Inequality, Taxation, and Sovereign Default Risk*

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Abstract

Income inequality and worker migration significantly affect sovereign default risk. Governments often impose progressive taxes to reduce inequality, which redistribute income but discourage labor supply and induce emigration. Reduced labor supply and a smaller high-income workforce erode the current and future tax base, reducing the government's ability to repay debt. I develop a sovereign default model with endogenous non-linear taxation and heterogeneous labor to quantify this effect. In the model, the government chooses the optimal combination of taxation and debt, considering its impact on workers' labor and migration decisions. With the estimated model, I find that income inequality and its interactions with migration explain one-third of the average U.S. state government spread.

Keywords: Sovereign default risk, Income inequality, Migration, Tax progressivity
JEL Codes: F34, F41, E62, H74

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1 Introduction

What determines government capacity to repay debt? Previous sovereign default literature generally focuses on aggregates such as total debt and GDP, and governments make default decisions based on these aggregates. However, this does not provide a complete picture of real-world sovereign debt decisions. In addition to issuing debt, governments have other crucial responsibilities that may conflict with the repayment goal. For example, a distortionary tax is widely used to reduce income inequality, but it is not ideal for increasing GDP. Moreover, when government increases taxes to repay debt, workers change their behavior. In particular, a highly progressive tax may lead to emigration of high-income workers. These examples of redistribution motives and endogenous responses of workers affect government default risk. A standard sovereign default model, however, is silent on such conflicting priorities of government.

This paper aims to improve the understanding of sovereign debt and default risk by incorporating government redistributive motives and endogenous labor choices (including migration) into a sovereign default model. By introducing the role of *income inequality* and its interactions with *migration*, this paper provides a framework to study defaultable government debt and progressive taxation in a context where workers are heterogeneous and can migrate.

Empirical evidence emphasizes the role of income inequality and migration on sovereign spreads. Berg and Sachs (1988), Aizenman and Jinjarak (2012), and Jeon and Kabukcuoglu (2018) find that high inequality is associated with high sovereign default risk and spreads using cross-country data. I find that an increase in the Gini index of 0.1 is associated with a 0.5 percentage points increase in government spreads for a sample of 35 countries. Moreover, I find a stronger positive correlation between inequality and government spreads using U.S. state-level data: increasing the Gini index by 0.1 is associated with an increase of about 0.8 percentage points in state government spreads. Recent literature finds a significant correlation between migration and government default risk. Gordon and Guerron-Quintana (2019) studies the interactions between regional borrowing, migration, and default using U.S. county-level data. Alessandria, Bai, and Deng (2020) finds that countries at the core of the European debt crisis, namely Spain, Ireland, Portugal, and Greece, experienced a substantial labor outflow, and emigration intensified default risk by reducing tax bases and investment.

To quantify the effect of inequality and its interaction with migration on sovereign risk, I develop a quantitative sovereign default model with inequality and migration. In the model, workers are heterogeneous in their labor productivity. They supply labor elastically and consume after-tax labor income. They can also migrate by paying an idiosyncratic migration cost. The redistributive government chooses a non-linear tax scheme, government debt, and whether to default. The optimal combination of taxation, debt, and default policies depends on income inequality and labor mobility in this economy. A progressive tax redistributes income but reduces labor supply and increases high-income emigration, eroding the tax base and the government's ability to repay debt. Higher debt spreads result. Thus, the government faces a *redistribution–spreads* tradeoff. In an economy where inequality is a key concern, the government opts for more redistribution and suffers higher spreads.

This paper's framework provides a tool to study the interactions between the distribution of income, taxation, borrowing, and default risk, which applies to both national and sub-national governments. As an application of the model, I parametrize the model using U.S. state-level data. Compared with national government spreads, state government spreads have received limited attention; one exception is Arellano, Atkeson, and Wright (2016), who analyze sovereign spreads data both in Europe and U.S. states. An advantage of using U.S. state-level data is that the measures for income inequality, tax progressivity, and migration flows are very comparable across the states and are consistent over time. The key data moments for estimating the model parameters include the Gini index, tax revenues, state-to-state migration flows of workers with heterogeneous incomes, and the first- and second-order moments related to state government debt and spreads.

The estimated model shows that income inequality and its interaction with migration account for one-third of the average U.S. state government spread. Inequality itself accounts for 23% of state government spreads. In the model, labor is elastic along both the intensive margin—through labor supply choices—and the extensive margin—through migration. The impact magnitude of inequality on government spreads relies on labor elasticity. With more elastic labor supply, equilibrium tax progressivity is lower. This is because, with a higher Frisch elasticity for labor supply or a lower migration cost and thus higher migration rates, the distortions from progressive taxes are higher. Thus, in the equilibrium, the government chooses a less progressive tax.

Model impulse response functions show that government spreads spike in recessions for an economy with severe income inequality concerns. Facing an adverse productivity shock, a government has incentives to lower tax progressivity to encourage labor supply and reduce high-income workforce outflows. However, lower tax progressivity conflicts with government redistributive motives. This tension between redistribution and sovereign spreads was key during the recent European sovereign debt crisis. The Greek government adopted rather regressive austerity measures (Matsaganis and Leventi (2014)), which raised concerns over the fiscal burden on low-income households.

Related literature. The model builds on the sovereign default models pioneered by Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), and Arellano (2008). Recent literature had paid attention to distortionary taxation with sovereign default, but in a closed economy setting (Pouzo and Presno (2014), Karantounias (2019)) or with no redistribution motives (Cuadra, Sanchez, and Sapriza (2010)). A growing body of sovereign default literature focuses on the distributional issues of default decisions (D'Erasmo and Mendoza (2016), D'Erasmo and Mendoza (2021), Tran Xuan (2020)), where government default has a distributional effect because of heterogeneous holdings of public debt across households. This paper shares the emphasis on explicit default options and distortionary taxes, but focuses on government redistribution motives in an open economy with external debt. This paper shows that default on external debt is in fact redistributive because of endogenous progressive taxation.

This paper also relates closely to the literature that focuses on inequality, sovereign spreads, and default risk. Empirically, Berg and Sachs (1988), Aizenman and Jinjarak (2012), and Jeon and Kabukcuoglu (2018) find that high inequality is associated with high sovereign default risk and spreads using cross-country data. This paper confirms the finding using updated cross-country data and provides further evidence using cross-state data. Theoretically, the literature has improved the understanding of inequality's influence on sovereign default risk using endowment economy models with exogenous taxation (Jeon and Kabukcuoglu (2018)), political economy models where the government needs voters' support to implement a fiscal program (Andreasen, Sandleris, and Van der Ghote (2019)), and heterogeneous-agent overlapping generation models (Dovis, Golosov, and Shourideh (2016)). This paper focuses on an explicit sovereign default option and redistributive taxation by developing a sovereign default model with heterogeneous agents and endogenous non-linear taxation. This paper is particularly closely related to Ferriere (2014). We share the focus on studying the effect of inequality and progressive taxation on sovereign default risk. However, the mechanism is different in that Ferriere (2014) focuses on how after-tax inequality encourages default. This paper focuses on the considerations and endogenous constraints when the government faces pre-tax inequality.

Recent literature has started to study the role of migration on debt and default risk. Gordon and Guerron-Quintana (2019) study the role of migration in regional borrowing by focusing on municipalities. Alessandria, Bai, and Deng (2020) find that emigration magnified sovereign default risk in Spain, in a model with homogeneous workers. This paper is the first to consider the joint effect of inequality and migration on sovereign default risk.

This paper relates broadly to the literature that focuses on inequality and debt dynamics. Azzimonti, De Francisco, and Quadrini (2014) show that when rising income inequality is associated with an increase in individual income risk, these higher risks result in more public debt. Arawatari and Ono (2017) show that higher inequality increases pressure on politicians to shift the fiscal burden from the present generation to future generations, thus incentivizing politicians to finance a part of government expenditure by issuing public debt. This paper focuses on government default risk and debt spreads rather than the debt level.

Layout. The rest of this paper proceeds as follows. Section 2 describes empirical findings that motivate the theoretical analysis. Section 3 presents the model, defines the equilibrium, and highlights the model mechanism. Section 4 discusses the model's parametrization and quantitative findings. Section 5 concludes. The Online Appendix provides data details, model proofs, solution method, and additional empirical and quantitative results.

2 Empirical Findings

This section documents empirical relationships between income inequality, migration flows, tax progressivity, and sovereign spreads using U.S. state-level data. U.S. states are sovereigns under the U.S. Constitution. The states can formulate and implement tax systems and issue bonds to finance operations. The states can also repudiate their debts without bondholders being able to claim assets in a bankruptcy process.[1] Thus, the states within the U.S. have sovereign immunity just as do countries within the Eurozone (Ang and Longstaff (2013)). Compared with national government spreads, state government spreads have received limited attention.

Beyond filling the gap in the literature, there are also advantages of using state-level data because data measures are more comparable and consistent over time. For example, in terms of income inequality, sources and methods used for calculation may vary

[1] States are sovereigns and cannot declare bankruptcy. Cities and municipalities can declare bankruptcy under Chapter 9 of the U.S. bankruptcy code. Detroit, for example, filed for Chapter 9 bankruptcy in 2013.

tremendously across countries. Atkinson and Brandolini (2001) show that both levels and trends in distributional data can be affected by data choices in different countries. Thus, this section mainly focuses on results using U.S. state-level data.[2] All data resources and details are available in the Online Appendix.

Income inequality and tax progressivity. One commonly used measure for income inequality is the Gini index. Here I use the pre-tax Gini index to proxy for the severity of inequality, reflecting the extent to which the government desires to redistribute. According to the Gini index in 2019, examples for states with relatively high income inequality include New York, Connecticut, California, and Illinois, while Utah, Idaho, South Dakota, and Wisconsin have relatively low income inequality.

In most states, individual income taxes are a major source of state government revenue, accounting for 37% of state tax collections.[3] Income tax is the major instrument for the government to redistribute; other taxes (including federal payroll and excise taxes and state sales taxes) are either less progressive or regressive. Thus, this paper focuses on income tax progressivity both in the data and the model. The degree of progressivity varies widely across the states. For instance, state marginal income tax rates in California ranged from 1% to 13.3% in 2019, while in North Dakota, they ranged from 1.1% to 2.9%. I use the maximum state income tax rate to measure the progressivity of a state's income tax.

Migration flows. State-to-state migration flow data shows that in 2019, the top three outbound states are Illinois, California, and New Jersey. The top three inbound states are Idaho, Arizona, and South Carolina. Besides climate, job opportunities, and other considerations, state policies also affect household migration decisions. In 2012, California enacted legislation that increased marginal income tax rates, especially for high-income households. Using data from the California Franchise Tax Board for all taxpayers, Rauh and Shyu (2019) find that high-income earners increased their rate of out-migration from California by 0.8% in response to the tax increase. They also find a substantial decrease in taxable income, which appears in 2012 and persists through the last year of their analysis in 2014. Using income inequality and state-to-state migration data, I further illustrate that income inequality and migration are tightly related to state government spreads.

[2] The Online Appendix provides additional results with cross-country data and more discussions about state government finances, including balanced budget rules and the role of the federal government.

[3] Source: U.S. Census Bureau, "State and Local Government Finance," the Fiscal Year 2016.

Relation between inequality and government spreads. I use five-year credit default swap spreads to measure state government default risk. A credit default swap (CDS) is a derivative contract in which the buyer purchases default protection on an underlying security from a seller. With higher default risk, CDS spreads are correspondingly higher.[4] A key advantage of using CDS spreads data is that it provides a more direct measure for a sovereign's default risk than debt spreads. Unlike CDS spreads, debt spreads are not only driven by default risk, but also by changes in interest rates, supply of underlying bonds, liquidity in the secondary market, and other factors. The drawback is that CDS data is limited to post-2008 and is not available for all U.S. states.

The daily spreads on five-year maturity CDS obtained from Bloomberg span July 1, 2009, to February 15, 2019. The states with valid data are California, Connecticut, Delaware, Florida, Illinois, Maryland, Michigan, Minnesota, Nevada, New Jersey, New York, North Carolina, Ohio, Rhode Island, South Carolina, Texas, Utah, Washington, and Wisconsin.[5]

Table 1 provides summary statistics for five-year CDS spreads for the states in the sample. The units are percentage points. The average CDS spread ranges widely across the states: from a low of 0.35% for South Carolina to a high of 2.37% for Illinois. For the maximum values during the sample period, California CDS spreads reached 3.60% in 2009, and Illinois CDS spreads reached 4.10% in 2016. The CDS spreads for the states are of similar magnitude as those for European countries.[6]

To estimate the correlation between income inequality and government spreads, I use the following specification:

$$spread_{jt} = \beta_0 + \beta_1 ineq_{j,t-1} + \Gamma' Z_{j,t-1} + \alpha_t + \epsilon_{jt}, \tag{1}$$

where $spread_{jt}$ denotes the CDS spreads for state j in year t. For yearly spreads, I use the average spreads in each year.[7] $ineq_{j,t-1}$ is income inequality for state j in year $t-1$, and it is proxied by the state pre-tax Gini index. When calculating the Gini index, household

[4] Note that the state government CDS spreads in the data are tied to default events on the underlying bonds, not potential missed pension payments. Pension payments are beyond the scope of this paper. Nevertheless, governments with large debts are more likely to have large unfunded pension liabilities in the data. Including unfunded pension liabilities as another source of government fiscal burden intensifies the result of this paper.

