}^b(\mathbf{s})} &= \breve{\mu}^e(\lambda, \mathbf{s}) - \breve{\mu}^r(\lambda, \mathbf{s})\partial_{\breve{q}^b\breve{b}}\Upsilon(\lambda, \mathbf{s}) \\
\lambda\breve{x}^d(\lambda, \mathbf{s})d &= \breve{z}(\mathbf{s})m + \breve{q}^b(\mathbf{s})\big(b - \breve{b}(\lambda, \mathbf{s})\big) + \breve{q}^k(\mathbf{s})\big(k - \breve{k}(\lambda, \mathbf{s})\big) \\
\breve{\mu}^r(\lambda, \mathbf{s}) &\approx \left(\frac{(1-\lambda)\breve{x}^d(\lambda, \mathbf{s})\,d}{\Upsilon(\lambda, \mathbf{s})}\right)^{\varpi^r - 1}
\end{aligned}$$

The prices $(\breve{q}^k(\cdot), \breve{q}^b(\cdot))$ *are then pinned down by the asset market clearing conditions in* (3.26)*.*

[9]For example, Ψ is convex and Υ is Cobb-Douglas.

Proof. The first four equations follow directly from rearranging the bank morning FOCs (3.20), (3.21), and (3.22) and the morning goods market clearing condition (3.25). The final equation is an approximation to the Lagrange multiplier that holds exactly in the limit as $\varpi \to \infty$. □

3.3 Morning (Inter-bank) Asset Market and "Captive Demand"

The morning market is governed by the difficulty of managing deposit withdrawals. In our environment, households have a desire for non-state-contingent deposit payouts. Banks offer such deposits but this exposes them to idiosyncratic deposit withdrawal shocks, which they have to try to manage. The economy has low return reserves that payoff in the morning period as well as high return long-term assets (capital and government bonds) that payoff in the afternoon market. In a frictionless world, banks could purchase long-term assets in the afternoon market, then cover deposit withdrawals in the morning market by raising resources from households using the future payout on long-term assets as backing. The difficulty for banks is that frictions in the morning market prevent them from interacting with households and instead force them to sell their long-term assets to other banks in the interbank market. This means that the household stochastic discount factor does not set the inter-temporal rate of substitution between morning and afternoon. Instead, the rate is set by prices in the interbank market. Unfortunately for banks, the interbank market rate is constrained by the aggregate reserves that banks have brought into the market and so morning market asset prices are low. This pushes the market's intertermporal rate of substitution above the household's rate, which potentially leads to banks defaulting on deposits.

Our government "exploits" the frictions in the interbank market rather than attempting to completely "resolve" them. In principle, the government could use tax revenue to directly intermediate the interbank market and overcome the frictions in the banking sector. Instead, our government chooses restrictions on the bank portfolios in order to change the cost of financing a path of government spending and taxes. Formally, these restrictions are given by equation (3.3), which says that government can potentially restrict both bank leverage and asset portfolios. If the government sets $\kappa = 1/2$ and $\alpha = 1$, then the regulatory constraint restricts bank leverage but allows perfect substitution between government bonds and capital to satisfy the regulatory constraint. As the government increases κ above 1/2, it increases pressure on the banking sector to hold government debt, which we refer to as "financial repression".

The banks have two variables they can choose in order to respond to withdraw shocks and the government's regulatory constraints: (i) their asset portfolio between government debt and capital and (ii) the extent to which they default on deposits. How they make this choice will end up determining the extent to which morning market prices or bank default changes in response to the aggregate shocks.

To highlight the different forces at play in the interbank market equations, we characterize equilibrium progressively for increasingly more complicated environments. We start by considering an environment without financial regulation to explain how the interbank market frictions lead to "cash-in-the-market" or "fire-sale" pricing that complicates the banking sector's capacity to handle withdrawal shocks. We then introduce financial repression and show that it generates "captive" bank demand for government debt in bad times and so changes the price process to make government debt a good hedge against the problems arising from withdrawal shocks. Finally, we study fiscal policy that devalues government debt in bad times and show that erodes the "captive" bank demand.

3.3.1 No Financial Regulation

We start without regulatory constraints ($\varrho = 0,\ \mu^r = 0$) to highlight how the interbank market frictions appear in the asset pricing. In this case, because there is no regulation and no shocks between morning and afternoon, capital and government bonds are perfect substitutes with equal returns between morning and afternoon $\breve{R}^k(\mathbf{s}) = \breve{R}^b(\mathbf{s})$.

The banking sector's inability to raise extra resources to supplement their reserves implies that the morning asset markets are characterized by 'fire-sale" pricing: capital and government bonds are traded below their fundamental value. To see this, observe that because there is no regulation and no shocks between morning and afternoon, capital and government bonds are perfect substitutes with equal returns between morning and afternoon $\breve{R}^k(\mathbf{s}) = \breve{R}^b(\mathbf{s})$. In addition, the equity raising constraints mean that the marginal value of resources is greater inside the bank than outside the bank so $\breve{\mu}^e(\lambda, \mathbf{s}) \geq 1$, where the lower bond comes from the storage option. Consequently, the return on assets between morning and afternoon is greater than one:

$$\breve{R}^k(\mathbf{s}) = \breve{R}^b(\mathbf{s}) = \breve{\mu}^e(\lambda, \mathbf{s}) \geq 1,$$

which is the mathematical statement that the market intertemporal rate of substitution, $\breve{R}^i(\mathbf{s})$ for $i \in (k, b)$ between morning and afternoon is greater than the households' intertermporal rate of substitute, 1. This implies that there could be "cash-in-the-market" (Allen and Gale, 1994) or "fire-sale" (Gale and Gottardi, 2020) pricing in the sense that prices in the morning market are less than their afternoon payoffs even though there is no risk or discounting between morning and afternoon:

$$\breve{q}^b(\mathbf{s}) \leq x^b(\mathbf{s}), \qquad\qquad \breve{q}^k(\mathbf{s}) \leq x^k(\mathbf{s})$$

These pricing wedges restrict the banking sector's ability to reallocate resources to distressed banks, which, in turn, leads to higher rates of default on deposits.

The interbank market problems are more severe in the low TFP state of the world when the aggregate reserves of the banking sector are low. To see this, from the good market clearing condition, we have:

$$\frac{\breve{z}(\mathbf{s})m}{d} = \sum_{\lambda} \lambda\Big(1 - \big[\partial_{\breve{x}^d}\Psi\big]^{-1}\Big(\lambda \breve{R}^i(\mathbf{s}) + (1-\lambda)\Big)\Big)\pi(\lambda) \qquad i \in \{b, k\}$$

which implies that, in the bad state, as $\breve{z}$ decreases, the return on assets increases so we have fire-sale pricing: $\breve{R}^k(\mathbf{s}') = \breve{R}^b(\mathbf{s}') > 1$, $\breve{q}^b(\mathbf{s}) < x^b(\mathbf{s})$, and $\breve{q}^k(\mathbf{s}) < x^k(\mathbf{s})$. We collect these results in Corollary 1.

Corollary 1. *Without any regulatory constraints ($\varrho = 0$, $\mu^r = 0$), government debt and capital are perfect substitutes in the interbank market. They have the same return, $\breve{R}^k(\mathbf{s}) = \breve{R}^b(\mathbf{s}) \geq 1$, with a strict inequality in the low aggregate state due to "fire-sale" pricing.*

We show these observations for a numerical example in Figure 4, which depicts asset prices as function of productivity $\breve{z}$. The black line shows that, without regulation, both government debt and capital prices decrease when productivity decreases.

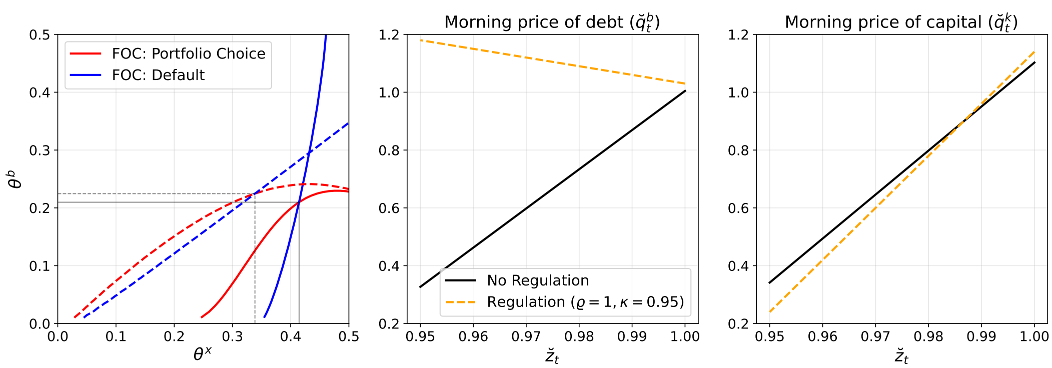

Figure 4: Morning Asset Prices With and Without Financial Repression.

Black line shows the morning market prices in an environment without regulation. The orange line shows the morning market asset prices in an environment with repression.

