The Macroeconomic Implications of US Market Power in Safe Assets*

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Abstract

The US government is the dominant supplier of global safe assets and faces a downward sloping demand for its debt. In this paper, we ask if the US exercises its market power when issuing debt and study its macroeconomic consequences. We develop a model of the global economy in which US public debt generates a non-pecuniary value for its holders and analyze the equilibrium in which the US government is the monopoly provider of this safe asset and contrast this with the case in which it acts a price taker. We use variation in estimated demand elasticities for US debt during flight-to-safety episodes to empirically distinguish between these two models and find that the data rejects price-taking behavior in favor of the monopoly one. We then quantify the distortions due to market power and find that it generates a significant under-provision of safe assets, a sizable markup in the convenience yield, and large welfare benefits for the US in detriment of the rest of the world. We also study the implications of increasing competition in safe assets from other sovereigns and private institutions.

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1 Introduction

The last few decades have seen an increasingly large demand for safe assets fueled by the rapid growth of high-saving emerging economies. These safe assets are produced by a small number of advanced economies that have the institutional capability to do so. One consequence of the relatively small number of safe asset issuers is that they have the ability to exert market power. As argued by Farhi and Maggiori (2018), this can lead to scarcity in the global supply of safe assets and distortions in the international monetary system. In recent history, the most prominent example of such a safe asset producer is the US government. A large empirical literature that builds on Krishnamurthy and Vissing-Jorgensen (2012) has documented a downward sloping demand for US Treasuries that reflects the value that investors have for their safety, liquidity, and collateral properties.

In this paper, we ask if the US internalizes this downward sloping demand curve and exploits its market power when issuing debt. We then study the macroeconomic implications of US market power in safe assets.. We develop a model of the global economy in which the US is the sole provider of a safe asset with a non-pecuniary benefit. The monopoly equilibrium is associated with a scarce supply of US debt and a spread between its return and that of other safe assets, what the literature refers to as a convenience yield, which reflects both this non-pecuniary value as well as monopoly rents. This model has different implications for how changes in demand elasticities for US debt affect equilibrium outcomes relative to a model in which the US acts as a price taker. We then measure these elasticities in the data and exploit variation in them during flight-to-safety episodes to empirically distinguish between the two models. We find that the data rejects price taking behavior in favor of the monopoly model, because the latter can better account for increases in yields during these flight-to-safety episodes with increases in markups. We then use our model to quantify the macroeconomic distortions due to market power. We find that this market power generates a significant underprovision of global safe assets, accounts for a sizable share of the observed convenience yield, and gives rise to large welfare benefits for the US. We also use our model to study the implications of increased competition in the market for safe assets.

We consider a dynamic model of international borrowing and lending with two countries, the US and the rest of the world. In our model, agents can trade two types of safe assets, public debt issued by the US and capital. We enrich this setting with two key features. First, following the recent theoretical literature on the convenience yield, US public debt provides a non-pecuniary benefit to its holders. This benefit can capture a variety of mechanisms studied in the literature, including the expansion in output associated with the ability to use such assets as collateral. Due to this non-pecuniary benefit, in equilibrium, the US issues external debt at low interest rates and invests in other foreign assets with higher returns, thereby operating as a world banker (Gourinchas and Rey (2007a)). Second, the US is the sole provider of this type of asset, and hence, enjoys monopoly power in its provision. As a result, the equilibrium convenience yield, which in the model corresponds to the spread between the return on US debt and safe capital, is a combination of both a non-pecuniary value and a markup. We show that this markup is completely determined by the elasticity of demand for US debt. In contrast, if the US is a price taker, this markup is zero. In addition, the presence of a monopolist in this market implies an under-provision of such assets relative to a benchmark in which the US is a price taker. We show that the degree of under-provision also depends on this demand elasticity.

Motivated by the theoretical predictions, we ask whether the data supports the model with market power, i.e., the one in which the US government acts strategically, over a price-taking benchmark. As is well understood from the industrial organization literature, price and quantity data are insufficient to distinguish between price taking and strategic behavior when marginal costs are unobservable. We use the important insight of Bresnahan (1982) to argue that rotations in the demand curve for US treasuries, i.e., changes in demand elasticities can help us test whether price taking or strategic behavior by the US provides a better representation of the data. We follow the firm conduct literature (e.g. Duarte et al. (2021), Backus et al. (2021)) and use the test developed by Rivers and Vuong (2002) to formally test between the price taking and monopoly model. To do so, we enrich the demand structure estimated in prior literature to include a demand rotator. We use proxies for flight-to-safety shocks as our measure of a demand rotator and find that the data rejects price-taking behavior in favor of monopoly model. This is because the monopoly model can better account for increases in the convenience yield during flight-to-safety episodes by increases in markups. We also find that the demand curve is relatively inelastic, with average elasticities in line with those in the literature.

We then use our estimates along with other aggregate moments to conduct a quantitative analysis of the monopoly model. We find that there is a significant underprovision of global safe assets, with safe asset supply in the monopoly case being almost half of that in the case when the US acts as a price taker. Additionally, the convenience yield in the monopoly model carries a markup of approximately two thirds, and is one and a half times that in the price-taking model. We also find that this market power confers sizable welfare benefits on the US and larger welfare losses on the rest of the world. In this sense, our analysis quantifies a notion of exorbitant privilege which arises due to the ability of the US to issue large amounts of debt at low interest rates.

Our next exercise tries to understand the effects of increasing safe asset competition on the global economy. This is motivated by the recent efforts to create alternative safe assets, both by other governments and the private financial sector. Examples of the former are the initiatives to create a supra-national safe asset at the European Union level (Zettelmeyer and Leandro (2018)), and the efforts by the Chinese government to establish itself as a safe asset issuer and a reserve currency country (Clayton et al. (2022)). In the latter, this has been achieved through increased securitization (Gorton et al. (2010); Sunderam (2015)). We use our model to assess the macroeconomic impacts of transitioning to an economy in which there is increased competition for safe assets that are substitutable with US government debt. We consider competition from two sources, other sovereigns and the financial sector. We model the former by considering an extension of our model in which N symmetric countries Cournot compete for the provision of safe assets. Our baseline monopolist model corresponds to case in which $N = 1$, and we consider the effects of transitioning to an economy with larger N. An economy with $N = 2$ features a global steady-state supply of such assets that is approximately two times larger than the baseline economy with monopoly provision. During the initial phase of the transition between these two steady states, the increased competition and larger issuance of debt by the US is associated with a consumption and investment boom for the US, as well as a temporary widening of global imbalances. Finally, we find that the transition to the $N = 2$ economy is associated with a consumption equivalent welfare reduction of 0.17% for the US and a 0.22% increase in welfare for the rest of the world.

We model competition arising from the financial sector by extending our model to include a competitive fringe. An important distinction is whether this competition arises from domestic or foreign firms. We find that the case of the foreign fringe closely resembles the model with Cournot competition. However, in the case of domestic competition, since the US government internalizes the profits from the domestic fringe, US welfare losses are much lower. One interesting result we find is that while the aggregate supply of safe assets substantially increases due to increased competition, US public debt-to-GDP is fairly stable across the different counterfactuals.

Related literature

Our paper is related to a literature in international finance that studies safe assets and the global economy. Maggiori (2017), Gourinchas et al. (2017), and He et al. (2019) develop macroeconomic theories of the determination of safe assets.[1] A closely related paper is Farhi and Maggiori (2018), which develops a model of the international monetary system. In their model, the shortage in the global supply of safe assets arises due to the presence of market power. Building on their insights, our model features an economy that enjoys market power due to its ability to supply a safe asset which provides a fundamental

[1]See Holmstrom and Tirole (1997); Krishnamurthy and Vissing-Jorgensen (2015); Lenel (2017); J Caballero and Farhi (2018); Jiang et al. (2020b); Gorton and Ordonez (2021) for contributions in the closed-economy literature.

non-pecuniary value. We contribute to this literature by providing empirical support for the idea that the US exercises its market power and quantifying the macroeconomic implications of it.

A related literature studies the special role of US public debt and the dollar demand. This literature builds on the important work of Krishnamurthy and Vissing-Jorgensen (2012), which documents a downward sloping demand for US Treasuries and the presence of a convenience yield that reflects the additional safety and liquidity attributes of US Treasuries. Subsequent work has studied the implications for the term structure and sustainability of US public debt (Greenwood et al., 2015; Jiang et al., 2019; Mian et al., 2021), and international safe assets and exchange rates (Du et al., 2018; Krishnamurthy and Lustig, 2019; Koijen and Yogo, 2020; Jiang et al., 2020c; Jiang et al., 2021b).[2] Motivated by these facts, a set of papers develop macroeconomic models to study the global implications of the special role of US debt (e.g., Engel and Wu, 2018, Jiang et al., 2020a, 2021a; Kekre and Lenel, 2021). Our theory shares this idea that US debt generates special benefits to its holders. We contribute to this literature by modeling the behavior of the US government when its debt generates non-pecuniary benefits to holders. Our analysis suggests that these benefits endows the US with market power in safe assets, which accounts for a sizable component of the convenience yield and gives rise to significant under-provision of safe assets. In this sense, our paper quantifies the welfare benefit of the "exorbitant privilege" (Gourinchas and Rey, 2007b,a) that the US enjoys due to its ability to issue large amounts of safe debt at low interest rates.

Finally, our analysis of increasing competition in global safe asset markets complements the work of Clayton et al. (2022), who develop a theory to study how countries compete to become safe asset issuers by building reputation. Our analysis focuses on the implications of imperfect competition by other sovereigns and private agents.

The rest of the paper is organized as follows. Section 2 presents the model and characterizes the prices and allocations in the monopoly and competitive equilibria. Section 3 presents the empirical test of US government behavior. Section 4 conducts a quantitative analysis of the model. We conclude in Section 5.

2 Model

We consider a model of international borrowing and lending with two countries, the US and the rest of the world. In our model, agents can trade two types of safe assets, public debt issued by the US and capital. We enrich this setting with two key features. First, following the recent theoretical literature on the convenience yield, US public debt

[2] A related literature has studied the substitutability of US Treasuries with other near-money assets (see, e.g., Nagel 2016; Krishnamurthy and Li 2022).

provides a non-pecuniary benefit to its holders, which captures the value associated with its high degree of liquidity and/or ability to serve as collateral. Second, building on Farhi and Maggiori (2018), the US is the sole provider of this type of asset, and hence, enjoys monopoly power in its provision.

The two countries are denoted by US and RoW. The environment is deterministic, and time is discrete, infinite, and denoted by $t = 0, 1, 2, ...$ Each country consists of households, competitive final goods producers, and competitive capital goods producers. In addition, there is a government in the US with the ability to issue public debt. We first describe the problem of agents in RoW. In addition to choosing consumption and investment, the representative RoW household can purchase debt issued by the US government. US public debt is valuable as a means of inter-temporal smoothing and also provides a non-pecuniary value. Purchasing b^*_{t+1} units of US debt in period t generates $f_{t+1}\left(b^*_{t+1}\right)$ units of the consumption good in period $t+1$, where f is an increasing and concave function. In Appendix B,we show that such a non-pecuniary value can arise due to the ability of US debt to serve as collateral to finance investment projects.

