Autocracies, Infrastructure, and Credit Spreads *

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Abstract

We examine the role of autocratic restrictions on property rights in explaining debt financing of infrastructure and the associated credit spreads. We focus on two autocratic powers; the ability to restrict out-migration and the ability to expropriate output. We show how these two restrictions provide a deeper basis for the 'democracy advantage,' the claim that democracies obtain better financing terms than autocracies. We show theoretically and empirically that restrictions on migration enhance debt repayment, increase the degree to which infrastructure is debt financed, and reduce credit spreads while the ability to expropriate wealth has the opposite affect.

JEL Codes: G10, G18

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1 Introduction

What determines a government's ability to credibly repay its debt? A large literature has documented that democracies often benefit from a "democracy advantage" in credit markets, grounded in stronger institutional checks and balances. These institutions are thought to enhance repayment credibility and reduce the required yield on sovereign debt. However, the relationship between regime type and credit spreads is not one-to-one. Countries with similar democratic institutions sometimes face markedly different borrowing costs. For example, India and Mexico have comparable democracy scores and yet Mexico's sovereign credit spreads are approximately twice as high as that of India's, and this despite Mexico scoring more highly on the UN's human development score. These differences may stem not just from variation in institutional quality or macroeconomic fundamentals, but from specific state capabilities that affect a government's capacity to manage economic shocks and enforce repayment. For example, the ability to retain a productive tax base during downturns or to divert economic output toward debt repayment—whether through formal institutions or coercive means—can meaningfully influence investor perceptions of sovereign risk.

This perspective highlights the importance of looking beyond broad regime classifications like "democracy" or "autocracy" and instead focusing on the mechanisms that determine a state's effective ability to repay. In this regard, the degree of protection of property rights is critical to the ability of the regime to support economic activity.[1]

In this paper, we examine how two distinct forms of state restrictions on property rights, the ability to restrict emigration and the ability expropriate output, affect sovereign financing and credit spreads, especially in the context of infrastructure investment. Intuitively, the two-edged debt repayment sword that we examine has the ability to keep citizens from leaving when debt repayment is difficult versus their ability to take output away from

[1]There is a large literature on the importance of property rights to general economic development. See Besley and Ghatak (2010), for example.

debt payment and towards the autocrat's personal consumption. Our study provides new insights into the determinants of the so-called 'democracy advantage,' the conjecture that democratic countries are able to finance investment at a lower yields than autocratic countries. We identify forces that can turn the autocratic disadvantage into an advantage. In this way we are delving into some of the possible reasons why democracies are not always associated with higher economic growth.[2]

In addressing the link between autocracy and sovereign debt financing we bring together four somewhat distinct literatures. One literature ponders the ability of democracy to support government commitments to repay debt. The notion that democratic institutions support commitment that is valued in financial markets has a long history. North and Weingast (1989) studied England following the 'Glorious Revolution of 1688' and concluded that the ability of democratic institutions to enforce property rights is "... remarkable, as evidence from the capital market shows." Although the actual source of the advantage is subject to debate it does seem that protection of property rights helped support investment and growth[3]. On the other hand, Hansen (2023) argues that the democratic advantage can turn into a disadvantage if a country finds itself in a vulnerable position, as measured by foreign reserves relative to external debt. He argues that, while democracies may be more committed to honoring debt contracts, they are also more cumbersome in responding to financial crises. He also presents evidence that vulnerable democratic countries face higher spreads and are more likely to default than their more autocratic counterparts. We suggest that restricting emigration is an alternative mechanism by which non-democratic countries enhance repayment commitment.

A second literature identifies the importance of net migration in repaying debt. Alessandria, Bai, and Deng (2020) highlight the importance of net migration for economic activity, investment, and default. A shock that makes a country more likely to default on existing

[2]See Gerring, Bond, Brandt, and Moreno (2005) for a nice summary of literature on democracy and economic growth.

[3]See Acemoglu, Naidu, Restrepo, and Robinson (2019) for a nice summary of the debate

debt may prompt labor to migrate from the country, reducing the productive labor force and the tax base and thereby exacerbating the initial shock. Anticipation of out-migration might reduce investment, impeding productivity, and thereby increasing the chances of default. We continue this line of research by considering how autocratic restrictions on migration would affect economic activity and financing.

A third literature examines the extent to which autocrats manage out-migration as a political tool. Miller and Peters (2018), for instance, conclude that "...autocrats determine emigration policy strategically, encouraging emigration when it aids their survival but restricting it otherwise." The focus of that literature is on political ideology, while we use similar measures of property right restrictions to explain debt financing of infrastructure investment.

A fourth literature examines the relationship of the ability of a government to expropriate output and the resulting nature of infrastructre financing. Acharya, Parlatore, and Sundaresan (2025) consider the double sided moral hazard that arises when public infrastructure requires private management. In such cases governements must provide incentive to the private sector to implement and/or manage infrastructure optimally while recognizing their own incentive to expropriate the resulting output. Acharya, Rajan, and Shim (2024) and Acharya and Rajan (2025) study how a myopic and self-interested government may actually be incentivized not to default on sovereign debt in order to preserve the ability to maintain financing and consume output in the future. We examine the importance of expropriation but have autocrats who are not myopic and reduce debt repayment through expropriation.