3.3.2 Financial Regulation and Captive Demand

We now introduce regulatory constraints ($\varrho > 0$, $\kappa \in [0,1]$) to highlight how the government can influence the morning price process. The regulatory constraint means that banks are no longer indifferent between government debt and capital in the morning market. Instead, they choose both asset holdings and deposit default in order to balance the need to manage withdrawals, the need to satisfy regulatory constraints, and the desire to earn a high return. Formally, let $\breve{a} := \breve{z}(\mathbf{s})m + \breve{q}^k(\mathbf{s})k + \breve{q}^b(\mathbf{s})b$ denote the wealth that a bank brings into the morning sub-period. Let $\breve{\theta}^b := \breve{q}^b(\mathbf{s})b/\breve{a}$ and $\breve{\theta}^x := \breve{x}\breve{q}^b(\mathbf{s})b/\breve{a}$ denote government debt purchases and value of deposits honored as a share of bank wealth. Rearranging the equations in Proposition 1, we can see that the bank's choices are governed by the equations:

$$R^k(\mathbf{s}) - R^b(\mathbf{s}) \approx \frac{\breve{\mu}^r(\lambda, \mathbf{s})}{(\Upsilon(\lambda, \mathbf{s})\breve{a}^{-1})^{\alpha-2}} \left(\frac{\kappa}{\varrho} \left(\breve{\theta}^b\right)^{\alpha-1} - \frac{1-\kappa}{\varrho} \left(1 - \breve{\theta}^x - \breve{\theta}^b\right)^{\alpha-1} \right) \tag{3.27}$$

$$\partial\Psi \left(1 - \breve{\theta}^x\right) \approx \frac{\breve{\mu}^r(\lambda, \mathbf{s})}{\lambda^{\varpi^r - 1}} \left(\lambda \left(\frac{\kappa}{\varrho}\right) \Upsilon(\lambda, \mathbf{s})^{1-\alpha} \left(\breve{\theta}^b \breve{a}\right)^{\alpha-1} + (1-\lambda)\frac{\varrho}{2} \right) + \lambda R^b(\mathbf{s}) + 1 - \lambda \tag{3.28}$$

where the Lagrange multiplier on the regulatory constraint is

$$\breve{\mu}^r(\lambda, \mathbf{s}) \approx \left(\frac{(1-\lambda)\breve{\theta}^x(\lambda, \mathbf{s})\breve{a}}{\Upsilon(\lambda, \mathbf{s})} \right)^{\varpi - 1} > 0,$$

which is strictly positive because the regulatory constraint binds. We refer to the first equation as the bank asset portfolio FOC because it says a bank chooses its share of wealth in government bonds to balance the return difference between bonds and capital (the LHS) against the strength of the regulatory constraint (the first term on the RHS) and the relative marginal usefulness of government debt in satisfying the regulatory constraint (the second term on the RHS). We refer to the second equation as the bank deposit default FOC because it says that a bank balances the marginal cost of default (the LHS) against the marginal value of relaxing the budget constraint and regulatory constraints in the interbank market through deposit default (the RHS).

We depict the bank's choice equations (3.27) and (3.28) graphically in the left plot of Figure 4 for the case that $R^k > R^b$. To illustrate how repression distorts the asset market, we consider the comparative static when κ is increased. Evidently, the portfolio FOC contour (the red line) shifts left and up while the default FOC contour (the blue line) rotates clockwise. Together this leads to an increase in fraction of wealth the bank holds in bonds, θ^b, and an increase in deposit default, $1 - \theta^x$. This is because financial repression skews the bank's morning portfolio choice to create "captive demand" for government bonds. Because government bonds have the lower return, this tightens the regulatory constraint and so leads to banks defaulting more.

Rearranging the portfolio FOC implies that (after some substitution):

$$\frac{\breve{q}^b(\mathbf{s})}{\breve{q}^k(\mathbf{s})} = \frac{x^b(\lambda, \mathbf{s})}{x^k(\lambda, \mathbf{s})} \left(\frac{1 - \frac{\breve{\mu}^r(\lambda, \mathbf{s})}{\breve{\mu}^e(\lambda, \mathbf{s})} \left(\frac{1-\kappa}{\varrho}\right) (1 - \breve{\theta}^x - \breve{\theta}^b)^{\alpha-1}}{1 - \frac{\breve{\mu}^r(\lambda, \mathbf{s})}{\breve{\mu}^e(\lambda, \mathbf{s})} \frac{\kappa}{\varrho} (\breve{\theta}^b)^{\alpha-1}} \right)$$

If government debt is sufficiently privileged in the regulatory constraint ($\kappa > 1/2$) and so $\frac{\kappa}{\varrho}(\breve{\theta}^b)^{\alpha-1} > \frac{1-\kappa}{\varrho}(1 - \breve{\theta}^x - \breve{\theta}^b)^{\alpha-1}$, then the regulatory constraint inflates the price of government debt in the interbank market and so the return on government debt is lower than the return on capital: $\breve{R}^k(\mathbf{s}) > \breve{R}^b(\mathbf{s})$. In this case, we can also see that $\breve{\mu}^r(\lambda, \mathbf{s})$ is higher for low $\breve{z}$ states and so the distortion from the regulatory constraint is higher following negative TFP shocks. This ultimately means that the price ratio $\frac{\breve{q}^b(\mathbf{s})}{\breve{q}^k(\mathbf{s})}$ is higher in bad states of the world and government debt becomes a good hedge against aggregate shocks. Conceptually, the government can exploit the fire-sale pricing in the morning market to skew the price of government debt high in bad states of the world.

The orange lines in the center and right plots in Figure 4 depict the equilibrium price outcomes for a particular numerical experiment. Evidently, with regulation, the price of government debt increases in bad times whereas the price of capital decrease further. In this sense, the government can use regulation to choose which asset appreciates in bad times. We summarize these results in Corollary 2 below.

Corollary 2. *With regulatory constraints that favor government debt ($\varrho > 0$, $\kappa > 1/2$), government debt and capital are imperfect substitutes in the interbank market. In the bad state of the world, the return on capital is higher $\breve{R}^k(\mathbf{s}_B) > \breve{R}^b(\mathbf{s}_B)$ and the relative morning price of government debt appreciates: $\breve{q}^b(\mathbf{s}_B)/\breve{q}^b(\mathbf{s}_B) > \breve{q}^b(\mathbf{s}_G)/\breve{q}^b(\mathbf{s}_G)$.*

3.3.3 Debt Devaluation and Financial Repression

Finally, we consider the impact of a government policy that devalues government debt in the bad aggregate state $x^b(\mathbf{s}_B) < x^b(\mathbf{s}_G)$ (e.g. setting $\sigma_z > 0$ so the government issues debt in bad states) in an environment with financial repression. The impact of such a policy on bank decisions is shown in the left plot of Figure 5 below. A decrease in $x^b(\mathbf{s}_B)$ shifts the portfolio choice curve down and to the right because it lowers the return on government debt. The default choice curve rotates slightly clockwise because default has become more valuable. The result is that demand for government debt falls (θ^b decreases) and the banks default more (θ^x decreases). The relative size of the adjustment through demand versus the relative size of the adjustment through bankruptcy is governed by the relative slope of the two FOCs. A higher default cost means that the default FOC is steeper and so more adjustment comes through θ^b. By contrast, a lower α makes debt and capital less substitutable so more adjustment comes through θ^x.

Conceptually, the combination financial repression and government devaluation in bad states of the world lead to these outcomes because they put the banking sector in a difficult position. If they don't purchase government debt, then they violate the regulatory penalty. If they purchase government debt, then the government's fiscal policy devalues their debt in the afternoon and forces losses onto the equity holders. The banks respond to this lose-lose situation by defaulting on depositors and effectively "exiting" the deposit market.

The center and right plots show how the bank behavior translates to the equilibrium prices in the morning market. The combination of repression and debt devaluation in bad states means that price of government debt once again becomes pro-cyclical. That is, so many banks default that the government loses their captive demand.

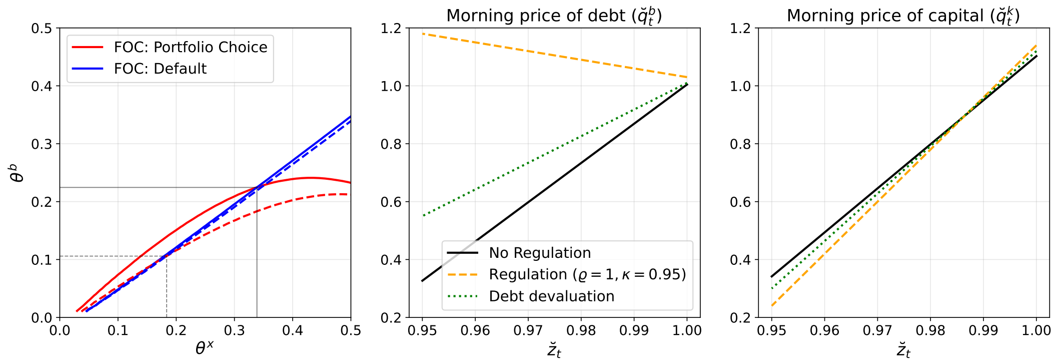

Figure 5: Morning Asset Prices With and Without Debt Devaluation.

Black line shows the morning market prices in an environment without regulation. The orange line shows the morning market asset prices in an environment with repression.

3.4 Afternoon Markets and Government Funding Advantage

We now return to the afternoon market to study how the frictions and regulation in the morning market generate a funding cost spread for the government in the afternoon market. We start by breaking down the spread between the yield on government debt and the log expectation of the household SDF. To do this decomposition, we need to define a collection of "synthetic" reference assets. Let h and f index bonds issued by the private sector with the same payouts as government debt (same ω) that are held by the banks and the family respectively. Let q^h and q^f denote the prices of the bonds and let $x^h := \omega + (1-\omega)q^h$ and $x^f := \omega + (1-\omega)q^f$ denote the afternoon payoffs on the bonds. Then, we can decompose the convenience yield as:

$$\begin{aligned}
&\log(q^b(\mathbf{s})) - \log(\mathbb{E}[\xi(\mathbf{s}') \mid \mathbf{s}]) \qquad (3.29)\\
&= \underbrace{\log\left(\mathbb{E}\left[\xi(\mathbf{s}')\breve{M}(\lambda',\mathbf{s}')\frac{\breve{q}^b(\mathbf{s}')}{x^b(\mathbf{s}')}\frac{x^b(\mathbf{s}')}{x^h(\mathbf{s}')}x^h(\mathbf{s}') \mid \mathbf{s}\right]\right) - \log\left(\mathbb{E}\left[\xi(\mathbf{s}')\breve{M}(\lambda',\mathbf{s}')x^h(\mathbf{s}') \mid \mathbf{s}\right]\right)}_{\text{Private-public borrowing cost spread } =: \ \chi}\\
&\quad + \underbrace{\log\left(\mathbb{E}\left[\xi(\mathbf{s}')\breve{M}(\mathbf{s}')x^h(\mathbf{s}') \mid \mathbf{s}\right]\right) - \log\left(\mathbb{E}\left[\xi(\mathbf{s}')x^f(\mathbf{s}') \mid \mathbf{s}\right]\right)}_{\text{Market segmentation spread } =: \ \chi^b}\\
&\quad + \underbrace{\log\left(\mathbb{E}\left[\xi(\mathbf{s}')x^f(\mathbf{s}') \mid \mathbf{s}\right]\right) - \log(\mathbb{E}[\xi(\mathbf{s}') \mid \mathbf{s}])}_{\text{Risk premium}}
\end{aligned}$$