The problem for the representative RoW household is

$$\max_{\left\{c^*_t, k^*_{t+1}, b^*_{t+1}\right\}_{t\geqslant 0}} \sum_{t=0}^{\infty} \beta^t u\left(c^*_t\right)$$

subject to

$$c^*_t + k^*_{t+1} + b^*_{t+1} \leqslant w^*_t + \left(1 - \delta + r^*_{K,t}\right) k^*_t + f_t\left(b^*_t\right) + \left(1 + r_t\right) b^*_t,$$

$$b^*_{t+1} \geqslant 0,$$

as well as standard non-negativity constraints. Here c^*_t and k^*_{t+1} denote consumption and capital choices in period t, $r^*_{K,t}$ denotes the return on RoW capital, r_t denotes the return on US public debt, and w^*_t denotes wages. We also assume that households are endowed with one unit of time and supply labor inelastically.

There are also RoW capital goods producers who rent capital from RoW and US households, produce a composite capital good, and rent this composite capital good to final goods producers in RoW. The problem for the representative capital goods producer is

$$\max_{\left\{k^*_{US,t}, k^*_{RW,t}\right\}} R^*_t K^*_t - r_{K,t} k^*_{US,t} - r^*_{K,t} k^*_{RW,t}$$

where K^*_t is generated using a CES technology,

$$K^*_t = \left[\sigma\left(k^*_{RW,t}\right)^{\frac{\theta-1}{\theta}} + (1-\sigma)\left(k^*_{US,t}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}.$$

Here, R^*_t is the rental rate of the foreign capital composite, $k^*_{US,t}$ is the capital rented from US households and $k^*_{RW,t}$ is the capital rented from RW households by the RW capital producer, and $r_{K,t}$ and $r^*_{K,t}$ their respective returns.

The problem for the final goods producer is

$$\max_{K^*_t, L^*_t} A^*_t {K^*_t}^{\alpha} {L^*_t}^{1-\alpha} - R^*_t K^*_t - w^*_t L^*_t.$$

We next turn to the problem of the US. US households choose consumption and capital to maximize their expected utility. They also supply labor inelastically. We state their problem in Appendix B. We assume that the US government can issue debt to RoW households and levies taxes on US households in order to finance debt repayment. These taxes are distortionary and generate resource costs. Recall that US debt generated a non-pecuniary benefit for RoW households. In our baseline model we assume that the US is the monopoly provider of such an asset. In Appendix B we show that the Ramsey problem for the US government is

$$\max_{\{c_t, k_{t+1}, b_{t+1}\}_{t, s^t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} - b_{t+1} = w_t - \chi_t(b_t) + (1 - \delta + r_{K,t}) k_t - (1 + r_t(b_t)) b_t,$$

where b_t is the debt issued by the US government and with some abuse of notation, $r_t(b_t)$ is the inverse demand function for US debt. We also show in Appendix B that the distortionary cost associated with debt repayment is captured by the function $\chi_t(b_t)$. More generally, this function captures the costs of expanding the size of the government's balance-sheet. We assume that χ is positive, decreasing, and convex function whenever $b_{t+1} > 0$ and zero otherwise. The capital goods producer in the US solves

$$\max_{\{k_{US,t}, k_{RW,t}\}} R_t K_t - r_{K,t} k_{US,t} - r^*_{K,t} k_{RW,t}$$

where K_t is generated using a CES technology

$$K_t = \left[\sigma (k_{RW,t})^{\frac{\theta-1}{\theta}} + (1-\sigma)(k_{US,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}},$$

while the final goods producer solves

$$\max_{K_t, L_t} A_t {K_t}^{\alpha} {L_t}^{1-\alpha} - R_t K_t - w_t L_t.$$

An allocation is this economy is given by $\mathbf{x}_t = (x_t^*, x_t)$ where

$$x_t^* = \left(\left\{c_t^*, k_{t+1}^*, b_{t+1}^*, k_{US,t}^*, k_{RW,t}^*, L_t^*\right\}_{t,s^t}\right)$$

and similarly for x_t.

We can now define an equilibrium for this environment.

Definition 1. A monopoly equilibrium is an allocation $\{\mathbf{x}_t\}_{t\geqslant 0}$ and prices $\left\{R_t, R_t^*, r_{K,t}, r_{K,t}^*, w_t, w_t^*\right\}$ such that

1. Given prices , the allocation $\{x_t\}$ solves the maximization problems for the US.
2. Given prices , the allocation $\{x_t^*\}$ solves the maximization problems for the RoW.
3. Markets clear:

$$b_t = b_t^*,$$

$$k_t = k_{US,t} + k_{US,t}^*$$

$$k_t^* = k_{RW,t} + k_{RW,t}^*$$

and

$$L_t^* = L_t = 1.$$

2.1 Equilibrium Characterization

In this section we show how this model guides our empirical and quantitative exercises. We start by analyzing a special case of our model in which US and RoW capital are perfect substitutes in the production function (i.e., $\theta = \infty$). We define the convenience yield in the model as the spread between the returns on US capital and US public debt, $\mathcal{S}_t \equiv (r_{K,t} - \delta) - r_t^{US}$. This model-based definition is consistent with the definition of the convenience yield used in the literature and in the empirical analysis, which is defined to be the spread between US safe corporate debt and US public debt. This is because, in the model, we can interpret the return on capital as the return on safe corporate debt.[3]

Next, we show that both the US and RoW problems can be rewritten so that the choice of debt solves a static problem. To do so, we define $a_{t+1} \equiv k_{t+1} - b_{t+1}$ as the net asset position of the US (and similarly for RW). Given this change of variable and using the fact

[3]Formally, our model is equivalent to one in which firms own the capital stock and borrow from households in order to make investments. In this model the return on firm debt is identical to the return on capital in our model.

that $b_{t-1} = -b^*_{t-1}$, the problem for the US government can be written as

$$\max_{\{c_t, a_{t+1}, b^*_t\}_t} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to,

$$\begin{aligned} c_t + a_{t+1} &= w_t l_t + (1 - \delta + r_{K,t}) a_t \\ &+ \mathcal{S}_t(b^*_t) b^*_t - \chi(b^*_t). \end{aligned}$$

This formulation recasts the choice of debt as a standard static monopoly problem where the relevant price is the convenience yield and the cost is given by χ. The first order conditions from this imply

$$\mathcal{S}_t(b^*_t) = \chi'(b^*_t) - \mathcal{S}'_t(b^*_t) b^*_t. \tag{1}$$

An implication of US and RW capital being perfect substitutes is that $r^*_{K,t} = r_{K,t}$ for all t. Using this result, one can rewrite the RoW problem using a similar change of variable. The first order conditions from RoW's problem implies that

$$\mathcal{S}_t(b^*_t) = f'_t(b^*_t). \tag{2}$$

Thus, due to the non-pecuniary benefit that US debt provides over capital, the return on US debt is lower than that of capital. One can use these conditions to show that spread and debt level in the monopoly equilibrium are

$$\mathcal{S}^{ME}_t = \frac{1}{[1 - \mu_t]} \chi'\left(b^{ME}_t\right) \tag{3}$$

and

$$b^{ME}_t = f'^{-1}\left(\mathcal{S}^{ME}_t\right). \tag{4}$$

Since the US is a monopolist, the convenience yield features a *markup* μ_t where :

$$\begin{aligned} \mu_t &\equiv \frac{\mathcal{S}'_t(b^*_t) - \chi'_t(b^*_t)}{\mathcal{S}_t(b^*_t)} \\ &= -\frac{f''(b^*_t)}{f'(b^*_t)} b^*_t \end{aligned} \tag{5}$$

where the last line follows from (1) and (2).

In contrast, consider an environment in which the US acts as a price taker in the market for safe assets. The problem for the RoW is unchanged, while the problem for the US is

$$\max_{\{c_t, a_{t+1}, b_t\}_t} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to,

$$c_t + a_{t+1} = w_t l_t + (1 - \delta + r_{K,t})\, a_t + \mathcal{S}_t b_t - \chi(b_t)$$

where the US takes the convenience yield as given. It is straightforward to see that the convenience yield in the competitive equilibrium is given by

$$\mathcal{S}_t^{CE} = \chi'\left(b_t^{CE}\right) \tag{6}$$

where the equilibrium level of debt is

$$b_t^{CE} = f'^{-1}\left(\mathcal{S}_t^{CE}\right). \tag{7}$$

The following lemma immediately follows from comparing the two monopoly and price taking equations.

Lemma 1. *The monopoly equilibrium features a higher spread and an underprovision of safe assets compared to the case in which the US acts as a price taker.*

A direct implication of the lemma is that the existence of safe asset underprovision depends on if the US behaves strategically. The degree of underprovision then depends crucially on the markup μ_t. The markup is completely pinned down by the elasticity of demand, $\mu_t = \varepsilon_{D,t}^{-1}$ where

$$\varepsilon_{D,t} \equiv \frac{db_t^*}{d\mathcal{S}_t}\frac{\mathcal{S}_t}{b_t^*} = -\frac{f'(b_t^*)}{f''(b_t^*)\, b_t^*}.$$

We summarize the above arguments in the lemma below.

Lemma 2. *In the model in which US and RW are perfect substitutes ($\theta = \infty$), and the US behaves as a monopolist, the convenience yield markup is $\mu_t = \varepsilon_{D,t}^{-1}$ where $\varepsilon_{D,t}$ is the elasticity of demand for US debt.*

Consider instead the model in which RoW and US capital are no longer perfect substitutes. We show in the appendix that the above analysis continues to hold in the steady state of this model.

There are two key takeaways from this section. First, to ascertain whether there is an underprovision of safe assets requires us to test if the US behaves strategically. Second, if there is strategic behavior, the degree of underprovision depends on the elasticity of demand. In the following section, we will use the model and data to provide support for strategic behavior assumption and also measure the degree of underprovision.

3 Empirical Analysis

In this section, we formally test if the data supports the monopoly model over the model in which the US acts as a price taker. The test uses the insight of Bresnahan (1982) who argues that rotations in the demand curve (through changes in demand elasticities) can help identify strategic from competitive behavior. A pure rotation of the demand curve will change prices *only* if the agent exploits market power, through changes in markups but not if the agent is a price taker. Thus, observing increases in prices when demand becomes more inelastic is an indication of strategic behavior. To implement the test, we first estimate the demand for US Treasuries. The key departure from the existing literature is that we also include a *demand rotator* as a dependent variable. Formally, we estimate:

$$y_t = \alpha + \beta \ln b_t + \gamma (\ln b_t \times z_t) + \delta X_t + \varepsilon_{t,} \tag{8}$$

where y_t is a measure of the convenience yield, $\ln b_t$ is log of the ratio of public debt to GDP, z_t is the demand rotator, and X_t is a vector of controls that includes z_t. In this specification, the demand semi-elasticity of prices to quantities is given $\beta + \gamma z_t$. To obtain an estimate of the actual elasticity we take the ratio of semi-elasticity to the average value of y_t in our sample.[4] When $\gamma = 0$ we obtain the same demand specification estimated in Krishnamurthy and Vissing-Jorgensen (2012). We also assume the following cost function, $\chi_t(b_t) = \lambda_{ft} \frac{b_t^{1+\lambda}}{1+\lambda}$, which implies that the (log) marginal cost of issuing debt is given by

$$\ln mc_t = \lambda_{ft} + \lambda \ln b_t,$$

where λ_{ft} is a marginal cost shifter. The working assumption is that the random variables z_t and λ_{ft} are independent, i.e., $\mathbb{E}[z_t \lambda_{ft}] = 0$.