Our theoretical analysis is similar to Arellano (2008) and Alessandria, Bai, and Deng (2020), who model sovereign default and economic activity, to which we add three important dimensions. First, we characterize autocratic regimes in terms of the flexibility of net migration with more autocratic regimes associated with less responsive net migration. Autocrats make it more difficult for tax payers/productive labor to leave in the face of negative output shocks or increases in taxation. Second, we allow autocrats to expropriate output even though such expropriation would encourage out-migration by reducing consumption by citizens. The ability to expropriate is dampened by the assumption that the probability of being forced out of office increases with expropriation. Finally, we show that, tax sensitive out-migration implies that, although governments have the ability to tax, that does not mean they have the ability to repay debt even if there is a political will to do so. Indeed, we identify the extent to which emigration can impose a non–strategic cap on the ability of a sovereign to repay debt, something we refer to as the country's debt capacity. The intuition here is that if creditors demanded higher taxation to repay sovereign debt, current citizens might find it advantageous to emigrate. Hence, total tax revenue can decline with higher tax rates. This is effectively a sovereign debt overhang problem. We show that the autocrat's ability to restrict out-migration dampens the net migration elasticity thereby implying a higher debt capacity.

By explicitly recognizing the ability to pay and relating it to default, we add to the long literature that has viewed default as primarily a strategic decision by sovereign nations, as in Eaton and Gersovitz (1981). Our recognition of a country's debt capacity captures changes that have occurred in the sovereign debt markets that have led to a more active role for the IMF.[4] This added dimension of sovereign debt default has empirical implications in that estimates of tax base migration sensitivity and the ability of governments to manage the sensitivities can help explain cross-sectional differences in sovereign debt capacity and their implications for credit spreads.

Our empirical results provide robust support for the theoretical model. We confirm that restrictions on emigration particularly reduce sovereign spreads during economic contractions, consistent with the model's prediction that credit spread sensitivity to economic shocks is dampened for autocracies with higher migration costs. Similarly, the positive

[4] See Diaz-Cassou, Rice-Dominguez, and Vasquez-Zamora (2008b) for a history of the change in lending and Diaz-Cassou, Rice-Dominguez, and Vasquez-Zamora (2008a) for case studies of IMF involvement.

and significant coefficient on expropriation risk confirms the prediction that credit spreads increase with expropriation risk. These findings demonstrate that autocratic powers have differential effects on sovereign risk: emigration restrictions enhance repayment commitment and reduce spreads during downturns, while expropriation power undermines this commitment and increases spreads.

To illustrate the importance of our insight in understanding spreads and returning to the example of India and Mexico, although the two countries are both considered democracies and have other similarities, our measure of the restrictions on migration are lower for Mexico while our measure of expropriation risk is higher, consistent with the higher spreads that Mexico pays.

The remainder of our paper is structured as follows. In section 2 we set out our basic theoretical model. In section 3 we examine a simplified version of the model for closed form solutions and empirical predictions. In section 4 we relax the restrictions of section 3 and solve the model numerically. We first confirm that the empirical implications of our simplified model hold and then derive additional empirical implications. We present empirical evidence to support our model in section 5

2 Model

We consider a country that consists of a single autocrat and L_t citizens who form the tax base/labour force of the economy. In addition there is a foreign, competitive, risk neutral financial market (FM) willing to purchase sovereign debt provided the debt has an expected return equal to the world interest rate r. For convenience we assume $r = 0$. The model has three points in time, t_0, t_1, and t_2. We study the autocrat's problem of financing long-lived infrastructure with a mix of debt and taxes, i.e. the country's capital structure problem[5] The structure of our model is presented in Figure 1.

[5] Here we have a narrow definition of capital structure in terms of real quantities. See Bolton and Huang (2018) for a broader definition of capital structure based on monetary quantities.