[5] Although the sample is not comprehensive, it almost doubles the number of states used in Ang and Longstaff (2013). Some state CDS data remains unavailable.

[6] Ang and Longstaff (2013) compared CDS spreads for U.S. states and the Eurozone countries. They show that many of the average Eurozone country CDS spreads are smaller than those for the states, and many of the maximum values for the Eurozone countries are comparable to those for the states.

[7] Using rolling-window averages or the last daily observation in each year does not change the results.

Table 1: Summary statistics for state CDS spreads (in percentage points)

State	Mean	Std.Dev.	Min	Max
California	1.20	0.85	0.24	3.60
Connecticut	0.99	0.25	0.47	1.67
Delaware	0.41	0.16	0.21	1.05
Florida	0.67	0.43	0.25	1.99
Illinois	2.37	0.77	0.81	4.10
Maryland	0.49	0.25	0.20	1.28
Michigan	0.89	0.59	0.30	2.88
Minnesota	0.45	0.22	0.25	1.09
Nevada	0.83	0.55	0.21	2.33
New Jersey	1.33	0.50	0.45	2.89
New York	0.77	0.61	0.23	2.91
North Carolina	0.42	0.22	0.21	1.08
Ohio	0.75	0.41	0.25	1.78
Rhode Island	0.71	0.40	0.34	1.72
South Carolina	0.35	0.16	0.21	0.94
Texas	0.52	0.22	0.24	1.34
Utah	0.41	0.11	0.20	0.73
Washington	0.49	0.23	0.24	1.11
Wisconsin	0.57	0.34	0.16	1.47

Note: This table reports summary statistics for five-year CDS spreads for the U.S. states in the sample. Units are percentage points. The sample consists of daily observations from July 1, 2009, to February 15, 2019.

income is defined as income received regularly (exclusive of certain money receipts such as capital gains) before payments for personal income taxes, social security, union dues, and Medicare deductions. $Z_{j,t-1}$ is a vector of control variables, including state total output, debt-to-output ratio, and political party control of state legislatures. Political party control is a set of indicator variables {Democratic, Split, Republican} and refers to which political party holds the majority of seats in the state Senate and the state House.[8] α_t is a time fixed effect. Coefficient β_1 captures the correlation between income inequality and government spreads, where the variations mainly come from differences between states.

Table 2 reports the results for empirical specification (1), showing that high pre-tax income inequality is positively associated with high spreads. The regression uses annual spreads. Columns (1) and (2) use the average spread in each year, and columns (3) and (4) use the last daily observation in each year. The results are robust to both measures. Increasing the Gini index by 0.1 (e.g., Utah to Connecticut) is associated with CDS spread increases of about 0.8%. This effect is quite large. The average CDS spread in the sample is 0.86%. A one standard deviation increase in the Gini index is associated with CDS spread increases of 0.16%, which is about a 20% increase from the mean. The results also show that the states with Democratic-controlled legislatures are more likely to have higher spreads than those with Republican-controlled legislatures. This may reflect strong preferences for income redistribution among Democrats. Stronger redistributive motives, i.e., less tolerance for income inequality, tilt the *redistribution–spreads* tradeoff towards more redistribution and thus higher spreads. The coefficients of other control variables are consistent with standard predictions of sovereign default models: total output negatively correlates with spreads and a higher debt-to-output ratio is associated with higher spreads.

Relation between migration and government spreads. Migration is also a critical factor shaping government spreads. Alessandria, Bai, and Deng (2020) show that high government spreads accompanied large labor outflows during European debt crises. Using U.S. state-level data, I find that high government spreads are also associated with labor outflows. Figure 1 plots state-level migration and government spreads. The y-axis shows the ratio of in-migrants to out-migrants, where a higher value indicates more in-migration and a lower value indicates more out-migration. The x-axis shows the government CDS spreads.

[8] "Democratic" indicates that both legislative chambers have Democratic majorities, "Split" indicates that neither party has majorities in both legislative chambers, and "Republican" indicates both legislative chambers have Republican majorities. Since political parties hold different views towards income redistribution, the indicator coefficients also provide information on the correlation between redistribution preference and government spreads.

Table 2: Regression of government spreads on inequality

	(1)	(2)	(3)	(4)
Gini	8.08***	8.13***	7.71***	7.96***
	(2.26)	(2.70)	(2.29)	(2.76)
Political (="Split")		0.25		0.29
		(0.18)		(0.19)
Political (="Democratic")		0.46***		0.44***
		(0.13)		(0.13)
Year FE	Yes	Yes	Yes	Yes
Controls		Yes		Yes
N	147	147	147	147
R^2	0.324	0.436	0.418	0.507

Standard errors in parentheses
* $p<.1$, ** $p<0.05$, *** $p<0.01$
Note: This table reports regression results for the cross-state sample. After merging all variables, the final panel spans 2009 to 2017. For annual spreads, columns (1) and (2) use the average spread in each year; columns (3) and (4) use the last daily observation in each year.

Each dot represents a state-year observation. It shows that (in-)migration is negatively correlated with government spreads.

According to emigrant characteristics provided by the Database on Immigrants in OECD and non-OECD Countries (DIOC-E), highly educated and wealthier workers are more likely to emigrate. This is because migration involves migration costs, and high-income workers are more able to cover the cost. Alessandria, Bai, and Deng (2020) does not model income heterogeneity and thus was silent on this phenomenon. When the economy has income inequality with considerable labor mobility, the government has to consider the potential impact of progressive taxation. A progressive tax may induce outflows of high-income workers, thus depressing the government's tax base, increasing government default risk and spreads.

In summary, empirical evidence emphasizes the role of income inequality and migration in shaping government spreads.[9] In the next section, I present a theory of inequality, migration, and sovereign default risk.

[9] The Online Appendix provides additional empirical results regarding state-level income inequality, tax progressivity, migration, and government spreads.

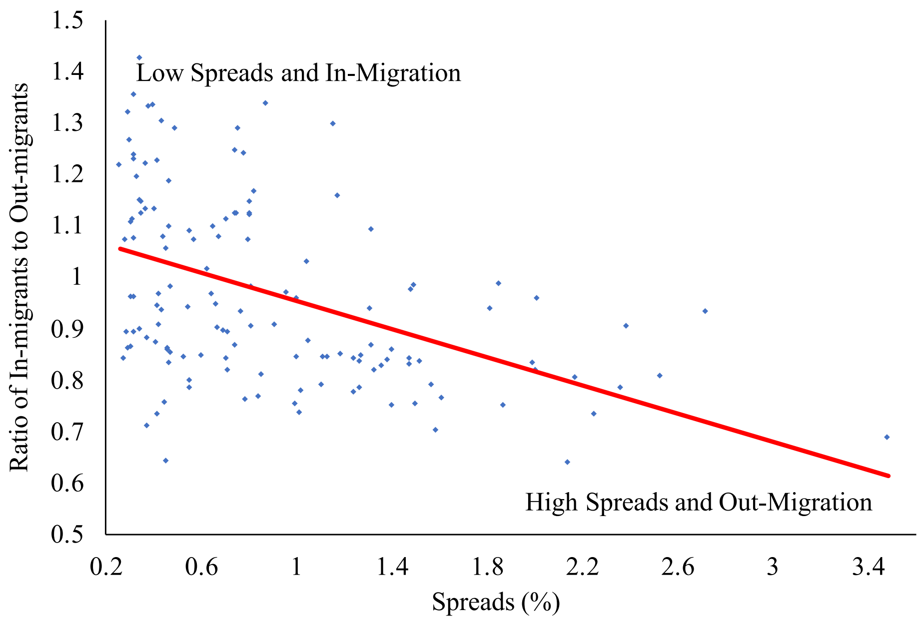


Figure 1: Government spreads and migration

Note: This figure plots migration patterns (ratio of in-migrants to out-migrants) and government CDS spreads using U.S. state-level data. Each dot represents a state-year observation.

3 Model

I now describe my model of sovereign default, endogenous non-linear taxation, income inequality, and migration. Consider a small open economy with a production technology, heterogeneous workers, and a benevolent government. Aggregate output Y is produced with aggregate labor L using $Y = AL$, where A is the stochastic aggregate productivity. The government imposes non-linear taxation, issues state-uncontingent bonds, and can default on them. If the government defaults, the economy suffers from a productivity loss and is temporarily excluded from the credit market. The main departure from the canonical sovereign default model is the introduction of endogenous labor supply and progressive taxation that aims to reduce income inequality. The endogenous labor supply comes from both labor supply choices and migration decisions.

3.1 Workers

There is a continuum of workers with heterogeneous labor productivity z_i. Each worker i has preferences over consumption c_i and labor ℓ_i given by

$$u(c_i, \ell_i) = \frac{c_i^{1-\sigma}}{1-\sigma} - \frac{\ell_i^{1+\gamma}}{1+\gamma},$$

where σ is the risk aversion parameter and $1/\gamma > 0$ is the Frisch elasticity of labor supply. Consumption c_i is bounded by after-tax labor income.

Each period, a worker makes a discrete choice to stay or emigrate. The worker migration setup closely follows Alessandria, Bai, and Deng (2020). If the worker emigrates, he receives an exogenous and constant value W^m, but also has to pay the stochastic and idiosyncratic migration cost δ. If the worker stays, he chooses labor supply ℓ_i, pays taxes (or receives transfers, if taxes are negative), and consumes the after-tax labor income.

The migration cost δ follows an exponential distribution with cumulative distribution function (henceforth, CDF) $F(x) = 1 - e^{-\zeta(z)x}$, where $\zeta(z)$ is a parameter that depends on labor productivity.[10] Rather than one constant parameter value, this reflects that the mean and volatility of migration costs for the high-income and low-income are different. There is also an exogenous inflow of workers. The exogenous immigration rate for heterogeneous workers is constant.[11]

3.2 Government

The government is benevolent and maximizes a social welfare function, which is the sum of the utility of domestic workers with a set of Pareto weights:

$$W = \int u(c_i, \ell_i)\omega_i di, \tag{2}$$

where $u(c_i, \ell_i)$ is the utility and ω_i is the Pareto weight for worker i.

[10] For example, a worker with labor productivity z_1 draws a migration cost from an exponential distribution with CDF $F(x) = 1 - e^{-\zeta_1 x}$, and a worker with labor productivity z_2 draws a migration cost from an exponential distribution with CDF $F(x) = 1 - e^{-\zeta_2 x}$. Quantitatively, I discipline $\zeta(z)$ to match emigration rates by income.

[11] What essentially matters is the *net emigration rate*, which is (emigration rate - immigration rate). Alternatively, I could assume exogenous immigration rates are different for heterogeneous workers and recalibrate $\zeta(z)$ to match the net emigration rates (or net migration rates).

The government imposes a distortionary income tax/transfer policy to redistribute income. Following Heathcote, Storesletten, and Violante (2017), I study the optimal degree of progressivity with the tax and transfer policies defined by:

$$T_i(y_i) = y_i - \lambda y_i^{1-\tau}, \tag{3}$$

where y_i is labor income for worker i and T_i is net tax revenue at income level y_i. The parameter τ determines the degree of tax progressivity. If the ratio of marginal to average tax rates is larger than one for every level of income, then a tax scheme is progressive. The ratio of marginal to average tax rates for tax function (3) is given by:

$$\frac{T'(y)}{T(y)/y} = \frac{1 - \lambda(1-\tau)y^{-\tau}}{1 - \lambda y^{-\tau}}.$$

Note that after-tax labor income is $\lambda y_i^{1-\tau}$. When $\tau = 1$, there is full redistribution with an after-tax income of λ for everyone. When $\tau = 0$, $T'(y) = \frac{T(y)}{y} = 1 - \lambda$, there is no redistribution with a flat tax rate $1 - \lambda$. When $\tau > 0$, $\frac{T'(y)}{T(y)/y} > 1$, thus the tax system is progressive. A higher τ implies that the tax rate increases faster with income, and thus the tax system is more progressive. Conversely, the tax system is regressive when $\tau < 0$. Given τ, the second parameter λ shifts the tax function and determines the average level of taxation. At the break-even labor income level $y^0 = \lambda^{\frac{1}{\tau}}$, the average tax rate is 0. If the tax system is progressive, workers with income lower than y^0 obtain net transfers rather than pay taxes. This is why tax function (3) is also called a tax/transfer policy.

The government can issue state-uncontingent bonds to creditors and can default on them. The creditors recognize that the government may default and set the government bond price to break even in expectation. Thus, the bond price is endogenously determined and reflects the government default risk. If the government defaults, it is excluded from the borrowing market for a period of time. In the case of default, as is standard in the sovereign debt literature, I impose an exogenous cost that reduces aggregate productivity: $A^d = f(A) < A$. The government regains the ability to borrow with probability θ. When forming tax, debt, and default policies, the government will internalize the labor supply and migration decisions of the heterogeneous workers.