The data for the demand estimation is gathered at a quarterly level from 1925-2020. We compute measures of convenience yields for short- and long-term US public debt. The short-term convenience yield is computed as the difference in the yields to maturity of short-maturity AAA corporate bonds and US Treasury Bills. The long-term convenience yield is computed as the difference in the yields of long-maturity AAA corporate bonds and US Treasury Bonds. Our baseline measure of the convenience yield consists of a

[4] As an alternative, one could directly measure the demand elasticity by using log of the convenience yield as the dependent variable. We prefer our empirical specification since t the observed convenience yield is negative during short windows of time.

weighted average of the short- and long-term convenience yields, with the weights given by the average share of short- and long-term US public debt over the sample period. Our baseline measure of public debt is privately held gross federal debt. In robustness analysis, we also conduct our empirical analysis using short- and long-term convenience yields separately, and externally held public debt. We provide details on the data sources and the construction of these and other variables in Appendix B. Panels (a) and (b) of Figure C.1 depict the time series of the convenience yield and the public debt-to-GDP ratio.

For the demand rotator, we use a measure of global volatility. In particular, $z_t = \mathbb{I}\left\{\tilde{z}_t \geqslant \bar{\tilde{z}}\right\}$ is an indicator variable that equals one when the volatility index, $\tilde{z}_t$, is higher than the sample median, and zero otherwise. We also estimate a specification in which we directly use the volatility measure, instead of the dummy variable. Our volatility measure is based on the VIX. Since the VIX is only available starting in 1990, we use a projection of the VIX based on the volatility of the stock market for the earlier part of the sample. The logic for including such a demand rotator is that there is a flight to US Treasuries during periods of high global volatility that increase the demand for public debt and makes it more inelastic. This measure of volatility has been used in the literature as a determinant of the demand for public debt (e.g., Krishnamurthy and Vissing-Jorgensen (2012), Krishnamurthy and Li (2022)). Panel (c) of Figure C.1 shows the evolution of the volatility measure over time. In Appendix B, we discuss its validity as a demand rotator and show that it is uncorrelated with various measures of fiscal supply shocks. In the baseline specification, the vector of controls X_t includes z_t, the slope of the yield curve, and a post-crisis dummy that equals one after 2007, to capture the increase in the demand for safe assets following the global financial crisis (Caballero et al. (2017)).

We pursue two estimation strategies to estimate the demand for public debt and show that they all reach similar conclusions. First, we estimate (8) using OLS. Second, we pursue a complementary instrumental variables strategy using two different instruments for the supply of public debt. The first instrument is the dependency ratio of the US population. The motivation for this instrument is that variations in Social Security expenditures are affected by changes in the demographic structure of the US population. Therefore, by instrumenting public debt with changes in the dependency ratio we are capturing a source of exogenous fluctuations in social security expenditures. The second instrument builds on the literature that studies the macroeconomic implications of fiscal shocks and instruments changes in the supply of US debt with a measure of news of military expenditure shocks. This measure was developed in Ramey (2011) and updated subsequently, and has been widely used to study the fiscal multipliers and the responses of macro variables to government expenditure shocks (see, for example, Barro and Redlick (2011); Auerbach and Gorodnichenko (2012); Ramey and Zubairy (2018)). In particular, the instrument consists of a variable that measures at a quarterly level, the announcements of military spending as a percent of GDP. The logic behind the instrument is that these shocks are related to military events—typically, war periods— which are unrelated to economic shocks that affect the demand for safe assets. Panel (d) in C.1 plots the evolution of the instruments over time. In Appendix C, we show that these instruments are uncorrelated with measures of global volatility and with the level of economic activity, and discuss the validity of the exclusion restriction. As part of robustness exercises described below, we also consider additional instruments.

The first two columns of Table 1 reports the estimation results for the demand when we allow the semi-elasticity to depend on the demand rotator.

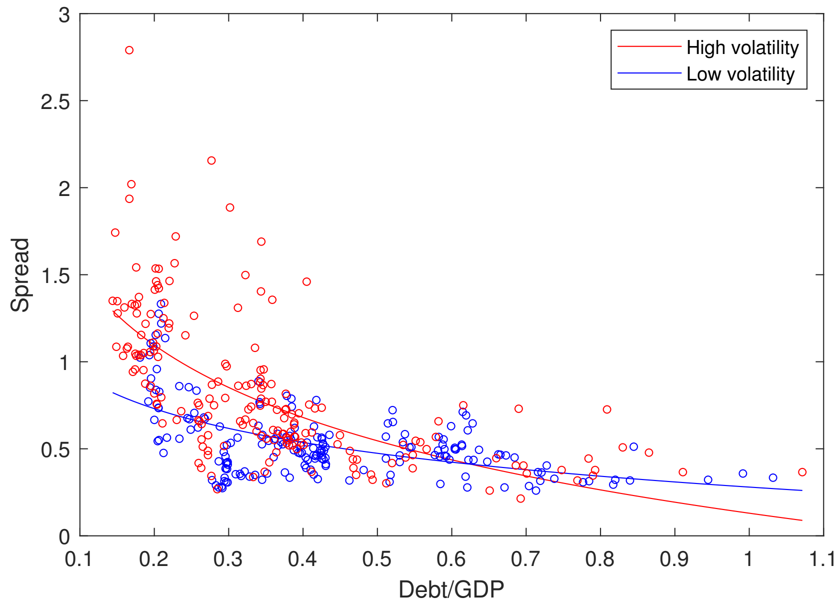
Table 1: Baseline demand estimation

VARIABLES	(1) OLS	(2) IV	(3) OLS	(4) IV
Log(dept/gdp)	-0.34***	-0.25***	-0.51***	-0.37***
	(0.05)	(0.06)	(0.04)	(0.05)
Volatility	-0.15**	-0.08	0.18***	0.22***
	(0.07)	(0.10)	(0.03)	(0.03)
Vol×Log(dept/gdp)	-0.32***	-0.29***		
	(0.06)	(0.09)		
Post-crisis dummy	0.13***	0.08*	0.14***	0.07
	(0.04)	(0.05)	(0.04)	(0.05)
Slope	-0.01	-0.02	-0.02	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.22***	0.32***	0.07	0.22***
	(0.05)	(0.07)	(0.05)	
Observations	380	374	380	374
R-squared	0.51		0.48	
Demand elasticity, high vol	1.04	1.28	1.34	1.84
Demand elasticity, low vol	2.03	2.76	1.34	1.84
Markup, high vol	0.97	0.78	0.75	0.54
Markup, low vol	0.49	0.36	0.75	0.54

Notes: The dependent variables are the weighted average of yield spreads between corporate and Treasury bonds both measured in percentage units. The main independent variable of interest is the log of the ratio of the Treasury debt outstanding to US GDP. Post-crisis dummy controls for structural shifts since the great financial crisis. Slope is the slope of the Treasury yield curve measured as the spread between the 10-year Treasury yield and the 3-month Treasury yield. Volatility is a dummy indicator for whether VIX is above sample median. The estimation method is OLS for columns 1 and 3, and IV for columns 3 and 4. See the main text for further details, and Appendix B for a description of the construction of all the variables. Standard errors are in parentheses. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% level, respectively.

The OLS estimates of β and γ are both negative and statistically significant. The point estimates imply that a 10% increase in the supply of government debt leads to a decrease in the convenience yield of 34 bps when volatility is low and 66 bps when volatility is high. Given that the sample average for the convenience yield is 69 bps, the implied demand elasticities are $\varepsilon_D^L = (0.34/0.69)^{-1} = 2.03$ and $\varepsilon_D^H = (0.66/0.69)^{-1} = 1.04$ during low and high volatility episodes, respectively (see the last rows of Table 1). In other words, the demand curve is more inelastic in periods of high volatility. This can be visually seen in Figure 1 where we plot the convenience yields and debt levels for high and low volatility episodes. Column (2) reports the IV estimates that uses both instruments simultaneously. In this specification the point estimates for β and γ are also negative and significant, and imply demand elasticities of 2.76 and 1.28 during low and high volatility episodes. The fact that the OLS estimate is similar to the IV estimates suggests that most of the variation in the debt-to-GDP ratio can be attributed to supply shocks, as originally emphasized by Krishnamurthy and Vissing-Jorgensen (2012). In Appendix C, we report the output of the first-stage regressions, which estimate the log of public debt on each of the instruments and the set of controls used in the main regressions. The last two columns of Table 1 reports the estimates of the demand specification when we drop the demand rotator. The average estimated elasticities are 1.34 and 1.84 in the OLS and IV specifications, respectively, which are within the range of the estimates in prior literature (see, e.g., Krishnamurthy and Vissing-Jorgensen (2012); Greenwood et al. (2015); Jiang et al. (2021b); Mian et al. (2021); Krishnamurthy and Li (2022)). We will use these point estimates in the quantitative analysis of our model.

Figure 1: Safe asset demand in times of high/low volatility



Notes: Spread is the weighted average of yield spreads between corporate and Treasury bonds both measured in percentage units. Debt/GDP is the ratio of the Treasury debt outstanding to US GDP. High (low) volatility are periods where VIX is above (below) the sample median.

We now test the validity of the competitive and monopoly models by comparing their relative fit of the data. Formally, we use a model selection test to distinguish between these two models. We build on the literature in industrial organization that uses the model selection test in Rivers and Vuong (2002) (RV) to test between different models of firm conduct (Backus et al. (2021), Duarte et al. (2021)). Under our structural model and the assumed parametric cost function, we can use equations 3 and 6 to express the log of innovations to the marginal costs as

$$\ln \lambda_{ft} = \ln \mathcal{S}_t - \xi \ln \mu_t - \lambda \ln b_t, \tag{9}$$

where $\xi = 1$ under monopoly and $\xi = 0$ under perfect competition. Recall that under the true model, we have the moment condition $\mathbb{E}[\tilde{z}_t \lambda_{ft}] = 0$. Following RV, we can define the sample analog of a measure of lack of fit for a model m using a GMM objective function, as

$$Q_m \equiv \left| \sum_{t=1}^{T} \frac{1}{T} \tilde{z}_t \lambda_t \right|,$$

where T is the total number of periods in our sample, and λ_{ft} is obtained from 9 using observed data for $\mathcal{S}_t$ and b_t, and estimated data for μ_t. Given this measure, the RV test statistic is

$$T^{RV} = \frac{\sqrt{T}\,(Q_1 - Q_2)}{\sigma_{RV}}$$

where $\sigma_{RV}/\sqrt{T}$ is the asymptotic standard error of the difference $(Q_1 - Q_2)$. RV show that T^{RV} has a standard normal distribution. This implies that we can reject the null hypothesis in favor of model 1 at the 5% significance level if T^{RV} is smaller than -1.96, and we can reject the null hypothesis in favor of model 2 if T^{RV} is larger than 1.96.