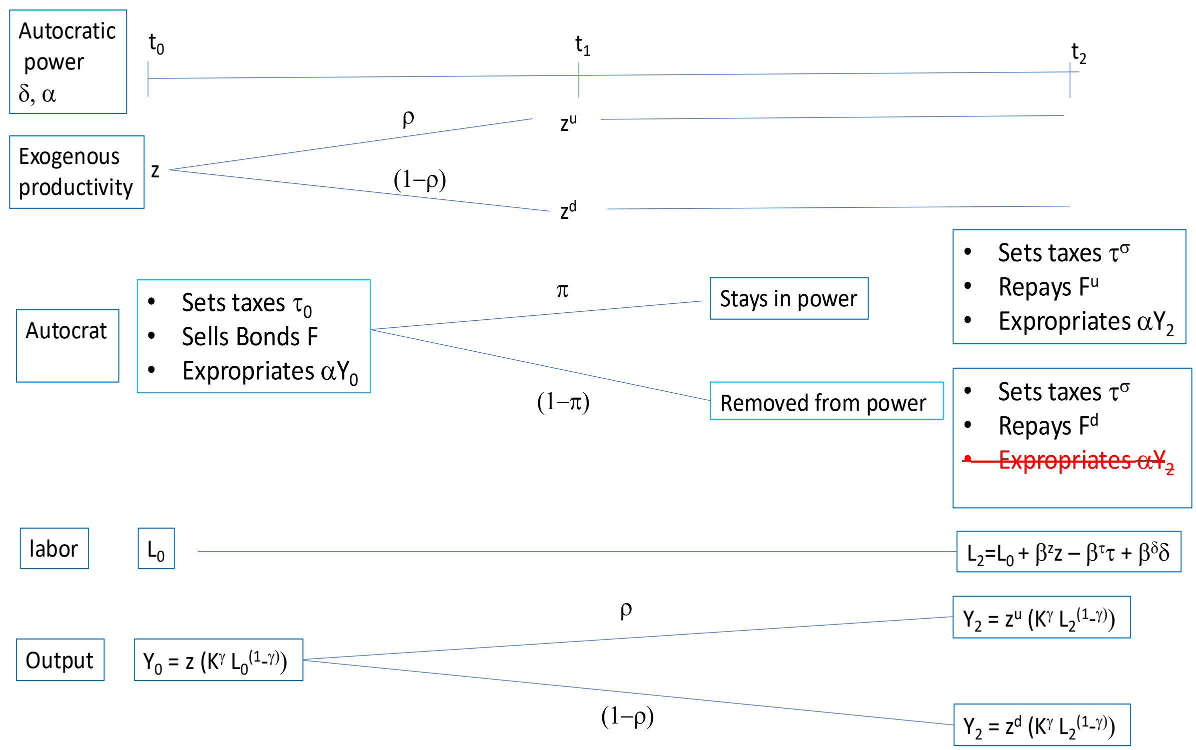

Figure 1: **Timeline**

2.1 Production

At each production period, t_0 and t_2, the country's total output, Y_t, is determined by the stock of infrastructure, K, the quantity of homogeneous labor, L_t, and productivity z_t according to

$$Y_t = z_t(K^\gamma L_t^{1-\gamma}). \tag{1}$$

The main source of risk in our model is a shock to productivity that occurs at t_1. To simplify, from an initial productivity of z we assume a binomial shock to total factor productivity at t_1 resulting in $z^\sigma, \sigma \in \{u, d\}, z^u > z^d$. That is, at t_1 initial productivity, z, either increases to z^u or decreases to z^d and persists at that level until production takes place at t_2. We assume z^u is realized with probability ρ and z^d with probability $1 - \rho$.

For convenience, when the context makes it clear we suppress the second period time subscript and use only the state as the identifier. That is, for example, Y_2 in state σ may be denoted by Y_σ instead of Y_σ^2.

2.2 Agents

All agents in our economy are risk neutral.

2.2.1 The Autocrat

The production function is managed by an autocrat who must finance capital K with taxes and debt. Additionally, the autocrat indirectly affects the size of the labor pool through the autocratic power she has and the choices she makes. In particular, in addition to the ability to set taxes and issue debt, the autocrat has power in the form of

- a cost imposed on those who want to leave the courntry, denoted δ, and
- an ability to expropriate a percentage of aggregate output, α, that is consumed by the autorcrat.

The autocratic environment prevails through t_2 unless the autocrat is removed from power. The removal from power happens at t_2 after taxation decisions are made but before the autocrat is able to consume the expropriated output. National output is not affected by the removal of the autocrat and the only change is that output that would have been expropriated is redistributed, tax free[6], equally to all citizens. Let $h \in \{0, 1\}$ be an indicator with $h = 1$ indicating the autocrat remains in power at t_2 and $h = 0$ indicating she is removed from power. Assume $h \sim (\pi(\alpha, \delta), \sigma_h)$, with $\frac{\partial \pi}{\partial \alpha} > 0$ and $\frac{\partial \pi}{\partial \delta} > 0$. That is the probability of being removed from power at t_2 increases with the degree of autocratic power that exists.

Autocrat's Actions

The following actions are taken by the autocrat at t_0 and t_2.

[6] The tax free assumption is for convenience in that it keeps total tax revenue independent of whether or not the autocrat has been removed from power.

- At t_0 the autocrat finances an exogneous level of long lived capital, K by setting taxes and selling sovereign debt. Capital is put in place at t_0 and lasts without depreciating until t_2.
  - Total tax revenue is determined by setting the income tax rate of τ_0 thereby generating total tax revenue of

$$TR_0 = \tau_0(1-\alpha)Y_0.$$

    Note that taxation is applied to the output that is not expropriated.
  - Sovereign debt financing involves selling a contract at t_0 for a price of D that promises to repay F at t_2. Although the promise is to repay an unconditional amount F, investors rationally expect that the amount actually paid will depend on the state at t_2. We denote the state dependent, expected, t_2 payments by F^σ. The determination of F^σ is discussed in more detail in section 2.3.1

  Hence, the autocrat faces a t_0 cash flow constraint

$$TR_0 \geq K - D. \tag{2}$$

- At t_2, conditional on the productivity shock σ the autocrat;
  - sets a tax rate t^σ to generate total tax revenue $TR^\sigma = \tau^\sigma(1-\alpha)Y_\sigma$ and
  - conditional on remaining in power, i.e. $h = 1$, expropriates α of Y_σ,

The cash flow constraint at t_2 is

$$TR^\sigma = F^\sigma. \tag{3}$$

2.2.2 Citizens

The L_t citizens in our model combine with capital to produce output and pay taxes set by the autocrat.