3.3 Recursive formulation

Each period the economy starts with a level of government debt B, an aggregate productivity shock A, the distribution of workers Φ, and an indicator variable aut that denotes whether the government is in financial autarky ($aut = 1$) or not ($aut = 0$). Thus, the aggregate state of the economy is summarized by $S = (B, A, \Phi, aut)$. Given the aggregate state, when the government is not in financial autarky, the government makes choices for borrowing, the tax system, and whether to default, with decision rules given by $B' = H_B(B, A, \Phi)$, $\tau = H_\tau(B, A, \Phi)$, $\lambda = H_\lambda(B, A, \Phi)$, and $D = H_D(B, A, \Phi)$. The individual workers are heterogeneous in labor productivity z and idiosyncratic migration cost δ. The worker's state is (S, z, δ), which includes the aggregate state S and idiosyncratic states (z, δ). I omit the time subscript t and use x' to denote a variable x in the next period.

The timing of the model is as follows. At the beginning of the period, the aggregate productivity shock A and the idiosyncratic shocks for migration cost δ and labor productivity z for each worker are observed. Given the aggregate state S and idiosyncratic state (z, δ), workers decide whether to emigrate. After the migration decision, the distribution of the workers becomes Φ'. The government then makes choices. If the government has access to the financial market, it decides whether to default, how much to borrow B', and the tax system $\{\lambda, \tau\}$. If the government is in financial autarky, it can only choose the tax system $\{\lambda, \tau\}$. Given taxation, the staying workers choose labor supply ℓ and consume c.

3.3.1 Worker's choice

A worker decides whether to stay or emigrate to maximize his value:

$$W(S, z, \delta) = \max\{W^s(S, z), W^m - \delta\}, \tag{4}$$

where $W^s(S, z)$ is the value of staying in their original location and W^m is the value after paying the migration cost and emigrating. The worker who stays chooses labor supply and consumption to maximize utility. Thus, the staying value $W^s(S, z)$ is:

$$W^s(S, z) = \max_{c, \ell}\{u(H_c(S, z), H_\ell(S, z)) + \beta \mathbb{E} W(S', z', \delta')\}, \tag{5}$$

where $H_c(S, z)$ and $H_\ell(S, z)$ are the consumption choice and labor supply choice depending on the aggregate state S and idiosyncratic state z.

The consumption and labor supply choices are subject to a budget constraint, which says that consumption is bounded by the after-tax income:

$$c \leq \lambda y^{1-\tau}, \tag{6}$$

where c is consumption and $y = wz\ell$ is pre-tax labor income in which w is the wage rate, z is labor productivity, and ℓ is labor supply. As illustrated by the tax/transfer function (3), λ and τ are chosen by the government.

A worker will choose to stay if and only if $W^s(S,z) \geq W^m - \delta$. Let $M(S,z,\delta) = 1$ denotes migration (to any other place). As δ follows an exponential distribution, the probability of a worker staying in their original location is then given by:

$$Pr(\delta \geq W^m - W^s(S,z)) = e^{-\zeta(z)(W^m - W^s(S,z))} \tag{7}$$

3.3.2 Taxation, borrowing, and default

After workers make migration choices, the distribution of workers becomes Φ'. Then government makes choices. The government is aware that its decisions over taxation, borrowing, and default affect labor supply in the current period and migration decisions in the next period. The government chooses whether to repay or default on its debt:

$$V(B, A, \Phi') = \max\{V^c(B, A, \Phi'), V^d(A, \Phi')\}, \tag{8}$$

where $V^c(B, A, \Phi')$ is the repayment value and $V^d(A, \Phi')$ is the default value. The government default policy can be characterized by default sets and repayment sets: the default set is $D(B, A, \Phi') = \{V^c(B, A, \Phi') < V^d(A, \Phi')\}$ and the repayment set is $R(B, A, \Phi') = \{V^c(B, A, \Phi') \geq V^d(A, \Phi')\}$.

If the government repays, it chooses a fiscal program with both borrowing and taxation $\{B', \tau, \lambda\}$ to maximize the social welfare function for domestic workers. The repayment value is given by:

$$V^c(B, A, \Phi') = \max_{B', \tau, \lambda}\{\int u(c_i, \ell_i)\omega_i di + \beta \mathbb{E} V(B', A', \Phi'')\}, \tag{9}$$

subject to the budget constraint:

$$B = \int_{\Phi'} T_i(y_i)di + q(B', A, \Phi')B', \tag{10}$$

where $\int_{\Phi'} T_i(y_i)di = \int_{\Phi'}(y_i - \lambda y_i^{1-\tau})di$ is the total tax revenue collected from all staying workers. $q(B', A, \Phi')$ is the bond price, which compensates lenders for the government's future default risk. There are two main purposes for taxation here: first to redistribute income, second to finance debt repayment.

If the government defaults, it is temporarily excluded from the financial market. The government chooses a fiscal program with only taxation $\{\tau, \lambda\}$ to maximize the social welfare function. With probability θ, the government returns to the financial market. The default value is given by:

$$V^d(A, \Phi') = \max_{\tau,\lambda}\{\int u(c_i^d, \ell_i^d)\omega_i di + \beta[\theta \mathbb{E} V(0, A', \Phi''_{aut=0}) + (1-\theta)\mathbb{E} V^d(A', \Phi''_{aut=1})]\}, \tag{11}$$

subject to the budget constraint:

$$0 = \int_{\Phi'} T_i(y_i)di, \tag{12}$$

where $u(c_i^d, \ell_i^d)$ is the utility of worker i when the economy is in financial autarky. During default, the government cannot borrow and does not service its debt. Thus, the only purpose for taxation is to redistribute income.

The external lenders are competitive and risk-neutral. They face a risk-free interest rate r and are willing to lend to the government as long as they break even in expected value. The lenders are aware of the government's incentives to default on its bonds. Thus, in equilibrium, the break-even condition implies that the bond price schedule $q(B', A, \Phi')$ satisfies:

$$q(B', A, \Phi') = \frac{\mathbb{E}[1 - D(B', A', \Phi''(B', A', \Phi'))]}{1+r}, \tag{13}$$

where $D(B, A, \Phi') = 1$ denotes default. As in standard sovereign default literature, the bond price depends on the aggregate productivity shock A and borrowing B'. Here, the bond price also depends on the endogenous worker distribution Φ'. The government spread is defined as the inverse of the bond price minus the risk-free rate, $sp = 1/q(B', A, \Phi') - (1+r)$.

3.3.3 Recursive equilibrium

The recursive equilibrium consists of the government policy functions for borrowing $B'(B, A, \Phi')$, the tax system $\{\tau(B, A, \Phi'), \lambda(B, A, \Phi')\}$, default set $D(B, A, \Phi')$; the government value functions $V(B, A, \Phi')$, $V^c(B, A, \Phi')$, and $V^d(A, \Phi')$; the worker choices for migration $M(S, z, \delta)$, consumption $c(S, z)$, labor supply $l(S, z)$; the wage rate $w(S)$ and aggregate labor $L(S)$; and the worker value functions $W(S, z, \delta)$, $W^S(S, z)$ such that:

1. Taking as given the government policies, a worker's choices for migration $M(S, z, \delta)$, consumption $c(S, z)$, and labor supply $l(S, z)$, along with their value functions $W(S, z, \delta)$ and $W^S(S, z)$, solve the worker's problem (4).

2. Taking as given the worker's choices, the government's choices for borrowing $B'(B, A, \Phi')$, the tax system $\{\tau(B, A, \Phi'), \lambda(B, A, \Phi')\}$, and default set $D(B, A, \Phi')$, along with its value functions $V(B, A, \Phi')$, $V^c(B, A, \Phi')$, and $V^d(A, \Phi')$, solve the government's problem (8).

3. The government bond price schedule (13) reflects the government's default probability and satisfies the external lenders' break-even condition.

4. Consistency. Future government decision rules $H_B = B''(B', A', \Phi')$, $H_\tau = \tau'(B', A', \Phi')$, $H_\lambda = \lambda'(B', A', \Phi')$, and $H_D = D'(B', A', \Phi')$ are consistent with the government policies. The future distribution of workers $H_\Phi(S) = \Phi'(S')$ is consistent with the workers' migration decision rules.

5. The labor market clears: $L(S) = \int_\Phi z_i \ell_i(S, z_i) di$.

3.4 Model mechanism

When the government makes policies, it internalizes that workers will make migration and labor supply choices based on government policies. Here I explain how these considerations change government policies and how income inequality plays a role in shaping government policies.

Consider a one-period version of the model in which I can provide intuitive analytic solutions. Assume the government has some exogenous debt stock B_0. The government chooses the tax system and whether to default on its debt B_0. Given the government tax system, the workers choose labor supply and consumption.

There are two types of workers with equal unit masses.[12] Let $z_L = \bar{z} - \sigma_z$ denote labor productivity for workers with type L, and $z_H = \bar{z} + \sigma_z$ denote labor productivity

[12]Note that this is a one-period version of the model. After analyzing the endogenous labor supply and consumption choices, we will focus on the migration choice and its impact on government policies.

for workers with type H, where $0 < \sigma_z < \bar{z}$. Thus, σ_z measures labor productivity heterogeneity without changing the average labor productivity level in this economy. A higher σ_z generates higher income inequality.

Assume workers have utility function $u(c, \ell) = \log c - \frac{\ell^{1+\gamma}}{1+\gamma}$. With logarithmic utility, I can obtain closed-form solutions for optimal labor choices and use the solutions to establish important properties relating tax progressivity and default risk.[13] The optimal labor and consumption choices for workers are:

$$\ell_L = (1-\tau)^{\frac{1}{1+\gamma}}, \quad \ell_H = (1-\tau)^{\frac{1}{1+\gamma}}, \tag{14}$$

$$c_L = \lambda(wz_L\ell_L)^{1-\tau}, \quad c_H = \lambda(wz_H\ell_H)^{1-\tau}, \tag{15}$$

where λ and τ are determined by the government. The functional form for labor supply (14) indicates that high tax progressivity τ discourages labor supply.[14] Note that with logarithmic utility, the tax level parameter λ has no impact on labor supply.

If the government decides to repay B_0, it collects taxes to finance the debt repayment. Assume equal weights (0.5 for each type of worker) in the government social welfare function. The repayment value is given by:

$$V^c(B_0, A) = \max_{\tau,\lambda}\{0.5u(c_L, \ell_L) + 0.5u(c_H, \ell_H)\} \tag{16}$$

subject to the budget constraint:

$$T_L + T_H = B_0, \tag{17}$$

where $T_L = wz_L\ell_L - \lambda(wz_L\ell_L)^{1-\tau}$ and $T_H = wz_H\ell_H - \lambda(wz_H\ell_H)^{1-\tau}$ are the taxes (transfers, if negative) collected from workers of type L and type H, respectively. Because the government budget constraint must be satisfied, the government in effect chooses τ and then λ is pinned down by the budget constraint:

$$\lambda = \frac{wz_L\ell_L + wz_H\ell_H - B_0}{(wz_L\ell_L)^{1-\tau} + (wz_H\ell_H)^{1-\tau}}. \tag{18}$$

If the government decides to default, there is no repayment of the outstanding debt. The government chooses the tax policy $\{\tau^d, \lambda^d\}$ to maximize social welfare. The superscript d

[13]The Online Appendix derives the optimal labor supply choices under constant relative risk aversion (CRRA) utility and shows that the main results stay unchanged.

[14]With logarithmic utility, high tax progressivity discourages labor supply equally for the low-income and the high-income. With more general CRRA utility, high tax progressivity still discourages labor supply, but disproportionately for different workers.

denotes the variables in the case of government default. The defaulting value is given by:

$$V^d(A) = \max_{\tau^d,\lambda^d}\{0.5u(c_L^d, \ell_L^d) + 0.5u(c_H^d, \ell_H^d)\} \tag{19}$$

subject to the budget constraint:

$$T_L^d + T_H^d = 0. \tag{20}$$

The budget constraint (20) shows that without debt repayment, the government taxes purely for redistribution. Denote $\alpha \equiv (z_L^{1-\tau})/(z_L^{1-\tau} + z_H^{1-\tau})$ and $\alpha^d \equiv (z_L^{1-\tau^d})/(z_L^{1-\tau^d} + z_H^{1-\tau^d})$. After applying the assumed functional form for utility, substituting the budget constraints and optimal conditions, the government's payoff under repayment (16) can be rewritten as:

$$V^c(B_0, A) = \max_{\tau}\Big\{\underbrace{\log\left(A\bar{z}\ell(\tau) - B_0\right)}_{\text{consumption}} - \underbrace{\frac{1-\tau}{1+\gamma}}_{\text{disutility from working}} + \underbrace{\frac{1}{2}\log[\alpha(1-\alpha)]}_{\text{redistribution}}\Big\}. \tag{21}$$

Each term of the value function has an economic interpretation and captures one of the forces determining the optimal tax progressivity τ^*. The first component $\log(A\bar{z}\ell(\tau) - B_0)$ represents total consumption. High tax progressivity discourages labor supply and thus decreases the total output and consumption. Thus, the first term of (21) is *decreasing* in τ.[15] The second term $\frac{1-\tau}{1+\gamma}$ shows the disutility from working. Higher tax progressivity discourages labor supply and thus generates less disutility from working. The second term, including the negative sign, is therefore *increasing* in τ. The first two terms show the tradeoff between consumption and leisure: high tax progressivity τ discourages labor supply and lowers consumption, but reduces disutility from working.