We implement this test in our framework, where Q_1 is the lack of fit for the price-taking model and Q_2 the equivalent for the monopoly model, for different values of λ, the elasticity of the marginal cost function. In Table 2, we display the test statistics for our baseline model and different values of λ.

Table 2: Conduct tests for different cost elasticities

	$\lambda = 0$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$	$\lambda = 4$
	Panel A. OLS				
T-stat	1.22	-3.86	-5.04	-5.29	-5.37
	(0.223)	(0.000)	(0.000)	(0.000)	(0.000)
	Panel B. IV				
	-6.64	-7.14	-6.55	-6.22	-6.02
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: This table shows the results of the RV statistical test comparing the fit of the monopoly and price-taking models for different values of the cost elasticity, λ. Values lower than -1.96 reject the price-taking model in favor of the monopoly model. See main text for further details. P-values are in parentheses.

Under both the OLS and IV specifications, the test rejects the price taking model in favor of the monopoly model, for various different values of λ. A visual inspection of the results of the test is illustrated in Figure C.2. The figure shows the estimated innovations to marginal cost under both the price-taking and monopoly model. The convenience yield tends to increase in periods of high volatility like the Great Depression, the mid 1970s and the Global Financial Crisis. These increases can be partly accounted for by the estimated rising markups in the monopoly model, whereas they can only be explained by increases in marginal costs in the price-taking model. The latter introduces correlation between innovations to marginal costs and the demand rotator, which makes the moment condition less likely to hold.

The empirical results are robust to how we measure the convenience yield and public debt, to the time sample used in the estimation, as well as to using alternative instruments for the supply of public debt. Tables C.2 and C.3 report the demand estimates with and without the demand rotator, while Table C.4 reports the corresponding test statistics. For the convenience yield, we we use the short and long-term convenience yields as dependent variables. For public debt, we also consider using external debt as a dependent variable. For the time sample, we consider the post 1995 sample as well as excluding periods in which the ZLB binds. As an alternative instrument, we use a measure of government expenditure shocks developed by Blanchard and Perotti (2002). This measure consists of the component of current government spending that is not explained by a set of controls, which include lagged values of taxes, output and government spending (see Appendix B for further details). The demand estimates are fairly stable across these specifications and imply more inelastic demand in periods of high volatility. Moreover, the test results are also stable and imply that we can reject the price taking model.

To summarize, our empirical analysis suggests that the monopoly model in which the US internalizes its market power when issuing debt yields a better representation of the data than the price-taking model. Consistent with prior literature, we also estimate the demand for public debt to be quite inelastic. As we will see in the next section, this implies sizable distortions due to market power.

4 Quantitative Analysis

In the previous section, we provided empirical support for the model in which the US behaves strategically and exploits its market power when issuing debt. In this section, we use this model along with the empirical estimates to quantify the macroeconomic implications of this market power.

As a first step, we use our empirical elasticity measure to decompose the average convenience yield across our sample into a non-pecuniary component and a markup (μ). Note that this analysis only requires the estimate of the elasticity of demand and is independent of the remaining parameters of the model. Recall that the markup is just the inverse of the elasticity of demand, which in our sample is 1.5. Thus the markup accounts for approximately two-thirds of the convenience yield. Given an average convenience yield of 68 basis points, the markup is significant and equals 45 basis points. This is in contrast to the price taking equilibrium in which the markup is zero.

To further understand the economic implications due to this market power, we calibrate our model. The model is calibrated at an annual frequency using data from 1925-2020. The 4 externally calibrated parameters are described in Table 3. We assume a utility function of the form $u(c) = c^{1-\gamma}/(1-\gamma)$, a benefit function of the form $f(b) = \eta_f b^{\eta}/\eta$, and a cost function of the form $\chi(b) = \lambda_f b^{1+\lambda}/(1+\lambda)$. The cost function is the same as the one used in the previous section. For parameters on preferences and technologies, we use standard values in the business-cycle literature: a coefficient of relative risk aversion of $\gamma = 2$, a capital share of $\alpha = 0.3$, and a depreciation rate of $\delta = 0.1$. We follow Barro (1979) and Jiang et al. (2022) and assume that $\lambda = 1$ in our baseline calibration but also consider robustness to different values.

Table 3: Externally calibrated parameters

γ	Risk aversion parameter	2
α	Capital share	0.3
δ	Depreciation rate	0.1
λ	Cost elasticity	1

The 8 internally calibrated parameters are described in Table 4 and are chosen to match 8 moments in steady state. The discount factor β and the parameters associated with the benefits and cost of issuing debt, η_f and λ_f, are calibrated to match the average convenience yield, the interest rate on US debt and its debt position. In particular, β is determined using the average convenience yield, the US interest rate, and the steady state model equation $\beta^{-1} = r^K - \delta$ which implies that

$$\beta^{-1} = \mathcal{S} - r^{US}$$

where $\mathcal{S} = r^K - \delta - r^{US}$ is the average convenience yield, which is 0.68% and r^{US}, the US interest rate which is 1.0%. We use an inverse elasticity of demand of 1.5—which is approximately the simple average of the estimates in Columns 3 and 4 of Table 1 and is also in line with the estimates found in prior literature—, which implies $\eta = 0.33$. To calibrate λ_f and η_f we use the above functional forms along with the model first order conditions in steady state to obtain

$$\mathcal{S} = \eta_f b^{\eta-1}$$

and

$$\mathcal{S} = \lambda_f + \eta_f (1 - \eta) b^{\eta-1}.$$

Using the average convenience yield, the average debt-to-GDP ratio of 0.39, and our empirical estimate of η, we can obtain η_f from the first equation. Next, we obtain λ_f from the second equation. The remaining parameters, which are related to the capital share and productivity levels target moments associated with the external balance sheet of the US, and the relative sizes of the two economies. In particular, the share parameter σ is calibrated using the degree of home bias in US private assets, measured as the ratio of k_{US}/k which we obtain from Warnock (2002). The foreign share parameter σ^* is calibrated to match the average NFA of the US in the data. We calibrate US TFP so that US GDP is normalized to 1 and the TFP of RoW, so that the steady state model ratio of US GDP to RoW GDP is equal to that in the data. Here the GDP of RoW corresponds to the GDP of EU and China during the sample period.

Table 4: Internally calibrated parameters

Full sample calibration				
β	Discount rate	0.98	Average convenience yield	0.68%
η_f	Benefit parameter	0.0036	Average US real interest rate	1.0%
λ_f	Cost parameter	0.0058	Average US debt-GDP ratio	0.39
σ	US own capital share	0.92	US home bias	0.8
σ^*	RW own capital share	0.79	US NFA	−0.05
A	US productivity	0.82	Normalize US GDP	1
A^*	RW productivity	0.94	Ratio of RW GDP/US GDP	1.1

We can now use our model to quantify the distortions due to market power, by comparing the baseline economy to a counterfactual one in which the US acts as a price taker. Table 5 displays the safe asset levels, spreads, and interest rates in in both economies. Our baseline calibration suggests that the level of safe asset underprovision due to market power is significant. The safe asset supply almost doubles in the counterfactual when the US acts as a price taker. Moreover, the spreads in the price taking case are almost two-thirds that in the monopoly case. In Table C.5 we show how these results depend on alternative parameterizations of the demand and cost elasticities. As the table shows, the effects are significant in all cases.

Table 5: Macroeconomic distortions due to market power

	ME	CE
Total safe assets/GDP	0.39	0.75
Convenience yield	0.68%	0.44%
Interest on public debt	1.00%	1.24%

Notes: This table reports the steady state equilibrium values of macroeconomic variables. ME refers to the baseline monopoly equilibrium in which the US exercises market power. CE refers to a competitive equilibrium in which the US acts as a price taker.

We next use our model to quantify welfare implications of the benefits to the US of having access to the technology for creating these safe assets. To do so, we study the transition from the monopoly steady state to an economy in which there is no special role for US assets (i.e, $f = 0$). We also consider the transition to an equilibrium in which the US acts as a price taker.

Table 6: Welfare implications of market power in safe assets

	No special role	CE with special role
US welfare	-0.25%	-0.14%
RW welfare	-0.69%	$+0.20\%$

Notes: No special role is an economy in which the benefit and cost function are both zero. CE with special role is a competitive equilibrium in which the US acts as a price taker. Welfare changes are expressed in permanent consumption equivalence terms considering the whole transition period starting from the baseline monopoly equilibrium.

Table 6 documents a significant welfare gain to the US from having access to this technology, almost half of which is due to market power. Clearly, the RoW also benefits from this technology but prefers an environment in which the US acts as a price taker. Table C.6 shows the results for alternative parameterizations of the demand and cost elasticities.

One can interpret these welfare gains as a measure of "Exorbitant Privilege" (Gourinchas et al. (2017)). Our measure focuses on the gains from the special role of US debt and abstracts from risk-premium considerations. Introducing such premia would increase these benefits.

4.1 Safe asset competition

Next, we use our model to understand the effects of increasing competition in the market for safe assets. We consider competition from two different sources; other sovereigns and private institution. We model the former case as a Cournot game and the latter as a monopolist competing against a competitive fringe.

4.1.1 Competition from sovereigns

We model sovereigns as "large" players and consider an extension of our model in which N symmetric countries Cournot compete for the provision of the safe asset. Our baseline model corresponds to the case in which $N = 1$. In such an environment, the problem for the US is

$$\max_{\{c_t, k_{t+1}, b_{t+1}\}_{t, s^t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} - b_{t+1} = w_t - \chi_t(b_t) + (1 - \delta + r_{K,t}) k_t - (1 + r_t(b_t + B_t)) b_t$$

where B_t is the level of safe assets provided by the other countries. The rest of the environment is unchanged.

Here, the markup as well as the level of safe asset provision depends on the level of competition which is captured by N. To see this consider the analytical model we analyzed earlier with perfectly substitutable capital and recall the expressions (3) and (4). The following lemma characterizes the equilibrium outcomes

Lemma 3. *When N countries Cournot compete for the provision of the safe asset, the equilibrium quantity of safe assets and the spread are given by*

$$\mathcal{S}_t^{CN} = \frac{1}{[1-\mu_t^{CN}]}\chi'\left(\frac{b_t^{CN}}{N}\right) \tag{10}$$

and

$$b_t^{CN} = f'^{-1}\left(\mathcal{S}_t^{CN}\right). \tag{11}$$

where $\mu_t^{CN} = (N\varepsilon_{D,t})^{-1}$.

All proofs are included in the Appendix. It follows directly from the lemma that the total quantity of safe assets will be higher and spreads lower when $N > 1$. However, the effect on the US issuance of debt is unclear. In a symmetric equilibrium the US issues b^{CN}/N. Since both the numerator and denominator are increasing, the effect of increasing N is ambiguous. We now show that US issuance always increases as we move from a monopoly to a duopoly but decreases with N after that.