At the core of our model is the notion that output depends on the labor force while the labor force depends on the autocrat's policies. To capture this dependence, we assume that the initial labor force N_0 is exogenous and is augmented by net migration, ν_0 to produce total t_0 population of $L_0 = N_0 + \nu_0$. In each period, net migration depends on economic productivity, taxes and the costs of migrating, δ. We simplify by using the following reduced form of the net migration function.

$$\nu_t = \beta^z z_t - \beta^\tau \tau_t + \beta^\delta \delta$$

Hence the population increases with aggregate productivity, decreases with taxes and increases with restrictions imposed on migration.

Therefore,

$$L_0 = N_0 + \beta^z z - \beta^\tau \tau_0 + \beta^\delta \delta$$

The second period labor force is equal to L_0 plus net migration ν^σ, i.e.

$$L^\sigma = L_0 + \beta^z z^\sigma - \beta^\tau \tau^\sigma + \beta^\delta \delta. \tag{4}$$

Citizen's Utility

The utility of each citizen depends on whether or not the autocrat remains in power. If the autocrat remains in power at t_2, then in each period she expropriates and consumes αY_t, sets tax rates and, hence, tax revenue of TR_t, and distributes the remainder $(1-\alpha)Y_t - TR_t$ equally to each citizen.[7] That is, each citizen receives private consumption of

[7]This allows us to ignore the domestic capital market where different agents would have different portfolios of claims on aggregate output.

$$c_t = \frac{(1-\alpha)Y_t - TR_t}{L_t} = (1-\alpha)(1-\tau_t)\frac{Y_t}{L_t}. \tag{5}$$

In the event that the autocrat is removed from power, the only change is that citizen consumption in the second period is

$$c_\sigma = \frac{Y_\sigma - TR_\sigma}{L_\sigma} = (1-(1-\alpha)\tau_\sigma)\frac{Y_\sigma}{L_\sigma}. \tag{6}$$

Note that, for tractability, the tax rate is set by the autocrat before being removed from power.

2.3 The Autocrat's Problem

The autocrat maximizes a long term utilitarian objective function, A_t. Her preferences are utilitarian in that the base component of her utility in each period is equal to the number of citizens (L_t) times the utility each citizen receives, c_t. The preferences are long term in that she cares about utilities over both t_0 and t_2 and optimizes recursively.[8]

In addition to her basic utilitarian objective, the autocrat gains utility $\Upsilon(\alpha Y_t)$ from the consumption of expropriated output, with

$$\frac{\partial \Upsilon(\alpha Y_t)}{\partial \alpha} > 0, \frac{\partial^2 \Upsilon(\alpha Y_t)}{\partial^2 \alpha} < 0.$$

In the event that the autocrat is removed she receives an outside utility of zero. The autocrat is removed after taxation decisions are made but before output is expropriated.

Hence, her objective at t_0 is

$$A_0 = L_0 c_0 + \Upsilon(\alpha Y_0) + \pi(\alpha,\delta)\left\{\rho(L_u c_u + \Upsilon(\alpha Y_u)) + (1-\rho)(L_d c_d + \Upsilon(\alpha Y_d))\right\} + (1-\pi(\alpha,\delta))0 \tag{7}$$

[8]By assuming long term preferences we are ignoring important consequences of myopic governments. See, for example, Acharya and Ragan.

The optimal choices are the result of a dynamic optimization that, recursively, consists of optimal t_2 choices, conditional on the productivity shock σ, remaining in power at t_2, decisions made at t_0, and the autocratic environment characterized by α and δ as well as the net migration equation 4.

Therefore, the Autocrat's problem at t_2 in state σ is:

$$\max_{\tau^\sigma} A^\sigma = L^\sigma c^\sigma + \Upsilon(\alpha Y^\sigma). \tag{8}$$

subject to the financing constraint 3

The t_0 problem, anticipating optimal t_2 decisions, is

$$\max_{\tau_0, F} A_0 = L_0 c_0 + \Upsilon(\alpha Y_0) + \pi(\alpha, \delta)\left\{(\rho((L_u c_u) + \Upsilon(\alpha Y_u))) + (1-\rho)((L_d c_d) + \Upsilon(\alpha Y_d))\right\}$$

subject to the budget constraint 2 that is satisfied by selling debt and setting tax rates.

2.3.1 Debt Financing

Sovereign debt financing involves selling at t_0, for a price of D, a commitment to repay F at t_2. We assume the foreign investors are competitive, risk neutral, and the prevailing interest rate is $r = 0$. As a result, the market price D is the expected value of a promise to pay F.

Let F^σ denote the expected bond payment that will be made at t_2 in state σ. Forming this expectation requires that all agents anticipate the probability that the promised amount will be repaid as well as the manner in which sovereign default is resolved when the promised amount is not paid, as discussed below. Therefore, in a competitive market, D satisfies the following 'fair pricing' constraint.

$$D = \frac{\rho F^U + (1-\rho)F^d}{1+r} = \rho F^U + (1-\rho)F^d \tag{9}$$

since $r = 0$.

