Reserve Asset Competition and the Global Fiscal Cycle*

Zhengyang Jiang†
Robert J. Richmond‡

Abstract

Governments tend to increase their borrowing at the same time, giving rise to a global fiscal cycle. This global fiscal cycle has a large component that is unexplained by global business cycle variables. We propose a novel explanation for the emergence of the global fiscal cycle: governments' competition over the provision of reserve assets gives rise to strategic complementarity in the issuances, even when the reserve assets are substitutes in partial equilibrium. We show our reserve-asset-competition channel explains economically significant common variation in fiscal variables, beyond the common variation induced by correlated business cycles. In doing so, our model of reserve asset demand and supply also shines light on the sources of variation in the convenience yields and seigniorage revenues earned on government debt.

Keywords: Government Debt, Reserve Assets, Exorbitant Privilege

*This draft: August 8, 2024. We thank Myeongrok Doh and Yudan Ying for excellent research assistance. For helpful discussions and comments we thank Ian Dew-Becker, Hanno Lustig, Holger Mueller, Theresa Kuchler, Tony Zhang, and seminar and conference participants.

†**Northwestern University, Kellogg School of Management, and NBER**;
E-mail: zhengyang.jiang@kellogg.northwestern.edu.

‡**New York University, Stern School of Business, and NBER**; E-mail: rrichmon@stern.nyu.edu.

In the past two decades, governments around the world embarked on fiscal expansions. As shown in Figure (1), developed countries' government debt increased dramatically during the 2008 financial crisis, and then again during the COVID-19 recession. A substantial amount of the variation in government debt/GDP ratios across countries can be explained by a single common factor, which we refer to as the *global fiscal cycle*. This global fiscal cycle has important implications for our understanding of developed countries' fiscal sustainability, as well as for shaping the global demand for government liabilities as reserve assets.

There are a number of potential explanations for the existence of the global fiscal cycle. First, demand for reserve assets tends to increase during global flight-to-safety episodes. This increased demand for reserve assets raises convenience yields on government debt and incentivizes government issuers to take advantage of the favorable funding terms. Second, countries have correlated business cycles. When they all enter recessions, the marginal benefits of expansionary fiscal policies tend to rise relative to the fiscal costs of additional debt issuances. As a result, correlated business cycles could also give rise to correlated debt issuances. Both channels relate the fiscal expansions in recent decades to the global financial crisis and the covid-19 crisis, as these crises could trigger a flight to safety and increase demand for reserve assets on the one hand, and increase the marginal efficacy of government spending on the other.

In this paper, we propose a third, novel explanation: the global fiscal cycle can arise when governments compete in the provision of reserve assets. By modeling the behavior of the governments in a setting in which reserve assets are imperfect substitutes, we show that a form of strategic complementarity leads other governments to issue more debt when one government issues more debt. As a result, a fiscal shock local to one country could trigger a global response in debt issuance, even when their demand and supply factors are uncorrelated.

We begin the paper by presenting empirical evidence on the global fiscal cycle. We first document the existence of a large common component in the growth of global debt/GDP ratios: the first principal component of the growth in debt/GDP ratios explains over 50% of their variation. Interestingly, a substantial fraction of the variation in debt/GDP growth in our panel remains unex-

plained by global business cycle variables. This unexplained variation points toward an additional channel which drives the global fiscal cycle.

Then, as evidence for the channel we propose in this paper, we present two sets of empirical tests on the response of government debt issuances to other countries' government debt issuances. First, we extract idiosyncratic shocks to U.S. debt issuance that are unexplained by the business cycle variables, and show that these shocks explain a substantial amount of debt issuance in other countries. Second, we construct an instrument for U.S. debt issuances using the narrative approach developed by Romer and Romer (2010). Specifically, we extend their methodology to identify exogenous tax changes from 1980 to 2023, focusing on policy changes motivated by long-run growth considerations. Using this instrument, we demonstrate that exogenous increases in U.S. debt issuance lead to significant increases in foreign countries' debt issuances. Both empirical tests suggest that a 10% increase in instrumented U.S. debt/GDP growth generates around a 2-7% increase in debt/GDP growth for the average non-U.S. developed country. These findings provide strong evidence for the existence of strategic complementarity in debt issuance across countries, even when controlling for global business cycle factors.

Motivated by our empirical findings, we develop a model of demand and supply for reserve assets. This model generates a novel strategic complementarity in the issuance of reserve assets. We present the results in three steps. We first consider the benchmark in which all governments are infinitesimally small. On the demand side, a representative investor derives utility from earning returns and from directly holding the reserve assets. The reserve assets are imperfect substitutes and are aggregated by a constant elasticity of substitution (CES) function with country-specific weights. As a result, reserve assets earn varying degrees of convenience yields, which are decreasing in their quantities outstanding and also depend on how much the investor values them for their reserve status.

On the supply side, each government balances the trade-off in debt issuance between earning the seigniorage revenues due to the convenience yields and incurring fiscal costs from debt repayment. We model the fiscal costs in a reduced form as an increasing function of the quantity of debt

issued. On the one hand, the government prefers higher seigniorage revenues since they could be used to fund domestic households' consumption. This term reflects the profit maximization view of government debt issuance as in Farhi and Maggiori (2018); Brunnermeier, Merkel, and Sannikov (2022). On the other hand, debt has to be paid back in the future, and the marginal utility of government spending declines with each additional dollar of spending. In equilibrium, we show that each government issuer charges a constant and proportional markup above its marginal cost of issuance. In particular, the equilibrium markup, conditional on the government's own issuance, does not depend on other governments' actions.

In our second step, we assume the governments are "granular": there are a finite number of governments and they have non-zero mass. In this case, the equilibrium markup each government charges on its debt is no longer a constant fraction of the marginal cost. Instead, the markup is adjusted by a factor related to the market share of each government's debt. Intuitively, when an asset has a higher market share, it faces a more inelastic demand curve because there are fewer assets to substitute towards. As a result, each government takes the market impact of its debt issuance decision into account and responds to other governments' issuances. Similar to standard results in oligopoly, when the demand curve becomes more inelastic, each government wants to under-supply relative to the competitive benchmark and raise its markup.

To understand the economics of the granular case, suppose one government (say, the U.S.) decides to issue more debt for idiosyncratic reasons. For other governments, this means their market shares decline and they earn lower seigniorage revenues, which leads to two considerations. First, the increase in debt issuance in the U.S. increases the global supply of reserve assets. Given the reserve assets are imperfect substitutes and the representative investor has a downward-sloping demand curve, the marginal seigniorage revenue that other government issuers can collect goes down. As a result, holding the supply curve fixed, other issuers will issue less debt because it has become less profitable to do so.

Second, each issuer's supply curve depends on its market share. When the U.S. issues more debt, other issuers' market shares decline, which means that they face a more elastic demand curve

and are incentivized to issue more debt. This feature gives rise to a strategic complementarity in debt issuance, so that other issuers' supply curves rotate in response to the U.S. issuance and motivates them to issue more debt and regain market shares. In our parameterization, when the governments are granular, the second consideration dominates, implying that other governments will issue more debt when a government issues more. In stark contrast, when the governments are infinitesimally small, only the first consideration is operative, as their market shares are effectively zero. In this case, governments will issue less debt when a non-zero mass of foreign governments issue more.

In the last step, we conduct a decomposition to answer how much of the global fiscal cycle is driven by common demand and supply shocks and by strategic complementarity identified in this paper. We take a stance on the preference parameters based on the prior literature that exploits exogenous variation for identification. Then, we estimate the model using method of moments, as we can back out each government's marginal cost of debt issuance and its convenience weight in the investor's preference based on the observed convenience yields and debt quantities.

This estimated model allows us to understand the effect of the reserve asset competition. We find that, once we turn off the strategic complementarity by assuming all governments behave as infinitesimally small issuers, the commonality in the fiscal cycles as measured by the variance explained by the first principal component declines from 70% to below 40% in the post-1998 sample which we use in our model estiamtion. This result suggests that correlated fundamentals and our novel reserve asset competition channel each explain about half of the commonality in the global fiscal cycle.

Our estimated model also allows us to revisit the notion of U.S. specialness in the global financial system. We find that the U.S. and the U.K. have the highest convenience weights among all countries in our sample, whereas Switzerland has the lowest. Importantly, our analysis reveals that a country's convenience weight does not necessarily correspond directly to its observed convenience yield. For instance, while Germany has a higher convenience yield than France, it issues much less debt. As a result, we back out similar levels of convenience weights for these two coun-

tries. This nuanced perspective on the "exorbitant privilege" suggests that the U.S.'s dominance in the reserve asset market manifests not only through higher convenience yields but also through its capacity to issue larger quantities of debt. Our findings thus provide a new quantitative framework for understanding the multifaceted nature of the U.S.'s special status in global financial markets.

Literature Review. Our paper contributes to a recent literature that studies governments' capacity to issue reserve assets and raise seigniorage revenues (Krishnamurthy and Vissing-Jorgensen, 2012; He, Krishnamurthy, Milbradt, et al., 2015; Farhi and Maggiori, 2018; Bahaj and Reis, 2020; Clayton, Dos Santos, Maggiori, and Schreger, 2022; Coppola, Krishnamurthy, and Xu, 2023). In particular, Brunnermeier, Merkel, and Sannikov (2020, 2022) raise the concept of the "government Laffer curve", which describes the trade-off between the amount of debt issued and the seigniorage revenue from debt issuance. Our paper studies the strategic interaction between multiple sovereign issuers when their incentives to issue debt vary across business cycles. Our paper is also related to the literature that examines fiscal sustainability through the lens of the government budget constraint (Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2019, 2021; Jiang, 2021, 2022; Mian, Straub, and Sufi, 2022). Croce, Kung, Nguyen, and Schmid (2012) study how fiscal policy affects asset prices in a general equilibrium model. We highlight a novel strategic driver of the common variation in fiscal dynamics.

On the empirical side, Krishnamurthy and Li (2020); Choi, Kirpalani, and Perez (2022) exploit exogenous variation to identify investors' demand elasticities for reserve assets. Koijen and Yogo (2020); Jiang, Richmond, and Zhang (2022); Fang, Hardy, and Lewis (2022) also study their substitution patterns using demand system models. Gomez Cram, Kung, and Lustig (2023) study how the Treasury's yield and convenience yield are affected by fiscal policy news. Our empirical part builds on these works, and explores the substitution patterns between different sovereign issuers' reserve assets. To do so, we construct an instrument for U.S. debt issuances using the Romer and Romer (2010) narrative approach and show that this instrument can explain foreign debt issuances.

Our result also generates a novel micro-foundation for the impact of granularity in international

economics. Granularity refers to the notion that idiosyncratic movements from large economic agents do not average out in aggregate, and could in fact cause spill-over effects to others (Gabaix, 2011). In our paper, we show that "granular effects" arise in the fiscal context due to strategic interactions of governments.

1 The Global Fiscal Cycle

This section documents a number of empirical facts about the global fiscal cycle and its relation to other global factors, such as those that drive the global business cycle. Building on these facts, the next section proposes a novel explanation for the existence of the global fiscal cycle.

1.1 Data

We obtain data on economic quantities from Oxford Economics. These data series include the quantity of outstanding general government debt, GDP, price level indices, interest rates, and unemployment rates. In this section we use the U.S. 1-year Treasury yield from Global Financial Data and construct foreign interest rates as the U.S. Treasury yield plus the 1-year forward premium, which is based on the exchange rate and currency forward rate data from Datastream. Our panel covers 8 developed countries which we consider as potential reserve asset issuers: Canada, France, Germany, Japan, Netherlands, Switzerland, United Kingdom, and the United States. Our sample is quarterly and runs from 1980Q1 to 2023Q4. Appendix A contains more details on the data construction.

1.2 Common Factors in Global Fiscal Policy

We begin by documenting the existence of a global fiscal cycle in countries' government debt issuances, building on Jiang (2022). We calculate the year-on-year log growth in the government debt quantity in each country, and conduct a principal component analysis. Figure (2) reports a striking result: the first principal component (PC1) captures about 52% of the variation. All coun-

tries have positive loadings on PC1, although there is considerable heterogeneity in the magnitude of the loadings. In other words, when countries choose to issue more debt, they tend to do so at the same time.

This first principal component is strongly correlated with the simple equal-weighted average of debt growth with a correlation of 0.99. As a result, in the next exercise, we use this equal-weighted average of countries' log debt growth as our measure of the global fiscal cycle.

1.3 Fiscal Cycle vs. Business Cycle

Given that there is a common factor in different countries' debt issuances, a natural question is whether this common factor is related to other standard business cycle measures. We now show that while there is some relation between the global fiscal cycle and common business cycle factors, the global fiscal cycle also has a substantial component unexplained by business cycle variables.

In Table (1), we regress the average log increase in debt/GDP ratio on the average log changes in GDP, CPI, interest rates, and unemployment rates. Each of these series themselves contain a large common component. For example, the first principal component of log GDP growth also explains 72% of the variation in GDP growth.

Columns (1) to (3) show that the common variations in inflation and interest rate changes individually explain a maximum of 19% of the variation in the average debt growth, while the common variation in GDP growth is not correlated with average debt growth. Column (4) shows that the common variation in unemployment growth has a stronger explanatory power, which suggests that fiscal policies in these countries are related to the unemployment cycle. Column (5) includes all 4 variables together and shows these standard business cycle explain 57% of the variation in the global fiscal cycle, which leaves about half of the variation in the fiscal cycle unexplained.

This result suggests that while a portion of the global fiscal cycle is related to factors representing the global business cycle, a large component of the global fiscal cycle is orthogonal to these factors.