With redistribution incentives, high tax progressivity τ brings extra benefits shown as the third term in (21). When $\tau = 1$, which implies $\alpha \equiv (z_L^{1-\tau})/(z_L^{1-\tau} + z_H^{1-\tau}) = 1/2$, the value of the third term in (21) is the largest. The optimal tax progressivty τ^* is determined by equating the marginal cost and the marginal benefit of increasing τ.

Debt and tax progressivity. When the outstanding debt B_0 is high, the marginal cost of increasing tax progressivity τ is high, leading to a less progressive tax in equilibrium. Intuitively, the government internalizes that a less progressive tax encourages labor supply and makes it easier to finance debt repayment. When the government has a large debt to

[15]The derivations for monotonicity are straightforward and are provided in the Online Appendix.

repay, it adopts a less progressive tax.[16]

Incentives to default. Similarly to the repayment value function decomposition, we can decompose the defaulting value function into three terms:

$$V^d(A^d) = \max_{\tau} \Big\{ \underbrace{\log\left(A^d \bar{z}\ell(\tau)\right)}_{\text{consumption}} - \underbrace{\frac{1-\tau}{1+\gamma}}_{\text{disutility from working}} + \underbrace{\frac{1}{2}\log[\alpha(1-\alpha)]}_{\text{redistribution}} \Big\}, \tag{22}$$

where A^d is lower than A, but there is no debt repayment. The government is facing a similar tradeoff when choosing the degree of tax progressivity: higher tax progressivity distorts labor supply and lowers consumption, but reduces disutility from working and increases welfare from redistribution. Comparing the repayment value (21) and defaulting value (22), the marginal cost of high τ on consumption is increasing with debt repayment B_0, while the marginal benefits of high τ are the same under both repayment and default. Thus, the optimal tax progressivity τ^* is higher under default. We can also see this property by deriving the first-order condition with respect to tax progressivity τ. Formally, the optimal tax progressivity τ satisfies the first-order condition:

$$\frac{1}{2}\frac{(z_H^{1-\tau} - z_L^{1-\tau})(\ln z_H - \ln z_L)}{z_L^{1-\tau} + z_H^{1-\tau}} + \frac{1}{1+\gamma} = \frac{\bar{z}\frac{1}{1+\gamma}(1-\tau)^{\frac{1}{1+\gamma}-1}}{\bar{z}(1-\tau)^{\frac{1}{1+\gamma}} - \frac{B_0}{A}}, \tag{23}$$

where $\frac{B_0}{A} > 0$. The left-hand side of (23) is a decreasing function of τ and the right-hand side of (23) is increasing in τ. When government defaults, the debt B_0 is wiped out and the aggregate productivity A is reduced to A^d. The left-hand side of (23) remains unchanged, and the right-hand side of (23) decreases because $\frac{B_0}{A} > 0$. This leads to a higher τ^*. In other words, when government chooses to default, it can achieve a higher equilibrium tax progressivity.

Debt repayment therefore forces a lower degree of tax progressivity. To repay the debt, the government has to encourage labor supply to finance repayment. By defaulting on its debt, the government can avoid this force and implement a more progressive tax. In standard sovereign default models, when making default/repayment decisions, the

[16] If the government debt is non-defaultable and we reinterpret the debt repayment as government spending, this relation between debt and tax progressivity echoes a remarkable finding in the optimal taxation literature. There, government spending is a force toward a less progressive tax because the planner internalizes that a less progressive tax encourages labor supply and makes it easier to finance expenditure (Heathcote, Storesletten, and Violante (2017)).

government weighs the benefit of not paying and the costs of productivity losses and temporary financial autarky. With endogenous taxation, the government has another incentive to default: implementing a more progressive tax to achieve more redistribution.

Effect of inequality. The level of inequality is the key determinant of optimal government policies when the government faces the tradeoff between debt repayment and redistribution. In a more unequal economy, the gap between z_H and z_L widens, which increases the redistribution benefit $\frac{1}{2}\log[\alpha(1-\alpha)]$. Thus, with high inequality, the government is more likely to choose default to achieve more redistribution.

We can also see this property by exploring the first-order condition (23) and then deriving the default set. Higher inequality means a larger gap between z_H and z_L. With higher inequality, the left-hand side of (23) increases, while the right-hand side does not change with inequality. Thus, a higher inequality results in higher optimal tax progressivity. Further, the default set is larger under higher inequality, for which the proof is in the Online Appendix.

Effect of migration. The one-period version of the model omits migration because migration is an intertemporal choice that affects the future. Nevertheless, we can illustrate the mechanism by revisiting the recursive problem. Recall that the government chooses $\{B', \tau, \lambda\}$ to maximize its value:

$$V^c(B, A, \Phi') = \max_{B',\tau,\lambda}\{\int u(c_i, \ell_i)\omega_i di + \beta\mathbb{E}V(B', A', \Phi'')\},$$

subject to the budget constraint:

$$B = \int_{\Phi'} T_i(y_i)di + q(B', A, \Phi')B'.$$

With inequality, the government chooses an optimal set of policies, including a more progressive tax than without inequality. A more progressive tax discourages labor, reduces after-tax income and consumption, and increases emigration. Emigration changes the next-period distribution of workers Φ'. The worker distribution Φ' enters into the government's problem in two ways. First, it affects the tax base, shown as the first term at the right-hand side of government budget constraint. Second, it affects the government bond price $q(B', A, \Phi')$ by affecting future default risk. The emigration of workers, especially high-income workers, lowers the government's future repayment capacity and lowers the bond price (pushes up the government spread).

3.5 Transformed problem

The government's problem is not stationary with the permanent change in population. Here I rewrite the model to obtain a stationary model in per-capita terms.[17] Denote the total population before migration choices as N. Then $b = B/N$ is the per-capita government bonds. Similarly, the aggregate variables in per-capita terms will be denoted by lower case letters.

With two types of workers (z_L, z_H), the distribution Φ can be represented by the fraction of workers with z_L. Denote the fraction of z_L workers as $f = N_L/N$, where $N = N_L + N_H$, N_L is the population with labor productivity z_L and N_H is the population with labor productivity z_H. Let the aggregate state be $s = (b, A, f, aut)$.

The value of a worker is given by $W(s, z, \delta) = \max\{W^s(s, z),\ W^m - \delta\}$. After the migration choices, the population of workers with z_i becomes N_i' $(i = L, H)$. Denote the growth rate of the population with z_i as $g_i(s) = N_i'/N_i = e^{-\zeta(z_i)(W^m - W^s(s,z_i))}$ $(i = L, H)$. The second equals sign comes from the exponential distribution for the migration cost δ.

The growth rate of the total population is:

$$\frac{N'}{N} = \frac{N_L' + N_H'}{N_L + N_H} = g_L(s)\, f + g_H(s)\, (1 - f),$$

which is a weighted average of the growth rates of the populations with z_L and z_H.

The fraction of workers with z_L after migration choices is:

$$f' = \frac{N_L'}{N'} = \frac{N_L'}{N_L}\frac{N_L}{N}\frac{N}{N'} = \frac{g_L(s)\, f}{g_L(s)\, f + g_H(s)\, (1 - f)}.$$

Also, note that

$$\frac{B'}{N} = \frac{B'}{N'}\frac{N'}{N} = b'\frac{N'}{N} = b'\, [g_L(s)\, f + g_H(s)\, (1 - f)].$$

Taking as given the growth rate of the population $g_i(s)$, the government chooses whether to repay or default depending on the per-capita value of repayment $v^c(b, A, f')$ and de-

[17] I prove the equivalence of the transformed problem and the original problem in the Online Appendix.

faulting $v^d(A, f')$:

$$v(b, A, f') = \max\{v^c(b, A, f'), v^d(A, f')\}.$$

Let the default decision be $d(b, A, f') = 1$ if $v^c(b, A, f') < v^d(A, f')$. The repayment value is:

$$\begin{aligned} v^c(b, A, f') = \max_{b',\tau,\lambda} \{ & g_L\, f\, u(c_L, \ell_L)\omega_L + g_H\,(1-f)\, u(c_H, \ell_H)\omega_H \\ & + \beta\,[g_L\, f + g_H\,(1-f)]\, \mathbb{E}v(b', A', f'')\}, \end{aligned} \tag{24}$$

subject to the budget constraint:

$$b \leq g_L\, f\,(y_L - c_L) + g_H\,(1-f)\,(y_H - c_H) + [g_L\, f + g_H\,(1-f)]\, q(b', A, f')b',$$

where the bond price $q(b', A, f') = \frac{1}{1+r}\mathbb{E}[1 - d(b', A', f'')]$. The future fraction of workers with z_L is given by $f'' = \frac{g_L(s')\, f'}{g_L(s')\, f' + g_H(s')\,(1-f')}$, where g_L and g_H are consistent with workers' optimal migration choices.

The defaulting value is:

$$\begin{aligned} v^d(A, f') = \max_{\tau,\lambda} \{ & g_L\, f\, u(c^d_L, \ell^d_L)\omega_L + g_H\,(1-f)\, u(c^d_H, \ell^d_H)\omega_H \\ & + \beta\,[g_L\, f + g_H\,(1-f)]\,[\theta\mathbb{E}v(0, A', f''_{aut=0}) + (1-\theta)\mathbb{E}v^d(A', f''_{aut=1})]\}, \end{aligned} \tag{25}$$

subject to the budget constraint:

$$0 \leq g_L\, f\,(y_L - c_L) + g_H\,(1-f)\,(y_H - c_H),$$

where $f''_{aut=0} = \frac{g_L(0, A', f', aut=0)\, f'}{g_L(0, A', f', aut=0)\, f' + g_H(0, A', f', aut=0)\,(1-f')}$ denotes the future fraction of workers with z_L when the government returns to the financial market and $f''_{aut=1} = \frac{g_L(0, A', f', aut=1)\, f'}{g_L(0, A', f', aut=1)\, f' + g_H(0, A', f', aut=1)\,(1-f')}$ denotes f'' when the government is still in financial autarky.

3.6 Discussion

Before moving forward, I discuss some assumptions in the model. In the model, the government borrows to smooth consumption, while workers do not borrow, although they make self-interested migration decisions.[18] The restriction is motivated mostly by tractability because my model's numerical solution when including worker assets as an extra individual state variable and the worker assets distribution as an extra aggregate state variable, while feasible, is substantially more involved. Besides, in the data, many households hold little wealth. In their Panel Study of Income Dynamics (PSID) sample, Aguiar, Bils, and Boar (2020) estimates that on average 40.2% of households are hand-to-mouth.[19] However, it is useful to emphasize that a modification with worker wealth would not alter the main results—because the government also has incentives to reduce wealth inequality with progressive taxation.

The model features external government debt. In the state government case, this means that the government borrows from other states. Although there is no good source for the exact holders of state government debt, we can infer from examining historical defaults. When the state of Arkansas defaulted in 1933, most creditors were from other states.[20] An extension of this model would include internal government debt where the workers can also hold government debt. When the government also borrows internally, the wealthy workers hold a large fraction of government debt. When government defaults, it defaults on all debt. Thus the wealthier workers are hurt more. In that case, the redistribution effect from default is intensified.

Finally, the model assumes the Heathcote, Storesletten, and Violante (2017) (HSV) tax function. It is important to emphasize, however, that the main results still hold without assuming the HSV tax function. An alternative tax regime such as a linear tax function with deductions and transfers for certain income levels can also generate the same tax rates for different workers as in the current model. The advantage of the HSV tax function is that it provides a parsimonious way to capture tax progressivity.

[18] In the sovereign default literature, many assume that only the government can borrow. The government then returns all proceeds to the workers. An alternative setting is that workers can also invest, borrow, and default. In this case, if the government imposes taxes or subsidies on domestic investment and capital flows due to pecuniary externalities, the allocations in this alternative setting are the same as those which assume that only the government can borrow.

[19] They treat households with low net worth or low liquid wealth as hand-to-mouth.

[20] 65% of all debt (95 of 146 million) was held by creditors from New England and the Middle Atlantic states, with the rest was held by creditors from the Midwest and the South.

4 Quantitative Analysis

In this section, I evaluate the quantitative properties of the model by taking the model to U.S. state-level data. After parameterizing the model, I study the quantitative role of income inequality and its interactions with migration in determining government spreads. I also study the role of inequality and migration during recessions. I then explore alternative government redistribution preferences and the elasticities of labor distortions.