It is helpful to define the yield to maturity of the debt, which, given that the risk free rate is zero, is also the credit spread of the country as

$$CS = \frac{F}{D} - 1 = \frac{F}{\rho F^U + (1-\rho)F^d} - 1.$$

The debt is considered safe if $F^u = F^d = F$ and the credit spread would be zero.

State Contingent Debt Repayment F^σ

The expected state contingent debt repayments, F^σ, depend on the *ability* and *willingness* to repay the promised amount, F.

Ability to Pay Evaluating the ability to repay must recognize a country's debt capacity, based on the sensitivity of the labor force to taxes, productivity, and the autocratic costs of migration, as set out in Section 2.2.2. Although debt repayment might require an increase in taxes, higher taxes could reduce consumption available to the population, thereby decrease net migration, output, and tax revenue.[9] Hence, countries face a 'Laffer' curve, where it is possible that increases in taxes are self defeating at some point.[10]

More specifically, the most that a country can repay is based on the Tax Revenue function, TR^σ, that determines the relationship of tax revenues to the tax rate.

$$TR^\sigma = \tau^\sigma(1-\alpha)Y^\sigma$$

Using 1 and 4 this becomes

$$\begin{aligned} TR^\sigma &= (1-\alpha)\tau^\sigma z^\sigma((L_0 + \beta^z z^\sigma - \beta^\tau \tau^\sigma + \beta^\delta \delta)^{(1-\gamma)} K^\gamma && (10)\\ &= (1-\alpha)\beta_\tau^{1-\gamma} z^\sigma \tau^\sigma[\bar{\tau}^\sigma - \tau^\sigma]^{(1-\gamma)} K^\gamma && (11) \end{aligned}$$

[9]This is dampened to some extent by the autocrat's ability to impede migration through δ.

[10]See Lundberg (2024) for estimates of the Laffer Curve for high income individuals.

where

$$\bar{\tau}^{\sigma} = \frac{L_0 + \beta^z z^{\sigma} + \beta^{\delta}\delta - \beta^{\alpha}\alpha)}{\beta_{\tau}}$$

Debt Capacity

We will use the term Debt Capacity to refer to the maximum tax revenue that can be collected by raising taxes. The debt capacity is therefore

$$\bar{F}^{\sigma} = \max_{0 \leq \tau^{\sigma} \leq 1} TR^{\sigma}.$$

Assuming an interior solution, the tax rate that achieves $\bar{F}^{\sigma}$, denoted $\tau^{\sigma}_{\bar{F}}$

$$\tau^{\sigma}_{\bar{F}} \;=\; \frac{1}{2-\gamma}\bar{\tau}_t \quad \text{with} \quad \bar{\tau}_t \;=\; \frac{L_{t-1} + \beta_z z_t + \beta_{\delta}\delta}{\beta_{\tau}} \tag{12}$$

and the *debt capacity* is

$$\begin{aligned}\bar{F} = \;& (1-\alpha)\beta_{\tau}^{1-\gamma} z_t \tau^{*}_{\bar{F}} \left[\bar{\tau}_t - \tau^{*}_{\bar{F}}\right]^{1-\gamma} K^{\gamma} \quad = \; (1-\alpha)\beta_{\tau}^{1-\gamma} z_t \frac{1}{2-\gamma}\bar{\tau}_t \left[\bar{\tau}_t - \frac{1}{2-\gamma}\bar{\tau}_t\right]^{1-\gamma} K^{\gamma} \\ = \;& (1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_{\tau}^{1-\gamma} z^{\sigma} K^{\gamma} \bar{\tau}_t^{2-\gamma}\end{aligned}$$

Comparative Statics

Proposition 1. *$\bar{F}$ is strictly increasing in both δ and K and decreasing in α.*

Proof. We relegated all the proofs to Appendix A. □

Note that this result shows that autocracies with higher restrictions on migration effectively commit to repay more during bad times. On the other hand, autocracies with high levels of expropriation commit to repay less. Therefore, in terms of ability to pay, the **most** that lenders should expect to be repaid is the minimum of the promised amount F and the maximum ability to pay, $\bar{F}^{\sigma}$.

Willingness to Pay

In terms of willingness to pay, since we are dealing with sovereign nations, there is no explicit legal mechanism, i.e. no bankruptcy law, that compels repayment of debt. We follow the sovereign default literature in assuming that failure to repay debt will result in sanctions in the product and financial markets that are costly to the defaulting country. We depart from the traditional approach, however, by assuming that the capital market recognizes the importance of the ability to pay and only punishes countries if they fail to repay $min\{F, \bar{F}^\sigma\}$. This corresponds to the IMF's policy on lending into arrears, as discussed in Diaz-Cassou, Rice-Dominguez, and Vasquez-Zamora (2008b).

Although any punishment imposed is likely to work through a reduction in productivity, as in Alessandria, Bai, and Deng (2020), we instead assume a simple reduced form cost of default ψ that is a constant and is independent of any choice variables.