1.4 Foreign Responses to Idiosyncratic Debt Expansions

Our results so far document the extent to which different countries' debt/GDP ratios comove. These comovements can come from either correlated macroeconomic fundamentals that lead these countries to make correlated borrowing decisions, or strategic responses to each other's debt issuance. To distinguish between these two possibilities, we next examine whether an exogenous event in a country that leads to its own debt expansion also drives debt expansion in other countries. We consider two approaches. First, in this section, we extract idiosyncratic U.S. shocks using a statistical model of the drivers of U.S. issuance decisions and show that these shocks can explain foreign issuances. Second, in the next section, we construct an instrument for U.S. issuances and show that instrumented U.S. debt issuances can explain foreign debt issuances.

We begin with our first approach of using a statistical model to extract idiosyncratic U.S. debt issuances. Our null hypothesis is that the change in U.S. government debt issuance is driven by policy responses to its own business cycles and idiosyncratic shocks which are orthogonal to the business cycles of other countries. Similarly, foreign government debt issuances are driven by their own business cycles and idiosyncratic shocks. As a result, while U.S. government debt issuance can be correlated with foreign debt issuances because the U.S. business cycle is correlated with foreign business cycles, the idiosyncratic component of U.S. debt issuance should be orthogonal to foreign debt issuances. If we observe that this idiosyncratic component is in fact correlated with foreign debt issuances, then, we can reject the null and find support for the view that the foreign debt issuances in fact respond to the idiosyncratic component in the U.S. debt issuance.

We extract the idiosyncratic component in U.S. debt issuance by regressing the year-on-year change in the U.S. debt/GDP ratio on the U.S. business cycle variables $x_{US,t}$, which include U.S. GDP growth, inflation, change in interest rate, and unemployment growth:

$$\frac{q_{US,t}}{y_{US,t}} - \frac{q_{US,t-4}}{y_{US,t-4}} = a + bx_{US,t} + u_{US,t},$$

and collecting the residual $u_{US,t}$ as the idiosyncratic component.

Then, we regress the year-on-year change in the debt/GDP ratio in each foreign country i on the U.S. idiosyncratic component:

$$\frac{q_{i,t}}{y_{i,t}} - \frac{q_{i,t-4}}{y_{i,t-4}} = \alpha_i + \gamma u_{US,t} + \beta x_{i,t} + \varepsilon_{i,t},$$

where we control for country-level fixed effects α_i and the business cycle variables $x_{i,t}$ in the foreign country.

Table (2) reports this regression with and without the foreign business cycle variables as controls. Both columns suggest that the U.S. idiosyncratic component has a positive and significant effect on the foreign debt expansions. In terms of magnitudes, the first column implies that a 10% increase in idiosyncratic debt/GDP growth leads to a 2% to 4.5% increase in debt/GDP growth for foreign countries – a non-trivial response.

1.5 Foreign Responses to Exogenous Tax Changes

Next, we turn to our second approach of empricially demonstrating the reserve asset competition channel. In particular, we construct an instrument for U.S. debt issuances that is plausibly uncorrelated with foreign countries' business cycle conditions and government debt issuance decisions. To do so, we extend Romer and Romer (2010)'s narrative approach to identify tax shocks from 1980 to 2023. Appendix B contains the full details of how we extend their approach to our full sample.

Romer and Romer (2010) use narrative records such as presidential speeches, executive-branch documents, and Congressional reports to categorize fiscal shocks into four groups: (1) endogenous countercyclical policies to return growth to normal, (2) endogenous policies motivated by spending changes, (3) exogenous policies to deal with an inherited budget deficit, and (4) exogenous policies motivated by a desire to raise long-run growth. For our purposes, we are interested in shocks to U.S. fiscal policy that are driven by decisions that are unrelated to global macroeconomic conditions or other countries' issuance decisions. Given this, we only use the shocks from category (4), which

we believe are the most likely to satisfy our exclusion restriction. As Romer and Romer (2010) notes, a very common reason for tax cut under this category is one in which policymakers say that the economy is doing fine (output is growing normally), but they want output to grow faster than normal. This category also includes tax cuts for philosophical reasons, such as to shrink the size of government or for fairness.

Before turning to our main tests, we document two important features of the data on these tax policy shocks and government debt issuances. First, it takes time for changes in tax policy to affect government borrowing. In Figure (3), we compute local projections by regressing the cumulative sum of debt growth rates from period t onward on the "long-run growth" category of tax change in period t. This figure shows that the debt growth rate declines steadily in the following 8 quarters after the tax change, and then slowly reverts to the pre-change level. Given this, we aggregate the tax changes over 2-year rolling windows up to period t and denote this variable as $RR_{US,t}$, which captures the exogenous tax changes in the U.S. that lead to its own debt reduction.

Second, U.S. government debt growth has a very different distribution before and after 2008. In Figure (4), we report the histogram of the realized year-on-year debt growth rates in the U.S. and color them by the pre- and post-2008 periods. We observe that the distribution of debt growth rates is more dispersed after 2008, and the mean debt growth rate is much higher (0.7% vs. 2.8% year-on-year). Given this regime break, debt growth that appears to be much higher than the average in the pre-2008 period may not be as high in the post-2008 period. As a result, we control for the differences in debt growth rates separately before and after 2008 by including a dummy variable $1_{t\geq 2008}$ in our regressions.

With these observations in hand, we empirically demonstrate the existence of the reserve asset competition change by regressing the year-on-year U.S. and foreign debt growth on the 8-quarter tax change $RR_{US,t}$:

$$\frac{q_{i,t}}{y_{i,t}} - \frac{q_{i,t-4}}{y_{i,t-4}} = \alpha_i + \gamma RR_{US,t} + \delta 1_{t\geq 2008} + \varepsilon_{i,t}.$$

We report the results in Table (3). In column (1), we find that a higher tax increase, which lowers the need for government borrowing, indeed leads to a lower debt issuance in the U.S. Moreover, as shown in column (2), this exogenous tax change also leads to a lower debt issuance in foreign countries, and the point estimates are similar between the U.S. and foreign countries. So, consistent with our previous result using the idiosyncratic U.S. debt expansions, we find that an exogenous event in the U.S. that leads to its own debt expansion also drives debt expansion in other countries of similar magnitudes.

2 A Model of Reserve Asset Competition

In this section, we present our model of reserve asset competition. We begin with the presentation of the demand side and then present the supply side.

2.1 The Demand for Reserve Assets

We consider government debt in a finite number of advanced economies as reserve assets. We index these countries by $n \in \{1, \ldots, N\}$. The government in country n issues a reserve asset of a unique variety. Let $r_t(n)$ denote its yield, and let μ_t denote the competitive funding rate. Then, $r_t(n) - \mu_t$ denotes the excess return of the asset, which is possibly negative due to the desirability of the reserve asset. We refer to $\mu_t - r_t(n)$ as the *convenience yield*.

There is a representative investor who can invest in all countries' reserve assets and takes prices as given.[1] This investor maximizes their utility, which is a combination of the excess returns earned on these assets and the additional liquidity benefit that depends on a constant elasticity of substitution (CES) aggregate over the N reserve assets:

$$u_t = \sum_{n=1}^{N} q_t(n)(r_t(n) - \mu_t) + \frac{\lambda_t}{1-\theta}\left(\sum_{n=1}^{N} \omega_t(n) q_t(n)^{\rho}\right)^{\frac{1-\theta}{\rho}},$$

[1] Alternatively, we can consider a unit mass of infinitesimally small and competitive investors and obtain the same results.

where $q_t(n)$ denotes the quantity of the safe asset from country n that is held by this investor. The CES aggregator is a multi-asset generalization of the money demand in Poterba and Rotemberg (1986); Krishnamurthy and Vissing-Jorgensen (2012); Nagel (2016). The coefficient λ_t captures the representative investor's overall demand for reserve assets, which we refer to as the *convenience demand* parameter. We also introduce heterogeneous weights $\omega_t(n)$ in the CES aggregation, which we refer to as the *convenience weight* of safe asset n. This weight measures the importance of this asset in terms of fulfilling the investor's demand for liquidity and safety. We assume $\omega_t(n) \geq 0$ for all reserve assets n, and we normalize the convenience weights by

$$\sum_{n=1}^{N} \omega_t(n) = 1.$$

We assume the investor has deep pockets and faces a competitive funding cost, μ_t. If there is an asset m without convenience benefit (i.e., $\omega_t(m) = 0$), then the first-order condition becomes $r_t(m) = \mu_t$. So, the funding cost μ_t can also be interpreted as the risk-free rate without the convenience yield. Otherwise, the first-order condition w.r.t. $q_t(n)$ implies

$$\frac{q_t(n_1)}{q_t(n_2)} = \frac{((\mu_t - r_t(n_1))/\omega_t(n_1))^{1/(\rho-1)}}{((\mu_t - r_t(n_2))/\omega_t(n_2))^{1/(\rho-1)}},$$

which demonstrates that the coefficient ρ governs the elasticity of the substitution between reserve assets issued by different countries.

We use Q_t to denote an index of the aggregate quantity of liquidity provided by all the reserve assets:

$$Q_t = \left(\sum_{k=1}^{N} \omega_t(k) q_t(k)^{\rho} \right)^{\frac{1}{\rho}}.$$

Then, we have the following result that characterizes the demand for reserve asset n:

Lemma 1. *Given $\rho < 1$, the demand for reserve asset n is decreasing in the convenience yield*

$\mu_t - r_t(n)$ and increasing in the convenience weight $\omega_t(n)$:

$$q_t(n) = \left(\frac{\mu_t - r_t(n)}{Q_t^{1-\theta-\rho} \lambda_t \omega_t(n)} \right)^{\frac{1}{\rho-1}}. \tag{1}$$

Lemma 1 implies the following equilibrium relationship:

$$(1-\theta) \log Q_t + \log \lambda_t = \log \sum_{k=1}^{N} (\mu_t - r_t(k)) q_t(k).$$

On the left-hand side, Q_t is the index of the aggregate liquidity provided by all the reserve assets, which directly enters the investor's utility. On the right-hand side, $\sum_{k=1}^{N} (\mu_t - r_t(k)) q_t(k)$ is the total amount of pecuniary payoff that the investor gives up in order to hold these reserve assets. This term on the right-hand side also captures the total amount of the seigniorage revenue earned by all reserve issuers combined. As a result, the coefficient θ governs the elasticity of substitution between earning higher returns and obtaining higher liquidity benefits. If $\theta > 1$, then, a lower provision of the aggregate liquidity is associated with a higher amount of the seigniorage revenue.

This simple demand specification provides a reason why the observed convenience yields, $(\mu_t - r_t(n))$, do not directly map to the convenience weights, $\omega_t(n)$. For example, consider U.S. and Swiss government debt. Even when the observed convenience yield $\mu_t - r_t(n)$ is the same for the two assets, it is still possible for the U.S. debt to have a much higher convenience weight, $\omega_t(US)$, which would then manifest itself as a much greater quantity outstanding of the U.S. safe assets, $q_t(US)$. In other words, depending on how much debt is issued, the "exorbitant privilege" of the U.S. government can show up either in the quantity of debt issued, or in the convenience yield.

This result requires that the assets are less-than-perfect substitutes, i.e., $\rho < 1$. If all reserve assets are perfect substitutes (i.e., $\rho \to 1$), the convenience weight $\omega_t(n)$ is fully manifested in the observed convenience yield $\mu_t - r_t(n)$. In this case, the quantities are determined by market

clearing, and the convenience yields satisfy

$$\mu_t - r_t(n) \propto \omega_t(n).$$

Finally, while our demand side specification uses the standard CES aggregator, $0 < \rho < 1$ is not a sufficient condition for the reserve assets being substitutes. We deviate from the textbook consumer problem with CES aggregation over goods in two ways: first, in our setting, the reserve assets also have pecuniary payoff in addition to the convenience utility derived from the CES function; second, investors have access to an elastic supply of funds at the competitive funding rate, as opposed to a fixed budget. In Appendix C.2, we provide a detailed discussion of these two features, and show that the reserve assets are imperfect substitutes only if $0 < \rho < 1$ and $\theta > 1 - \rho$, which is the parameter region we consider in the paper.

Having said that, even though the reserve assets are imperfect substitutes in partial equilibrium, strategic interaction between the issuers will lead to a complementarity in their debt issuance decisions and give rise to global comovements in issuance decisions, as we show next.

2.2 The Supply of Reserve Assets

We now turn to the supply side, which contains N government issuers. We assume that each government faces the same competitive discount rate μ_t, and its utility from debt issuance is

$$v_t(n) = q_t(n)(\mu_t - r_t(n)) - C_n(q_t(n)),$$

where the first term represents the seigniorage revenue from issuing debt at a yield below the competitive discount rate, and the second term represents the fiscal cost of debt issuance. The fiscal cost can be interpreted as the cost of future taxation that is required to pay back the debt, minus the benefit of government spending that is made possible in the current period. This term could potentially capture the incentive to save some dry powder for future crisis, or a debt overhang problem, although these considerations are beyond the scope of our model. We assume that the

marginal fiscal cost is positive, i.e., $C_n'(q) > 0$, since a higher borrowing today implies higher government spending today and higher expected tax in the future. We expect the marginal cost of future taxation to be increasing, while the marginal benefit of current spending to be decreasing.

Each government sets the quantity of debt issued to maximize utility, taking other governments' actions as given. Government n's first-order condition is

$$(\mu_t - r_t(n)) + q_t(n)\frac{\partial(\mu_t - r_t(n))}{\partial q_t(n)} - C_n'(q_t(n)) = 0,$$

which implies the following rate-setting rule:

$$r_t(n) = \mu_t - C_n'(q_t(n)) + q_t(n)\frac{\partial(\mu_t - r_t(n))}{\partial q_t(n)}.$$

We interpret μ_t as the competitive funding cost, $C_n'(q_t(n))$ as the marginal cost of debt issuance, and the third term as a markup. Because the governments are oligopolists whose assets are imperfect substitutes, they have incentives to under-supply and charge a price above their marginal cost.