The first component is the difference between the yield on government debt and the yield on a hypothetical asset issued by the private sector that has the same payout process as government debt (under the assumption that both assets are held by the financial sector). We interpret this as our model counterpart to the private-public borrowing cost spread χ that we defined and measured in Section 2 (with $\tilde{\xi} = \xi\breve{M}$. In our model, this spread arises from the different roles that government debt and capital play in the financial sector the morning market. We can see this by expanding the first term to get the approximate expression:

$$\chi(\mathbf{s}) \approx \log\left(\mathbb{E}\left[\frac{\breve{q}^b(\mathbf{s}')}{x^b(\mathbf{s}')}\frac{x^b(\mathbf{s}')}{x^h(\mathbf{s}')}\right]|\mathbf{s}\right) + \mathrm{Cov}\left(\frac{\xi(\mathbf{s})\breve{M}(\mathbf{s})x^h(\mathbf{s})}{\mathbb{E}[\xi(\mathbf{s}')\breve{M}(\mathbf{s}')x^h(\mathbf{s}')]}, \frac{\breve{q}^b(\mathbf{s})/x^h(\mathbf{s})}{\mathbb{E}\left[\breve{q}^b(\mathbf{s}')/x^h(\mathbf{s}')\right]}\right)$$

So, the government's funding advantage potentially comes from the average appreciation of the government debt in the next period's morning and afternoon markets and covariance between government debt appreciation and the bank's marginal valuation of additional resources. By introducing regulation that ensures that re-trading government debt is valuable in bad times, the government introduces a positive covariance and so introduces a government borrowing cost advantage. That is, regulation makes government debt a particularly "good-hedge" for mitigating the banking sector's frictions in the morning market and so earns a premium.

The second component is the difference between the banking sector's valuation of a hypothetical bond with the same cash-flows as government debt and the household's valuation of the same bond. We interpret this wedge as the spread coming from the market segmentation that prevents households from directly holding assets. Expanding the second term gives the analogous expression:

$$\chi^b(\mathbf{s}) \approx \log\left(\mathbb{E}\left[\breve{M}(\mathbf{s}')\right]\right) + \mathrm{Cov}\left(\frac{\xi(\mathbf{s})x^b(\mathbf{s})}{\mathbb{E}[\xi(\mathbf{s}')x^b(\mathbf{s}')]}, \frac{\breve{M}(\mathbf{s})}{\mathbb{E}\left[\breve{M}(\mathbf{s}')\right]}\right),$$

which shows that the frictions in the banking sector, as captured by $\breve{M}$, distort the return required by the banking sector to hold government debt. That is, χ^f is the risk-premium arising from market segmentation and bank frictions. The final component is the risk premium on government debt, as valued by the households in the economy.

The decomposition in equation (3.29) highlights how our model nests or relates to alternative models of government funding advantage used in the literature:

1. *Bond-in-the-utility (BIU):* Suppose we remove the morning market, regulatory constraints, and banking sector and instead introduce a utility benefit of holding government debt and capital in the afternoon market. Then the household Bellman equation

becomes:

$$V(a,\mathbf{s}) = \max_{c,b',k'} \left\{u(c) + \nu(q^b(\mathbf{s})b, q^k(\mathbf{s})k) + \beta\mathbb{E}[V(a',\mathbf{s})]\right\} \quad s.t.$$

$$c + q^b(\mathbf{s})b' + q^k(\mathbf{s})k' \leq a - \tau(\mathbf{s})$$

$$a' = x^b(\mathbf{s})b' + x^k(\mathbf{s})k',$$

which leads to the FOC for government debt:

$$q^b(\mathbf{s}) = \left(\frac{1}{1 - \partial_{q^b b}\nu(q^b b, q^k k)/u'(c)}\right)\mathbb{E}_{\mathbf{s}}[\xi(\mathbf{s}';\mathbf{s})q^b(\mathbf{s}')]$$

and the private-public borrowing cost spread becomes:

$$\chi(\mathbf{s}) = \log\left(\frac{1}{1 - \partial_{q^b b}\nu(q^b b, q^k k)/u'(c)}\right). \tag{3.30}$$

This implies that government policies only impact the private-public borrowing cost spread by changing $q^b b$ rather than changing the elasticity parameters and so we have the problems/features discussed in (2.3). Relative to the BIU formulation, our model endogenizes how the scale and elasticity parameters in the functional form BIU $\nu(q^b(\mathbf{s})b, q^k(\mathbf{s})k)$ relate to the government repression parameters and fiscal rule.

2. *Segmentation with Bond-in-Utility:* Suppose we take the BIU formulation from the previous bullet (i.e. no morning market) but now introduce a banking sector that receives utility from holding government debt. In this case, the private-public borrowing cost spread is still given by equation (3.30) so we still have all the problems/features discussed in (2.3). However, the model does opens up a market segmentation spread $\chi^b > 0$ that can be used to match additional spreads in the data.

3. *Bond collateral/bond-in-advance:* A number of papers model a binding bond collateral constraint (motivated by moral hazard problems or other information frictions). We can nest this in our environment by removing the interbank market frictions, removing idiosyncratic deposit withdrawal shocks, removing the possibility of bank deposit default, and replacing our regulatory constraint by a linear collateral ratio in the morning market:

$$(1-\lambda)d \leq \kappa\breve{q}^b(\mathbf{s})\breve{b}$$

Deposits, d, are chosen in the previous afternoon and, in equilibrium banks hold all the government debt so $\breve{b} = B$. Assuming the collateral constraint binds, this implies that the bond price in the morning market is given by:

$$\breve{q}^b(\mathbf{s}) = \frac{(1-\lambda)d}{\kappa B}$$

So, the morning price is inversely related to κ and is not influenced by future government debt prices or other government policies. In this sense, the bond collateral model creates very captive demand that is very hard for the government to erode.

3.5 Funding Cost Spreads and Fiscal Policy

The previous sections showed that our environment has both a potential positive feedback loop and a potential negative feedback. The positive feedback loop is: introducing repression that makes government debt a good hedge leads to banks issuing more deposits and taking more leverage, which in turn means that the banks are dependent on having a good hedge. In this sense, the government can use the frictions in the interbank market to create additional demand for government debt. However, there is also a negative feedback loop: introducing financial repression and while running fiscal policy that devalues government debt in bad states of the world forces banks to take losses. Instead of crowding into the government debt market, the banks default on deposits and essentially exit the market. In this sense, the additional demand for government debt collapses under fiscal policies that do not protect the value of debt.

We explore the negative feedback loop numerically in Figure 6, which plots the decomposition of government bond yields from equation (3.29) as the government devalues debt more in the bad state, i.e., $x^b(\mathbf{s}_L)$ decreases. The plots are constructed so that moving from left to right increases the risk on government debt. Evidently, the risk penalty becomes more negative as government debt becomes riskier. However, what's more interesting is that the funding cost spread and segmentation premium also decreases as government debt becomes more risky. We interpret this as the model counterpart to the empirical observation that government debt return risk decreases the government's funding advantage.

Empirical connections: We motivated our paper with historical US data, which we revisit in the final section of the paper. However, there are also recent studies that offer empirical evidence that is consistent with our mechanisms. First, the importance of the covariance terms in the funding cost spread formula has been explored empirically by Acharya and Laarits (2023) who argue that the key source of the spread on US treasuries is its hedging role. Second, for the modern period, we can use data from credit default swaps (CDS) to make risk adjustments to compare bonds with synthetically comparable cash flows. In Appendix C, we follow Jiang et al. (2020b) and do this for European countries during the Eurozone crisis (2009-15). We show that, even after controlling for the different risk

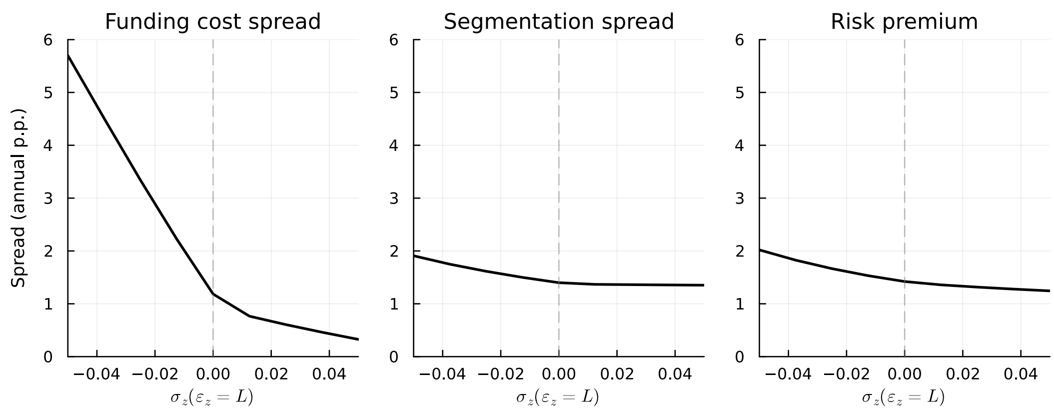

Figure 6: Decomposition of Equilibrium Pricing

Aggregate states, with the exception of ε_t^z, are evaluated at their ergodic mean values. The x-axis represents $\sigma^z(\varepsilon_t^z = L)$, i.e., the size of a primary deficit-to-output shock when the TFP shock is low. Positive values can be interpreted as "debt issuance shocks", i.e., surprise increases in the debt-to-output ratio. The size of the shock in the high TFP state, $\sigma^z(\varepsilon_t^z = H)$, was adjusted so that the conditional mean of the shock remains zero. Spreads are expressed as annualized percentage points.

characteristics of sovereign bonds, there was a higher erosion of the sovereign debt premium in countries facing fiscal challenges during the crisis. We interpret this as evidence that fiscal considerations are important for understanding the non-pecuniary spreads associated with government debt.