The benefit of defaulting is avoiding debt payments $min\{\bar{F}^\sigma, F\}$. We assume

$$\psi \geq \bar{F}^u.$$

Since $\bar{F}^u > \bar{F}^d$, this ensures that the cost of defaulting is greater than the potential benefit, so that the repayment of $min\{F, \bar{F}^\sigma\}$ is self-enforcing.

Hence, the rationally anticipated debt repayments are $F^\sigma = min\{\bar{F}^\sigma, F\}$.

3 Simplified Model

In order to clearly demonstrate important empirical implications of the model, we begin with simplifications that allow closed form solutions while preserving empirical implications of the model. These simplifications are removed in section 4 where we derive other empirical implications while demonstrating numerically that the implications of the simple model hold in more complex settings.

We make the following simplifying assumptions.

- $\nu_0 = 0$, i.e. there is no net migration at t_0 so that $L_0 = N_0$, and

- $\tau_0 = 0$, so that all infrastructure is entirely debt financed.

These assumptions allow us to show that the credit spread is decreasing in restrictions on migration, δ, increasing in expropriation, α, and increasing in the size of the infrastructure investment, K.

First, note that with the assumption that $TR_0 = 0$ (implying $\tau_0 = 0$) the first period budget constraint, 2,becomes

$$D \geq K.$$

This will be binding since excess cash is not productive, hence $D = K$. The fair pricing constraint in the capital market, 9 then becomes

$$\begin{aligned} K = & \ \rho F + (1-\rho)F^d. \\ \Longrightarrow F = & \ \frac{K - (1-\rho)F^d}{\rho}. \end{aligned}$$

In terms of the second period budget constraint, when $\sigma = u$, τ^u must be set so that $TR^u = F$. Let τ^{u*} indicate the tax rate that provides the required tax revenue. The equilibrium tax rate is the lowest solution of the equation

$$(1-\alpha)\tau_u Y_u = F \quad \Longleftrightarrow \quad \tau_u \left[\bar{\tau}_u - \tau_u\right]^{1-\gamma} = \frac{F}{(1-\alpha){\beta_\tau}^{1-\gamma} z^u K^\gamma}$$

On the other hand, when $\sigma = d$ the repayment will be F^d, which requires a tax rate of τ_{d*}

$$\tau_{d*} = \tau^*_{\bar{F}} = \frac{L_0 + \beta_z z_t + \beta_\delta \delta}{(2-\gamma)\beta_\tau}.$$

In this simplified version of the model, the autocrat has little choice but to satisfy the budget constraints in setting taxes. However, the solution provides clear empirical implications about autocratic powers and the credit spread.

In particular, recalling that the credit spread CS, is defined as

$$CS \equiv \frac{F}{D} - 1 = \frac{\left(K - (1-\rho)\bar{F}^d\right)}{\rho K} - 1\,.$$

and plugging in the expression for $\bar{F}^d$ yields

$$CS \equiv \frac{F}{D} - 1 = \frac{1-\rho}{\rho}\left[1 - \frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_\tau^{1-\gamma} z_t K^{\gamma-1}\bar{\tau}_t^{2-\gamma}\right].$$

Proposition 2. *The credit spread is decreasing in both δ and K, and increasing in α.*

In addition, we find the following result which has an important empirical implication.

Proposition 3. *The credit spread is decreasing in the (expected) total productivity z. Moreover,*

$$\frac{\partial CS^2}{\partial z_t \partial \delta} < 0\,.$$

This result implies that, as expected growth changes, the responsiveness of the credit spread will be dampened for autocracies with higher migration costs.

4 Full Model

In this section we examine the model when the assumptions that $\nu_0 = 0$ and $\tau_0 = 0$ are removed. This allows us to examine how much of the infrastructure investment is tax financed relative to debt financed, i.e. the autocrat's capital structure. Unfortunately, this model does not yield closed form analytical results and is therefore solved numerically.

In order to find meaningful numerical solutions we impose the following restrictions on our model.

Restriction I: It is necessary that the population L_t is always greater than 1:

$$L_t \geq 1\,.$$

It follows that

$$\tau_t \;\leq\; \tau_L; \quad \text{with} \quad \tau_L \;\equiv\; \frac{L_{t-1} + \beta_z z_t + \beta_\delta \delta - 1}{\beta_\tau}\,.$$

The total tax revenue for a given tax rate is

$$TR_t = \;(1-\alpha)\beta_\tau^{1-\gamma} z_t \tau_t \left[\bar{\tau}_t - \tau_t\right]^{1-\gamma} K^\gamma$$

where

$$\bar{\tau}_t \;=\; \frac{L_{t-1} + \beta_z z_t + \beta_\delta \delta}{\beta_\tau}\,.$$

Thus, we recover the Laffer curve and the tax rate that maximizes the tax revenue is

$$\tau_{\bar{F}}^* \;=\; \frac{1}{2-\gamma}\bar{\tau}_t\,. \tag{13}$$

Remark: The above solution isn't exact. The exact solution is

$$\tau_{\bar{F}}^* \;=\; \min\left\{\frac{1}{2-\gamma}\bar{\tau}_t;\, 1;\, ,\tau_L\right\}\,.$$

Our second restriction below guarantee that the tax-rate defined in Equation (13) is less than one:

Restriction II: We require that the tax-rate in Equation (13) belongs to $(0, \min\{\tau_L\,, 1\})$.