The following proposition characterizes each government issuer's optimal behavior.

Proposition 1. *Each issuer's optimal markup is a fraction of the marginal issuance cost, which is scaled by a function related to the issuer's market share:*

$$\mu_t - r_t(n) = \frac{C_n'(q_t(n))}{\rho + (1-\theta-\rho)\frac{\omega_t(n)q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k)q_t(k)^\rho}}. \tag{2}$$

To understand this result, we break down this formula into a few steps. First, let us consider the case in which the debt assets issued by all countries are perfect substitutes, i.e., $\rho = 1$. In this case, The convenience yield is set to be equal to the marginal cost of issuing debt, which is what we expect when the issuers are behaving competitively:

$$\mu_t - r_t^{Competitive}(n) = C_n'(q_t^{Competitive}(n)).$$

Second, we assume that government debt is an imperfect substitute, i.e., $\rho < 1$. However, the governments are small in the sense that their actions do not affect the aggregate liquidity, which is now an integral over the quantity of debt issued by a unit mass of infinitesimally small governments: $Q_t = \left(\int_n \omega_t(n) q_t(n)^\rho dn\right)^{\frac{1}{\rho}}$. In this case, each government's debt issuance is a tiny fraction of the aggregate liquidity, and the optimal markup is a fixed fraction of the marginal issuance cost:

$$\mu_t - r_t^{SmallIssuers}(n) = \frac{C_n'(q_t^{SmallIssuers}(n))}{\rho}. \tag{3}$$

This result recovers the standard result under CES aggregation that the optimal markup is a constant fraction of the marginal cost, which we see, for example, in New Keynesian models. A direct implication is that if all governments have identical marginal costs, their bonds should have the same convenience yields. Conversely, if a government's marginal cost is *higher*, it has a higher convenience yield. This is intuitive: suppose the U.S. has a much higher convenience weight $\omega_t(n)$ than Switzerland, and as a result issues much more debt. This puts the U.S. on the far end of the issuance cost curve, thereby incurring a higher marginal cost. In this way, we are able to connect the convenience weight $\omega_t(n)$ to the convenience yield through the marginal cost function.

Finally, when the issuers are big, they take their size into consideration. This effect is captured by the additional term $(1-\theta-\rho)\frac{\omega_t(n)q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k)q_t(k)^\rho}$ in the denominator on the right-hand side of Eq. (2). If an asset has a greater market share, it faces a more inelastic demand curve, because there are fewer assets to substitute with. As a result, this additional effect lowers the denominator below ρ for large issuers, who behave as if they were facing more inelastic demand and therefore charge higher markups. Moreover, this term also depends other issuers' decisions. As we will see in the next subsection, each issuer's optimal issuance strategy now takes other issuers' actions into account.

2.3 Equilibrium Issuance Decisions

The assumption of small versus big issuers has different implications for the issuance decisions in equilibrium. For concreteness, we assume that the cost of issuance follows

$$C_n(q) = \frac{1}{2}\gamma_n q^2,$$

which implies that the marginal cost of issuance is $C_n'(q) = \gamma_n q$.

Then, in the case of small or competitive issuers, the equilibrium quantity of debt issued by country n is determined by the intersection of the demand curve Eq. (1),

$$q_t(n) = \left(\frac{\mu_t - r_t(n)}{Q_t^{1-\theta-\rho}\lambda_t\omega_t(n)}\right)^{\frac{1}{\rho-1}},$$

and the supply curve Eq. (3),

$$\mu_t - r_t(n) = \frac{\gamma_n q_t(n)}{\rho}.$$

Figure (5)(a) plots these demand and supply curves using parameter values we specify in the next section. As expected, the demand curve is downward-sloping whereas the supply curve is upward-sloping. The equilibrium quantity is determined by the intersection of these two curves:

$$q_t^{SmallIssuers}(n) = \frac{\gamma_n^{\frac{1}{\rho-2}}}{\rho^{\frac{1}{\rho-2}}}\left(Q_t^{1-\theta-\rho}\lambda_t\omega_t(n)\right)^{\frac{1}{2-\rho}}. \tag{4}$$

This formula implies that a higher aggregate liquidity Q_t leads to a lower issuance quantity $q_t(n)$ by issuer n. In the figure, we consider an increase in the foreign bond quantity by 50%, which increases Q_t and drives an inward shift for the demand curve for the domestic bond. As the supply curve does not respond to this shock, the market clears at a lower equilibrium quantity and a lower equilibrium convenience yield. Therefore, given $\rho < 1$ and $\theta > 1 - \rho$, the reserve assets behave like substitutes.

In comparison, when the issuers are big, the equilibrium quantity of debt issued by country n is determined by the intersection of the same demand curve Eq. (1),

$$q_t(n) = \left(\frac{\mu_t - r_t(n)}{Q_t^{1-\theta-\rho} \lambda_t \omega_t(n)} \right)^{\frac{1}{\rho-1}},$$

and the supply curve Eq. (2),

$$\mu_t - r_t(n) = \frac{\gamma_n q_t(n)}{\rho + (1-\theta-\rho) \frac{\omega_t(n) q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k) q_t(k)^\rho}}.$$

Figure (5)(b) plots the demand and supply curves in this case. While the demand curve is still downward-sloping and the supply curve is still upward-sloping, they both respond to shocks to aggregate liquidity Q_t. In particular, we consider the same 50% increase in the foreign bond quantity, which not only shifts the demand curve inward, but also rotates the supply curve outward. To understand the supply curve response, we note that the increase in foreign bond issuance changes the home issuer's market share, i.e., the $\frac{\omega_t(n) q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k) q_t(k)^\rho}$ term in Eq. (2). In our demand specification, an asset with a smaller market share faces a more elastic demand curve. As a higher issuance abroad lowers the home issuer's market share, the home issuer faces a more elastic demand curve, as captured by a greater value of the $\rho + (1-\theta-\rho) \frac{\omega_t(n) q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k) q_t(k)^\rho}$ term in the denominator. As a result of this more elastic demand curve, the home issuer is incentivized to issue more debt. This strategic interaction between the issuers affects the marginal seigniorage revenue each issuer gains from issuing debt, and leads to a complementarity in their issuance decisions.

Algebraically, the equilibrium issuance decision of country n becomes

$$q_t^{BigIssuers}(n)^{-\frac{1}{\rho-1}-1} = \frac{\gamma_n}{\left(\rho + (1-\theta-\rho)\omega_t(n) q_t^{BigIssuers}(n)^\rho Q_t^{-\rho}\right) Q_t^{1-\theta-\rho} \lambda_t \omega_t(n)}. \quad (5)$$

Now, the aggregate liquidity Q_t enters this equation twice. While the $Q_t^{1-\theta-\rho}$ term captures the same demand response as in the case of small issuers, the new term $Q_t^{-\rho}$ arises from the strategic decision of the issuer. Given $\rho < 1$ and $\theta > 1-\rho$, the right-hand side of Eq. (5) is increasing

in Q_t in the first term, but decreasing in Q_t in the second term. As a result, the relationship between country n's issuance decision and the aggregate quantity of liquidity could be different. In Figure (5)(b), the shifted demand and supply curves intersect at a higher equilibrium quantity, which means that the home issuer responds to the foreign issuer's issuance decision by issuing more debt.

2.4 Numerical Example

To further trace out the equilibrium quantities and convenience yields in the small-issuer and big-issuer cases, we consider a numerical example with just two countries, the U.S. ($n = 1$) and foreign ($n = 2$). For both countries, we assume that the cost of issuance follows $C_n(q) = \frac{1}{2}\gamma_n q^2$. We assume $\theta = 1.36$ and $\rho = 0.7$, so that the investors have some curvature in the utility derived from the reserve asset holding, and they perceive the two countries' government bonds as imperfect substitutes. We justify these parameter values in the next section. We consider a symmetric case with $\lambda_n = 1$, $\omega = 1$, and $\gamma_n = 0.1\%$. This implies bond quantities of $q(n) = 4.13$ and bond convenience yields of $\mu_t - r_t(n) = 5.51\%$.

Now we consider a reduction in the U.S.'s marginal cost of issuing debt. As we discuss above, this can result from the U.S. entering a recession in which the marginal benefit of deficit spending increases. For example, if γ_1 reduces by half. Then, we find a new equilibrium at $q(1) = 5.30$, $q(2) = 4.31$, $\mu_t - r_t(1) = 4.31\%$, $\mu_t - r_t(2) = 4.87\%$. In this case, there is strategic complementarity in the two countries' issuance decisions: the foreign country's best response to the fiscal expansion in the U.S. is to also issue more debt, albeit a smaller amount. As a result of higher issuances in both countries, the equilibrium convenience yields decline for both countries' debt and more so for the U.S. because of its higher issuance.

In Figure (6), we plot the equilibrium quantities and convenience yields as functions of the shock to γ_1. As the U.S. issues more debt due to a reduction in the marginal cost of debt issuance, the foreign country also responds by issuing more debt. The equilibrium convenience yields decline for both countries' debt.

To see whether the foreign country's strategic decision play any role in its issuance decision, we next consider the alternative case in which the foreign countries are infinitesimally small. Specifically, we assume that the U.S. accounts for half of the measure of the issuers, whereas an infinite number of foreign countries account for the other half. We again consider a shock to the U.S., and plot the equilibrium quantities and convenience yields as functions of the shock to γ_1 in Figure (7). In this case, consistent with Eq. (4), when the issuance cost declines for the U.S., the U.S. issues more debt whereas the foreign countries choose to issue less debt, which is the opposite of the previous case.

This numerical result confirms our theoretical result that the strategic interaction between the issuers can lead to a complementarity in their issuance decisions, despite their assets being imperfect substitutes. In the next section, we take this model to the data.

3 Estimation and Quantification

To quantify how the reserve asset competition affects the equilibrium fiscal decisions, we estimate our model using the panel data of reserve assets' quantities and convenience yields.

We begin by calibrating the two demand side parameters: the elasticity of substitution between reserve assets, ρ, and the curvature in the utility derived from holding reserve assets, θ.

First, for ρ, Krishnamurthy and Li (2022) examine the substitution pattern between bank deposits and Treasury debt, and find the ρ parameter to be between 0.5 and 0.7. This range of the parameter value indicates that bank deposits and Treasury debt are fairly substitutable but are not perfect substitutes. While our focus is the substitution pattern between different government debt, we find this range of elasticity to be plausible. Since the government debt we study in this paper is all on the safer side of the risk spectrum and appears in a basket such as the S&P Global Developed Sovereign Bond Index, we pick 0.7 which is on the higher end of the range.

For θ, we link this curvature parameter to the demand elasticity of the reserve assets. Krishnamurthy and Vissing-Jorgensen (2012) use a long sample to trace out the negative relationship

between Treasury supply and bond convenience yield. Quantitatively, they find that a 1% increase in the log U.S. government debt/GDP ratio is associated with a 0.75 basis point decline in the Treasury's convenience yield, which is proxied by the AAA-Treasury yield spread or the commercial paper-Treasury yield spread. Given an average convenience yield of 0.52%, this estimate suggests a demand elasticity of $1\%/(0.75/52) = 0.69$ approximately.

To interpret this elasticity estimate through the lens of our model, we first note that, in the one-issuer case of our model, the log convenience yield and the log asset quantity satisfy

$$\mu_t - r_t(n) = q_t(n)^{-\theta}\lambda_t.$$

So, the elasticity is equal to

$$-\frac{\partial \log q_t(n)}{\partial \log(\mu_t - r_t(n))} = \frac{1}{\theta}, \tag{6}$$

which implies that the implied θ parameter is around $1/0.69 = 1.44$.

With more than one issuer, our equilibrium conditions become

$$\begin{aligned} 1 = (\rho-1)\frac{\partial \log q_t(n)}{\partial \log(\mu_t - r_t(n))} + (1-\theta-\rho)\frac{\omega_t(n)q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k)q_t(k)^\rho}\frac{\partial \log q_t(n)}{\partial \log(\mu_t - r_t(n))} \\ + (1-\theta-\rho)\sum_{m\neq n}\frac{\omega_t(m)q_t(m)^\rho}{\sum_{k=1}^N \omega_t(k)q_t(k)^\rho}\frac{\partial \log q_t(m)}{\partial \log(\mu_t - r_t(n))}, \end{aligned}$$

which additionally depends on the share of the U.S. debt in the total liquidity (i.e., $\frac{\omega_t(n)q_t(n)^\rho}{\sum_{k=1}^N \omega_t(k)q_t(k)^\rho}$), and how other countries' issuances respond to the convenience yield shock to the U.S. debt (i.e., $\frac{\partial \log q_t(m)}{\partial \log(\mu_t - r_t(n))}$). We assume that (1) the U.S. on average accounts for 20% of the total liquidity, which is based on the debt quantity data, the ρ parameter, and the estimated convenience weights ω. We also assume that (2) foreign countries' issuance responses are 72% of the U.S. response, which is based on our empirical estimate using the instrumental variable regressions reported in Table (3). Then, we obtain an implied θ parameter of 1.36, which is close to the single-issuer

case. This calibration choice implies that the bond investors have a slight curvature in their utility derived from holding reserve assets.