Lemma 4. *Suppose that f is concave and has constant elasticity. Then US safe asset provision increases as N goes from 1 to 2 but decreases for all N thereafter.*

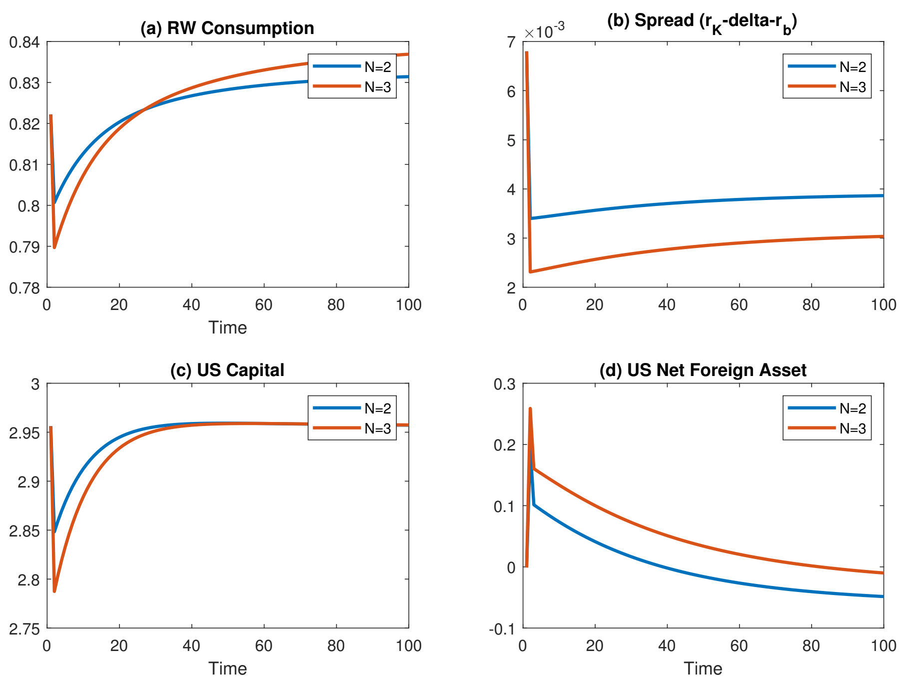
When the first competitor arrives, its effect on increased competition more than offsets the fact that the same demand can now be satisfied by more competitors, thus increasing the issuance of US debt. As the number of competitors increase, the additional effect on competition is smaller and the latter effect dominates.

We now study the effects of increased competition in a quantitative version of our model with imperfect substitution of of capital. Note that the above results apply to the steady state of this model. To study the transition, we assume that at date zero, there is an unanticipated increase in the number of competitors N. We consider different values for N . As mentioned in the introduction, this exercise is motivated by the increase in the private provision of safe assets as well as the desire in some countries to introduce an indigenous safe asset that can rival US Treasuries. The calibration is identical to that in the previous section.

In Figure 2 we plot the transition path for the quantity of safe assets and US consumption. Table 7 documents the change in convenience yields, interest rates and welfare changes as a consequence of this transition. In the Appendix C (Figure C.3), we plot the transition path for other variables, including RoW consumption. We observe a significant increase in the equilibrium quantity of safe assets and decrease in spreads. Note that equilibrium quantity of safe assets is larger than the case in which the US acts as a price taker due to the assumption of increasing marginal costs. As more countries contribute to the provision of safe assets the marginal cost for each country decreases which results in a larger aggregate quantity.

During the transition, the US issuance of debt falls sharply leading to a consumption drop which recovers over time as the economy converges to the new steady state. In line with Lemma 4, US issuance of debt is larger in the new steady state. However, an interesting result here is that owing the non-monotonicity result described in Lemma 4, as N increases the steady state level of US debt is not very different than the monopoly case. Of course, the US now faces a much higher interest rate and its welfare decreases significantly as N increases. In contrast, the RoW is much better off when there is more competition.

Figure 2: Transition path due to increased competition



Notes: US indicates safe asset produced by US only, while total includes safe assets produced by all cournot competitors in the economy.

Table 7: The effects of increasing competition

	ME	Cournot		Fringe	
		N = 2	N = 3	Foreign	Domestic
Panel A. Steady state variables					
Total safe assets	0.39	0.90	1.25	1.07	0.98
US public debt	0.39	0.45	0.42	0.47	0.34
Convenience yield	0.68%	0.39%	0.31%	0.35%	0.37%
Interest on public debt	1.00%	1.29%	1.37%	1.33%	1.31%
Panel B. Welfare					
Steady State					
US welfare	–	−0.27%	−0.25%	−0.34%	−1.33%
RW welfare	–	+1.24%	+2.07%	+1.64%	+1.42%
Transition					
US welfare	–	−0.17%	−0.23%	−0.21%	−0.12%
RW welfare	–	+0.22%	+0.33%	+0.29%	+0.26%

Notes: Panel A shows steady state values of key macroeconomic variables for various equilibria. Panel B shows welfare change expressed in permanent consumption equivalence terms. The first two rows indicate the welfare change if the economy instantaneously jumped to the new competitive steady state. The last two rows consider the transition period.

4.1.2 Competition from financial intermediaries

Unlike sovereigns we model financial intermediaries as a competitive fringe. These intermediaries are owned by households. Using a similar argument to the one earlier we can write the problem of the consolidated household-intermediary pair as

$$\max_{\{c_t, a_{t+1}, b_t\}_t} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$\begin{aligned} c_t + a_{t+1} = & w_t l_t + (1 - \delta + r_{K,t}) a_t \\ & + \mathcal{S}_t(b_t) b_t - \chi_F(b_t). \end{aligned}$$

where χ_F is cost of issuing safe assets for the intermediary. An important assumption is whether these intermediaries/households correspond to ones from a third country or the US. In the former case, the US government will be in direct competition with these intermediaries while in the latter, the US government would like to consolidate market power. First consider the case in which the households reside in a third country. The Ramsey problem for the US government is

$$\max_{\{c_t, a_{t+1}, b_t\}_t} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$\begin{aligned} c_t + a_{t+1} = &w_t l_t + (1 - \delta + r_{K,t})\, a_t \\ &+ \mathcal{S}_t \left(b_t + b_t^f (b_t)\right) b_t - \chi (b_t) \end{aligned}$$

where $b_t^f (b_t)$ is the level of safe assets issued by the fringe and is the solution to

$$\mathcal{S}_t \left(b_t + b_t^f (b_t)\right) = \chi_F' \left(b_t^f (b_t)\right). \tag{12}$$

As before, the demand for safe assets is determined via the first order conditions of RoW

$$\mathcal{S}_t \left(b_t + b_t^f (b_t)\right) = f' \left(b_t + b_t^f (b_t)\right). \tag{13}$$

Lemma 5. *When there is competition from a foreign competitive fringe, the equilibrium spread and quantities of safe assets* $\left(b_t, b_t^f\right)$ *are given by*

$$\mathcal{S}_t^F = \frac{1}{[1 - \mu_t (b_t, b_t^f)]} \chi' (b_t), \tag{14}$$

$$b_t + b_t^f = f'^{-1} \left(\mathcal{S}_t^F\right), \tag{15}$$

and

$$b_t^f = \chi_F'^{-1} \left(\mathcal{S}_t^F\right) \tag{16}$$

where the markup

$$\mu_t \left(b_t, b_t^f\right) = \left(\left(1 - \frac{f'' \left(b_t + b_t^f (b_t)\right)}{\chi_f'' \left(b_t^f (b_t)\right)}\right) \varepsilon_{D,t}\right)^{-1} \frac{b_t}{b_t + b_t^f}.$$

The increase in competition from the fringe lowers the spread and increases the equilibrium quantities of safe assets.

Next, we consider the case in which the competition arises from US household-intermediary pairs. In this case the Ramsey problem for the US government is

$$\max_{\left\{c_t, a_{t+1}, b_t, b_t^f\right\}_t} \sum_{t=0}^{\infty} \beta^t u (c_t)$$

subject to

$$\begin{aligned} c_t + a_{t+1} = &w_t l_t + (1 - \delta + r_{K,t})\, a_t \\ &+ \mathcal{S}_t \left(b_t + b_t^f (b_t)\right) b_t - \chi (b_t) + \mathcal{S}_t \left(b_t + b_t^f (b_t)\right) b_t^f - \chi_F \left(b_t^f\right) \end{aligned}$$

and where as before

$$\mathcal{S}_t\left(b_t + b^f_t\left(b_t\right)\right) = f'\left(b_t + b^f_t\left(b_t\right)\right).$$

Lemma 6. *When there is competition from a domestic fringe, the equilibrium spread and quantities of safe assets* $\left(b_t, b^f_t\right)$ *are given by equations in Lemma 5 except that*

$$\mu_t\left(b_t, b^f_t\right) = \left(\left(1 - \frac{f''\left(b_t + b^f_t\left(b_t\right)\right)}{\chi''_f\left(b^f_t\left(b_t\right)\right)}\right)\varepsilon_{D,t}\right)^{-1}.$$

When compared with the case when foreign intermediaries we can see that the markup is larger and the equilibrium quantity of debt is smaller.

We now consider the transition from our initial monopoly steady state to the steady state with the fringe in our quantitative model. Table 7 highlights they key statistics in the transition and compares them with the monopoly and Cournot cases. There are two key takeaways. First, while the aggregate supply of debt varies considerably by type of competition, the amount issued by the US is relatively stable. Second, the welfare loss to the US in the domestic fringe case is half as much as that in the other cases owing to the fact that the benefits from the fringe are also internalized by the US.

5 Conclusion

In this paper, we find empirical support for the idea that the US government behaves strategically and exploits its market power when issuing debt, as emphasized by Farhi and Maggiori (2018). We quantify the distortions due to this power and find that they are sizable. For example, we find that there is significant under-provision of global safe assets. This provides one interpretation of the "shortage" of safe assets highlighted by academics and policy-makers. Motivated by the growth of private and other sovereign safe assets, we study the effects of increasing safe asset competition. One implication of our analysis is that increased competition will alleviate the safe asset shortage. We also find that while the US issuance of debt is relatively unchanged, the cost of servicing this debt rises sharply which can have implications for the sustainability of public debt, as pointed out in recent work by Mian et al. (2021).

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A Theoretical Appendix

Consider the model in which US and RoW capital are imperfect substitutes in the aggregate capital technology. We show that the results in Section 2.1 continue to hold in the steady state of this model.

Lemma 7. *In the steady state, the level of debt is given by*

$$f'\left(b^{ME}\right) = \chi'\left(b^{ME}\right) - f''\left(b^{ME}\right) b^{ME}$$

and the convenience yield is given by

$$\mathcal{S}^{ME} = \chi'\left(b^{ME}\right) - f''\left(b^{ME}\right) b^{ME}.$$

In the steady state of the price-taking equilibrium, the level of debt is given by

$$f'\left(b^{CE}\right) = \chi'\left(b^{CE}\right)$$

and the convenience yield is given by

$$\mathcal{S}^{CE} = \chi'\left(b^{CE}\right).$$

Therefore, $b^{ME} < b^{CE}$*and* $\mathcal{S}^{ME} > \mathcal{S}^{CE}$.

The proof follows directly from comparing the first order conditions from the monopoly and price taking equilibria. In comparing the steady states, we see in the the monopoly case, the equilibrium level of debt is lower and the spread is higher.

A.1 Microfoundation for the benefit and cost functions

We now derive the benefit and cost functions from a more primitive environment. Alternative microfoundations include the use of public debt to provide liquidity (e.g., Woodford, 1990; Perez, 2018) or to undermine search frictions (e.g., Bianchi et al., 2021).