Mathematically, these two restrictions are equivalent to

$$\min\left\{\frac{1}{2-\gamma}\bar{\tau}_t;\, 1;\, ,\tau_L\right\} \;=\; \frac{1}{2-\gamma}\bar{\tau}_t\,,$$

These restrictions will help us avoid certain singularities when solving the model numerically. The equality above hold if

$$\frac{2(2-\gamma)}{(1-\gamma)} \;<\; L_0 + \beta_z z_t + \beta_\delta \delta \;<\; (2-\gamma)\beta_\tau\,.$$

The equation above implies domain for τ_0 since

$$L_0 \;=\; N_0 - \beta_\tau \tau_0 + \beta_z z_0 + \beta_\delta \delta \,.$$

Explicitly, the restriction is

$$\frac{N_0 + \beta_z z_0 + \beta_\delta \delta + \beta_z z_t + \beta_\delta \delta - (2-\gamma)\beta_\tau}{\beta_\tau} \;<\; \tau_0 \;<\; \frac{N_0 + \beta_z z_0 + \beta_\delta \delta + \beta_z z_t + \beta_\delta \delta - \frac{2(2-\gamma)}{(1-\gamma)}}{\beta_\tau} \,.$$

We begin by verifying Propositions 1 and 2 our numerical model.

Result I: $\bar{F}$ is strictly increasing in both δ and K and decreasing in α.

Figure 2 presents the relationships between debt capacity, $\bar{F}$, and and K for our two measures of autocracy. In the first panel, expropriation risk α is associated with *lower* debt capacity and debt capacity is increasing in infrastructure, K. In the second panel, higher restrictions on migration, δ, are associated with *higher* debt capacity.

Result II: *The credit spread is decreasing in both δ and K, and increasing in α.*

Figure 3 confirms that Result II holds in our full numerical model. In panel 1 higher risk of expropriation is associated with higher credit spreads while in panel 2 higher restrictions on migration are associated with lower credit spreads

4.1 Capital Structure

Finally, by relaxing the requirement that $\tau_0 = 0$ we are able to address the question of how much infrastructure will be financed with debt versus taxes. The results are presented in Figure 4. Panel 1 illustrates how, for each level of K, greater expropriation results in a lower level of debt financing. The intuition for this result is straight forward; as the autocrat takes more of the countries output there is less available to repay creditors. Panel 2 shows how greater restrictions on migration prompt autocrats to finance more of the infrastructure with debt. Intuitively, higher migration costs mean that labor is not able to