3.1 Estimation

We estimate our model using the same sample of countries as in the empirical section, which includes Canada, France, Germany, Japan, Netherlands, Switzerland, United Kingdom, and the United States. We use the 1-year Treasury yield to proxy for the debt yield $r_t(n)$, and use the 1-year Libor rate to proxy for the competitive funding rate μ_t. By using the Treasury-Libor spread as the convenience yield, we implicitly assume that the competitive funding rate can be different across currencies, which is consistent with the evidence presented in the literature on covered interest parity violation (Du et al., 2018). As the Libor rates ceased to be published in recent years, we extend the sample using 1-year swap rates. We obtain a balanced sample for model estimation from 1998Q4 to 2023Q4. Additional details on the data construction are provided in Appendix A.

We assume that the observed data are generated by the model with big issuers. We parameterize the marginal cost of issuance as $C_n'(q) = \gamma_t(n)q$, where the parameter $\gamma_t(n)$ can be country-specific and time-varying. We use the market value of outstanding government debt in each country normalized by the concurrent GDP to proxy for the debt quantity $q_t(n)$. The normalization by GDP only requires us to rescale the unobserved convenience weights $\omega_t(n)$ and the issuance costs $\gamma_t(n)$, which does not affect the model's implications.

The unknowns in this model are the unobserved convenience weights $\omega_t(n)$ and issuance costs $\gamma_t(n)$. We can estimate these parameters using the following equilibrium condition from the supply side,

$$(\mu_t - r_t(n)) \left(\rho + (1 - \theta - \rho) \frac{\omega_t(n) q_t(n)^\rho}{\sum_{k=1}^{N} \omega_t(k) q_t(k)^\rho} \right) = \gamma_t(n) q_t(n),$$

and the following equilibrium condition from the demand side,

$$q_t(n) = \left(\frac{\mu_t - r_t(n)}{Q_t^{1-\theta-\rho} \lambda_t \omega_t(n)} \right)^{\frac{1}{\rho-1}}.$$

The number of unknowns matches the number of equilibrium conditions, so that the model is solved exactly. We report the demand side parameter values in Figure (8). The convenience demand λ_t increased significantly during the 2008 global financial crisis, and has remained high since then. It had another minor spike in early 2020 during the COVID-19 pandemic crisis. On average over our full sample, the U.S. and the U.K. have the highest weights $\omega_t(n)$. This is consistent with the U.S. being the world's dominant reserve asset. That said, the convenience weight of the U.S. has been declining steadily over the sample.

We report the supply side parameter values in Figure (9). The marginal utility of debt issuance, $\gamma_t(n)$, also increased during the 2008 global financial crisis. In the cross-section, Japan has the lowest average issuance cost γ_t, which explains why Japan has issued so much debt even after we account for its convenience weight; in comparison, Switzerland and Germany have higher average issuance cost γ_t, which explains why they have issued less debt.

3.2 How Much Comovement in Debt Issuances Is Driven by Strategic Interaction?

Using our estimated model, we can evaluate the role strategic interaction plays in the global comovements in debt issuances. First, taking the U.S. issuance as given, we can ask what each foreign country would have done if it behaved non-strategically. More precisely, we assume that the foreign countries behave like infinitesimally small issuers who do not take the effects of their action into consideration. Instead, they decide their issuance quantities by following the policy specified in Eq. (3). We first consider their partial equilibrium response which fixes the behavior of the U.S. and other foreign countries.

Table (4) reports the correlation between the log growth rate of the U.S. debt quantity and that

of a foreign country's debt quantity. We first report this correlation using the actual quantities of debt issued by each country. Consistent with our earlier empirical results, these countries exhibit a high degree of comovement in their debt issuance.

Then, we compute the correlation in the counterfactual case in which the issuers take their marginal cost curves as given but behave like small issuers. The correlation in debt issuance is still positive, which captures the comovements in debt issuance due to the correlated fundamentals. For example, in a recession, the marginal utility of debt issuance goes up for all countries, driving them to issue more debt at the same time. Similarly, if the investor demand for reserve assets goes up, all countries will also respond by issuing more debt.

The difference between the big issuer case and the small issuer case captures the comovements in debt issuance due to strategic interaction. In the last column, we report the fraction of the correlation not captured by the small issuer case. On average, this fraction is 55%, suggesting that strategic interaction among countries plays a quantitatively large role in the global comovements in debt issuance policies.

Finally, we consider the general equilibrium responses when all foreign issuers behave non-strategically. Figure (10) repeats the PCA analysis in the small and big issuer cases. We observe that the first PC explains 73% of the variations in government debt growth across countries in the data, which we assume to coincide with the equilibrium with big issuers. This number drops to around 40% if we take the same parameter value and compute the equilibrium with small issuers. In other words, absent the strategic oligopolist behaviors that arise when issuers are big, the major countries' fiscal cycles demonstrates substantially less commonality.

3.3 Revisiting the U.S. specialness

Our model estimation also helps us revisit the U.S. specialness in the global financial system. As we discussed earlier, each government issuer's convenience weight does not necessarily correspond

to its observed convenience yield. More precisely, the demand curve in log can be written as

$$(1-\theta-\rho)\log Q_t + \log\lambda_t + \log\omega_t(n) = \log(\mu_t - r_t(n)) + (1-\rho)\log q_t(n). \tag{7}$$

For given aggregate state variables Q_t and λ_t, each government issuer faces a linear trade-off between the log convenience yield $\log(\mu_t - r_t(n))$ and the log quantity of debt issued $\log q_t(n)$. If its debt has a higher convenience weight, the demand curve shifts up and the issuer could issue more debt at a given convenience yield.

Figure (11) plots the average log convenience yield against the average log debt/GDP ratio for each country. The figure also includes "iso-convenience weight" lines that trace out the trade-off between the convenience yield and the debt/GDP ratio for different convenience weights according to Eq. (7). We can see that the pair of the convenience yield and debt quantity implies the U.S. and U.K. have the highest convenience weight, whereas Switzerland has the lowest. A country's convenience weight does not necessarily correspond directly to its observed convenience yield. For instance, while Germany and France lie on the same iso-convenience weight line, Germany has a higher convenience yield than France, whereas France issues more debt. Similarly, while the U.S. debt does not have the highest convenience yield, the sheer quantity of debt issued by the U.S. implies a high convenience weight. This result is consistent with the U.S. specialness in the global financial system, which is driven by the U.S. issuing a large quantity of debt.

4 Conclusion

In this paper we study competition among countries in the provision of reserve assets and demonstrate how the issuers' strategic interaction can give rise to the global fiscal cycle. Our findings have important implications for understanding the global comovements in government debt issuance, and for the design of optimal fiscal policies in a world where countries are interdependent. Furthermore, our model provides a new perspective on the U.S. specialness in the global financial system, and offers a new way to quantify the convenience weights of different government issuers.

Future work could incorporate other assets such as private sector debt, or study the implications of the global fiscal cycle for the global financial stability.

References

Bahaj, Saleem, and Ricardo Reis, 2020, Jumpstarting an international currency, HKIMR Working Paper .

Brunnermeier, Markus K, Sebastian A Merkel, and Yuliy Sannikov, 2020, The fiscal theory of price level with a bubble, Technical report, National Bureau of Economic Research.

Brunnermeier, Markus K, Sebastian A Merkel, and Yuliy Sannikov, 2022, Debt as safe asset, Technical report, National Bureau of Economic Research.

Choi, Jason, Rishabh Kirpalani, and Diego J Perez, 2022, The macroeconomic implications of us market power in safe assets.

Clayton, Christopher, Amanda Dos Santos, Matteo Maggiori, and Jesse Schreger, 2022, Internationalizing like china, Available at SSRN .

Coppola, Antonio, Arvind Krishnamurthy, and Chenzi Xu, 2023, Liquidity, debt denomination, and currency dominance, Technical report, National Bureau of Economic Research.

Croce, M Max, Howard Kung, Thien T Nguyen, and Lukas Schmid, 2012, Fiscal policies and asset prices, The Review of Financial Studies 25, 2635–2672.

Driscoll, John C, and Aart C Kraay, 1998, Consistent covariance matrix estimation with spatially dependent panel data, Review of economics and statistics 80, 549–560.

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan, 2018, Deviations from covered interest rate parity, The Journal of Finance 73, 915–957.

Fang, Xiang, Bryan Hardy, and Karen K Lewis, 2022, Who holds sovereign debt and why it matters, Technical report, National Bureau of Economic Research.

Farhi, Emmanuel, and Matteo Maggiori, 2018, A model of the international monetary system, The Quarterly Journal of Economics 133, 295–355.

Gabaix, Xavier, 2011, The granular origins of aggregate fluctuations, Econometrica 79, 733–772.

Gomez Cram, Roberto, Howard Kung, and Hanno N Lustig, 2023, Can us treasury markets add and subtract?, Available at SSRN .

He, Zhiguo, Arvind Krishnamurthy, Konstantin Milbradt, et al., 2015, A model of the reserve asset, Work. Pap., Stanford Univ., Stanford, CA .

Jiang, Zhengyang, 2021, Us fiscal cycle and the dollar, Journal of Monetary Economics 124, 91–106.

Jiang, Zhengyang, 2022, Fiscal cyclicality and currency risk premia, The Review of Financial Studies 35, 1527–1552.

Jiang, Zhengyang, Hanno Lustig, Stijn Van Nieuwerburgh, and Mindy Z Xiaolan, 2019, The us public debt valuation puzzle, Technical report, National Bureau of Economic Research.

Jiang, Zhengyang, Hanno Lustig, Stijn Van Nieuwerburgh, and Mindy Z Xiaolan, 2021, What drives variation in the us debt/output ratio? the dogs that didn't bark, Technical report, National Bureau of Economic Research.

Jiang, Zhengyang, Robert J Richmond, and Tony Zhang, 2022, A portfolio approach to global imbalances, Technical report, National Bureau of Economic Research.

Koijen, Ralph SJ, and Motohiro Yogo, 2020, Exchange rates and asset prices in a global demand system, Technical report, National Bureau of Economic Research.

Krishnamurthy, Arvind, and Wenhao Li, 2020, Dissecting mechanisms of financial crises: Intermediation and sentiment, Technical report, National Bureau of Economic Research.

Krishnamurthy, Arvind, and Wenhao Li, 2022, The demand for money, near-money, and treasury bonds, Technical report, National Bureau of Economic Research.

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen, 2012, The aggregate demand for treasury debt, Journal of Political Economy 120, 233–267.

Mian, Atif R, Ludwig Straub, and Amir Sufi, 2022, A goldilocks theory of fiscal deficits, Technical report, National Bureau of Economic Research.

Nagel, Stefan, 2016, The liquidity premium of near-money assets, The Quarterly Journal of Economics 131, 1927–1971.

Poterba, James M, and Julio J Rotemberg, 1986, Money in the utility function: An empirical implementation.

Romer, Christina D, and David H Romer, 2010, The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks, American economic review 100, 763–801.

Table 1: Fiscal Cycle vs. Business Cycle

	Dependent Variable: Mean Year-on-Year Growth in Log Debt				
	(1)	(2)	(3)	(4)	(5)
GDP	−0.139				0.508***
	(0.110)				(0.127)
Price Level		0.519***			−0.171
		(0.162)			(0.180)
Interest Rate			−1.236***		−0.590***
			(0.194)		(0.163)
Unemployment				0.202***	0.222***
				(0.016)	(0.022)
Observations	172	172	172	172	172
Adjusted R^2	0.004	0.051	0.187	0.491	0.573

Notes: We regress the average log increase in debt quantity on the average log increase in GDP, CPI, interest rate, and unemployment rates. Sample is quarterly, 1980Q1 to 2023Q4.

Table 2: Foreign Debt Issuance Responding to U.S. Idiosyncratic Debt Growth

	Model 1	Model 2
U.S. Idiosyncratic Debt Growth	0.45^{***}	0.20^{**}
	(0.17)	(0.09)
GDP Growth		-1.03^{***}
		(0.09)
Unemployment Rate Change		0.10^{***}
		(0.02)
Inflation		0.13
		(0.24)
Interest Rate Change		-1.08^{***}
		(0.33)
Num. of Obs.	1204	899
Adj. R^2 (full model)	0.12	0.56
Adj. R^2 (proj model)	0.05	0.54

Notes: We regress the year-on-year growth in government debt/GDP ratio on the U.S. idiosyncratic debt growth, which is defined as the residual from the regression of its year-on-year growth in government debt/GDP ratio on its own business cycle variables. Sample is quarterly, 1980Q1 to 2023Q4. We control for country fixed effects. We report Driscoll and Kraay (1998) standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 3: U.S. and Foreign Debt Issuance Responding to U.S. Tax Change

	Model 1 U.S. only	Model 2 non-U.S. countries
Romer-Romer LR Shock	-0.39^{**}	-0.28^{**}
	(0.18)	(0.13)
Post 2008 Dummy	0.02	0.00
	(0.02)	(0.02)
Num. of Obs.	169	1183
Adj. R^2 (full model)	0.05	0.08
Adj. R^2 (proj model)	0.05	0.01