4 Macroeconomic Policy Implications

Our model with an endogenous, policy-variant government funding advantage leaves the government with complicated trade-offs. We close the paper by examining these trade-offs. We start by illustrating a numerical "trilemma" style result that highlights restrictions on the government's ability to jointly choose afternoon government debt payoffs, private-public borrowing cost spreads, and bank profitability. We then consider the dynamic, general equilibrium trade-offs associated with a particular government fiscal policy variable: the cyclicality of surpluses.

4.1 Policy Trade-offs: A Financing Trilemma

We start by considering the relationship between financial repression (which the government directly controls through regulation), the afternoon payoff on government debt (which the government indirectly controls in equilibrium through fiscal policy), and two variables: the average rate of default and the private-public borrowing cost spread. Figure 7 shows the equilibrium relationship visually, where the government polices are on the x and y-axes and the equilibrium default and borrowing cost spread (at the ergodic mean) given by the heat map. Evidently, increasing financial repression can increase the private-public borrowing cost spread. However, when accompanied by a devaluation of US debt, increasing financial repression also leads to higher default rates in the financial sector. As discussed in Section 3.5, this is because banks are being forced to hold debt with a negative return and so they start to default and exit the deposit market.

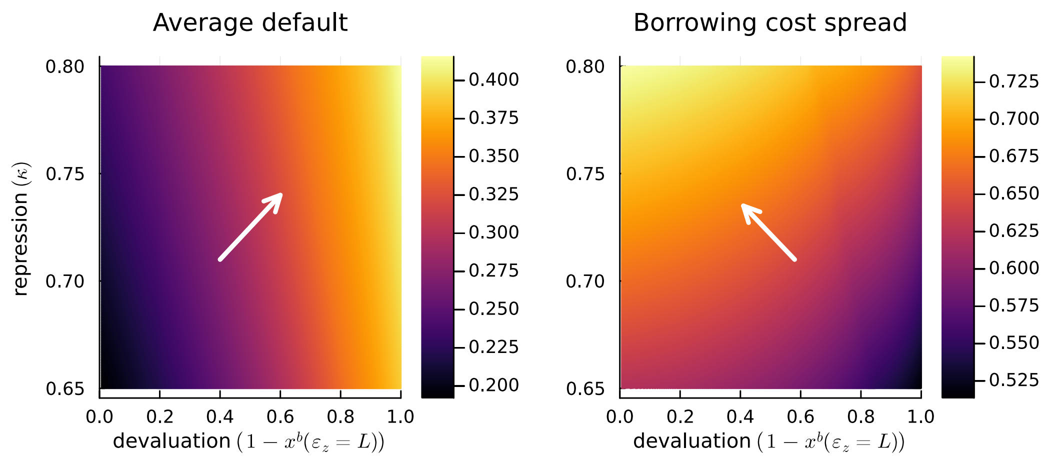

Figure 7: Government Financing Trade-offs

The left subplot shows a heat map with level of government repression on the y-axis, the devaluation of government debt on x-axis, and average default rate in the financial sector as the color. The right subplot shows a heat map with the same x and y-axes but with the private-public borrowing cost spread as the color.

We summarize this observation as a stylized "trilemma" for the government. In our model, by varying κ and x^b, the government cannot choose all three of:

1. High funding advantage,
2. A well-functioning financial sector (profitable and stable), and
3. Fiscal policy that leads to systematic debt devaluation (e.g. "default", "counter-cyclical" issuance, "inflation").

At a very stylized level, we can interpret some historical periods through the lens of our trilemma. During the 1970s, the US government ran systematically high (and volatile) inflation leading to the real devaluation of US debt. According to the trilemma, this meant it had to choose between maintaining its funding advantage by forcing the financial sector hold more government debt and maintaining financial stability by allowing the financial sector to substitute away from government debt and so lose the funding advantage. Ultimately, we can see from Figure 1 that the government chose to lose the funding advantage from 1975 to 1990.

Another period of interest in the National Banking Era (1865-1913). During this time, the government placed heavy financial repression on the banking sector to generate a high government funding advantage. According to the trilemma, this meant it had to choose between a profitable financial sector and fiscal-monetary policy that would lead to the systematic devaluation of its debt. Again, we can see from Figure 1 that the government chose to maintain stable bond prices (through the return to the gold standard after the Civil War) and ensure banking sector profitability.

4.2 Surplus Cyclicality and Funding Costs

The previous subsection shows results when an equilibrium government debt payoff, x^b, is taken as given. To make these arguments more concrete, we now focus on a particular government fiscal policy that could lead to systematic debt devaluation (and so activate the third branch of the trilemma): a fiscal rule that runs deficits in bad times and so forces debt issuance in bad times ($\sigma^z > 0$). In Section 3, we discussed how such a policy would impact the interbank asset markets. We now study the impact on the macroeconomy.

Figure 8 shows the empirical relationship between real GDP growth (per capita) and primary surplus-to-GDP for the period from 1860 to 2024. The blue line is real GDP growth and the green line is primary surplus to GDP. The red horizontal lines represent correlations between the two variables computed using observations in three separate subperiods (excluding the Civil War, World War I, and World War II) indicated by the vertical dotted lines. Evidently, the correlation was close to zero through World War II (especially through the late 1920s), approximately -0.25 for the period from 1952 to 1994, and then approximately 0.3 for the period from 1994 to 2024. Loosely speaking, we can summarize fiscal policies in the three eras by using different degrees of surplus cyclicality (σ^z) in the fiscal rule (3.2): the period 1870-1951 can be described by $\sigma^z \approx 0$, the post-WW2 period until the early 1990s can be described by $\sigma^z < 0$ and the post-1994 period can be described by $\sigma^z > 0$.

To understand the role of these government policies in our environment, we solve the model for a range of σ_z and κ values. Where possible, we take parameters from the literature. The details of the parameter choices are discussed in Appendix B. Figure 9 shows a collection of variables at their ergodic means for economies with different economic parameters: the private-public borrowing cost spread, investment, welfare, seigniorage, deficit-to-GDP, debt-to-GDP, return volatility, average default, and return on bank equity.

To provide some illustrative numerical results, in Table 3, we approximately match the within-subperiod empirical correlations between GDP growth and primary surplus-to-GDP by setting the value of $\sigma^z(\varepsilon^z = L)$ (deficit shock in "recessions"). We then calibrate the value

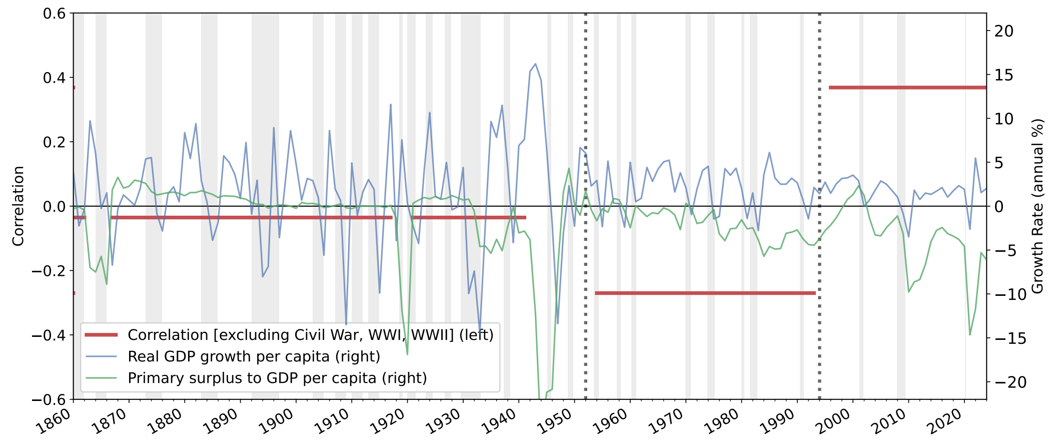

Figure 8: GDP growth per capita and primary surplus to GDP per capita

	1870-1951	1952-1993	1994-2024
σ^z	0.0	-0.03	0.05
κ	0.9	0.7	0.8
χ	1.3	0.3	0.7

Table 3: Ergodic variables for the different policy eras.

of κ for each subperiod by matching the subperiod-specific average private-public borrowing cost spread from Table 1. Show these calibrated policy combinations visually with circles on Figure 9.

Figure 9 and Table 3 illustrate a number of points about the connections between financial-fiscal policies and macroeconomic outcomes. First, we can see that the government is able to create a borrowing cost spread, which generates "seigniorage" revenue and so allows the government to run a long term deficits. In this sense, the government can generate a funding advantage that allows it to issue debt "unbacked" by future tax revenue. Both more repression (an increase in κ) and more counter-cylical surplus policy (a decrease in σ^z) lead to higher seigniorage revenue and larger long run deficits because they both make government debt a more useful hedge for the financial sector and so lead to higher borrowing cost spreads.