4.1 Parameterization and moments

The model is calibrated at an annual frequency. Aggregate productivity A follows a first-order autoregressive process: $\log(A_t) = \rho \log(A_{t-1}) + \varepsilon_t$, where ε_t follows a normal distribution with mean zero and a standard deviation of σ. If the government defaults, the economy suffers a productivity loss. Following Chatterjee and Eyigungor (2012), the productivity loss takes a quadratic form $A_d = h(A) = A - \max\left\{d_1 A + d_2 A^2, 0\right\}$. The government cares about each type of worker equally ($\omega_i = 0.5$) in the social welfare function.[21]

I parameterize the model to match key properties of state-level data in the U.S. from 2009-2019.[22] There are two groups of parameters. The first group of parameters are assigned, and those in the second group are chosen to jointly match relevant empirical moments. The first group includes $\{r, \gamma, \theta, \rho\}$. The risk-free rate r is 4%. $\gamma = 2$ so that the Frisch elasticity ($1/\gamma$) is 0.5. This value is in line with microeconomic evidence (e.g., survey by Keane (2011)) and estimation by Heathcote, Storesletten, and Violante (2014). The return parameter θ is 0.25, so that a defaulting government is excluded from financial markets for four years on average.[23] The persistence of the productivity process ρ is set to be 0.9.

The second group includes eight parameters $\{\sigma, \beta, d_1, d_2, \bar{z}, \sigma_z, \zeta_L, \zeta_H\}$. I choose these parameters to jointly target the following empirical moments: the volatility of GDP (3%), the average spread (0.83%) and spread volatility (0.4%), the average debt-to-GDP ratio

[21] Section 4.4 explores the results in an alternative setting by letting the Pareto weights be $\omega_i = z_i^\eta / (\sum_I z_i^\eta)$, where $\eta = 0$ indicates equal weights in the social welfare function.

[22] I focus on quantifying the role of inequality and migration in explaining the variation in government spreads across U.S. states. The model, however, is more general and can be parameterized to a country and quantify the role of inequality and migration in explaining government spreads for that country.

[23] State government default triggers financial exclusions. For example, after Arkansas defaulted in 1933, large financial centers remained closed to Arkansas for some time. In New York and Pennsylvania, the banks and trusts could not invest in Arkansas bonds until 1944 and not until 1954 for investors in Massachusetts and Connecticut.

(0.18), the average Gini index (0.46), average state income tax revenue as a share of GDP (1.8%), and the average emigration rates of the low-income (4.0%) and the high-income (2.8%). Even though the parameters are chosen jointly, I can give a heuristic description of how the sample moments included in the estimation inform specific parameters. The volatility of productivity shocks η mainly affects the volatility of GDP and spreads. The discount factor β and the two parameters in the productivity loss function, d_1 and d_2, mostly affect the average debt-to-GDP ratio, the average spread, and the volatility of spreads. The average Gini index and the ratio of income tax revenue to GDP provide information for the labor productivity parameters $\{\bar{z}, \sigma_z\}$. The average emigration rates for the low-income and the high-income in the Internal Revenue Service (IRS) Migration Dataset are informative about the parameters in the migration cost distribution $\{\zeta_L, \zeta_H\}$.[24] Table 4 reports the moments in the model and the data.

Table 3: Parameters values

Risk-free rate	r	4%
1/Frisch elasticity	γ	2
Return probability	θ	0.25
Productivity persistence	ρ	0.9
Productivity volatility	σ	0.02
Discount factor	β	0.87
Productivity loss	d_1	-0.4
	d_2	0.475
Labor heterogeneity	$\bar{z}$	0.45
	σ_z	0.414
Migration cost distribution	ζ_L	0.0027
	ζ_H	0.0044

4.2 Quantitative effects of inequality and migration

I focus on the effect of inequality on government spreads in a context where workers have labor mobility. As shown in the theoretical model, because government internalizes that

[24] Low-income is defined as income lower than the median, and high-income is defined as income higher than the median. The interstate migration data produced by the IRS do not include households that do not file tax returns, thus missing 13% of the population. However, it is quite precise because they are not based on survey data, such as the migration data produced by the U.S. Census Bureau. The emigration rates used in the calibration are from the 2016 data.

Table 4: Moments in data and model

	Data	Model
Std. GDP	0.03	0.04
Avg. spread (%)	0.83	0.81
Std. spread (%)	0.40	0.61
Avg. debt-to-GDP	0.18	0.19
Gini index	0.46	0.46
Avg. income tax revenue/GDP (%)	1.8	1.35
Avg. emigration rate of low-income (%)	4.0	4.0
Avg. emigration rate of high-income (%)	2.8	2.8

Note: GDP in the table refers to per capita GDP.

workers decide their own labor supply and can also migrate based on government policies, the government faces a tradeoff between redistribution and debt repayment. Repaying debt is a force toward less redistribution.

The degree to which inequality affects government default risk (and thus government spreads) depends on the magnitude of labor distortions. The *intensive* margin of labor distortion depends on the Frisch elasticity. With a more elastic labor supply, the ability to increase tax progressivity is less, leading to a larger effect of inequality on government spreads.[25] The *extensive* margin of labor distortion depends on labor mobility. The impact of inequality on government default risk is lower if people are unlikely to move even when facing a very progressive tax.

To explore the quantitative role of inequality on government spreads, I compare the benchmark model with a reference model with no inequality (denoted as *no-inequality*). To explore the role of migration, I further shut down the labor mobility channel to generate a reference model with no inequality and no labor mobility (denoted as *no-inequality-no-migration*).

In the no-inequality model, labor productivity is the same for all workers ($\sigma_z = 0$). In the no-inequality-no-migration model, $\sigma_z = 0$ and workers are not allowed to migrate. The no-inequality-no-migration model is similar to a canonical model in the sovereign default literature. Both reference models share the same parameter values as the benchmark. For each model, I simulate 3000 paths for 500 periods, then drop the first 100 periods to

[25]The Online Appendix tests for different Frisch elasticities.

eliminate the influence of the arbitrary (but reasonable) choice of the initial guesses. I then take the average of government spreads across the paths conditional on the government not defaulting.

I now compare the government spreads generated in the benchmark model and the reference models. In the benchmark, the average government spread is 0.81%. In the no-inequality model, the average spread is 0.62%. The average spread is even smaller (0.54%) in the no-inequality-no-migration model. Compared with the benchmark model, inequality accounts for 23% ($= (0.81 - 0.62)/0.81$) of the average government spreads. Income inequality and its interaction with migration account for one-third ($= (0.81 - 0.54)/0.81$) of the average government spreads.

4.3 Effects in a recession

To explore the effects of income inequality and migration on government spreads during a recession, I now analyze the impulse response functions (IRFs) of taxes and spreads to a negative productivity shock. I simulate 3000 paths for the model for 500 periods. From periods 1 to 400, the aggregate productivity shock follows its underlying Markov chain. In period 401, there is a 5 percent negative productivity shock. From period 401 on, the productivity shocks follow the conditional Markov process. The impulse responses plot the average, across the 3000 paths, of the variables.

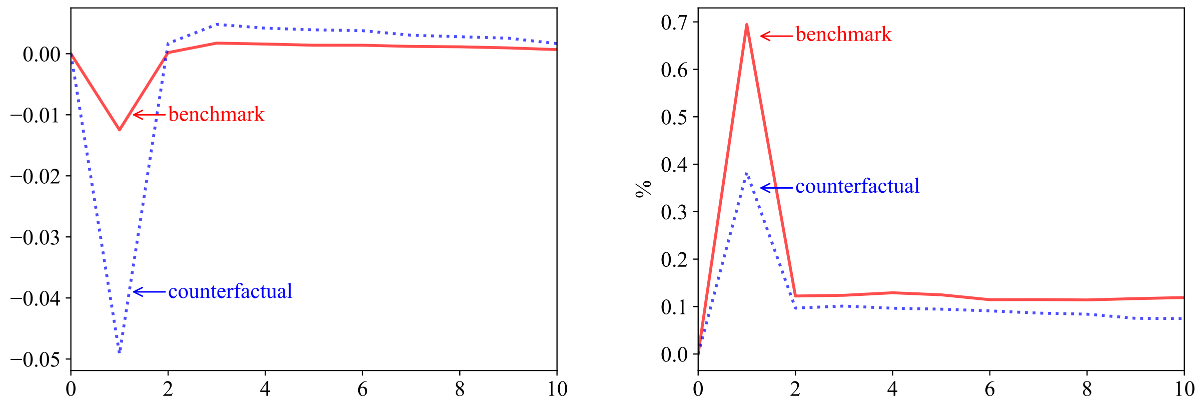
Figure 2 plots the IRFs for the benchmark model and the counterfactual case with no income inequality or labor mobility from period 400 to 410 (period 0 to 10 in the figure). Panel (a) plots for τ in the HSV tax/transfer function, and Panel (b) plots government spreads. The solid lines are for the benchmark model, and the dotted lines are for the counterfactual case. I normalize each series by its value in period 0.[26]

When there is a bad shock, government decreases tax progressivity τ to encourage labor supply. In the benchmark model, the government only decreases tax progressivity by 0.012, because the government values the redistribution benefit from a progressive tax. While in the counterfactual model, the government decreases tax progressivity by 0.05.[27] Although government decreases tax progressivity, spreads still go up (Panel (b)). This is because the productivity shock is negative and persistent. Lower productivity increases

[26] For example, the value for period 1 plots the value in period 1 minus the value in period 0.

[27] Note that taxation in the benchmark model has two purposes. One is income redistribution, and another is debt repayment. Thus, in the counterfactual case where there is no income inequality, the government still imposes taxes and decreases τ to increase labor supply.

the probability that the government will default. The spreads rise to compensate for the heightened default risk. In the counterfactual model, the spreads increase by 0.38%. For the benchmark economy, since the government cannot decrease tax progressivity to stimulate labor supply, as shown in Panel (a), the spreads increase by 0.7%.



(a) Tax τ

(b) Spreads

Figure 2: IRFs to a decline in productivity: role of inequality and migration

Note: Panel (a) and (b) plot for the responses of tax, τ, and spreads when there is a decline in productivity in period 1. The solid lines plot the benchmark model and the dotted lines plot a counterfactual model with no income inequality and labor mobility.

4.4 Redistribution preference

Empirical evidence shows that governments with stronger redistribution preferences are more likely to have higher spreads. Here I explore the effects of redistribution preferences in the model by varying the Pareto weights in the government social welfare function. Let the Pareto weights be $\omega_i = z_i^\eta / (\sum_I z_i^\eta)$, where $\eta = 0$ corresponds to equal weights in the social welfare function as in the benchmark model. Higher η represents a weaker redistribution preference.

Table 5 compares the statistics of model moments under different Pareto weights. With higher η, the government assigns lower weights to the low-income workers and imposes a less progressive tax (lower τ). A less progressive tax encourages labor supply and reduces the emigration rate of high-income workers. The emigration rate of low-income workers, however, increases. With higher labor supply and less emigration of high-income workers, the total output is larger. With a larger tax base, the government default risk falls, and the government spread declines.

Table 5: Experiments with Pareto weights

	tax prog. τ	labor supply	emig. rate ($i = L$)	emig. rate ($i = H$)	spread
$\eta = 0$	0.59	0.74	4.0%	2.8%	0.81%
$\eta = 0.4$	0.41	0.83	4.6%	2.4%	0.79%
$\eta = 0.7$	0.18	0.93	5.5%	2.1%	0.62%

Note: This table reports the results with Pareto weights. $\eta = 0$ is the benchmark model case. Higher η reflects a weaker government redistribution preference from the government. The numbers in the table are the averages from model simulations.

5 Conclusion

Income inequality affects fiscal policies dealing with taxation, government borrowings, and default. Empirical evidence shows that income inequality and migration play an important role in determining sovereign spreads, both across countries and U.S. states. This paper builds a sovereign default model with income inequality, migration, and endogenous taxation to capture and explain the interactions between taxation, debt, and income inequality.

With high inequality and strong preferences for redistribution, the government imposes progressive taxation, which distorts labor supply decisions and increases emigration of high-income workers, eroding the tax base. Facing a tradeoff between redistribution and low spreads, the government is more likely to choose redistribution over low spreads in an economy where inequality is a serious concern. Quantitatively, income inequality and its interactions with migration explain one-third of the average U.S. state government spreads.

The standard sovereign default literature usually assumes homogeneous agents and lump-sum transfers. Thus it is silent on the government's distributional incentives and their impact on government policies. Moreover, there are no distortions under lump-sum transfers, and default only involves wealth effects for domestic agents. By introducing heterogeneous workers and endogenous taxation, this paper provides a framework to consider inequality and a rich set of fiscal policies, including taxation, government borrowing, and default.

Additional fruitful research can be done. For example, the framework can be used to evaluate the welfare consequences of austerity plans during a debt crisis. The proponents of austerity argue that by reducing the government transfers, a country would have more capacity to repay its debt, reducing sovereign spreads and alleviating the debt crisis. On the other hand, the opponents of austerity argue that austerity hurts low-income workers and reduces equality. An interesting future step would be to address these two views with the model framework.