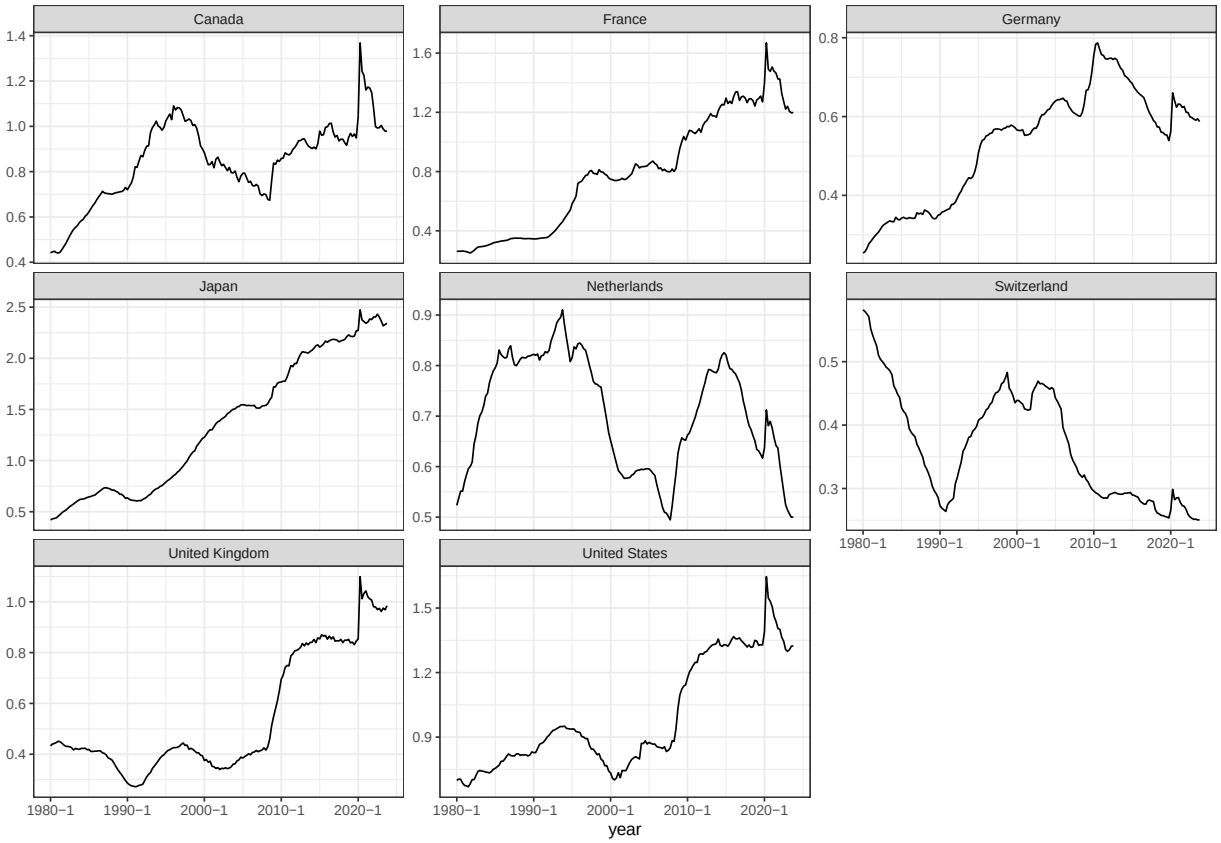
Notes: We regress the year-on-year growth in government debt/GDP ratio on the 2-year cumulative tax change in the U.S., which Romer and Romer (2010) classifies as exogenous and motivated by a desire to raise long-run growth. Sample is quarterly, 1980Q1 to 2023Q4. We control for country fixed effects. We report Newey-West standard errors in Model 1 and Driscoll and Kraay (1998) standard errors in Model 2. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 4: Correlation in Debt Issuance.

Country	Big Issuer Case	Small Issuer Case	Fraction Due to Coordination
CAN	0.73	0.27	63%
CHE	0.51	0.16	69%
DEU	0.68	0.42	39%
FRA	0.74	0.43	42%
GBR	0.71	0.32	54%
JPN	0.50	0.09	82%
NLD	0.70	0.45	35%
Average	0.65	0.30	55%

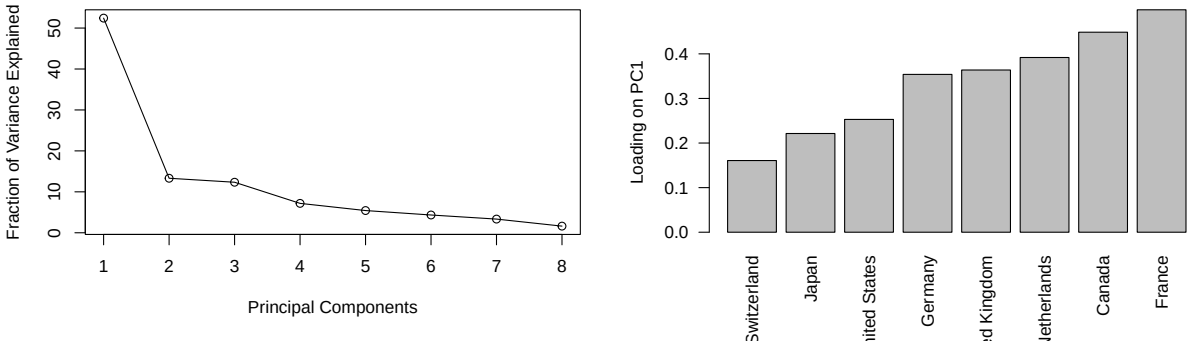
Notes: We report the correlation between the U.S. debt growth and that of each foreign country. The big issuer case is obtained from the data, and the small issuer case is computed under the counterfactual case in which the foreign issuers are behaving non-strategically. The last column reports the fraction of the correlation in the big issuer case that is not explained by the correlation in the small issuer case.

Figure 1: General Government Debt/GDP Ratio



Notes: We report the general government debt/GDP ratio for developed countries we study.

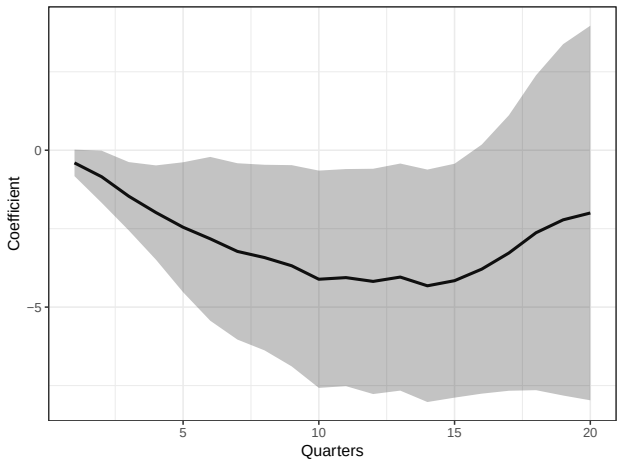
Figure 2: Principal Component Analysis



Panel (a) % of Variances Explained by PCs *Panel (b) Loadings on PC1*

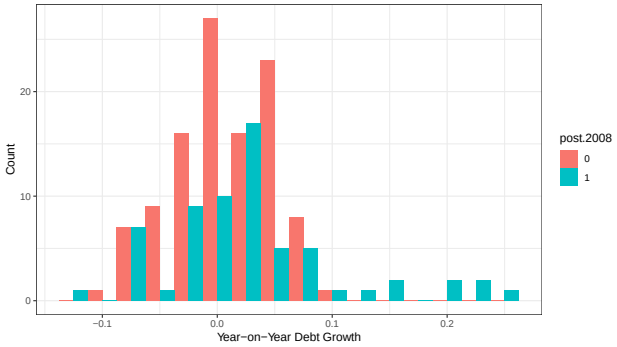
Notes: Principal component analysis of log growth of government debt quantities across developed countries. Sample is quarterly, 1980Q1 to 2023Q4. The first panel presents the share of the variance explained by each principal component. The second panel presents each country's loading on the first principal component.

Figure 3: Local Projection of U.S. Debt Growth on the U.S. Tax Change



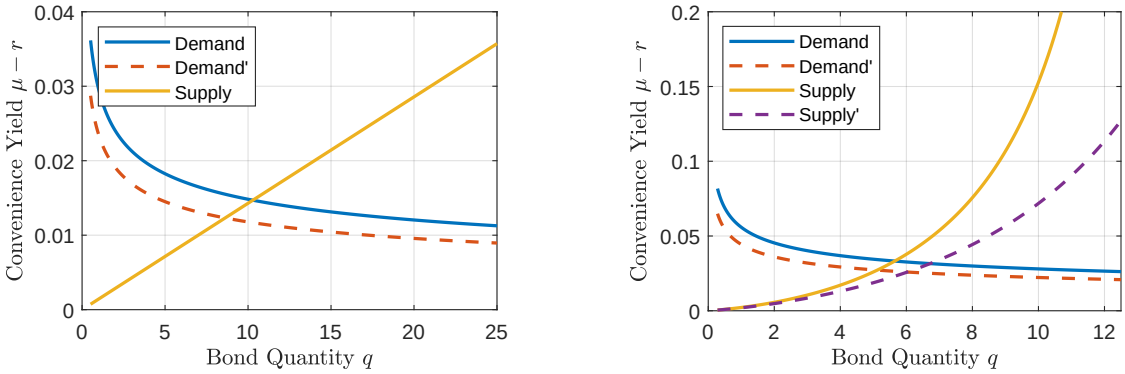
Notes: We regress the cumulative year-on-year growth in U.S. government debt/GDP ratio from period t onward on the Romer and Romer (2010) exogenous U.S. tax change in period t. We report the 95% confidence interval based on Newey-West standard errors.

Figure 4: Distribution of U.S. Debt Change before and after 2008



Notes: We report the distribution of the year-on-year growth in U.S. government debt/GDP ratio before and after 2008.

Figure 5: Demand and Supply Curves

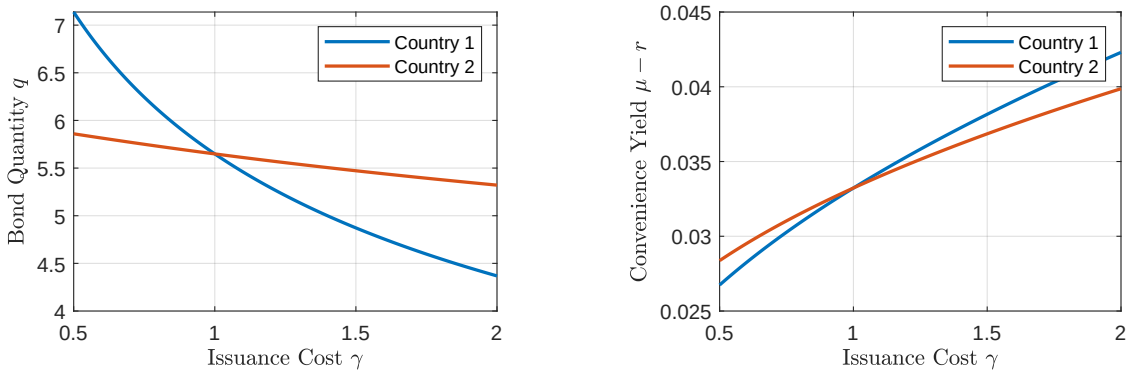


Panel (a) Small Issuers

Panel (b) Big Issuers

Notes: We plot the demand and supply curves for Country 1's reserve asset. The dashed curves reflect the case in which the foreign bond issuance increases by 50%. There is no dashed supply curve in Panel (a) because the supply curve does not respond to the foreign debt issuance in this case.

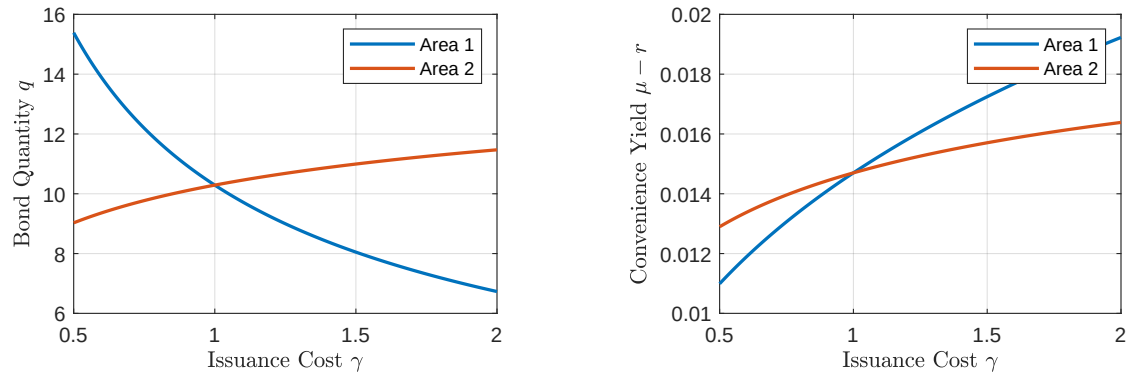
Figure 6: Numerical Example: Big and Few Issuers



Panel (a) Debt Quantity *Panel (b) Convenience Yield*

Notes: We vary Country 1's issuance cost γ and trace out the equilibrium responses in both countries' debt quantities and convenience yields.