However, we can also see that the government policies required to generate seigniorage revenue have large macroeconomic consequences. The investment rate, bank profitability, and liquidity creation all fall because the government is generating the borrowing cost spread by either manipulating the financial sector or running austerity policies that squeeze household consumption in bad times. In this sense, there is no free lunch! The government can

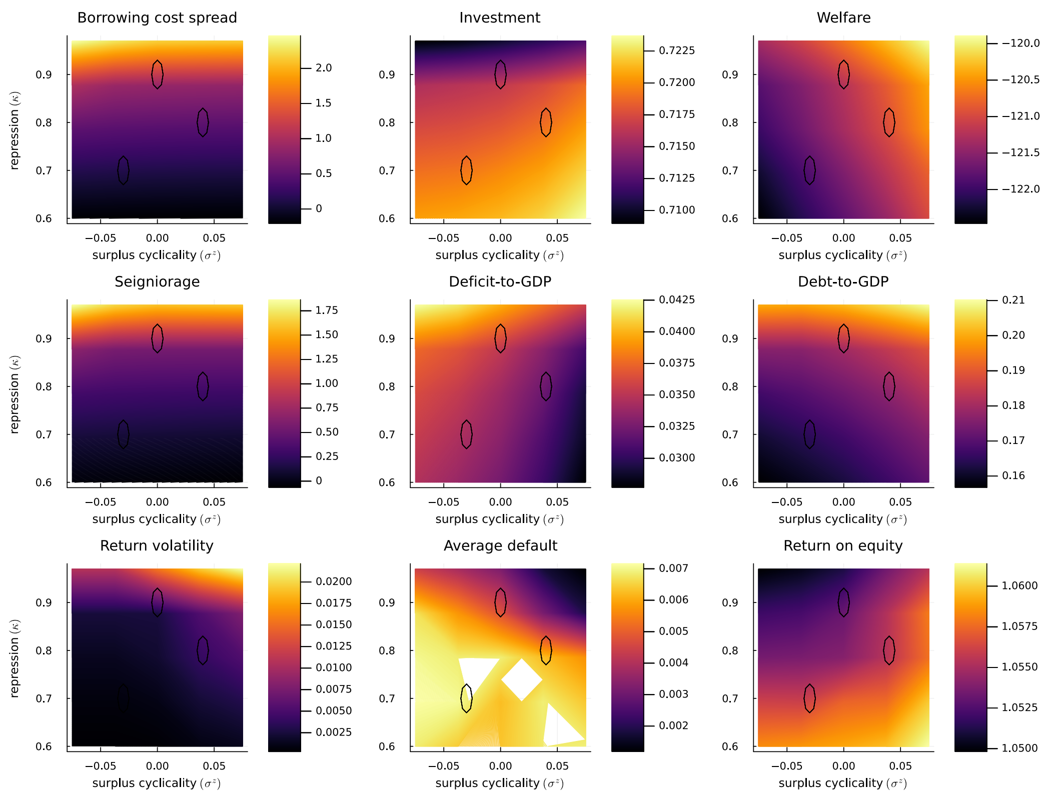

Figure 9: Government Financing Trade-offs. The black circles correspond to the three different regulatory eras in Table 3.

engineer a special role for its assets but it cannot do so without distorting the rest of the economy.

4.3 Connection to Different Fiscal Literatures:

Our paper is connected to a number of very large literatures studying fiscal and financial policies in general equilibrium models. We close this section by providing some thoughts on how our analysis is distinct but complementary to these literatures:

(i) *Ramsey and constrained planner models*[10]: Our environment has an incomplete secondary interbank market that restricts the movement of resources to distressed banks. Consequently, the constrained planner would respond by reallocating resources across islands to liquidity constrained banks in the morning market and across states by restricting the leverage of the banking sector in the afternoon market. In principle, a Ramsey planner could implement this without any "financial regulation" if it had

[10] E.g. Chari et al. (2020), Bassetto and Cui (2021)

a sufficiently large set of tax and transfer tools. By contrast, our paper considers a government facing political restrictions that limit its policy choice set to financial regulation. This allows us to focus on the "costs" of using financial regulation to increase government fiscal capacity. We show that these costs involve subtle covariances between the different wedges on the private sector Euler equations and so the government faces a trade-off between expanding fiscal capacity and the stability of the financial sector. We view our work as microfounding the (implicit) cost of "taxing" the financial sector. Future work could consider how a Ramsey planner might balance this cost against the distortionary costs of other taxes.

(ii) *Macroeconomic safe asset models*[11]: In our model, the household need for deposits and the frictions on the banking sector create bank demand for a safe-asset that allows them to hedge default risk and the associated costs. In this sense, we have a similar argument to the "safe-asset" literature, which suggests government debt can earn a "convenience yield" by playing the role of the "liquid" or "safe" asset in the economy. However, this literature typically models the special role of government debt using an exogenous bond-in-utility or bond-in-advance formulation, which allows the government to easily increase fiscal capacity by exploiting the funding cost spread. This is helpful for studying asset pricing but we believe this makes these models less suitable for studying fiscal policy. By contrast, we generate a private-public funding cost spread through government financial regulations that create a captive market for government debt in bad times, which endogenously makes government debt a good hedge against both aggregate and idiosyncratic risk. One benefit of endogenizing the government's funding advantage in this way is that we can show how fiscal policy can potentially erode the safe-asset role of government debt. Another benefit is that we can see that the full cost of making government debt a safe asset involves financial instability and the crowding out of real investment and private liquidity creation.

(iii) *Non-Ricardian macro-fiscal models*[12]: Similar to this literature, we are very interested in the trade-offs about how the government backs its liabilities. In our model, government debt is partially backed by an exogenous surplus process but also by restrictions that create captive demand within the financial sector in bad times and so change the price process of government debt. We believe this makes the following important contributions to this literature: (i) we provide a model of an endogenous private-public borrowing cost spread that, unlike other papers in the literature, is intimately related to government fiscal policy, and (ii) we relate the government private-public borrowing cost spread to frictions within the financial sector that reflect some overlooked features

[11] Caballero et al. (2008), Caballero et al. (2017), Choi et al. (2022), Kekre and Lenel (2024).

[12] This includes (but is not limited to) Sargent and Wallace (1981) and the "fiscal theory of the price level" literature, e.g., Leeper (1991), Sims (1994), Woodford (1994), Cochrane (2023), Bianchi et al. (2023), and the recent literature on fiscal backing, e.g., Jiang et al. (2022a,b); Chen et al. (2022).

of financial history. Ultimately, this means that, in our model, exploiting the government's funding cost spread is hard work that depends very tightly on the fiscal rule, and doesn't invalidate the key trade-offs in models where government debt is backed by future taxation. In this sense, we show that non-pecuniary benefits of government debt are not an alternative backing. There is no free lunch. Overall, we believe we show how to introduce a government private-public funding cost spread while maintaining the importance of fiscal policy for determining the role of government debt.

5 Conclusion

In this paper, we show how the government can generate a funding advantage through restrictions on the financial sector that make government debt a "safe-asset" for the economy. Endogenizing government funding advantage in this way allows us to characterize how it is related to financial and fiscal policy. We show that government default erodes its funding advantage because it changes the role that government debt plays in the financial sector and so changes the debt demand function. This is very different to bond-in-utility and bond-in-advance models where bond demand is exogenous and the fundinga advantage increases when the government starts to default (because the real value of government debt becomes scarce). Our results suggest that macroeconomists should be very cautious about modeling government funding advantage using exogenous, immutable demand functions that fit empirical "safe-asset" curves. Like for the Phillips Curve, these relationships break down once the government attempts to exploit them.

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A Equilibrium Characterization

We set up the equilibrium recursively using the notation that $(\breve{v}, v)$ denotes a variable in the morning and afternoon of the current period respectively and $(\breve{v}', v')$ denotes a variable in the morning and afternoon of the next period respectively. The aggregate state vector each afternoon sub-period is $\mathbf{s} := (\mathbf{z}, b, k, d, m)$, where $\mathbf{z} = (\breve{z}, z)$ is the realization of the exogenous aggregate TFP values, k is aggregate capital stock, and b is government debt outstanding (both determined in the previous afternoon sub-period). We guess and verify that afternoon prices are functions $(q^d(\mathbf{s}), q^e(\mathbf{s}), q^k(\mathbf{s}), q^b(\mathbf{s}))$ and the follow period morning prices are functions $\breve{q}^k(\mathbf{s}'), \breve{q}^b(\mathbf{s}')$.

A.1 Household Problem

Family problem: The family solves the problem:

$$
\begin{aligned}
V(a, \mathbf{s}) = \max_{\{c, e', d'\}} \quad & \left\{ u(c) + \beta \mathbb{E} \left[\sum_{\lambda} \lambda' u\big(\breve{x}^d(\lambda', \mathbf{s}') d'\big) \pi(\lambda') + (1 - \Lambda) V(a', \mathbf{s}') \mid \mathbf{s} \right] \right\} \\
s.t. \qquad & c + q^d(\mathbf{s}) d' + q^e(\mathbf{s}) e' \leq a - \tau(\mathbf{s}) \\
& a' = \sum_{\lambda'} \Big(x^e(\lambda', \mathbf{s}') e' + (1 - \lambda') \breve{x}^d(\lambda', \mathbf{s}') d' \Big) \pi(\lambda').
\end{aligned}
$$

After substituting in the law of motion wealth, the Lagrangian is:

$$
\begin{aligned}
\mathcal{L} = u(c) + \beta \mathbb{E} \Big[& \sum_{\lambda} \lambda' u\big(\breve{x}^d(\lambda', \mathbf{s}') d'\big) \pi(\lambda') \\
& + (1 - \Lambda) V \Big(\sum_{\lambda'} \Big(x^e(\lambda', \mathbf{s}') e' + (1 - \lambda') \breve{x}^d(\lambda', \mathbf{s}') d' \Big) \pi(\lambda'), \mathbf{s}' \Big) \mid \mathbf{s} \Big] \\
& + \mu^c(\mathbf{s}) \big(a - \tau(\mathbf{s}) - c - q^d(\mathbf{s}) d' - q^e(\mathbf{s}) e' \big)
\end{aligned}
$$

where $\mu^c(\mathbf{s})$ is the Lagrange multipliers on the afternoon budget constraint. The FOCs are:

$$
\begin{aligned}
[c]: \qquad & 0 = \partial_c u(c) - \mu^c(\mathbf{s}) \\
[e']: \qquad & 0 = \mathbb{E} \left[\beta (1 - \Lambda) \partial_{a'} V(a', \mathbf{s}') \sum_{\lambda'} x^e(\lambda', \mathbf{s}') \pi(\lambda') \;\Big|\; \mathbf{s} \right] - \mu^c(\mathbf{s}) q^e(\mathbf{s}) \\
[d']: \qquad & 0 = \mathbb{E} \left[\beta (1 - \Lambda) \partial_{a'} V(a', \mathbf{s}') \sum_{\lambda'} (1 - \lambda') \breve{x}^d(\lambda', \mathbf{s}') \pi(\lambda') \;\Big|\; \mathbf{s} \right] - \mu^c(\mathbf{s}) q^d(\mathbf{s}) \\
& \quad + \mathbb{E} \left[\beta \sum_{\lambda} \lambda' \breve{x}^d(\lambda', \mathbf{s}') \partial_c u\big(\breve{x}^d(\lambda', \mathbf{s}') d'\big) \pi(\lambda') \;\Big|\; \mathbf{s} \right]
\end{aligned}
$$