Finally, the connection between the sovereign debt crises and heterogeneous households is a major open question for macroeconomics. This paper helps to understand how income inequality constrains government policies, including taxation, borrowing, and default decisions. An important area for future work is understanding the details of the financial and fiscal links between sovereign debt crises and the labor market.

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Online Appendix to "Inequality, Taxation, and Sovereign Default Risk"

by Minjie Deng

A Data

A.1 Data sources

State government CDS spreads: Bloomberg.
State Gini index: U.S. Census Bureau and American Community Survey.
State party control: National Conference of State Legislatures.
State total output: U.S. Bureau of Economic Analysis.
State government debt: U.S. Census State Finances Dataset.
State-to-state migration: Internal Revenue Service Migration Dataset.
State government tax revenue: U.S. Census Bureau, "State and Local Government Finance".
Maximum state income tax rate: NBER's calculations using TAXSIM model, http://www.nber.org/~taxsim.
State unemployment rate: Local Area Unemployment Statistics.
State real personal income: Bureau of Economic Analysis.
State price parities: Bureau of Economic Analysis.
Country government bond spreads: OECD Database.
Country Gini index: World Income Inequality Database (WIID4).
Country income shares by quintile groups: World Income Inequality Database (WIID4).
Country debt-to-GDP ratio: central government debt as the percentage of GDP, IMF.

A.2 State-level Additional Results

Inequality, tax progressivity, and spreads. A novel mechanism in this paper that generates the positive correlation between spreads and income inequality is endogenous tax progressivity. Here I use state-level data to test the following two model predictions. First, with higher inequality, a government tends to impose a more progressive income tax system; and second, more progressive tax is associated with higher government spread.

The empirical specification that explores the relationship between tax progressivity and income inequality is as follows:

$$prog_{jt} = \beta_0 + \beta_1 ineq_{j,t-1} + \Gamma' Z_{j,t-1} + \alpha_t + \epsilon_{jt}, \tag{A.1}$$

where $prog_{jt}$ is income tax progressivity in state j in year t, which is proxied by maximum state income tax rate; $ineq_{j,t-1}$ is pre-tax income inequality proxied by Gini index for state j in year $t-1$; $Z_{j,t-1}$ is a vector of control variables, including state total output, debt-to-output ratio, and political party control of state legislatures. α_t is a time fixed effect. Data covers 49 states from 2006 to 2017.[28] Coefficient β_1 captures the correlation between income inequality and tax progressivity.

Table A.1 reports the result for regression (A.1), showing that a more unequal state tends to impose a more progressive income tax system. Also, the states with Democratic-controlled or Split-controlled legislatures are more likely to impose a more progressive tax than those with Republican-controlled legislatures.

Table A.1: Regression of tax progressivity on inequality

	(1)	(2)
Gini	26.78***	16.38*
	(7.64)	(8.33)
Political (="Split")		1.55***
		(0.47)
Political (="Democratic")		3.10***
		(0.36)
Year FE	Yes	Yes
Controls	Yes	Yes
N	408	392
R^2	0.05	0.20

Standard errors in parentheses
* p<.1, ** p<0.05, *** p<0.01

To explore the correlation between government bond spreads and tax progressivity, I use the following empirical specification:

$$spread_{jt} = \beta_0 + \beta_1 prog_{j,t-1} + \Gamma' Z_{j,t-1} + \alpha_t + \epsilon_{jt}, \tag{A.2}$$

where $spread_{jt}$ is CDS spread for state j in year t. Table A.2 shows the regression results.

[28] Nebraska does not have partisan composition (political party control of state legislatures) data since it is a non-partisan unicameral legislature. Thus, after merging the variables, the panel covers 49 states.

A more progressive tax is associated with higher government bond spreads. Since CDS spreads data is available for 19 states, the size of observation is smaller than that in regression (A.1).

Table A.2: Regression of spreads on tax progressivity

	(1)	(2)
Progressivity	0.03**	0.02**
	(0.01)	(0.01)
Political (="Split")		0.33**
		(0.16)
Political (="Democratic")		0.29**
		(0.11)
Year FE	Yes	Yes
Controls	Yes	Yes
N	109	109
R^2	0.55	0.58

Standard errors in parentheses

* p<.1, ** p<0.05, *** p<0.01

High-inequality states have larger transfers to low-income households. I classify 50 states into three groups according to their Gini index in 2016, and compare their spending on public welfare programs such as Medicaid and Temporary Assistance for Needy Families (TANF).[29] The three groups are classified as follows: *Low-inequality states* are Alaska, Utah, New Hampshire, Wyoming, Hawaii, Iowa, Nebraska, South Dakota, Minnesota, Wisconsin, Maryland, Idaho, Maine, Delaware, Indiana, North Dakota, and Vermont; *Middle-inequality states* are Kansas, Nevada, Oregon, Colorado, Washington, Oklahoma, Missouri, Montana, Ohio, Pennsylvania, Michigan, Virginia, West Virginia, Arizona, Arkansas, and South Carolina; *High-inequality states* are New Mexico, North Carolina, Rhode Island, Massachusetts, Tennessee, Texas, Illinois, Kentucky, New Jersey, Georgia, Mississippi, Alabama, Florida, California, Connecticut, Louisiana, and New York.

Table A.3 lists the mean and median level of total expenditures on Medicaid and TANF by inequality group. It shows that high-inequality states are more likely to spend more on Medicaid and TANF. To control for the fact that states are different in size, Table A.4 shows the ratio of total expenditures on Medicaid and TANF to total output. It shows that high-inequality states are still more likely to spend more on Medicaid and TANF relative

[29] I also classify 50 states into five groups, and also compare for different years. The pattern stays similar in both cases.

to their output.

Table A.3: Total expenditures on Medicaid and TANF (in billions)

	Medicaid		TANF	
Inequality groups	mean	median	mean	median
Low	3.05	1.65	0.16	0.08
Middle	7.24	5.02	0.42	0.27
High	15.73	8.80	1.08	0.49

Table A.4: Total expenditure on Medicaid and TANF over total output (%)

	Medicaid		TANF	
Inequality groups	mean	median	mean	median
Low	2.4	2.2	0.12	0.11
Middle	2.6	2.5	0.13	0.12
High	2.9	2.7	0.15	0.14

Not all funds for programs targeted of low-income households come from the state governments' pocket. Some programs, including TANF, Supplemental Security Income (SSI), and the Federal Low Income Home Energy Assistance Program, are mostly funded at the federal level. At the state level, health spending, and particularly payments to health providers through Medicaid, represents the largest share of state welfare costs. Expenditures primarily dedicated to low-income households are classified as "public welfare" on the government financial statements. The Census Bureau's classification of public welfare funding includes Medicaid, TANF, child welfare services, and a range of other assistance programs mostly for low-income individuals. According to data from the 2015 Annual Survey of State Government Finances, federal aid made up nearly two-thirds (64%) of states' public welfare general expenditures. Table A.5 shows total public welfare spending and the federal share. High-inequality states spend a lot more on public welfare than low-inequality states. The federal share, however, does not necessarily increase with the inequality level of the state. As a result, although the federal government helps to fund part of the spending, the states with high inequality still spend more on welfare programs relative to low-inequality states.

Income tax progressivity positively correlates with outward migration. Using state-to-state migration flows, I examine the effect of income tax progressivity on migration. The empirical specification is as follows:

$$\ln x_{ijt} = \beta_0 + \beta_1 \Delta \ln prog_{ijt} + \Gamma_1' \Delta \ln Z_{ijt} + \Gamma_2' \ln Z_{it} + \alpha_t + \alpha_i + \alpha_j + \epsilon_{ijt}, \tag{A.3}$$

Table A.5: Public welfare spending (in billions) and federal shares

	Public welfare spending		Federal share	
Inequality groups	mean	median	mean	median
Low	4.60	2.48	0.62	0.60
Middle	9.77	8.16	0.69	0.70
High	22.0	12.2	0.65	0.62

where x_{ijt} is the outflow from state i to state j in year t, $\Delta \ln prog_{ijt}$ is the gap between income tax progressivity in state i and state j. ΔZ_{ijt} is a vector of controls including the gap of unemployment rate ($\Delta \ln unemp$), real personal income ($\Delta \ln income$), regional price parities between state i and state j ($\Delta \ln price$), and the geographical distance between state i and j ($\ln distance$). Z_{it} includes the levels of the controls in the origin state (state i). α_t is a time fixed effect; α_i is the origin state fixed effect; and α_j is the destination state fixed effect. The sample covers 2009-2016. The coefficient β_1 estimates the effect of income tax progressivity on out-migration. Table A.6 reports the results for empirical specification (A.3), showing that people are likely to migrate to a state with lower income tax progressivity.

Table A.6: Regression of outflow on income tax progressivity

	(1)	(2)	(3)	(4)
$\Delta \ln prog$	0.275***	0.265***	0.252***	0.171***
	(0.04)	(0.03)	(0.03)	(0.05)
$\Delta \ln unemp$	-0.114***	-0.867***	-0.827***	0.080
	(0.04)	(0.05)	(0.04)	(0.05)
$\Delta \ln income$	0.830***	0.620***	0.722***	-1.238***
	(0.12)	(0.12)	(0.09)	(0.21)
$\Delta \ln price$	-4.420***	-4.023***	-4.137***	-2.488***
	(0.17)	(0.16)	(0.13)	(0.59)
$\ln distance$	-1.084***	-1.041***	-1.130***	-1.226***
	(0.02)	(0.02)	(0.01)	(0.01)
Level controls	Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes
Origin state FE			Yes	Yes
Destination state FE				Yes
N	12451	12451	12451	12451
R^2	0.363	0.405	0.648	0.928

Standard errors in parentheses

* p<.1, ** p<0.05, *** p<0.01

In summary, using state-level data, I find that 1) inequality positively correlates with income tax progressivity; 2) income tax progressivity positively correlates with government spreads; 3) high-inequality states have larger transfers to low-income households; and 4) income tax progressivity positively correlates with outward migration. Next I provide institutional details on the state government finances.

Balanced budget requirements. Balanced budget requirements typically only apply to states' operating budgets. Bond finance for capital projects generally does not fall within any constraints of a balanced budget requirement. Less attention (if any) is given to the question of whether a state's entire budget is in balance.[30] The details of balanced budget requirements vary across states, and political cultures reinforce the requirements.

State debt limits. States structure their debt limits very differently. For authorized debt, some states have quite a strict limit, for example, Georgia restricts less than 3.5% debt to personal income and less than $1200 in debt per capita as specified in the Debt Management Plan.[31] Some states have less restrictive debt limits. For example, the policy to limit authorized debt for Illinois is that a three-fifths vote of the legislature is required to increase the state debt limit. Out of 50 states, seven states do not have any debt limits (including authorized debt and debt service): Arkansas, California, Montana, New Hampshire, New Mexico, Oklahoma, and Oregon.

State tax and expenditure limits. Tax and expenditure limits (TELs) restrict the growth of government revenues or spending by either capping them at fixed-dollar amounts or limiting their growth rate to match increases in population, inflation, personal income, or some combination of those factors. Most states do not have a revenue limit.[32] About half of the states don't have a spending limit.[33]

[30]National Conference of State Legislatures Fiscal Brief, `https://docs.house.gov/meetings/JU/JU00/20170727/106327/HHRG-115-JU00-20170727-SD002.pdf`

[31]The Debt Management Plan is adopted by the Georgia State Financing and Investment Commission annually and sets target planning ratios for current and future debt for a five-year projection cycle.

[32]Only four states (Colorado, Florida, Michigan, Missouri) have a revenue limit. Florida, for instance, its revenue is limited to the average growth rate in state personal income for the previous five years. Source: National Association of State Budget Officers, "Budget Processes in the States," Spring 2015.

[33]States with no limits on spending: Alabama, Arkansas, Florida, Georgia, Illinois, Kansas, Kentucky, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Mexico, New York, North Dakota, Pennsylvania, South Dakota, Vermont, Virginia, West Virginia, Wisconsin, Wyoming. Source: National Association of State Budget Officers, "Budget Processes in the States," Spring 2015.

A.3 Cross-country Empirical Evidence

To explore the correlation between government spreads and income inequality across countries, I use the following empirical specification:

$$spread_{jt} = \beta_0 + \beta_1 ineq_{j,t-1} + \Gamma' Z_{j,t-1} + \alpha_t + \epsilon_{jt}, \tag{A.4}$$

where $spread_{jt}$ is the government bond spread of country j in period t. Spread here is defined as the 10-year government bond interest rate of country j in period t minus that of the U.S. for the same period; $ineq_{j,t-1}$ is the income inequality for country j in period $t-1$. Here I use two measures for income inequality: pre-tax Gini index and the gap between the income shares of top 20% and that of bottom 20%. $Z_{j,t-1}$ includes real per-capita GDP and debt-to-GDP ratio as controls. α_t is the time fixed effect. The panel covers 1960-2017 and contains 35 countries.[34]

Table A.7 shows the results of specification (A.4). Columns (1) and (2) use the Gini index as the measure of income inequality, and columns (3) and (4) use the gap between income share of the top 20% and that of the bottom 20% to measure inequality. The results show that high inequality is associated with high government default risk. Increasing the Gini index by 0.1 (e.g., Sweden to Portugal) is associated with government bond spread increases of about 0.5%.