Consider first the US. We assume that the US is populated by households who solve

$$\max_{\{c_t, k_{t+1}\}_{t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} = w_t l_t + \left(1 - \delta + r_{K,t}\right) k_t - T_t$$

where T_t is the the total tax burden on private agents. The capital and final goods producers are identical to those described in the main text. We assume that the US government can issue debt and uses taxes to pay back its debt. We assume that taxation is distortionary and results in a resource cost $\chi(\cdot)$. We also assume that existing debt and interest payments must be paid back before new debt can be issued. These assumptions imply that

$$T_t = \left(1 + r_t^{us}\right) b_t + \chi\left(\left(1 + r_t^{us}\right) b_t\right) - b_{t+1}$$

The equations characterizing the equilibrium given these taxes are

$$u'(c_t) = \beta\left(1 - \delta + r_{K,t}^{us}\right) u'(c_{t+1})$$

and

$$c_t + k_{t+1} = w_t l_t + (1 - \delta + r_{K,t}) k_t - T_t$$

Thus we can write the Ramsey problem as

$$\max_{\{c_t, k_{t+1}, b_{t+1}\}_{t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} + b_{t+1} = w_t l_t + (1 - \delta + r_{K,t}) k_t + \left(1 + r_t^{us}\right) b_t - \chi(-(1 + r_t) b_t)$$

$$u'(c_t) = \beta(1 - \delta + r_{K,t+1}) u'(c_{t+1}).$$

Consider the relaxed problem where we drop the last constraint. The first order conditions of this relaxed problem yield exactly this constraint. So the Ramsey problem is

$$\max_{\{c_t, k_{t+1}, b_{t+1}\}_{t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} + b_{t+1} = w_t l_t + (1 - \delta + r_{K,t}) k_t + \left(1 + r_t^{us}\right) b_t - \chi(-(1 + r_t) b_t)$$

This problem is identical to that in main text except for the factor $(1 + r_t)$ in the cost function. For simplicity we consider the formulation without this factor but show using numerical exercises that our results are unchanged.

Next, consider RW. As before assume RW is populated by households who consume and save in capital. In addition, households have investment opportunities and need to raise funds. Let $f(x_t)$ denote the profit associated with investing x_t units in the investment opportunity. We assume that households have access to intra-period loans which need to be collateralized by safe assets. Thus, the amount that households can borrow in period t is given by

$$x_t \leqslant b_t.$$

The problem for the household in RW is

$$\max_{\{c_t, l_t, k_{t+1}, b_{t+1}\}_{t \geqslant 0}} \sum_{t=0}^{\infty} \beta^t u(c_t^*)$$

subject to

$$c_t^* + k_{t+1}^* + b_{t+1}^* = f\left(x_t^*\right) + (1 - \delta + r_{K,t}^*) k_t + (1 + r_t)\, b_t^* + w_t^* l_t^*,$$

$$x_t \leqslant b_t$$

$$b_{t+1} \geqslant 0.$$

Assuming that the collateral constraint binds, this problem is equivalent to the one in the main text.

A.2 Proofs from Section 4.1

Proof of Lemma 3

Using a similar argument to that in the baseline we can write the US problem as

$$\max_{\{c_t, a_{t+1}, b_t\}_t} \sum_{t=0}^{\infty} \beta^t u\left(c_t\right)$$

subject to

$$\begin{aligned} c_t + a_{t+1} = {} & w_t l_t + (1 - \delta + r_{K,t})\, a_t \\ & + \mathcal{S}_t\left(b_t + B_t\right) b_t - \chi\left(b_t\right). \end{aligned}$$

The first order condition for the US is

$$\mathcal{S}_t\left(b_t + B_t\right) = \chi'\left(b_t\right) - \mathcal{S}_t'\left(b_t + B_t\right) b_t.$$

Thus, in any symmetric equilibrium we have

$$S_t\left(b_t^{CN}\right) = f'\left(b_t^{CN}\right)$$

and

$$\mathcal{S}_t\left(b_t^{CN}\right) = \chi'\left(\frac{b_t^{CN}}{N}\right) - f''\left(b_t^{CN}\right)\frac{b_t^{CN}}{N}.$$

Therefore,

$$\mathcal{S}_t\left(b_t^{CN}\right) = \frac{1}{1-\mu_t^{CN}}\chi'\left(\frac{b_t^{CN}}{N}\right)$$

where $\mu_t^{CN} = (N\varepsilon_{D,t})^{-1}$. Q.E.D.

Proof of Lemma 4

From the proof of Lemma 3

$$\chi'\left(\frac{b}{N}\right) - \frac{1}{N}f''(b)\,b = f'(b)$$

Let $z \equiv b/N$. Then totally differentiating the above equation wrt N yields

$$\chi''(z)\,z'(N) - f''(Nz)\,z'(N) - f'''(Nz)\,z\,(Nz'(N)+z) = f''(Nz)\,(Nz'(N)+z)$$

which implies that

$$z'(N) = z\frac{\frac{f'''(Nz)Nz}{f''(Nz)}\frac{1}{N}+1}{\left[\frac{c''(z)}{f''(Nz)} - 1 - \frac{f'''(Nz)zN}{f''(Nz)} - N\right]}.$$

Suppose that $f = \eta_f b^\eta/\eta$. Then,

$$z'(N) = z\frac{(2-\eta)\frac{1}{N}-1}{\left[-\frac{c''(z)}{f''(Nz)} + N + \eta - 1\right]}.$$

Note that for $N \geqslant 1$ the denominator is positive. Thus the sign depends on $2-\eta-N$. Thus as N increases from 1 to 2 US safe asset provision increases while as N increases beyond 2, US safe asset provision is decreasing in N. Q.E.D.

Proof of Lemma 5

Proof. The first order condition for the US is

$$\mathcal{S}_t'\left(b_t + b_t^f(b_t)\right)\left[1 + b_t^{f'}(b_t)\right]b_t + \mathcal{S}_t\left(b_t + b_t^f(b_t)\right) - \chi'(b_t) = 0 \qquad (17)$$

Using the (12) we have

$$\mathcal{S}_t' \left(b_t + b_t^f(b_t)\right) \left[1 + b_t^{f'}(b_t)\right] = \chi_f'' \left(b_t^f(b_t)\right) b_t^{f'}(b_t)$$

and so

$$b_t^{f'}(b_t) = \frac{\mathcal{S}_t' \left(b_t + b_t^f(b_t)\right)}{\chi_f''(b_t^f(b_t)) - \mathcal{S}_t'(b_t + b_t^f(b_t))}.$$

Next, using (13) we have $\mathcal{S}_t' \left(b_t + b_t^f(b_t)\right) = f'' \left(b_t + b_t^f(b_t)\right)$ and so inserting this into the previous equation yields

$$b_t^{f'}(b_t) = \frac{f'' \left(b_t + b_t^f(b_t)\right)}{\chi_f''(b_t^f(b_t)) - f''(b_t + b_t^f(b_t))}.$$

Substituting the above into (17) yields

$$\left[1 - \varepsilon_D^{-1} \left[\frac{\chi_f'' \left(b_t^f(b_t)\right)}{\chi_f''(b_t^f(b_t)) - f''(b_t + b_t^f(b_t))}\right] \frac{b_t}{b_t + b_t^f(b_t)}\right] \mathcal{S}_t \left(b_t + b_t^f(b_t)\right) - \chi'(b_t) = 0$$

and using the definition of markup in the text of the lemma yields the result. The equilibrium quantities can be obtained from (12) and (13). Q.E.D.

Proof of Lemma 6

The first order condition for the US is

$$\mathcal{S}_t' \left(b_t + b_t^f(b_t)\right) \left[1 + b_t^{f'}(b_t)\right] \left(b_t + b_t^f\right) + \mathcal{S}_t \left(b_t + b_t^f(b_t)\right) - \chi'(b_t) = 0 \qquad (18)$$

Using (12) and (13) we have

$$b_t^{f'}(b_t) = \frac{f'' \left(b_t + b_t^f(b_t)\right)}{\chi_f''(b_t^f(b_t)) - f''(b_t + b_t^f(b_t))}.$$

Substituting the above into (18) yields

$$\left[1 - \varepsilon_{D,t}^{-1} \left[\frac{\chi_f'' \left(b_t^f(b_t)\right)}{\chi_f''(b_t^f(b_t)) - f''(b_t + b_t^f(b_t))}\right]\right] \mathcal{S}_t \left(b_t + b_t^f(b_t)\right) - \chi'(b_t) = 0$$

and using the definition of markup in the text of the lemma yields the result. The equilibrium quantities can be obtained from (12) and (13). Q.E.D.

B Empirical analysis

B.1 Data description

We use quarterly frequency data from 1925 to 2020.

- *Debt-to-GDP*: Debt from 1942 to 2020 is par value of privately held gross federal debt from the Dallas Fed. Historical debt data from 1925 to 1941 is U.S. net interest-bearing federal debt from NBER Macro History database.

- *AAA-Treasury*: The percentage spread between Moody's Aaa-rated long-maturity corporate bond yield and the yield on long-maturity Treasury bonds. Moody's Aaa index is from FRED. Long-maturity Treasury yields are Long-term U.S. government securities for 1925-2000 and Market yield on U.S. Treasury securities at 20-year constant maturity for 2001-2020, both from FRED. We follow Krishnamurthy and Vissing-Jorgensen (2012) in this construction.

- *CP-Bills*: The percentage yield spread between high-grade commercial paper and Treasury bills. For commercial paper rates, we use "3-month AA nonfinancial commercial paper rate" for 1997-2020, and "average of offering rates on 3-month commercial paper placed by several leading dealers for firms whose bond rating is AA or equivalent" for 1971-1996. For 1925-1970, we use prime commercial paper, 4-6 month maturity, from Banking and Monetary Statistics. The Treasury bill rates are 3-month Treasury bills for 1971-2020 and 6-month Treasury bills for 1959-1970 from FRED. For 1925-1958, we use 3-6 month Treasury bills from NBER Macro History database. We follow Krishnamurthy and Vissing-Jorgensen (2012) in this construction.

- *Maturity-weighted convenience yield*: Our baseline measure of convenience yield is an average of AAA-Treasury and CP-Bills spreads weighted by the maturity share of outstanding US Treasury debt. We consider the short term share to be Treasuries with maturities less than or equal to 3 years, and long term to be those with maturities longer than 3 years. We obtain US Treasury auction data from the US Treasury from 1980 to 2020 to construct a time series of the maturity composition of outstanding US Treasuries. Specifically, we add newly issued Treasuries, drop matured Treasuries, and keep track of maturities of still outstanding debt. Given the stability of the maturity share within this timeframe, we take the average of the weights to get a short term weight of 0.6 and long term weight of 0.4.

- *Slope*: The slope of the Treasury yield curve is the different between the 10-year Treasury yield and the 3-month Treasury yield. The yield on 10-year interest rates from 1953-2020 is from FRED, while the yields from 1925-1952 is from the NBER Macro History Database.

- *Volatility*: We use VIX, CBOE Volatility Index from 1990 to 2020. For 1925 to 1990, we create a historical predicted series of VIX by regressing VIX on annualized standard deviation of weekly log stock returns on the S&P 500 index from 1990 to 2020. The regression estimates are reported in table B.1. Value-weighted S&P index was obtained from CRSP.