Using the envelope condition, we have:

$$\partial_a V(a, \mathbf{s}) = \mu^c(\mathbf{s}) = \partial_c u(c)$$

and so we get the asset pricing conditions:

$$\begin{aligned}
q^e(\mathbf{s}) &= \mathbb{E}\left[\beta(1-\Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))}\sum_{\lambda'} x^e(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\right] \\
q^d(\mathbf{s}) &= \mathbb{E}\left[\beta(1-\Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))}\sum_{\lambda'}(1-\lambda')\breve{x}^d(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\right] \\
&\quad + \mathbb{E}\left[\beta\sum_{\lambda}\lambda'\frac{\partial_c u(\breve{x}^d(\lambda', \mathbf{s}')d')}{\partial_c u(c(\mathbf{s}))}\breve{x}^d(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\right] \\
&= \mathbb{E}\left[\beta(1-\Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))}\sum_{\lambda'}\left(1-\lambda'+\lambda'\frac{\partial_c u(\breve{x}^d(\lambda', \mathbf{s}')d')}{(1-\Lambda)\partial_c u(c(\mathbf{s}'))}\right)\breve{x}^d(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\right]
\end{aligned}$$

We define:

$$\begin{aligned}
\xi(\mathbf{s}'; \mathbf{s}) &:= \beta(1-\Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))}, \\
\breve{N}(\mathbf{s}') &:= \sum_{\lambda'}\left(\left(1-\lambda'+\lambda'\frac{\partial_c u(\breve{x}^d(\lambda', \mathbf{s}')d')}{(1-\Lambda)\partial_c u(c(\mathbf{s}'))}\right)\breve{x}^d(\lambda', \mathbf{s}')\right)\pi(\lambda')
\end{aligned}$$

to get the expressions:

$$\begin{aligned}
q^d(\mathbf{s}) &= \mathbb{E}\Big[\xi(\mathbf{s}'; \mathbf{s})\breve{N}(\mathbf{s}') \mid \mathbf{s}\Big] \\
q^e(\mathbf{s}) &= \mathbb{E}\Big[\xi(\mathbf{s}'; \mathbf{s})\sum_{\lambda'} x^e(\lambda', \mathbf{s}')\pi(\lambda') \mid \mathbf{s}\Big]
\end{aligned}$$

A.2 Bank Problem

The bank solves:

$$\max_{\substack{m',k',b',d',\breve{x}^d(\cdot),\\ \breve{b}(\cdot),\breve{k}(\cdot),x^e(\cdot),\iota(\cdot)}} \left\{ \mathbb{E}\left[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\Big(x^e(\lambda',\mathbf{s}') - \Psi(1-\breve{x}^d(\lambda',\mathbf{s}'))d'\Big)\pi(\lambda') \mid \mathbf{s}\right] + q^d(\mathbf{s})d' \right.$$
$$\left. - m' - q^k(\mathbf{s})k' - q^b(\mathbf{s})b' \right\}$$
$$\begin{aligned}
s.t. \quad & \lambda'\breve{x}^d(\lambda',\mathbf{s}')d' \le \breve{z}'m' + \breve{q}^b(\mathbf{s}')\big(b' - \breve{b}(\lambda',\mathbf{s}')\big) + \breve{q}^k(\mathbf{s}')\big(k' - \breve{k}(\lambda',\mathbf{s}')\big) \\
& x^e(\lambda',\mathbf{s}') + (1-\lambda')\breve{x}^d(\lambda',\mathbf{s}')d' \\
& \quad \le \big(z' + (1-\delta)q^k(\mathbf{s}') + q^k(\mathbf{s}')\Phi(\iota(\lambda',\mathbf{s}')) - \iota(\lambda',\mathbf{s}')\big)\breve{k}(\lambda',\mathbf{s}') \\
& \qquad + \big(\omega + (1-\omega)q^b(\mathbf{s}')\big)\breve{b}(\lambda',\mathbf{s}'), \\
& \frac{\varrho}{2}(1-\lambda')\breve{x}^d(\lambda',\mathbf{s}')d' \le \kappa\ \breve{q}^b(\mathbf{s}')\breve{b}(\lambda',\mathbf{s}') + (1-\kappa)\ \breve{q}^k(\mathbf{s}')\breve{k}(\lambda',\mathbf{s}'), \\
& 0 \le b',\ k',\ m',\ d',\ \breve{b}(\lambda',\mathbf{s}'),\ \breve{k}(\lambda',\mathbf{s}'),\ 1-\breve{x}^d(\lambda',\mathbf{s}') \qquad \forall(\lambda',\mathbf{s}')
\end{aligned}$$

where $\iota(\lambda',\mathbf{s}')$ is the investment rate per unit of available capital $\breve{k}(\lambda',\mathbf{s}')$. In our model, the bank must have zero dividends in the morning, $\breve{x}^e = 0$. This means that all the adjustment when the bank takes losses must go through wither the deposit payout or afternoon dividends.

The Lagrangian is:

$$\begin{aligned}
\mathcal{L} = {} & \mathbb{E}_{\mathbf{s}}\left[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\Big(x^e(\lambda',\mathbf{s}') - \Psi(1-\breve{x}^d(\lambda',\mathbf{s}'))d'\Big)\pi(\lambda')\right] + q^d(\mathbf{s})d' - m' - q^k(\mathbf{s})k' \\
& - q^b(\mathbf{s})b' + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\breve{\mu}^e(\lambda',\mathbf{s}')\Big(\breve{z}'m' + \breve{q}^b(\mathbf{s}')\big(b' - \breve{b}(\lambda',\mathbf{s}')\big) \\
& \qquad + \breve{q}^k(\mathbf{s}')\big(k' - \breve{k}(\lambda',\mathbf{s}')\big) - \lambda'\breve{x}^d(\lambda',\mathbf{s}')d'\Big)\pi(\lambda')\Big] \\
& + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\mu^e(\lambda',\mathbf{s}')\Big(\big(z' - \iota(\lambda',\mathbf{s}') + q^k(\mathbf{s}')(1-\delta+\Phi(\iota(\lambda',\mathbf{s}')))\big)\breve{k}(\lambda',\mathbf{s}') + \\
& \qquad + \big(\omega + (1-\omega)q^b(\mathbf{s}')\big)\breve{b}(\lambda',\mathbf{s}') - x^e(\lambda',\mathbf{s}') - (1-\lambda')\breve{x}^d(\lambda',\mathbf{s}')d'\Big)\pi(\lambda')\Big] \\
& + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\breve{\mu}^r(\lambda',\mathbf{s}')\Big(\kappa\ \breve{q}^b(\mathbf{s}')\breve{b}(\lambda',\mathbf{s}') + (1-\kappa)\ \breve{q}^k(\mathbf{s}')\breve{k}(\lambda',\mathbf{s}') \\
& \qquad - \frac{\varrho}{2}(1-\lambda')\breve{x}^d(\lambda',\mathbf{s}')d'\Big)\pi(\lambda')\Big] + \underline{\mu}^b(\mathbf{s})b' + \underline{\mu}^k(\mathbf{s})k' + \underline{\mu}^m(\mathbf{s})m' + \underline{\mu}^d(\mathbf{s})d' \\
& + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}\Big(\underline{\breve{\mu}}^b(\lambda',\mathbf{s}')\breve{q}^b(\mathbf{s}')\breve{b}(\lambda',\mathbf{s}') + \underline{\breve{\mu}}^k(\lambda',\mathbf{s}')\breve{q}^k(\mathbf{s}')\breve{k}(\lambda',\mathbf{s}')\Big)\pi(\lambda')\Big]
\end{aligned}$$

where $\mathbb{E}_{\mathbf{s}} = \mathbb{E}[\cdot|\mathbf{s}]$. The first order conditions for the portfolio choice at formation are:

$$
\begin{aligned}
[m']: \qquad & 0 = -1 + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'} \breve{\mu}^e(\lambda',\mathbf{s}')\breve{z}'\pi(\lambda')\Big] + \underline{\mu}^m \\
[k']: \qquad & 0 = -q^k(\mathbf{s}) + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'} \breve{\mu}^e(\lambda',\mathbf{s}')\breve{q}^k(\mathbf{s}')\pi(\lambda')\Big] + \underline{\mu}^k \\
[b']: \qquad & 0 = -q^b(\mathbf{s}) + \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'} \breve{\mu}^e(\lambda',\mathbf{s}')\breve{q}^b(\mathbf{s}')\pi(\lambda')\Big] + \underline{\mu}^b \\
[d']: \qquad & 0 = q^d(\mathbf{s}) - \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'} \Big(\Psi(1-\breve{x}^d(\lambda',\mathbf{s}')) + \lambda'\breve{\mu}^e(\lambda',\mathbf{s}')\breve{x}^d(\lambda',\mathbf{s}') \\
& \qquad + (1-\lambda')\Big\{1+\breve{\mu}^r(\lambda',\mathbf{s}')\Big\}\breve{x}^d(\lambda',\mathbf{s}')\Big)\pi(\lambda')\Big] + \underline{\mu}^d
\end{aligned}
$$

These equations can be rearranged as:

$$
\begin{aligned}
[m']: \quad & 1 = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{z}'\Big] + \underline{\mu}^m \\
[k']: \quad & q^k(\mathbf{s}) = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^k(\mathbf{s}')\Big] + \underline{\mu}^k \\
[b']: \quad & q^b(\mathbf{s}) = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^b(\mathbf{s}')\Big] + \underline{\mu}^b \\
[d']: \quad & q^d(\mathbf{s}) = \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\Big(\sum_{\lambda'}\Big\{\Big(\lambda'\breve{\mu}^e(\lambda',\mathbf{s}') + (1-\lambda') + \\
& \qquad + (1-\lambda')\breve{\mu}^r(\lambda',\mathbf{s}')\Big)\breve{x}^d(\lambda',\mathbf{s}') + \Psi(1-\breve{x}^d(\lambda',\mathbf{s}'))\Big]\pi(\lambda')\Big\} - \underline{\mu}^d
\end{aligned}
$$

where:

$$
\breve{M}(\mathbf{s}') := \sum_{\lambda'} \breve{\mu}^e(\lambda',\mathbf{s}')\pi(\lambda')
$$