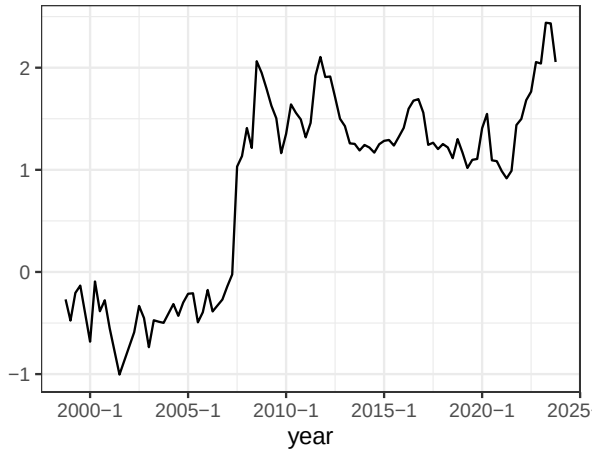
Figure 7: Numerical Example: Small and Many Issuers



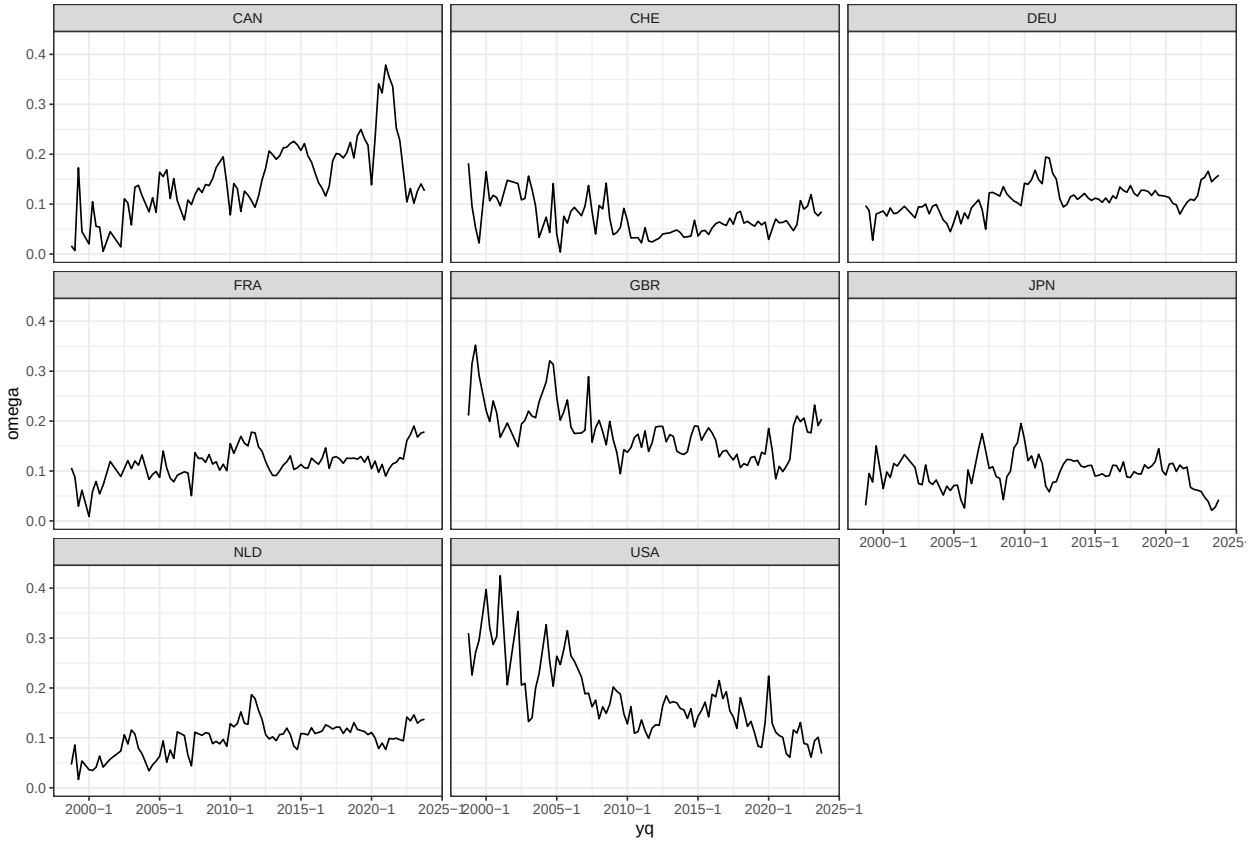
Panel (a) Debt Quantity *Panel (b) Convenience Yield*

Notes: We split the unit mass of small issuers into two halves called Area 1 and Area 2. Since countries are infinitesimally small in this case, we uniformly vary the issuance cost γ of all countries in Area 1 together, and trace out the equilibrium responses in both areas' debt quantities and convenience yields.

Figure 8: Model Estimates: Demand Side

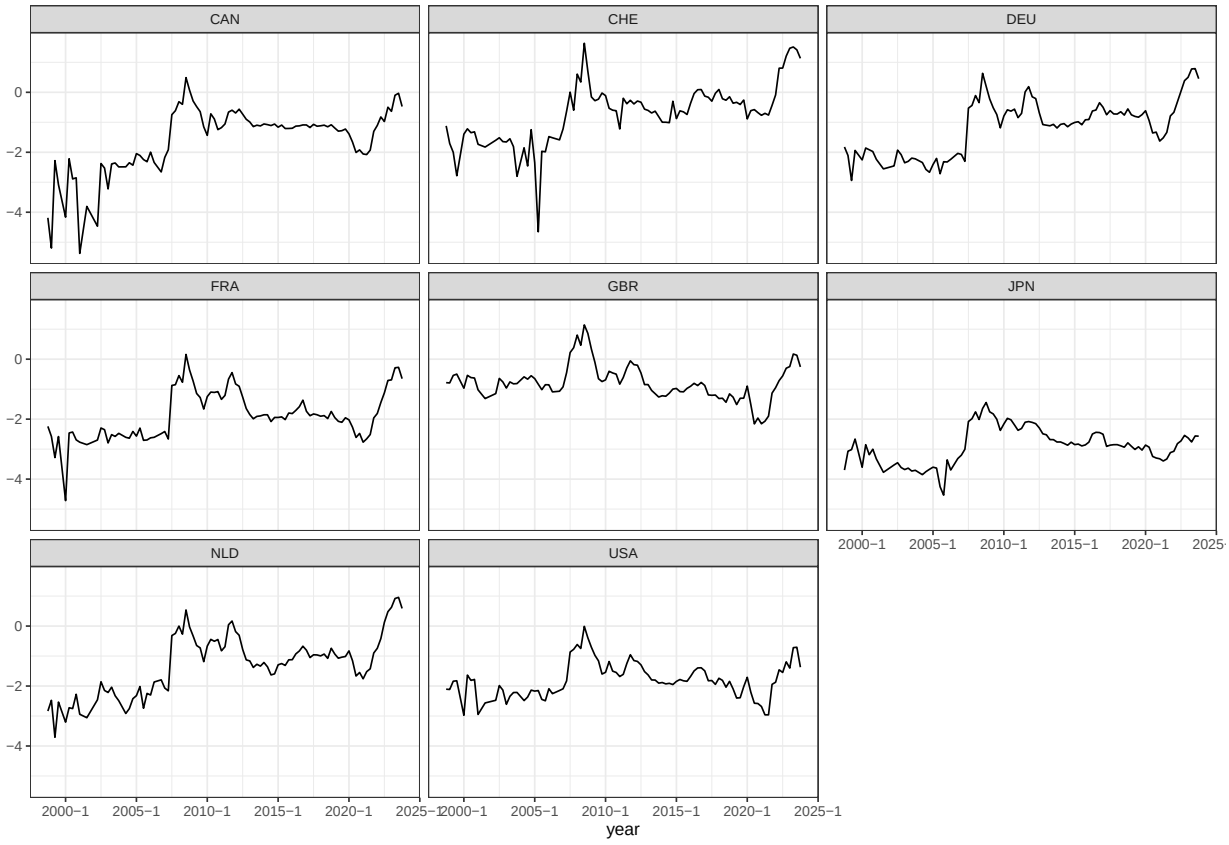


Panel (a) Log Convenience Demand $\log \lambda_t$



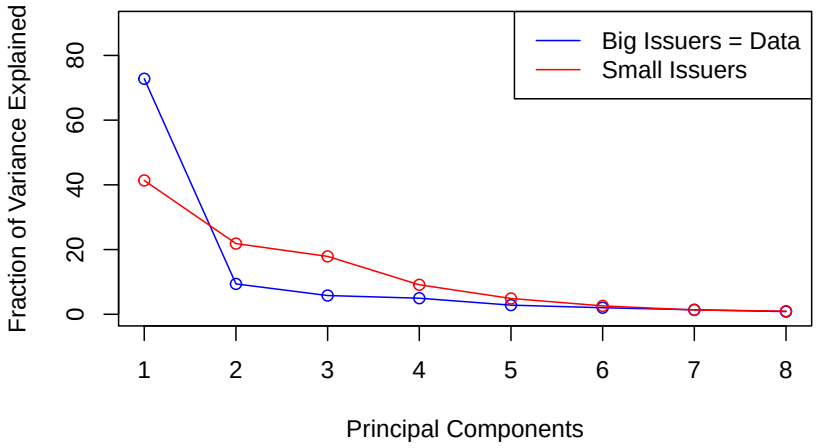
Panel (b) Log Convenience Weights $\omega_t(n)$

Figure 9: Model Estimates: Supply Side



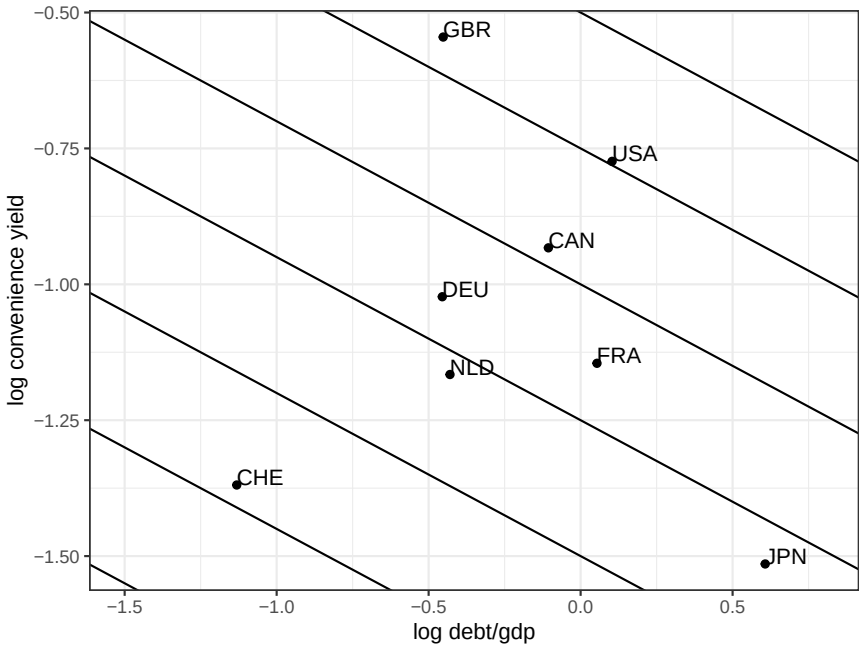
Panel (a) Log Issuance Costs $\log \gamma_t$

Figure 10: General Equilibrium Responses



Notes: Principal component analysis of log growth of government debt quantities across developed countries. Sample is quarterly, 1988Q1 to 2023Q4. The figure compares big issuer case to small issuer case, and reports % of variances explained by PCs.

Figure 11: Convenience Yield-Debt Quantity Trade-off



Notes: We plot the mean log convenience yield $\log(\mu - r)$ against the mean log debt/GDP ratio $\log q_t$. The straight lines are "iso-convenience weight" lines with slope $-(1-\rho)$, which traces out the demand curves corresponding to varying degrees of convenience weights.

Appendix

A Data

We obtain outstanding debt quantity of the general government, nominal GDP, unemployment rate, and CPI data from Datastream. We obtain Libor rates from Datastream, and swap rates from Bloomberg. Libor rates ceased to be published in the recent past, we extend the sample using 1-year swap rates from 2013Q2 to 2023Q4 for Canada and 2021Q4 to 2023Q4 for other seven countries. The swap rates are highly correlated with the Libor rates: regressing the swap rates on the Libor rates yields an R^2 of 93%. However, as the levels are different by 40 basis points on average, we adjust the swap rates by the mean difference in each country's overlapping period in which both Libor and swap rates are available. Due to Libor rates' data availability, we estimate our model using the sample period from 1998Q4 to 2023Q4. Moreover, this approach yields 8 observations (CAN 1999Q4, CAN 2001Q2, CAN 2002Q1, CHE 2004Q1, CHE 2006Q3, DEU 2002Q1, NLD 2001Q4, NLD 2002Q1) in which the Treasury yield was slightly above the Libor rate, which implies a negative convenience yield. We drop all observations in these quarters from our estimation.

B Extension of Romer and Romer (2010)

We extend the narrative analysis conducted by Romer and Romer (2010) to cover our full sample. They provide separate revenue effects based on the motivations behind significant federal tax legislation enacted from 1945 to 2003. Their dataset consists of quarterly revenue effects from 1945 to 2007, covering tax legislation starting from the Revenue Act of 1945 to the Jobs and Growth Tax Relief Reconciliation Act of 2003. The motivations identified in their paper are categorized as spending-driven (SD), countercyclical (CC), deficit-driven (DD), and long-run (LR) growth. Romer and Romer (2010) group spending-driven and countercyclical tax changes into endogenous tax changes, and deficit-driven and long-run tax changes are grouped into exogenous tax changes.

We follow their narrative approach to identify the motivation for legislation enacted from 2004 to 2022.

Congressional Budget Office (CBO) and Joint Committee on Taxation (JCT). To construct the budget effects of more recent legislation, we extract the list of major federal legislation with significant impacts on revenues from *Revenue Projections, by Category*, which supplements the Congressional Budget Office (CBO)'s February 2024 report *The Budget and Economic Outlook: 2024 to 2034*.[2] We then measure the revenue effects of major legislation from the list by referring to documents prepared by the Joint Committee on Taxation (JCT).[3] We download the latest versions of files from the JCT website, detailing the budget or revenue effects of entire legislation or specific revenue provisions covering the period from 2005 to 2027. The comprehensive list of downloaded files is provided in Table A1.

The downloaded budget effects of major legislation undergo a data cleaning process that sums the effects of different provisions for each year by each legislation. The basic rules of this process are as follows. We use data available as of the publication date, ignoring future estimates such as "Estimate to be Provided by the Congressional Budget Office." For each piece of legislation, we measure the budget effects for the first five years following the legislation's first year in effect. For each provision under legislation, we consider only the budget effects of the first full year in effect. For instance, if a provision's effective date is 7/1/05, we record the budget effect of 2006, not 2005, as its only budget effect.