- *Dependency ratio*: Total population in the US aged 65+ divided by population between ages 15-65. Data from Current Population Survey, Bureau of Labor Statistics.

- *Military news shocks*: We directly use the series constructed by Valerie Ramey (Ramey (2011), Ramey and Zubairy (2018)) of news in changes in military spending. We scale this by nominal GDP and create a cumulative series. Since news about military expenditures are often announced ahead of the time in which expenditures actually take place, we allow for these shocks to affect public debt with a lag. In addition, since we are interested in instrumenting the stock of public debt and military spending shocks affect the change in public debt, we accumulate the shocks over time to compute our instrument. In particular, the instrument for the supply of public debt is given by

$$z_t = \sum_{s=t-t_1}^{s=t-t_2} r_s,$$

where r_t is the military news shock variable constructed in Ramey (2011); t_1 is the number of lags with which news affect actual spending; and $t_2 > t_1$ is the lead time at which we stop accumulating the news shocks to account for changes in the stock of public debt. We pick the appropriate t_1 and t_2 by running the first stage regression for $(t_1, t_2) \in [0, 12] \times [4, 80]$. We choose (t_1, t_2) that maximizes the explanatory power of the first-stage regression by selecting the pair that gives the highest F-stat value.

$$b_t = \beta_0 + \beta_1 z_t (t_1, t_2) + \gamma X_t + \varepsilon_t$$

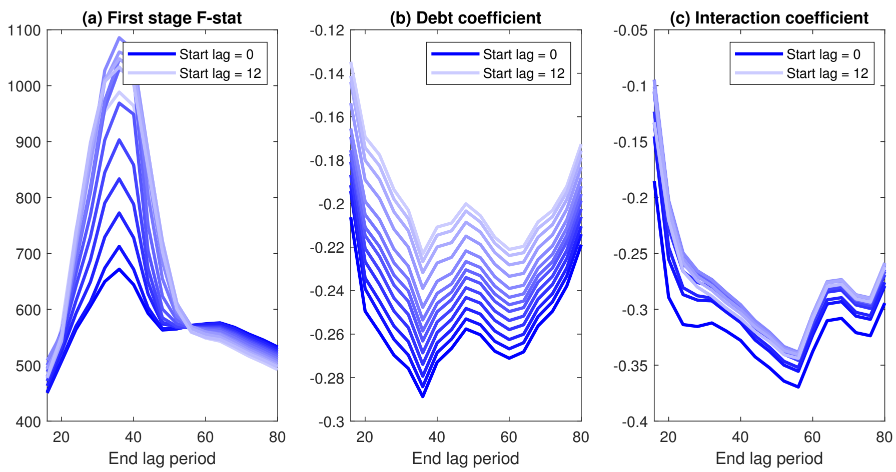
where b_t is log of the ratio of public debt to GDP, and X_t is a vector of controls. The pair selected was $t_1 = 40$ and $t_2 = 5$. In figure B.1, we show this accumulation procedure for different lags and leads. The left panel shows the first stage F-stat and how the lags and leads were selected; the middle and right panels show that the regression coefficients are stable across the group of reasonable lags and leads.

- *Blanchard-Perotti shocks*: To construct Blanchard-Perotti shocks, we use data from Ramey and Zubairy (2018). We run the following regression to obtain the shock series, ε_t^{BP}.

$$g_t = \beta_0 + \sum_{s=1}^{4} \beta_s X_{t-s} + \varepsilon_t^{BP}$$

where g_t is real government expenditures scaled by trend GDP, X_t is a vector of controls containing real GDP, real government expenditures, and real government tax revenues all scaled by trend GDP. Trend GDP is sixth-degree polynomial for the logarithm of GDP. We use the same accumulation procedure as with Military news shocks explained above.

Figure B.1: Military news shock accumulations



Notes: The left panel shows the first stage F-stat for various lags and leads selected; the middle and right panels show that the IV regression coefficients from the second stage.

Table B.1: Volatility measure construction

VARIABLES	VIX
S&P500 Volatility	364.42***
	(18.86)
Constant	8.34***
	(0.66)
Observations	124
R-squared	0.75

Notes: Dependent variable is VIX, CBOE Volatility Index from 1990 to 2020. Independent variable is annualized standard deviation of weekly log stock returns on the S&P 500 index. Value-weighted S&P index was obtained from CRSP. Standard errors are in parentheses. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% level, respectively.

B.2 Instrument validity

In this section we expand on the robustness of our estimation strategy. Firstly, in the specification with a demand rotator used for conduct testing, the key assumption is that the random variables z_t and λ_{ft} are independent, i.e., $\mathbb{E}[z_t \lambda_{ft}] = 0$ where λ_{ft} is a marginal cost shifter. This means our measure of the demand rotator, VIX or indicator of high/low VIX, are unrelated to fiscal supply shocks. We show below that both measures have low correlation to various measures of fiscal supply shocks - exogenous government spending shocks from Blanchard-Perotti regression, federal government spending growth rate, and government spending to GDP.

Table B.2: Demand rotator correlations

	Blanchard-Perotti shocks	Gov. spending growth	Gov. spending / GDP
$\widehat{\text{VIX}}$	-0.162	0.025	0.186
Binned $\widehat{\text{VIX}}$	-0.141	0.058	0.143

Notes: We report correlations in the table. VIX hat is a 1925 to 2020 historical predicted series of VIX by regressing VIX on annualized standard deviation of weekly log stock returns on the S&P 500 index from 1990 to 2020. Binned VIX hat is an indicator function for whether VIX hat is above sample median value. Blanchard-Perotti is the cumulative exogenous government expenditure shocks from the Blanchard-Perotti regression; we accumulate from t-4 to t-44. Government spending is US federal government spending.

Secondly, when using instrumental variables, we assume the exclusion restriction that the instruments are not related to demand shocks and only affect the spread through its direct effect on debt quantity, that is, the instruments are exogenous supply shocks. We show below that all our instruments exhibit low correlation against various measures of demand for safe assets - VIX, a projected extended sample of VIX, and GDP growth rate.

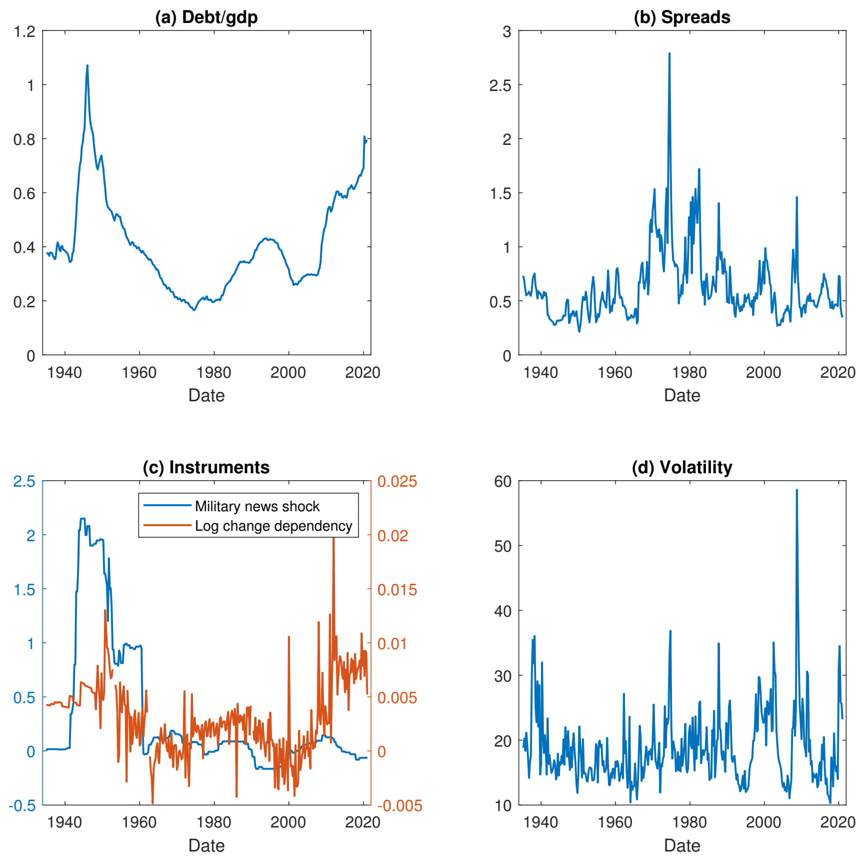
Table B.3: Instrument correlations

	VIX	$\widehat{\text{VIX}}$	GDP growth
Dependency	-0.079	0.093	-0.033
Military news	-0.250	-0.141	-0.013
Blanchard-Perotti	-0.061	-0.398	-0.113

Notes: We report correlations in the table. VIX is the CBOE Volatility Index from 1990 to 2020. VIX hat is a 1925 to 2020 historical predicted series of VIX by regressing VIX on annualized standard deviation of weekly log stock returns on the S&P 500 index from 1990 to 2020. GDP growth is real US GDP growth rate. Dependency ratio is the US population aged 65+ divided by population ages 15-65. Military news is the cumulative news in changes in military spending scaled by GDP; we accumulate from t-5 to t-40. Blanchard-Perotti is the cumulative exogenous government expenditure shocks from the Blanchard-Perotti regression; we accumulate from t-4 to t-44.

C Additional Figures and Tables

Figure C.1: Key variable plots



Notes: Debt/gdp is the ratio of the Treasury debt outstanding to US GDP. Spreads is the benchmark weighted average of yield spreads between corporate and Treasury bonds both measured in percentage units. Ramey shock is cumulative changes in military spending news scaled by GDP; we accumulate from t-5 to t-40. Dependency ratio is the US population aged 65+ divided by population ages 15-65. Volatility is VIX, CBOE Volatility Index from 1990 to 2020. For 1925 to 1990, we create a historical predicted series of VIX by regressing VIX on annualized standard deviation of weekly log stock returns on the S&P 500 index from 1990 to 2020. Appendix B details the construction of all the variables.