B Model

B.1 Model Proofs

Here I prove some results in Section 3.4 including 1) the monotonicity of each term in (21) with respect to tax progressivity τ; and 2) default set is larger under higher inequality. I also show the equivalence of the transformed problem (in Section 3.5) and the original problem.

[34]Countries in the sample: Australia, Austria, Belgium, Canada, Switzerland, Chile, Colombia, Costa Rica, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, India, Ireland, Iceland, Israel, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovenia, Sweden, and South Africa.

Table A.7: Regression of government spreads on inequality (cross-country)

	(1)	(2)	(3)	(4)
Gini	12.29***	4.96***		
	(1.32)	(1.59)		
top-bottom-gap			11.96***	4.84***
			(1.34)	(1.53)
Year FE	Yes	Yes	Yes	Yes
Controls		Yes		Yes
N	688	540	604	486
R^2	0.30	0.48	0.31	0.47

Standard errors in parentheses

* p<.1, ** p<0.05, *** p<0.01

Note: This table reports regression results for the cross-country sample. Columns (1) and (2) report the results when using Gini index as measure for inequality; columns (3) and (4) use the gap between income shares of the top 20% and that of the bottom 20% as measure for inequality.

Monotonicity of each term in (21). Take derivatives for each term in the government repayment value (21) with respect to τ generates:

(i)

$$\frac{\partial \log(Y - B_0)}{\partial \tau} = -\frac{A\bar{z}\frac{1}{1+\gamma}(1-\tau)^{\frac{1}{1+\gamma}-1}}{A\bar{z}(1-\tau)^{\frac{1}{1+\gamma}} - B_0} < 0$$

(ii)

$$\frac{\partial \frac{1-\tau}{1+\gamma}}{\partial \tau} = -\frac{1}{1+\gamma} < 0$$

(iii)

$$\frac{\partial \frac{1}{2}\log[\alpha(1-\alpha)]}{\partial \tau} = \frac{1}{2}\frac{(z_H^{1-\tau} - z_L^{1-\tau})(\ln z_H - \ln z_L)}{z_L^{1-\tau} + z_H^{1-\tau}} > 0$$

Thus, in the repayment value function, total consumption is decreasing in τ, disutility from working is decreasing in τ, and redistribution is increasing in τ.

Default set is larger under higher inequality. The government's productivity threshold $\bar{A}$ that satisfies $V^d(A) = V^c(B_0, A)$ is given by:

$$\bar{A} = \frac{B_0}{\bar{z}(\ell - \Theta \ell^d)}$$

where

$$\Theta = \exp\left(-\frac{1}{2}\log\frac{\alpha(1-\alpha)}{\alpha^d(1-\alpha^d)} - \frac{\tau - \tau^d}{1+\gamma}\right),$$

and

$$\alpha \equiv \frac{(\bar{z}-\sigma_z)^{1-\tau}}{(\bar{z}-\sigma_z)^{1-\tau} + (\bar{z}+\sigma_z)^{1-\tau}},$$

$$\alpha^d \equiv \frac{(\bar{z}-\sigma_z)^{1-\tau^d}}{(\bar{z}-\sigma_z)^{1-\tau^d} + (\bar{z}+\sigma_z)^{1-\tau^d}}.$$

Since Θ is increasing in σ_z, we have $\frac{\partial \bar{A}}{\partial \sigma_z} > 0$. That is to say, higher inequality (a higher value for σ_z) would lead to a higher productivity threshold $\bar{A}$, and thus a larger default set. Alternatively, one can write down the borrowing threshold and show that a higher σ_z leads to a lower borrowing threshold $\bar{B}_0$.

Derivation of "Θ is increasing in σ_z" is as follows:

Take the derivative of Θ with respect to σ_z:

$$\frac{\partial \Theta}{\partial \sigma_z} = \Theta \frac{\partial\left[-\frac{1}{2}\log\frac{\alpha(1-\alpha)}{\alpha^d(1-\alpha^d)}\right]}{\partial \sigma_z},$$

where

$$\frac{\alpha(1-\alpha)}{\alpha^d(1-\alpha^d)} = \left[(\bar{z}-\sigma_z)(\bar{z}+\sigma_z)\right]^{\tau^d-\tau}\left[\frac{(\bar{z}-\sigma_z)^{1-\tau^d} + (\bar{z}+\sigma_z)^{1-\tau^d}}{(\bar{z}-\sigma_z)^{1-\tau} + (\bar{z}+\sigma_z)^{1-\tau}}\right]^2,$$

then

$$\frac{\partial \Theta}{\partial \sigma_z} = \frac{\Theta\,\bar{z}}{\ln(10)(\bar{z}-\sigma_z)(\bar{z}+\sigma_z)}\left[(1-\tau)\frac{(\bar{z}+\sigma_z)^{1-\tau} - (\bar{z}-\sigma_z)^{1-\tau}}{(\bar{z}+\sigma_z)^{1-\tau} + (\bar{z}-\sigma_z)^{1-\tau}} - (1-\tau^d)\frac{(\bar{z}+\sigma_z)^{1-\tau^d} - (\bar{z}-\sigma_z)^{1-\tau^d}}{(\bar{z}+\sigma_z)^{1-\tau^d} + (\bar{z}-\sigma_z)^{1-\tau^d}}\right]$$

Since $f(\tau) = (1-\tau)\frac{(\bar{z}+\sigma_z)^{1-\tau} - (\bar{z}-\sigma_z)^{1-\tau}}{(\bar{z}+\sigma_z)^{1-\tau} + (\bar{z}-\sigma_z)^{1-\tau}}$ is decreasing in τ and $\tau^d > \tau$, we have:

$$\frac{\partial \Theta}{\partial \sigma_z} = \frac{\Theta\,\bar{z}}{\ln(10)(\bar{z}-\sigma_z)(\bar{z}+\sigma_z)}\left[(1-\tau)\frac{(\bar{z}+\sigma_z)^{1-\tau} - (\bar{z}-\sigma_z)^{1-\tau}}{(\bar{z}+\sigma_z)^{1-\tau} + (\bar{z}-\sigma_z)^{1-\tau}} - (1-\tau^d)\frac{(\bar{z}+\sigma_z)^{1-\tau^d} - (\bar{z}-\sigma_z)^{1-\tau^d}}{(\bar{z}+\sigma_z)^{1-\tau^d} + (\bar{z}-\sigma_z)^{1-\tau^d}}\right] > 0.$$

Equivalence of the transformed problem and the original problem. The following relations hold:

$$W^s(S,z) = W^s(s,z),$$

$$W(S,z,\delta) = W(s,z,\delta),$$

$$g_i(S) = g_i(s) = N_i'/N_i = e^{-\zeta(z_i)(W^m - W^s(s,z_i))} \; (i = L, H),$$

$$\frac{N'}{N} = \frac{N_L' + N_H'}{N_L + N_H} = g_L(s)\, f + g_H(s)\, (1-f),$$

$$f' = \frac{N_L'}{N'} = \frac{N_L'}{N_L} \frac{N_L}{N} \frac{N}{N'} = \frac{g_L(s)\, f}{g_L(s)\, f + g_H(s)\, (1-f)},$$

$$\frac{B'}{N} = \frac{B'}{N'} \frac{N'}{N} = b' \frac{N'}{N} = b' \left[g_L(s)\, f + g_H(s)\, (1-f)\right],$$

$$\frac{V(B,A,\Phi')}{N} = v(b,A,f'),$$

$$\frac{V^c(B,A,\Phi')}{N} = v^c(b,A,f'),$$

$$\frac{V^d(A,\Phi')}{N} = v^d(A,f').$$

In the original problem, the government chooses whether to repay or default:

$$V(B,A,\Phi') = \max\{V^c(B,A,\Phi'), V^d(A,\Phi')\}$$

Divide both sides of the default decision by N:

$$\frac{V(B,A,\Phi')}{N} = \max\{\frac{V^c(B,A,\Phi')}{N}, \frac{V^d(A,\Phi')}{N}\},$$

which implies

$$v(b,A,f') = \max\{v^c(b,A,f'), v^d(A,f')\}.$$

Thus the default decisions satisfy

$$D(B,A,\Phi') = d(b,A,f').$$

Let the default decision be $d(b, A, f') = 1$ if $v^c(b, A, f') < v^d(A, f')$. Thus, for the bond price, we have:

$$
\begin{aligned}
q(B', A, \Phi') &= \frac{1 - Pr[D(B', A', \Phi'')]}{1+r} \\
&= \frac{1 - Pr[d(b', A', f'')]}{1+r} \\
&= q(b', A, f').
\end{aligned}
$$

Now I derive the repayment value in the transformed problem. The repayment value function in the original problem is:

$$
V^c(B, A, \Phi') = \max_{B',\tau,\lambda} \{u(c_L, \ell_L) N'_L \omega_L + u(c_H, \ell_H) N'_H \omega_H + \beta \mathbb{E} V(B', A', \Phi'')\}.
$$

Divide both sides by N:

$$
\begin{aligned}
\frac{V^c(B, A, \Phi')}{N} &= \max_{B',\tau,\lambda} \{u(c_L, \ell_L) \frac{N'_L}{N_L} \frac{N_L}{N} \omega_L + u(c_H, \ell_H) \frac{N'_H}{N_H} \frac{N_H}{N} \omega_H + \beta \frac{N'}{N} \frac{1}{N'} \mathbb{E} V(B', A', \Phi'')\} \\
&= \max_{B',\tau,\lambda} \{u(c_L, \ell_L) g_L f \omega_L + u(c_H, \ell_H) g_H (1-f) \omega_H \\
&+ \beta (f g_L + (1-f) g_H) \frac{1}{N'} \mathbb{E} V(B', A', \Phi'')\},
\end{aligned}
$$

which gives

$$
\begin{aligned}
v^c(b, A, f') = \max_{b',\tau,\lambda} \{ & g_L\, f\, u(c_L, \ell_L)\omega_L + g_H\,(1-f)\, u(c_H, \ell_H)\omega_H \\
& + \beta\, [g_L\, f + g_H\,(1-f)]\, \mathbb{E} v(b', A', f'')\},
\end{aligned}
$$

The budget constraint in the original problem is:

$$
B \leq T + qB'.
$$

Divide both sides by N:

$$
\frac{B}{N} \leq \frac{N'_L}{N_L} \frac{N_L}{N} (y_L - c_L) + \frac{N'_H}{n_H} \frac{N_H}{N} (y_H - c_H) + q \frac{B'}{N'} \frac{N'}{N},
$$

which gives

$$
b \leq g_L\, f\, (y_L - c_L) + g_H\, (1-f)\, (y_H - c_H) + [g_L\, f + g_H\, (1-f)]\, q(b', A, f') b'.
$$

The derivation of the defaulting value function in the transformed problem follows similar steps. The defaulting value function in the original problem is:

$$V^d(A,\Phi') = \max_{\tau,\lambda}\{u(c_L^d,\ell_L^d)N_L'\omega_L + u(c_H^d,\ell_H^d)N_H'\omega_H + \beta[\theta\mathbb{E}V(0,A',\Phi''_{aut=0}) + (1-\theta)\mathbb{E}V^d(A',\Phi''_{aut=1})]\}$$

Divide both sides by N:

$$\begin{aligned}
\frac{V^d(A,\Phi')}{N} &= \max_{\tau,\lambda}\{u(c_L^d,\ell_L^d)\frac{N_L'}{N_L}\frac{N_L}{N}\omega_L + u(c_H^d,\ell_H^d)\frac{N_H'}{N_H}\frac{N_H}{N}\omega_H \\
&+ \beta[\theta\frac{N'}{N}\frac{1}{N'}\mathbb{E}V(0,A',\Phi''_{aut=0}) + (1-\theta)\frac{N'}{N}\frac{1}{N'}\mathbb{E}V^d(A',\Phi''_{aut=1})]\} \\
&= \max_{\tau,\lambda}\{u(c_L^d,\ell_L^d)g_L f\omega_L + u(c_H^d,\ell_H^d)g_H(1-f)\omega_H \\
&+ \beta[\theta\mathbb{E}v(0,A',f''_{aut=0}) + (1-\theta)\mathbb{E}v^d(A',f''_{aut=1})][fg_L + (1-f)g_H]\}
\end{aligned}$$

which gives

$$\begin{aligned}
v^d(A,f') = \max_{\tau,\lambda}\{&g_L\, f\, u(c_L^d,\ell_L^d)\omega_L + g_H\,(1-f)\,u(c_H^d,\ell_H^d)\omega_H \\
&+ \beta\,[g_L\, f + g_H\,(1-f)]\,[\theta\mathbb{E}v(0,A',f''_{aut=0}) + (1-\theta)\mathbb{E}v^d(A',f''_{aut=1})]\}.
\end{aligned}$$