If multiple effective dates are specified for a provision, we generally use the budget effects of the earlier full-cycle year. For example, in the American Recovery And Reinvestment Tax Act Of 2009,[4] we use the budget effects of 2010 for Provision II.1. of Title I, when its effective dates are stated for property placed in service after 12/31/09 and 12/31/10. However, if there are multiple effective dates for a provision and one of the dates records no measured effect, we consider only the

[2]The link is available at https://www.cbo.gov/data/budget-economic-data

[3]The link is available at https://www.jct.gov/publications/?searchWithin=&category_name=&find-publication=Find+a+Publication

[4]Document name: *Estimated Budget Effects Of The Revenue Provisions Contained In Titles I And III Of S. 350, The "American Recovery And Reinvestment Tax Act Of 2009," As Reported By The Committee On Finance*

date with measured effects. For instance, in Division Q of the Consolidated Appropriations Act, 2016,[5] we use the budget effects of 2017 for Provision II.1, as there is no measured effect of this provision in 2016, even though its effective dates are returns and statements relating to calendar years beginning after date of enactment, which is assumed 12/16/15, and credits or refunds made after 12/31/16.

If the effective date is unspecified within the document, we assume the first year in effect as the budget effect year. For example, in the American Jobs Creation Act Of 2004,[6] there is no effective date specified for Provision VIII.C.4.[7] Therefore, we assume the budget effect of 2006 as this provision's effect, considering there is no effect measured in 2005, which is the first year available for the entire legislation.

If the effective date of a provision is earlier than the first year presented in the table of the legislation's budget effects, we use the first year available in the table as the provision's budget effect. For example, in the Emergency Economic Stabilization Act of 2008,[8] we use 2009 as the effective year for Provision III.1., since 2009 is the first year in the table, even though its effective date is sales or exchanges occurring after 12/31/07 in taxable years ending after 12/31/07.

Several considerations and concerns should be noted regarding the rules stated above. In Division P of the Consolidated Appropriations Act, 2016,[9] multiple provisions record the date of enactment (DOE) as their effective dates, but the actual effects start one or two years after the DOE. Since there are no measured effects in the first full year, these provisions are considered to have zero effect, which may understate some budget impacts. Additionally, for the provision effective from months beginning after 12/31/18 in the document of Tax Cuts And Jobs Act,[10] 2019

[5]Document name: *Estimated Budget Effects Of Division Q Of Amendment #2 To The Senate Amendment To H.R. 2029 (Rules Committee Print 114-40), The "Protecting Americans From Tax Hikes Act Of 2015"*

[6]Document name: *Estimated Budget Effects Of The Conference Agreement For H.R. 4520, The "American Jobs Creation Act Of 2004"*

[7]"[30] Effective 180 days after the date on which the Secretary issues the regulations, which are required no later than 180 days after the date of enactment."

[8]Document name: *Estimated Budget Effects Of The Tax Provisions Contained In An Amendment In The Nature Of A Substitute To H.R. 1424, Scheduled For Consideration On The Senate Floor On October 1, 2008*

[9]Document name: *Estimated Budget Effects Of Division P Of Amendment #1 To The Senate Amendment To H.R. 2029 (Rules Committee Print 114-39)*

[10]Document name: *Estimated Budget Effects Of The Conference Agreement For H.R. 1, The "Tax Cuts And Jobs Act"*

is considered the first full year of effect, as the exact starting month in 2019 is unspecified.

In the Coronavirus Aid, Relief, And Economic Security ('CARES') Act,[11] the first full year in effect of provisions with DOE as effective dates should be 2021 according to the rule stated above, assuming the publication date (April, 23, 2020) as the enactment date. However, reflecting the short-term nature of the legislation, some provisions report much bigger effects in the first year (2020) than in the second year, which is the first full year. Despite this, we strictly follow the rules, potentially downplaying the effects of this particular legislation with short-term impacts. In the Consolidated Appropriations Act, 2021,[12] we assume the first year in effect as the budget effect year for provisions with effective dates referring to other legislation (e.g., "Effective as if included in section 2201 of CARES Act (Public Law 116-136)").

Generally, we consider the first five years of budget effects given in a table for each legislation. However, exceptions exist in three pieces of legislation. If no provision shows a full-year effect in the first year presented, we drop the first year and use the second year as the starting point for the five-year period. This can occur in two scenarios: A) no effect is measured in the first year despite it being the first full-cycle year, and B) some effect is measured in the first year of legislation, but the first year is not the first full-cycle year. The Inflation Reduction Act of 2022 can serve as an example for the first scenario.[13] The examples for the second scenario can also be observed in the Children's Health Insurance Program Reauthorization Act Of 2009[14] and Families First Coronavirus Response Act.[15]

[11] Document name: *Estimated Revenue Effects Of The Revenue Provisions Contained In An Amendment In The Nature Of A Substitute To H.R. 748, The "Coronavirus Aid, Relief, And Economic Security ('CARES') Act," As Passed By The Senate On March 25, 2020, And Scheduled For Consideration By The House Of Representatives On March 27, 2020*

[12] Document name: *Estimated Budget Effects Of The Revenue Provisions Contained In Rules Committee Print 116-68, The "Consolidated Appropriations Act, 2021"*

[13] Document name: *Estimated Budget Effects Of The Revenue Provisions Of Title I - Committee On Finance, Of An Amendment In The Nature Of A Substitute To H.R. 5376, "An Act To Provide For Reconciliation Pursuant To Title II Of S. Con. Res. 14," As Passed By The Senate On August 7, 2022, And Scheduled For Consideration By The House Of Representatives On August 12, 2022*

[14] Document name: *Estimated Revenue Effects Of The Internal Revenue Code Provisions Contained In H.R. 2, The "Children's Health Insurance Program Reauthorization Act Of 2009," As Amended By The Senate On January 29, 2009*

[15] Document name: *Estimated Revenue Effects Of The Revenue Provisions Contained In Division G Of H.R. 6201, The "Families First Coronavirus Response Act"*

Identification of Legislation Motivation and Merging of Two Datasets. After extracting and summing the budget effects of different provisions under each major legislation from JCT documents, we identify the primary motivation behind each piece of legislation, following the approach of Romer and Romer (2010). The motivations identified for each legislation, evidence for the identification, and the sources of evidence are covered in Table A2 on the following pages. If external evidence for identification is not available, motivations are determined based on major provisions of the legislation, with their Source of Evidence listed as "Identification Based on Major Provisions" in Table A2. Finally, we combine the two series: the budget effects of the earlier legislation from Romer and Romer (2010) and the effects of the later legislation constructed. Since the budget effects of later legislation are provided as yearly data, while the earlier data is provided as quarterly data, we assume that the effects of the later legislation occur in the last quarter of each year.

Table A1: JCT Files Downloaded

Title	Date	File Number
Estimated Budget Effects Of The Conference Agreement For H.R. 4520, The "American Jobs Creation Act Of 2004"	October 7, 2004	JCX-69-04
Estimated Budget Effects Of H.R. 4, The "Pension Protection Act Of 2006," As Introduced In The House Of Representatives On July 28, 2006	July 28, 2006	JCX-36-06
Estimated Budget Effects Of The "Economic Stimulus Act Of 2008," As Passed By The House Of Representatives And The Senate On February 7, 2008	February 8, 2008	JCX-17-08
Estimated Budget Effects Of The Tax Provisions Contained In H.R. 3221, The "Housing And Economic Recovery Act Of 2008," Scheduled For Consideration By The House Of Representatives On July 23, 2008	July 23, 2008	JCX-64-08
Estimated Budget Effects Of The Tax Provisions Contained In An Amendment In The Nature Of A Substitute To H.R. 1424, Scheduled For Consideration On The Senate Floor On October 1, 2008	October 1, 2008	JCX-78-08
Estimated Revenue Effects Of The Internal Revenue Code Provisions Contained In H.R. 2, The "Children's Health Insurance Program Reauthorization Act Of 2009," As Amended By The Senate On January 29, 2009	February 2, 2009	JCX-15-09
Estimated Budget Effects Of The Revenue Provisions Contained In Titles I And III Of S. 350, The "American Recovery And Reinvestment Tax Act Of 2009," As Reported By The Committee On Finance	February 5, 2009	JCX-16-09 R
Estimated Revenue Effects Of The Revenue Provisions Contained In Senate Amendment 3310, The "Hiring Incentives To Restore Employment Act," Under Consideration By The Senate	February 23, 2010	JCX-5-10
Estimated Revenue Effects Of The Amendment In The Nature Of A Substitute To H.R. 4872, The "Reconciliation Act Of 2010," In Combination With The Revenue Effects Of H.R. 3590, The "Patient Protection And Affordable Care Act ('PPACA')," As Passed By The Senate	March 18, 2010	JCX-16-10
Estimated Budget Effects Of The Revenue Provisions Contained In Senate Amendment #4594 To H.R. 5297, The "Small Business Jobs Act Of 2010," Scheduled For Consideration By The United States Senate On September 16, 2010	September 16, 2010	JCX-48-10

Table A1: JCT Files Downloaded (continued)

Title	Date	File Number
Estimated Revenue Effects Of The Revenue Provisions Contained In The Conference Agreement For H.R. 22, The "Fixing America's Surface Transportation ('FAST') Act"	December 3, 2015	JCX-140-15
Estimated Budget Effects Of Division P Of Amendment #1 To The Senate Amendment To H.R. 2029 (Rules Committee Print 114-39)	December 16, 2015	JCX-142-15
Estimated Budget Effects Of Division Q Of Amendment #2 To The Senate Amendment To H.R. 2029 (Rules Committee Print 114-40), The "Protecting Americans From Tax Hikes Act Of 2015"	December 16, 2015	JCX-143-15
Estimated Budget Effects Of The Conference Agreement For H.R. 1, The "Tax Cuts And Jobs Act"	December 18, 2017	JCX-67-17
Estimated Budget Effects Of The Revenue Provisions Contained In The House Amendment To The Senate Amendment To H.R. 1865, The Further Consolidated Appropriations Act, 2020 (Rules Committee Print 116-44)	December 17, 2019	JCX-54-19 R
Estimated Revenue Effects Of The Revenue Provisions Contained In Division G Of H.R. 6201, The "Families First Coronavirus Response Act"	March 16, 2020	JCX-9-20
Estimated Revenue Effects Of The Revenue Provisions Contained In An Amendment In The Nature Of A Substitute To H.R. 748, The "Coronavirus Aid, Relief, And Economic Security ('CARES') Act," As Passed By The Senate On March 25, 2020, And Scheduled For Consideration By The House Of Representatives On March 27, 2020	April, 23, 2020	JCX-11R-20
Estimated Budget Effects Of The Revenue Provisions Contained In Rules Committee Print 116-68, The "Consolidated Appropriations Act, 2021"	December 21, 2020	JCX-24-20
Estimated Revenue Effects Of H.R. 1319, The "American Rescue Plan Act Of 2021," As Amended By The Senate, Scheduled For Consideration By The House Of Representatives	March 9, 2021	JCX-14-21
Estimated Budget Effects Of The Revenue Provisions Of Title I - Committee On Finance, Of An Amendment In The Nature Of A Substitute To H.R. 5376, "An Act To Provide For Reconciliation Pursuant To Title II Of S. Con. Res. 14," As Passed By The Senate On August 7, 2022, And Scheduled For Consideration By The House Of Representatives On August 12, 2022	August 9, 2022	JCX-18-22

Table A2: Major Motivations of Each Legislation

Legislation	Motivation	Evidence	Source of Evidence
American Jobs Creation Act of 2004	LR	"Official Title as Introduced To amend the Internal Revenue Code of 1986 to remove impediments in such Code and make our manufacturing, service, and high-technology businesses and workers more competitive and productive both at home and abroad."	https://www.congress.gov/bill/108th-congress/house-bill/4520/titles
Pension Protection Act of 2006	LR	"H.R. 4 changes the Employee Retirement Income Security Act of 1974 (ERISA) and the Internal Revenue Code (IRC), affecting the operations of private pension plans."	https://www.cbo.gov/sites/default/files/109th-congress-2005-2006/costestimate/hr4pgo0.pdf
Economic Stimulus Act of 2008	CC	"Policymakers moved quickly to address the slowing economy early in the year."	https://www.govinfo.gov/content/pkg/ERP-2009/pdf/ERP-2009.pdf
Housing and Economic Recovery Act of 2008	CC	"Provide temporary authority to the Secretary of the Treasury to purchase any obligations and other securities in any amounts issued by the government-sponsored enterprises (GSEs) involved in the mortgage market."	https://www.cbo.gov/sites/default/files/110th-congress-2007-2008/costestimate/hr322100.pdf
Emergency Economic Stabilization Act of 2008	CC	"The bill would appropriate such sums as are necessary, for as many years as necessary, to enable the Secretary to purchase or insure troubled assets and to cover all administrative expenses of purchasing, insuring, holding, and selling those assets."	https://www.cbo.gov/sites/default/files/110th-congress-2007-2008/costestimate/09-28-honorablefrank00.pdf

Table A2: Major Motivations of Each Legislation (continued)