Table C.1: First stage regressions

VARIABLES	Log(dept/gdp)	Volatility×Log(dept/gdp)
Military news	0.41***	0.08***
	(0.04)	(0.03)
Dependency	29.39***	-26.46***
	(6.99)	(5.98)
Volatility×Military news	0.11**	0.41***
	(0.05)	(0.05)
Volatility×Dependency	-21.61**	44.21***
	(8.68)	(7.43)
Volatility	-0.12***	-1.34***
	(0.04)	(0.03)
Post-crisis dummy	0.54***	0.35***
	(0.05)	(0.04)
Slope	0.08***	0.07***
	(0.01)	(0.01)
Constant	-1.34***	-0.10***
	(0.03)	(0.03)
Observations	374	374
R-squared	0.65	0.88

Notes: The dependent variables are the log of the ratio of the Treasury debt outstanding to US GDP, and an interaction with volatility. The independent variables are the various instruments we use. Military news is the cumulative news in changes in military spending scaled by GDP; we accumulate from t-5 to t-40. Dependency ratio is the US population aged 65+ divided by population ages 15-65. Post-crisis dummy controls for structural shifts since the great financial crisis. Slope is the slope of the Treasury yield curve measured as the spread between the 10-year Treasury yield and the 3-month Treasury yield. Volatility is a dummy control for whether VIX is above sample median. See the main text for further details, and Appendix B for a description of the construction of all the variables. Standard errors are in parentheses. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table C.2: Demand estimation (Robustness)

VARIABLES	(1) Baseline	(2) Short Mat.	(3) Long Mat.	(4) No ZLB	(5) Post 1995	(6) Military	(7) Dependency	(8) BP shock	(9) External Debt
Log(debt/gdp)	-0.25***	-0.09	-0.49***	-0.24***	-0.01	-0.28***	-0.05	-0.10	-0.78***
	(0.06)	(0.09)	(0.07)	(0.07)	(0.12)	(0.08)	(0.11)	(0.20)	(0.17)
Volatility	-0.08	-0.04	-0.14	-0.11	-0.09	-0.07	0.25	-0.23	0.30*
	(0.10)	(0.14)	(0.10)	(0.12)	(0.09)	(0.12)	(0.18)	(0.22)	(0.18)
Vol.$\times$Log(debt/gdp)	-0.29***	-0.28**	-0.29***	-0.32***	-0.29***	-0.27**	-0.03	-0.43*	0.04
	(0.09)	(0.13)	(0.10)	(0.10)	(0.11)	(0.12)	(0.16)	(0.22)	(0.06)
ε_D, high vol	1.28	1.62	1.05	1.27	1.80	1.25	8.41	1.27	0.83
ε_D, low vol	2.76	7.01	1.66	2.97	59.95	2.46	13.93	6.60	0.78
Markup, high vol	0.78	0.62	0.96	0.79	0.56	0.80	0.11	0.79	1.21
Markup, low vol	0.36	0.14	0.60	0.34	0.02	0.41	0.07	0.15	1.28

Notes: The dependent variables are the weighted average of yield spreads between corporate and Treasury bonds both measured in percentage units. The main independent variable of interest is the log of the ratio of the Treasury debt outstanding to US GDP. Post-crisis dummy controls for structural shifts since the great financial crisis. Blanchard-Perotti is the cumulative exogenous government expenditure shocks from the Blanchard-Perotti regression; we accumulate from t-4 to t-44. Slope is the slope of the Treasury yield curve measured as the spread between the 10-year Treasury yield and the 3-month Treasury yield. Volatility is a dummy control for whether VIX is above sample median. See the main text for further details, and Appendix B for a description of the construction of all the variables. Standard errors are in parentheses. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table C.3: Demand estimation without rotator (Robustness)

VARIABLES	(1) Baseline	(2) Short Mat.	(3) Long Mat.	(4) No ZLB	(5) Post 1995	(6) Military	(7) Dependency	(8) BP shock	(9) External Debt
Log(dept/gdp)	-0.37***	-0.20***	-0.63***	-0.36***	-0.05	-0.40***	-0.06	-0.42***	-0.75***
	(0.05)	(0.07)	(0.05)	(0.05)	(0.12)	(0.05)	(0.12)	(0.09)	(0.17)
Volatility	0.22***	0.26***	0.16***	0.24***	0.16***	0.20***	0.29***	0.20***	0.17***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
Demand elasticity	1.84	3.06	1.28	1.94	9.95	1.69	11.61	1.63	0.83
Markup	0.54	0.33	0.78	0.52	0.10	0.59	0.09	0.61	1.20

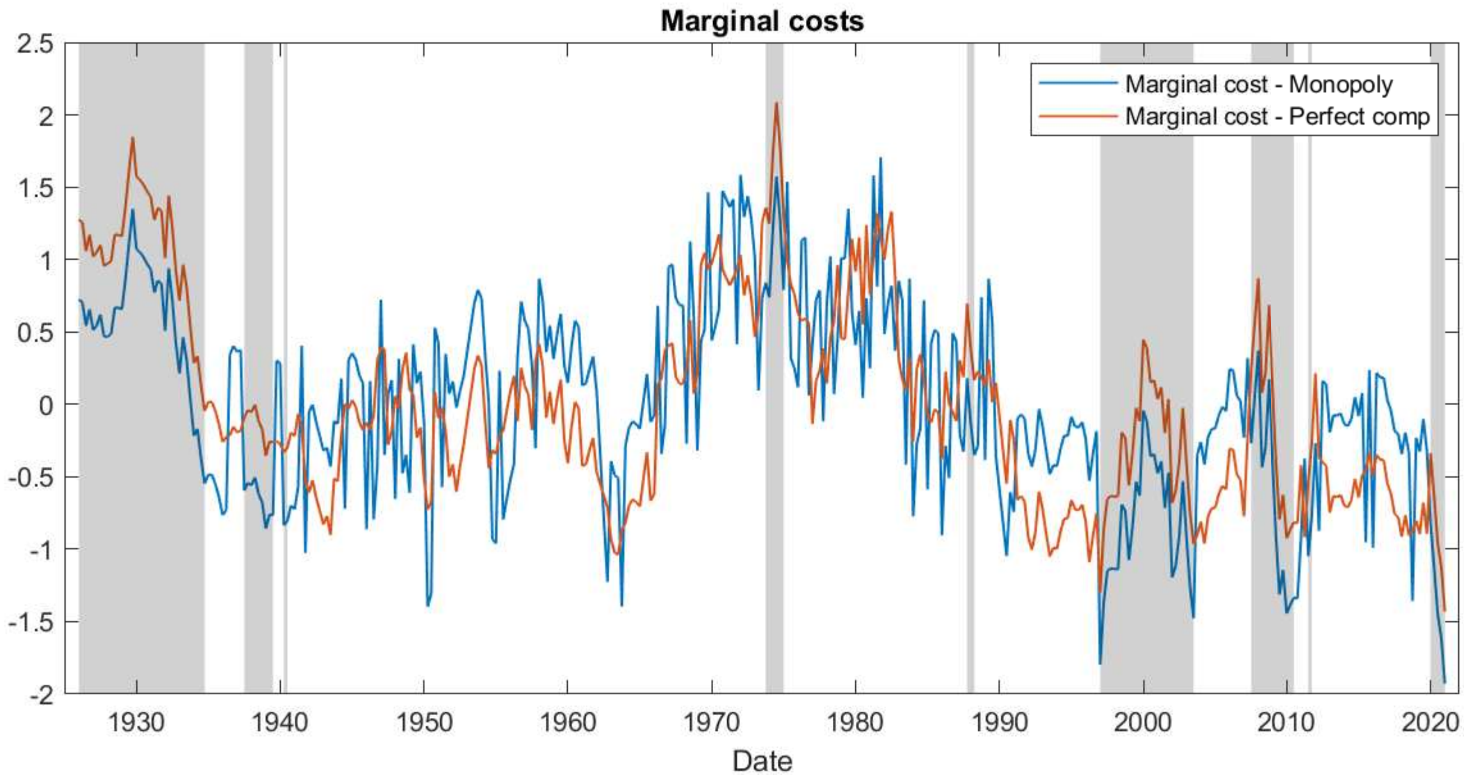
Notes: The dependent variables are the weighted average of yield spreads between corporate and Treasury bonds both measured in percentage units. The main independent variable of interest is the log of the ratio of the Treasury debt outstanding to US GDP. Post-crisis dummy controls for structural shifts since the great financial crisis. Blanchard-Perotti is the cumulative exogenous government expenditure shocks from the Blanchard-Perotti regression; we accumulate from t-4 to t-44. Slope is the slope of the Treasury yield curve measured as the spread between the 10-year Treasury yield and the 3-month Treasury yield. Volatility is a dummy control for whether VIX is above sample median. See the main text for further details, and Appendix B for a description of the construction of all the variables. Standard errors are in parentheses. $*$, $**$, and $***$ represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table C.4: Test statistics (Robustness)

	$\lambda = 0$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$	$\lambda = 4$
Panel A. Baseline					
	-6.64	-7.14	-6.55	-6.22	-6.02
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Panel B. Different Maturity					
Short	-7.53	-7.51	-7.07	-6.73	-6.49
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Long	4.31	-2.58	-4.35	-4.76	-4.92
	(0.000)	(0.010)	(0.000)	(0.000)	(0.000)
Panel C. Other time samples					
No ZLB	-6.33	-6.80	-6.12	-5.77	-5.56
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Post 1995	-0.64	-0.54	-0.39	-0.25	-0.15
	(0.521)	(0.589)	(0.698)	(0.800)	(0.878)
Panel D. Different demand instruments					
Military	-6.28	-6.80	-6.14	-5.76	-5.53
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dependency	-9.85	-8.38	-7.58	-7.15	-6.89
	(0.215)	(0.020)	(0.010)	(0.009)	(0.009)
BP shock	-4.65	-6.29	-5.87	-5.58	-5.40
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Panel E. Different testing instrument					
Binned $\widehat{\text{VIX}}$	4.16	-0.27	-2.11	-3.03	-3.57
	(0000)	(0.786)	(0.035)	(0.002)	(0.000)

Notes: This table shows the results of the RV statistical test comparing the fit of the monopoly and price-taking models for different values of the cost elasticity, λ. Panel A shows the baseline estimates, and Panels B-D shows the results using alternative demand estimations. Panel E shows the test when we use the indicator variable z_t for the moment condition. Values lower than -1.96 reject the price-taking model in favor of the monopoly model. See main text for further details. P-values are in parentheses.

Figure C.2: Estimated marginal cost shocks



Notes: This figures shows the estimated marginal costs from the monopoly model and the price taking model. Shaded areas correspond to selected periods of high volatility.

Table C.5: Steady state comparisons for different elasticities

	Total safe assets/GDP	Convenience yield	Interest on Public Debt
ME	0.39	0.68%	1.00%
	$\epsilon = 1.5, \lambda = 1$		
CE	0.75	0.44%	1.24%
	$\epsilon = 2.02, \lambda = 1$		
CE	0.62	0.54%	1.14%
	$\epsilon = 1.5, \lambda = 0$		
CE	1.38	0.34%	1.18%
	$\epsilon = 1.5, \lambda = 2$		
CE	0.54	0.65%	0.88%

Notes: ME refers to the baseline monopoly equilibrium in which the US exercises market power. CE refers to counterfactual competitive equilibria in which the US acts as a price taker. We report these CE economies if we had calibrated the monopoly equilbrium to different elasticities. Epsilon is the demand elasticity, and lambda is the cost function elasticity.

Table C.6: Welfare comparisons for different elasticities

	No special role	CE with special role
	$\epsilon = 1.5, \lambda = 1$	
US welfare	−0.25%	−0.14%
RW welfare	−0.69%	+0.20%
	$\epsilon = 2.02, \lambda = 1$	
US welfare	−0.21%	−0.09%
RW welfare	−0.38%	+0.12%
	$\epsilon = 1.5, \lambda = 0$	
US welfare	−0.19%	−0.27%
RW welfare	−0.73%	+0.42%
	$\epsilon = 1.5, \lambda = 2$	
US welfare	−0.31%	−0.10%
RW welfare	−0.77%	+0.15%

Notes: No special role is an economy in which the benefit and cost function are both zero. CE with special role is a competitive equilibrium in which the US acts as a price taker. Welfare change is expressed in permanent consumption equivalence terms considering the whole transition period starting from the baseline monopoly equilibrium. Epsilon is the demand elasticity, and lambda is the cost function elasticity.

Figure C.3: Cournot transition