The first order conditions for the portfolio choice in the morning market are:

$$
\begin{aligned}
[\breve{x}^d(\lambda',\mathbf{s}')]: \qquad & 0 = \Psi'(1-\breve{x}^d(\lambda',\mathbf{s}')) - \lambda'\breve{\mu}^e(\lambda',\mathbf{s}') - (1-\lambda')\Big(1+\frac{\varrho}{2}\breve{\mu}^r(\lambda',\mathbf{s}')\Big) \\
[\breve{b}(\lambda',\mathbf{s}')]: \qquad & 0 = -\breve{\mu}^e(\lambda',\mathbf{s}')\breve{q}^b(\mathbf{s}') + \Big(\omega + (1-\omega)q^b(\mathbf{s}')\Big) \\
& \quad + \breve{\mu}^r(\lambda',\mathbf{s}')(\kappa/\varrho)\breve{q}^b(\mathbf{s}') + \underline{\breve{\mu}}^b(\lambda',\mathbf{s}')\breve{q}^b(\mathbf{s}') \\
[\breve{k}(\lambda',\mathbf{s}')]: \qquad & 0 = \breve{\mu}^e(\lambda',\mathbf{s}')\breve{q}^k(\mathbf{s}') - \Big(z' - \iota(\lambda',\mathbf{s}') + q^k(\mathbf{s}')(1-\delta+\Phi(\iota(\lambda',\mathbf{s}')))\Big) \\
& \quad - \breve{\mu}^r(\lambda',\mathbf{s}')((1-\kappa)/\varrho)\breve{q}^k(\mathbf{s}') - \underline{\breve{\mu}}^k(\lambda',\mathbf{s}')\breve{q}^k(\mathbf{s}') \\
[\iota(\lambda',\mathbf{s}')]: \qquad & 0 = -1 + q^k(\mathbf{s}')\partial\Phi_\iota(\iota(\lambda',\mathbf{s}'))
\end{aligned}
$$

A.3 Government

The government budget constraint

$$\Big(\omega + (1-\omega)q^b(\mathbf{s})\Big)b = \tau zk - g(\mathbf{s}) + q^b(\mathbf{s})b'.$$

The government faces an exogenous stochastic fiscal rule. Taxes are an exogenous function of output: $\tau(\mathbf{s}) = \tau zk$. Spending follows an exogenous stochastic process:

$$g(\mathbf{s}) = \Big(\tau + \eta\omega\bar{b} + \sigma^z\varepsilon_z + \sigma^g\varepsilon_g\Big)zk - \eta\omega b$$

A.4 Equilibrium Conditions

The functions:

$$\Big(c(\mathbf{s}),\ g(\mathbf{s}),\ \iota(\mathbf{s}),\ m'(\mathbf{s}),\ d'(\mathbf{s}),\ q^d(\mathbf{s}),\ q^e(\mathbf{s}),\ q^k(\mathbf{s}),\ q^b(\mathbf{s})\Big)$$

solve the equations: (assuming underlined Lagrange multipliers are soft functions, otherwise they should have complementarity conditions)

$$\begin{aligned}
zk &= c(\mathbf{s}) + m'(\mathbf{s}) + \iota(\mathbf{s})k + g(\mathbf{s}) \\
1 &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{z}'\Big] + \underline{\mu}^m(\mathbf{s}) \\
q^k(\mathbf{s}) &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^k(\mathbf{s}')\Big] + \underline{\mu}^k(\mathbf{s}) \\
q^b(\mathbf{s}) &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{M}(\mathbf{s}')\breve{q}^b(\mathbf{s}')\Big] + \underline{\mu}^b(\mathbf{s}) \\
q^d(\mathbf{s}) &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\Big(\sum_{\lambda'}\Big[\Big(\lambda'\breve{\mu}^e(\lambda',\mathbf{s}') + (1-\lambda')\Big\{1 + \breve{\mu}^r(\lambda',\mathbf{s}')\Big\}\Big)\breve{x}^d(\lambda',\mathbf{s}') \\
&\qquad + \Psi(1-\breve{x}^d(\lambda',\mathbf{s}'))\Big]\pi(\lambda')\Big)\Big] - \underline{\mu}^d(\mathbf{s}) \\
q^d(\mathbf{s}) &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\breve{N}(\mathbf{s}')\Big] \\
q^e(\mathbf{s}) &= \mathbb{E}_{\mathbf{s}}\Big[\xi(\mathbf{s}';\mathbf{s})\sum_{\lambda'}x^e(\lambda',\mathbf{s}')\pi(\lambda')\Big] \\
q^k(\mathbf{s}) &= \Big[\partial_\iota\Phi(\iota(\mathbf{s}))\Big]^{-1} \\
g(\mathbf{s}) &= \Big(\tau + \eta\omega\bar{b} + \sigma^z\varepsilon_z + \sigma^g\varepsilon_g\Big)zk - \eta\omega b
\end{aligned}$$

and functions

$$\Big(\breve{x}^d(\lambda,\mathbf{s}),\ \breve{b}(\lambda,\mathbf{s}),\ \breve{k}(\lambda,\mathbf{s}),\ \breve{\mu}^e(\lambda,\mathbf{s}),\ \breve{\mu}^r(\lambda,\mathbf{s}),\ x^e(\lambda,\mathbf{s}),\ \mu^e(\lambda,\mathbf{s}),\ \breve{q}^k(\mathbf{s}),\ \breve{q}^b(\mathbf{s})\Big)$$

solve the equations (assuming underlined Lagrange multipliers are soft functions, otherwise they should have complementarity conditions)

$$
\begin{aligned}
\Psi'(\lambda,\mathbf{s}) &= \lambda\breve{\mu}^e(\lambda,\mathbf{s}) + (1-\lambda)\Big(1+\breve{\mu}^r(\lambda,\mathbf{s})\Big) \\
\breve{q}^b(\mathbf{s}) &= \Big[\breve{\mu}^e(\lambda,\mathbf{s}) - (\kappa/\varrho)\breve{\mu}^r(\lambda,\mathbf{s}) - \underline{\breve{\mu}}^b(\lambda,\mathbf{s})\Big]^{-1}\Big(\omega + (1-\omega)q^b(\mathbf{s})\Big) \\
\breve{q}^k(\mathbf{s}) &= \Big[\breve{\mu}^e(\lambda,\mathbf{s}) - ((1-\kappa)/\varrho)\breve{\mu}^r(\lambda,\mathbf{s}) - \underline{\breve{\mu}}^k(\lambda,\mathbf{s})\Big]^{-1}\Big(z - \iota(\mathbf{s}) + q^k(\mathbf{s})k'/k\Big) \\
\lambda\breve{x}^d(\lambda,\mathbf{s})d &= \breve{z}m + \breve{q}^b(\mathbf{s})\big(b - \breve{b}(\lambda,\mathbf{s})\big) + \breve{q}^k(\mathbf{s})\big(k - \breve{k}(\lambda,\mathbf{s})\big) \\
x^e(\lambda,\mathbf{s}) &= \Big(z - \iota(\mathbf{s}) + q^k(\mathbf{s})\frac{k'}{k}\Big)\breve{k}(\lambda,\mathbf{s}) + \big(\omega + (1-\omega)q^b(\mathbf{s})\big)\breve{b}(\lambda,\mathbf{s}) - (1-\lambda)\breve{x}^d(\lambda,\mathbf{s})d \\
0 &= \Big(\kappa\ \breve{q}^b(\mathbf{s})\breve{b}(\lambda,\mathbf{s}) + (1-\kappa)\ \breve{q}^k(\mathbf{s})\breve{k}(\lambda,\mathbf{s}) - \frac{\varrho}{2}(1-\lambda)\breve{x}^d(\lambda,\mathbf{s})d\Big)\breve{\mu}^r(\lambda,\mathbf{s}) \\
b &= \sum_\lambda \breve{b}(\lambda,\mathbf{s})\pi(\lambda) \\
\breve{z}m &= \sum_\lambda \big(\lambda\breve{x}^d(\lambda,\mathbf{s})d\big)\pi(\lambda)
\end{aligned}
$$

with the state vector $\mathbf{s} = (\mathbf{z}, k, b, d, m)$ evolving according to:

$$
\begin{aligned}
\breve{z}' &= \varepsilon_z' \\
z' &= z(\varepsilon_z') \\
k' &= (1-\delta)k + \Phi(\iota(\mathbf{s}))k \\
q^b(\mathbf{s})b' &= g(\mathbf{s}) - \tau z k + \Big(\omega + (1-\omega)q^b(\mathbf{s})\Big)b \\
d' &= d'(\mathbf{s}) \\
m' &= m'(\mathbf{s})
\end{aligned}
$$

and where

$$
\begin{aligned}
\xi(\mathbf{s}';\mathbf{s}) &:= \beta(1-\Lambda)\frac{\partial_c u(c(\mathbf{s}'))}{\partial_c u(c(\mathbf{s}))} \\
\breve{N}(\mathbf{s}') &:= \sum_{\lambda'}\left(1 - \lambda' + \lambda'\frac{\partial_c u(\breve{x}^d(\lambda',\mathbf{s}')d')}{(1-\Lambda)\partial_c u(c(\mathbf{s}'))}\right)\breve{x}^d(\lambda',\mathbf{s}')\pi(\lambda') \\
\breve{M}(\mathbf{s}') &:= \sum_{\lambda'}\breve{\mu}^e(\lambda',\mathbf{s}')\pi(\lambda')
\end{aligned}
$$

B Numerical Illustration

	Value
β	0.96
γ	1.0
δ	0.1
λ	[0.9, 0.1]
λ	[0.25, 0.75]
$\breve{z}$	[1.0, 0.95]
z	[0.3, 0.2]
P	[0.95 0.05; 0.95 0.05]
$\bar{b}$	0.2
τ_y	0.1
η	0.9
η	0.9

Table 4: Parameters.