Legislation	Motivation	Evidence	Source of Evidence
Children's Health Insurance Program Reauthorization Act of 2009	SD	"The program provides health insurance to targeted children of low-income families. The legislation provides performance bonus payments to states to cover enrollment costs resulting from specified enrollment and retention efforts."	https://www.cbo.gov/sites/default/files/111th-congress-2009-2010/costestimate/hr2paygo0.pdf
American Recovery and Reinvestment Tax Act of 2009	CC	"The Act is an extraordinary response to a crisis unlike any since the Great Depression, and includes measures to modernize our nation's infrastructure, enhance energy independence, expand educational opportunities, preserve and improve affordable health care, provide tax relief, and protect those in greatest need."	https://www.fcc.gov/general/american-recovery-and-reinv~:text=The%20Act%20is%20an%20extraordinary,protect%20those%20in%20greatest%20need.%22
Hiring Incentives to Restore Employment Act	CC	"A consensus is forming that, partly because of the necessary - and often unpopular - measures we took over the past year, our economy is now growing again and we may soon be adding jobs instead of losing them. The jobs bill I'm signing today is intended to help accelerate that process."	https://obamawhitehouse.archives.gov/blog/2010/03/18/putting-americans-back-work
Patient Protection and Affordable Care Act	SD	"This year, we'll start offering tax credits to about 4 million small businessmen and women to help them cover the cost of insurance for their employees. (Applause.) That happens this year."	https://obamawhitehouse.archives.gov/the-press-office/remarks-president-and-vice-

Table A2: Major Motivations of Each Legislation (continued)

Legislation	Motivation	Evidence	Source of Evidence
Small Business Jobs Act of 2010	CC	"Chapter 7 examines the heavy toll the recession took on small businesses, dramatically reducing the availability of credit and capital needed to add capacity, hire more workers, and develop new products. In response to these challenges, the Administration has taken several important steps, most notably through the Recovery Act, the Small Business Jobs Act, and the Startup America initiative, to increase the flow of credit and capital to small business."	https://fraser.stlouisfed.org/files/docs/publications/ERP/2011/2011_erp.pdf?utm_source=direct_download
Fixing America's Surface Transportation Act	SD	"In December 2015, the bipartisan Fixing America's Surface Transportation Act (H.R. 22), which authorizes a $17.8 billion increase in surface transportation investment over five years, was enacted into law. This funding is an important down payment, but the country must further transform our transportation system to achieve a cleaner, safer transportation future."	https://fraser.stlouisfed.org/files/docs/publications/ERP/2016_erp.pdf?utm_source=direct_download
Division P - Consolidated Appropriations Act, 2016	SD	"The passage of the Consolidated Appropriations Act of 2016 in December 2015 set programmatic spending levels consistent with the new caps established by the budget agreement, including increases in investment in research and development, early education, and infrastructure."	https://fraser.stlouisfed.org/files/docs/publications/ERP/2016_erp.pdf?utm_source=direct_download
Division Q - Consolidated Appropriations Act, 2016	SD	"The passage of the Consolidated Appropriations Act of 2016 in December 2015 set programmatic spending levels consistent with the new caps established by the budget agreement, including increases in investment in research and development, early education, and infrastructure."	https://fraser.stlouisfed.org/files/docs/publications/ERP/2016_erp.pdf?utm_source=direct_download

Table A2: Major Motivations of Each Legislation (continued)

Legislation	Motivation	Evidence	Source of Evidence
Tax Cuts and Jobs Act	LR	"Elasticities from this literature suggest that reducing the U.S. corporate tax rate will have two effects. First, U.S. net capital outflows (NCO) would decline. This is both because foreign firms would invest more in U.S. capital and because U.S. firms would invest less in capital abroad. Second, U.S. firms would be less incentivized to shift their profits abroad, as discussed below. The former effect will tend to result in a dollar appreciation, which will reduce net exports (NX). The latter effect will tend to raise net exports. Provisions of the Tax Cut and Jobs Act to reduce the abuses of a territorial tax system would be critical to the realization of these gains."	https://fraser.stlouisfed.org/files/docs/publications/ERP/2018_erp.pdf?utm_source=direct_download
Further Consolidated Appropriations Act, 2020	LR	"DIVISION M - BIPARTISAN AMERICAN MINERS", "DIVISION O - SETTING EVERY COMMUNITY UP FOR RETIREMENT ENHANCEMENT"	Identification Based on Major Provisions
Families First Coronavirus Response Act	SD	"Division G - Tax Credits for Paid Sick and Paid Family and Medical Leave"	Identification Based on Major Provisions
Coronavirus Aid Relief and Economic Security Act	SD	"This legislation provides for direct payments to individuals and unprecedented support to small businesses. We're going to keep our small businesses strong and our big businesses strong. And that's keeping our country strong and our jobs strong."	https://trumpwhitehouse.archives.gov/briefings-statements/remarks-president-trump-sig
Consolidated Appropriations Act 2021	SD	"DIVISION N - ADDITIONAL CORONAVIRUS RESPONSE AND RELIEF", "DIVISION EE - THE 'TAXPAYER CERTAINTY AND DISASTER TAX RELIEF ACT OF 2020' "	Identification Based on Major Provisions

Table A2: Major Motivations of Each Legislation (continued)

Legislation	Motivation	Evidence	Source of Evidence
American Rescue Plan Act of 2021	SD	"The American Rescue Plan is already doing what it was designed to do: make a difference in people's everyday lives. And we're just getting started. By the time all the money is distributed, 85 percent of American households will have gotten a $1,400 rescue checks."	https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/03/15/remarks-by-president-biden-
Inflation Reduction Act of 2022	DD	"SUBTITLE A - DEFICIT REDUCTION"	Identification Based on Major Provisions

Note: SD indicates spending-driven; CC means countercyclical; DD refers to deficit-driven; LR indicates long-run.

C Proof and Derivations

C.1 Proposition 1

Proof. Since

$$\mu_t - r_t(n) = q_t(n)^{\rho-1} L_t^{1-\theta-\rho} \omega_t(n)$$

then

$$\begin{aligned}
q_t(n)\frac{\partial(\mu_t - r_t(n))}{\partial q_t(n)} &= (\rho-1) q_t(n)^{\rho-1} L_t^{1-\theta-\rho} \omega_t(n) \\
&\quad + q_t(n)^{\rho-1}\omega_t(n)\frac{1-\theta-\rho}{\rho}\left(\sum_{k=1}^{N}\omega_t(k)q_t(k)^{\rho}\right)^{\frac{1-\theta-\rho}{\rho}-1}\omega_t(n)\rho q_t(n)^{\rho} \\
&= (\rho-1)(\mu_t - r_t(n)) \\
&\quad + (\mu_t - r_t(n))(1-\theta-\rho)\left(\sum_{k=1}^{N}\omega_t(k)q_t(k)^{\rho}\right)^{-1}\omega_t(n)q_t(n)^{\rho}
\end{aligned}$$

So

$$(\mu_t - r_t(n)) + q_t(n)\frac{\partial(\mu_t - r_t(n))}{\partial q_t(n)} - C_n'(q_t(n)) = 0$$

implies

$$\begin{aligned}
(\mu_t - r_t(n))\left[\rho + (1-\theta-\rho)\left(\sum_{k=1}^{N}\omega_t(k)q_t(k)^{\rho}\right)^{-1}\omega_t(n)q_t(n)^{\rho}\right] &= C_n'(q_t(n)) \\
(\mu_t - r_t(n))\left[\rho + (1-\theta-\rho)L_t^{-\rho}\omega_t(n)q_t(n)^{\rho}\right] &= C_n'(q_t(n))
\end{aligned}$$

□

C.2 A Note on Asset Substitutability.

Textbook benchmark. First, let us consider a setting that is similar to the textbook case. We assume that the investors have a fixed budget c_t, and only derive the non-pecuniary convenience utility from the face values of the reserve assets as opposed to the market values. The preference is

$$\frac{\lambda_t}{1-\theta}\left(\sum_{n=1}^{N}\omega_t(n)(q_t(n)r_t(n))^{\rho}\right)^{\frac{1-\theta}{\rho}},$$

with the budget constraint $\sum_{n=1}^{N} q_t(n) = c_t$. In this alternative specification, we have dropped the pecuniary term in the utility function, i.e., $\sum_{n=1}^{N} q_t(n)r_t(n)$. Moreover, the relevant quantities for utilities are face values as opposed to the market values, which is similar to the consumer problem in which the buyers care about having 5 units of goods instead of 5 dollars' worth of goods.

The Lagrangian can be written as

$$\frac{\lambda_t}{1-\theta}\left(\sum_{n=1}^{N}\omega_t(n)(q_t(n)r_t(n))^{\rho}\right)^{\frac{1-\theta}{\rho}} - \mu_t\left(\sum_{n=1}^{N} q_t(n) - c_t\right),$$

which implies that for any $n \neq m$,

$$\frac{\partial q_t(n)}{\partial(\mu_t - r_t(m))} = -\frac{\rho}{\rho-1}\frac{q_t(n)^2\mu_t^{1/(\rho-1)}/c_t}{(\mu_t\omega_t(m)/r_t(n)^{\rho}\omega_t(n))^{1/(\rho-1)}}(r_t(m))^{\frac{1-2\rho}{\rho-1}}.$$

In this textbook case, $\partial q_t(n)/\partial(\mu_t - r_t(m))$ is positive for $0 < \rho < 1$ and negative for $\rho < 0$. We interpret the convenience yield $\mu_t - r_t(m)$ as a price measure. When $0 < \rho < 1$, the demand for asset n increases when the price of asset m rises, implying that the assets are substitutes. When $\rho < 0$, the demand for asset n decreases when the price of asset m rises, implying that the assets are complements. In this way, we obtain the standard result in models with the CES aggregator.

Introducing the pecuniary payoff. Our model deviates from this textbook case in two steps. First, we introduce the pecuniary term in the utility function, and assume that the investors derive convenience utility from the market values of the reserve assets. With these assumptions, the

Lagrangian is

$$\sum_{n=1}^{N} q_t(n) r_t(n) + \frac{\lambda_t}{1-\theta} \left(\sum_{n=1}^{N} \omega_t(n) q_t(n)^{\rho} \right)^{\frac{1-\theta}{\rho}} - \mu_t \left(\sum_{n=1}^{N} q_t(n) - c_t \right),$$

which implies that, for any $n \neq m$,

$$\frac{\partial q_t(n)}{\partial(\mu_t - r_t(m))} = -\frac{1}{\rho - 1} (\mu_t - r_t(m))^{\frac{1}{\rho-1}-1} \frac{q_t(n)^2/c_t}{((\mu_t - r_t(n))\omega_t(m)/\omega_t(n))^{1/(\rho-1)}},$$

which is always positive for $\rho < 1$, implying that the reserve assets issued by different countries are always substitutes.

Elastic supply of competitive funding rate. Our second deviation from the textbook case is that we assume that the investors have a flexible budget subject to a competitive funding rate μ_t. This assumption allows the investors to increase their aggregate investments in the reserve asset market when the demand is higher. In our model, we obtain the following result.

Proposition 2. *When $\rho < 1$ and $\theta > 0$, the sign of $\partial q_t(n)/\partial(\mu_t - r_t(m))$ depends on $\rho + \theta - 1$. If $\rho + \theta - 1 > 0$, then, $\partial q_t(n)/\partial(\mu_t - r_t(m)) > 0$, and reserve assets are substitutes, i.e. investors hold more of other assets when the return for asset m declines. If $\rho + \theta - 1 < 0$, then, $\partial q_t(n)/\partial(\mu_t - r_t(m)) < 0$, reserve assets are complements.*

Proof. By Eq. (1),

$$\begin{aligned} Q_t^{\rho} &= \sum_{n=1}^{N} \omega_t(n) q_t(n)^{\rho} \\ &= \left(\frac{1}{\lambda_t}\right)^{\frac{\rho}{\rho-1}} Q_t^{\rho \frac{\rho+\theta-1}{\rho-1}} \left[\sum_{n=1}^{N} (\mu_t - r_t(n))^{\frac{\rho}{\rho-1}} \left(\frac{1}{\omega_t(n)} \right)^{\frac{1}{\rho-1}} \right], \end{aligned}$$

which implies

$$Q_t^{\frac{\rho\theta}{\rho-1}} = \lambda_t^{\frac{\rho}{\rho-1}} \frac{1}{\left[\sum_{n=1}^{N} \left(\mu_t - r_t(n)\right)^{\frac{\rho}{\rho-1}} \left(\frac{1}{\omega_t(n)}\right)^{\frac{1}{\rho-1}}\right]}$$

$$Q_t^{\theta} = \lambda_t \frac{1}{\left[\sum_{n=1}^{N} \left(\mu_t - r_t(n)\right)^{\frac{\rho}{\rho-1}} \left(\frac{1}{\omega_t(n)}\right)^{\frac{1}{\rho-1}}\right]^{\frac{\rho-1}{\rho}}}.$$

Hence, for any $n \neq m$,

$$\begin{aligned}
\frac{\partial q_t(n)}{\partial(\mu_t - r_t(m))} &= \frac{\partial q_t(n)}{Q_t} \frac{\partial Q_t}{\partial(\mu_t - r_t(m))} \\
&= \frac{\rho + \theta - 1}{\rho - 1} q_t(n)^{2-\rho} Q_t^{\rho+\theta-2} \left(-\frac{1}{\theta}\right) \frac{1}{\lambda_t} Q^{1+\theta} \\
&\times \left[\sum_{k=1}^{N} \left(\mu_t - r_t(k)\right)^{\frac{\rho}{\rho-1}} \left(\frac{1}{\omega_t(k)}\right)^{\frac{1}{\rho-1}}\right]^{-\frac{1}{\rho}} \left(\frac{1}{\omega_t(m)}\right)^{\frac{1}{\rho-1}} \left(\mu_t - r_t(m)\right)^{\frac{1}{\rho-1}}
\end{aligned}$$

when $\rho < 1$ and $\theta > 0$, the sign of $\partial q_t(n)/\partial(\mu_t - r_t(m))$ depends on $\rho + \theta - 1$. In the case where $\rho + \theta - 1 > 0$, reserve assets issued by different countries are (net) substitutes, i.e. investors hold more of other assets when the return for asset m declines.

□