The budget constraint under default in the original problem is:

$$0 \leq T.$$

Divide both sides by N:

$$0 \leq \frac{N_L'}{N_L}\frac{N_L}{N}(y_L - c_L) + \frac{N_H'}{N_H}\frac{N_H}{N}(y_H - c_H),$$

which gives

$$0 \leq g_L\, f\,(y_L - c_L) + g_H\,(1-f)\,(y_H - c_H).$$

B.2 CRRA utility

I derive the optimal labor supply choices under a constant relative risk aversion (CRRA) utility function and shows that the main results stay unchanged. Assume the utility of household i is given by:

$$u(c_i, \ell_i) = \frac{c_i^{1-\sigma}}{1-\sigma} - \frac{\ell_i^{1+\gamma}}{1+\gamma},$$

where σ is the parameter for risk aversion ($\sigma = 1$ gives logarithmic utility). The optimal choice of labor supply for household i satisfies:

$$\ell_i^{\sigma-\tau\sigma+\tau+\gamma} = (1-\tau)\lambda^{1-\sigma}(wz_i)^{1-\sigma+\tau\sigma-\tau}.$$

To illustrate, I calculate the optimal labor supply and λ under the following set of parameters: $A = 1$, $z_L = 0.3$, $z_H = 0.7$, and $\sigma = 2$. Then I calculate and plot the social welfare functions under different τ. The optimal solutions that maximize the value function are characterized by three unknowns ℓ_L, ℓ_H, and λ and three nonlinear equations:

$$\ell_L^{\sigma-\tau\sigma+\tau+\gamma} - (1-\tau)\lambda^{1-\sigma}(wz_L)^{1-\sigma+\tau\sigma-\tau} = 0,$$

$$\ell_H^{\sigma-\tau\sigma+\tau+\gamma} - (1-\tau)\lambda^{1-\sigma}(wz_H)^{1-\sigma+\tau\sigma-\tau} = 0,$$

$$\lambda - \frac{wz_L\ell_L + wz_H\ell_H - B_0}{(wz_L\ell_L)^{1-\tau} + (wz_H\ell_H)^{1-\tau}} = 0.$$

With $\{\ell_L^*, \ell_H^*, \lambda^*\}$, it is easy to solve for output, tax revenue, and consumption. Given consumption and labor choices, I calculate and plot social welfare under different scenarios.

Figure B.1 plots the social welfare as a function of tax progressivity τ. The blue dashed line plots for the scenario with $z_L = 0.5$ and $z_H = 0.5$ (no inequality). The comparison between the solid line with inequality and the dashed line without inequality shows that inequality increases the optimal tax progressivity. When the government chooses to default, it can achieve a larger τ^*, as shown in Figure B.2. Those results are consistent with the predictions under logarithmic utility.

Recall that with logarithmic utility, tax progressivity τ discourages labor. Figure B.3 shows that it is still the case with CRRA utility. The yellow dashed line plots for the total effective labor. The total effective labor is decreasing in tax progressivity τ, and thus the total output is decreasing in tax progressivity τ.

Figure B.4 plots for tax revenues collected from different workers and relative consumption as a function of τ. With a more progressive tax, low-income workers pay less tax, high-income workers pay more tax, and the relative consumption of low-income workers to that of high-income workers increases.

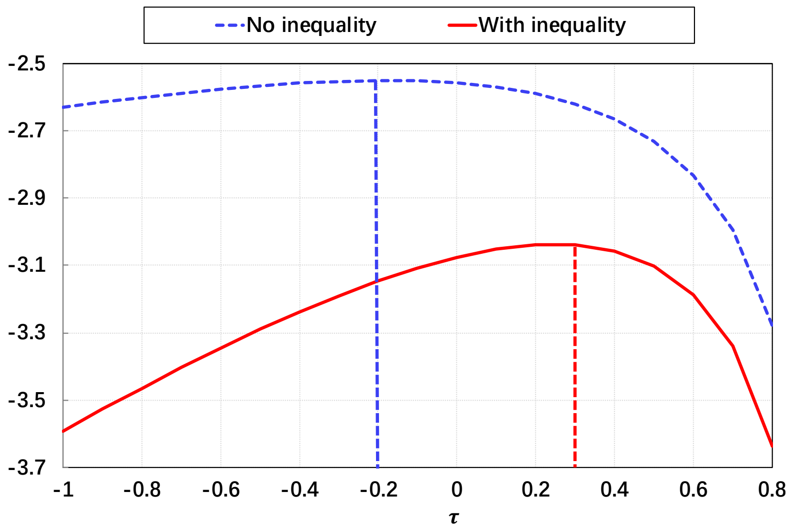

Figure B.1: CRRA utility: inequality and optimal tax progressivity

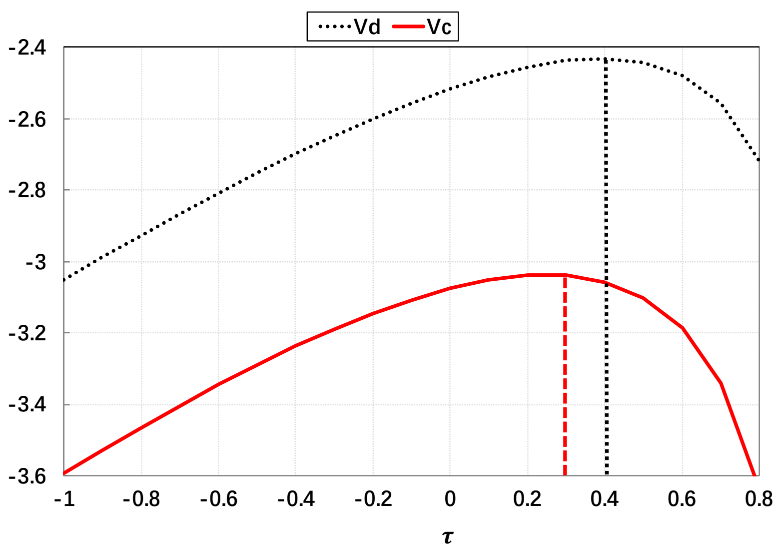

Figure B.2: CRRA utility: default and optimal tax progressivity

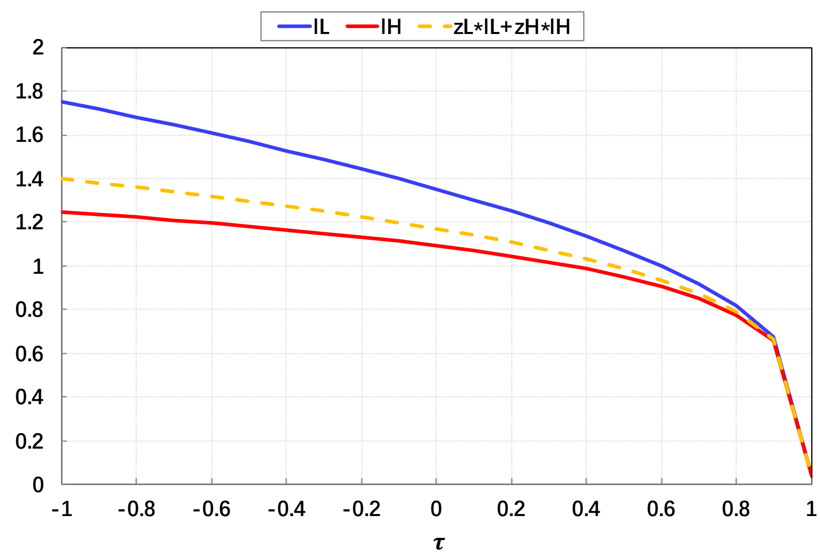

Figure B.3: CRRA utility: labor supply and tax progressivity

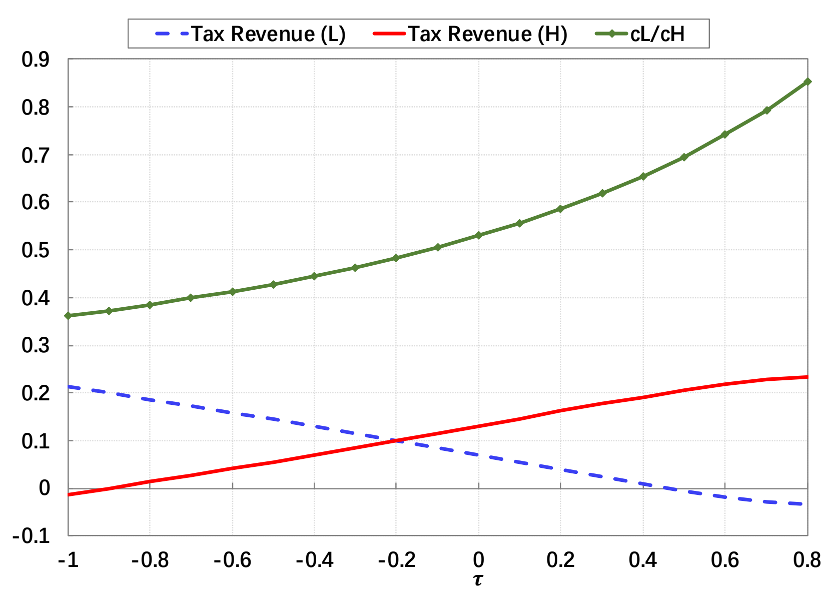

Figure B.4: CRRA utility: tax revenue, relative consumption, and tax progressivity

B.3 Frisch Elasticity

The elasticity of labor supply determines the response of labor supply to changes in the tax and determines the degree of distortions that taxation introduce. The value of this elasticity, however, is well known to be controversial. On the one hand, researchers who look at micro data typically estimate relatively small labor supply elasticities, while on the other hand, researchers who use representative agent models to study aggregate outcomes typically employ parameterizations that imply relatively large aggregate labor supply elasticities. In the benchmark model, I choose the Frisch elasticity to be 0.5 ($\gamma = 2$), which is consistent with micro data. I also explore the model outcomes with alternative Frisch elasticities. Given inequality level (Gini index = 0.46) and redistribution preference ($\eta = 0.7$)[35], Table B.8 reports the average of key variables from 3,000 simulations with alternative values for Frisch elasticities. With higher Frisch elasticity, the equilibrium tax progressivity is lower. The magnitude of the changes, however, is not very large.

Table B.8: Experiments with alternative Frisch elasticity $(1/\gamma)$

	tax prog. τ	labor supply	emig. rate ($i = L$)	emig. rate ($i = H$)	spread
γ = 2	0.18	0.93	5.52%	2.07%	0.62%
γ = 1	0.15	0.92	5.89%	2.53%	0.66%
γ = 0.5	0.13	0.91	6.21%	2.98%	0.76%

B.4 Solution Method

I compute the problems of the government and workers using value function iteration. The AR(1) process for aggregate productivity shock A is discretized using 21 equally spaced grid points with Tauchen's method. The government makes a borrowing decision b' and tax progressivity choice τ if not in default, but makes only a tax progressivity choice τ if in default (λ will be determined by the government budget constraint). For government bond, I use a grid with 120 equally spaced points on $b \in [0, 0.3]$. For tax progressivity, I use a grid with 120 equally spaced points on $\tau \in [-0.6, 0.6]$. For the fraction of low-income workers f, I use a grid with 11 equally spaced points on $f \in [0, 1]$. Given optimal government policies,

[35] Heathcote, Storesletten, and Violante (2017) estimates that the current income tax progressivity in the U.S. is $\tau = 0.181$, which corresponds to $\eta = 0.7$ in this model. I also compare the outcomes with alternative Frisch elasticities under different values of η. The results are available upon request.

workers determine whether to migrate or not. The staying workers choose labor supply and consumption to maximize lifetime utility. Given the workers' choices, the government updates the repayment value and default value, and decides whether to default. For each iteration, we update the value of the government and the value of each type of worker. The code stops running when the value function of the government and the value function for each type of worker converge.

Here is a more detailed description of the algorithm:

1. Create grids and discretize Markov process for productivity shock A. Create grids for government bond b, tax progressivity τ, and fraction of low-income workers f.
2. Guess initial value function of government $v_0(b, A, f)$ and bond price function $q_0(b, A, f)$; guess the initial value functions for workers $W_0(b, A, f, aut, z)$.
3. Update the repayment value $v^c(b, A, f)$ and the default value $v^d(A, f)$.
4. Compare $v^c(b, A, f)$ and $v^d(A, f)$, update the defaulting rule, price function, and the value function of the government $v(b, A, f)$.
5. Compute the optimal policy of the government with and without access to the credit market. With access to the financial market, the optimal policies including borrowing $b'(b, A, f)$ and taxation $\tau(b, A, f), \lambda(b, A, f)$; without access to the financial market, the optimal policy includes taxation $\{\tau(A, f), \lambda(A, f)\}$.
6. Given government policies, update the staying value for workers $W^s(b, A, f, aut, z)$.
7. Update workers' value $W(b, A, f, aut, z)$.
8. Check the distance $dist_g$ between the updated value function of the government and the one from the last iteration, the distance $dist_i$ between the updated value function of worker i and the one from last iteration. If any of these distances are larger than tolerance, then go back to 3. Otherwise, stop.