C Funding Advantage Across the Eurozone

The historical US data provides a comparison across very different regulatory eras. However, it is difficult to isolate changes in the role of government debt from changes in the risk on government debt. For the modern period, we can use data from credit default swaps (CDS) to approximate risk-adjusted borrowing cost spreads, which we consider an alternative empirical proxy to our notion of funding advantage. In this subsection, we follow Jiang et al. (2020b) and do this for European countries during the Eurozone crisis (2009-15). To help illustrate the connection to their paper and acknowledge that this is different object to a high grade corporate-treasury spread, we use their terminology and refer to the spread as the risk-adjusted convenience yield rather than risk adjusted borrowing cost. Doing this analysis allows us to study an important prediction of our model: increases in the likelihood of government debt devaluation (implicit or explicit) erode the risk-adjusted convenience yield.

C.0.1 Regulatory Context

In the Eurozone context, there are a number of components of regulation that are particularly important to our analysis and are well captured by our model. The first is the treatment of government debt from European countries as collateral by the European Central Bank (ECB). Before 2005, the ECB decided collateral terms using a private discretionary rating system that could deviate from those of private credit agencies. In 2005, the ECB moved to a market based criteria that linked the collateral value to a combination of the credit ratings from different agencies. In principle, this meant that the government debt of a number of European countries (particularly Greece and Cyprus) should have become ineligible as collateral during the Eurozone crisis (2009-2015). However, the ECB repeatedly relaxed the criteria. In 2008, they lowered the minimum market credit rating requirement and then announced wavers for Greek debt (April 2010), Irish debt (March 2011), and Portugese debt (July 2011). From May 2010, the ECB started to purchase Greek, Portugese, and Irish bonds as part of its "Security Markets Programme" (SMP), which was extended to Spanish and Italian bonds in 2011. We interpret the April 2010 announcement as resolving uncertainty that European government debt could lose its collateral status. Ultimately, the ECB treatment of Greek, Irish, Portugese, Spanish, and Italian debt as collateral allowed the European banks to take low interest loans from the ECB and purchase high yielding government assets without increasing their risk-weighted assets or their TIER 1 capital ratio.

In addition, the deposit insurance system in Europe does not have the same backing as in the US. All European Union member states are required to maintain a minimum government deposit guarantee. However, this guarantee is not backed by the ECB or the European Union but instead by the independent member state. So, for countries in the Eurozone, they cannot easily create money to recapitalize their banking sectors. In this sense, as in our model, the Eurozone deposits are not necessarily risk free, particularly when the government is unable to access debt markets. We saw this risk materialize in Iceland, Cyprus, and Greece during the Eurozone crisis.

C.0.2 Borrowing Cost Spreads (Risk Adjusted Convenience Yields)

We can express the yield on a government bond from Eurozone country i with maturity h and price $q_t^{i,h}$ as:

$$y_t^{i,h} = r_t^h - \chi_t^{i,h}$$

where $y_t^{i,h} = -\frac{1}{h}\log(q_t^{i,h})$ is the yield on the bond, $r_t^h = -\frac{1}{h}\log\mathbb{E}[\Xi_{t,t+h}]$ is the expectation of the h period (nominal) SDF pricing government debt, and $\chi_t^{i,h}$ is the convenience yield on the bond. We breakup the convenience yield into:

$$\chi_t^{i,h} = \widetilde{\chi}_t^{i,h} - s_t^{i,h}$$

where $s_t^{i,h} = -\frac{1}{h}\log\mathbb{E}_t\left[\Xi_{t,t+h}\prod_{j=1}^{h}(1-\mathfrak{d}_{t+j}^i)\right] + \frac{1}{h}\log\mathbb{E}[\Xi_{t,t+h}]$ is market rate for default risk insurance, $\mathfrak{d}_{t+j}^i$ is the probability of government default, and $\widetilde{\chi}_t^{i,h}$ is the risk-adjusted convenience yield on the bond. Following the approach in Jiang et al. (2020b), we proxy

$s_t^{i,h}$ by the credit default spread and, instead of estimating r_t, we focus on the difference between the convenience yield in country i and Germany. Assuming that there is a common SDF across the Eurozone, we have that:

$$\widetilde{\chi}_t^{i,h} - \widetilde{\chi}_t^{DE} = s_t^{i,h} - s_t^{DE,h} - (y_t^{i,h} - y_t^{DE,h})$$

We plot the risk-adjusted convenience yield differentials in Figure 10 for key Eurozone countries over the period from 2004 to 2024 which includes the European Sovereign Debt Crisis. The top row are countries that maintained relatively strong fiscal positions during the Eurozone crisis while the bottom row are countries that faced ratings downgrades and speculation about their fiscal sustainability. For calculations, we use Euro denominated 5 year CDS spreads from Markit and 5 year sovereign yields from Global Financial Data. Evidently, risk-adjusted convenience yields decreased significantly more in the countries on the bottom row. In Figure 11 we plot the risk-adjusted convenience yield against the CDS spread and show that the negative relationship we saw in the cross-section is also true in the time series. These plots suggest that, even after controlling for the different risk characteristics of the sovereign bonds, there was a higher erosion of sovereign debt premia in the countries facing fiscal challenges during the crisis. As we saw in Subsection **??**, this is a puzzle for workhorse macroeconomic models that use BIU or BIA formulations to generate convenience yields because those models predict the risk-adjusted convenience yield increases when the market value of government debt falls. By contrast, our model suggests a potential resolution: that an increase in the probability of government default lead to a decrease in the risk adjusted convenience yield because the hedging role of Irish, Italian, Portuguese, and Spanish debt diminished ($\widetilde{\chi}_h$ decreased) even though their collateral role at the ECB stayed the same ($\widetilde{\chi}_r$ stayed the same). A complementary explanation is proposed by Jiang et al. (2020b), which suggests that the heterogeneous decreases in the risk-adjusted convenience yields reflect how different fiscal policies during the crisis lead to different expectations about post-crisis debt issuance. We nest both explanations in our macroeconomic model.

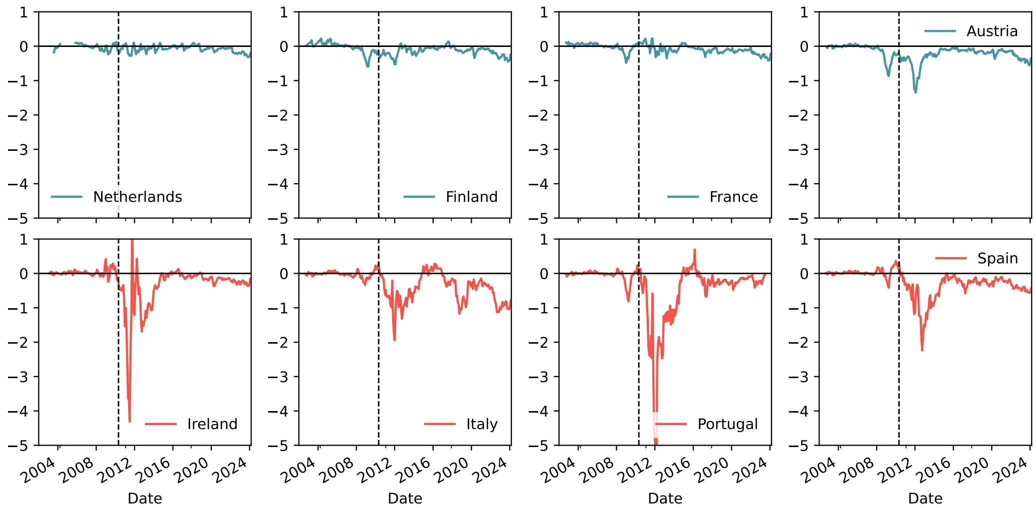

Figure 10: Difference in Risk Adjusted Convenience Yields to Germany.

The dashed line is at April 2010, the date at which the ECB announced the waver for Greek debt.

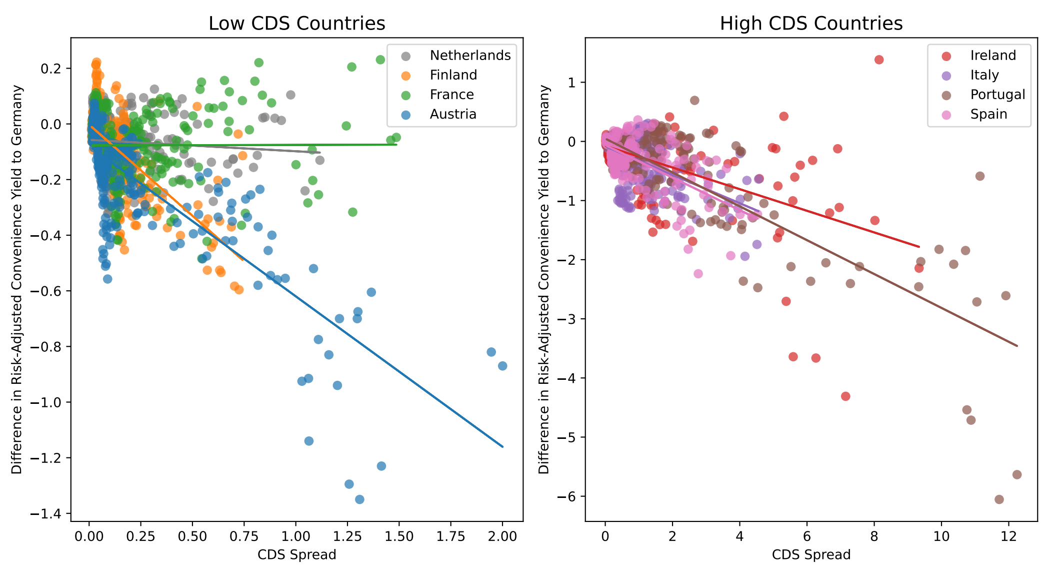

Figure 11: Difference in Risk Adjusted Convenience Yields to Germany vs CDS Spreads.

The left plot show countries that maintained low CDS spreads during the Eurozone crisis while the right plots shows countries that had high CDS spreads. The dots represent monthly observations and the lines represent linear regressions for each country.