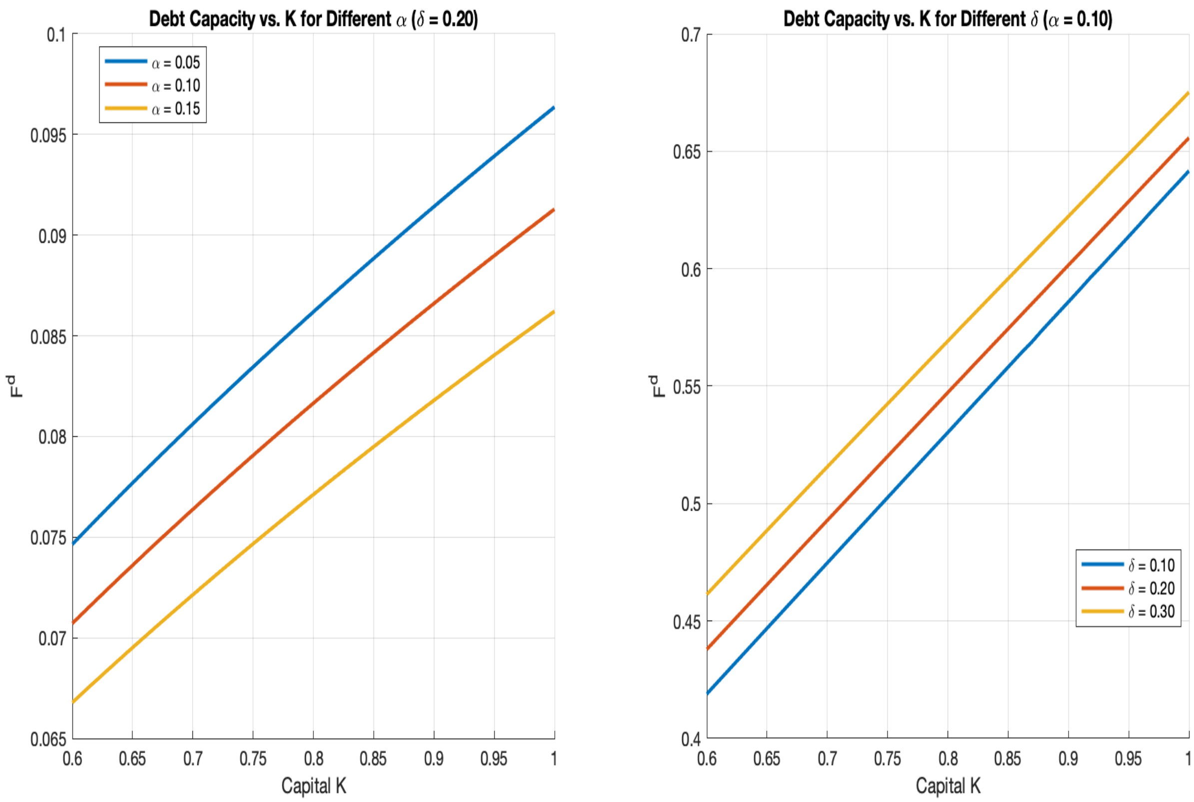

Figure 2: **Debt capacity $\bar{F}$ and autocratic power**

depart when taxes have to raised to repay creditors, making debt financing relatively more attractive.

5 Data and Estimation

5.1 Data

Our analysis draws on cross-country panel data spanning the period from 2001 to 2022. We combine several specialized datasets to measure emigration policies, sovereign default risk, expropriation risk, and macroeconomic conditions. The emigration policy data and sovereign credit default swap spreads provide time-varying measures across countries, while our expropriation risk measure offers a cross-sectional dimension that complements the

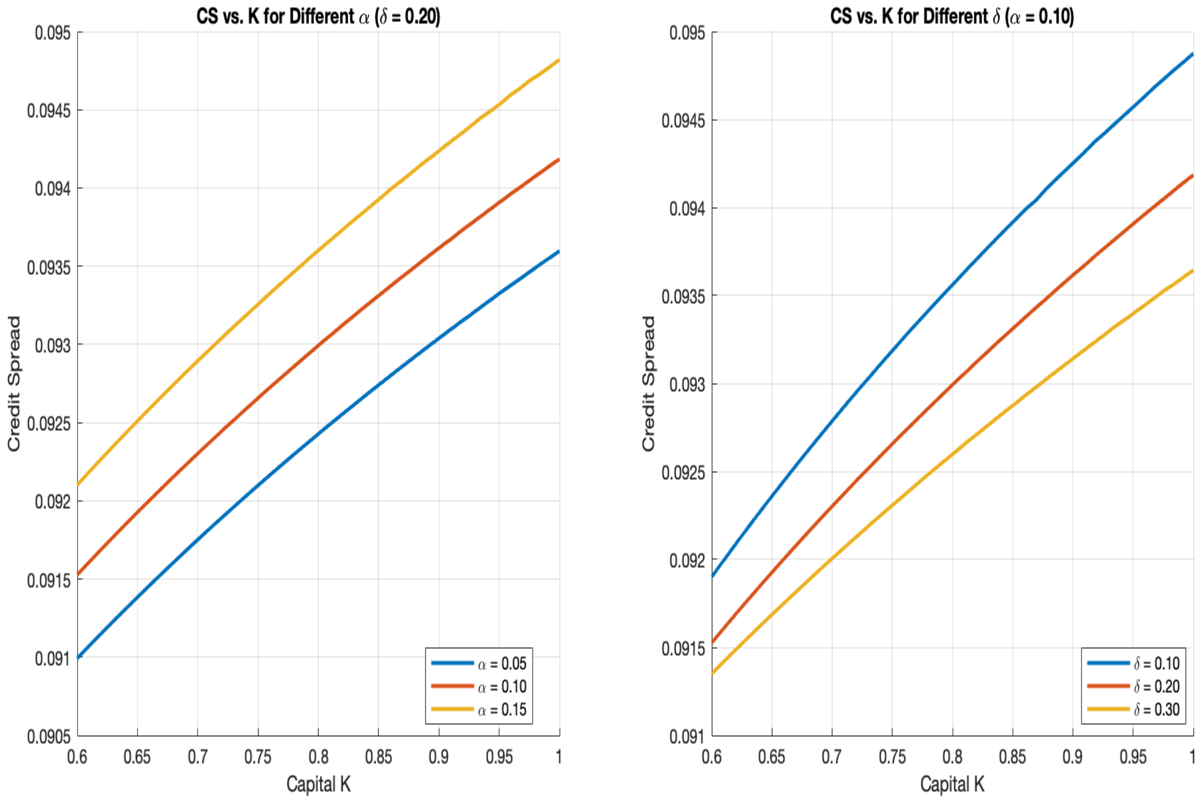

Figure 3: **Credit Spreads and autocratic power**

panel structure. Below, we describe each data component in detail, including its source, measurement approach, and relevance to our theoretical framework.

5.1.1 Emigration Policy Data

We use CIRIGHTS data `https://cirights.com/` to measure emigration restrictions with the "Freedom of Foreign Movement and Travel" variable, which captures government policies limiting citizens' ability to leave and return to their country. This includes passport/visa restrictions, travel document delays, exit control lists, limitations on duration abroad, group-specific restrictions, penalties for leaving, and repatriation barriers.

The measure uses a three-point scale: 0 (severely restricted), 1 (somewhat restricted), and 2 (unrestricted). Following Miller and Peters (2018), we create a binary restrictive

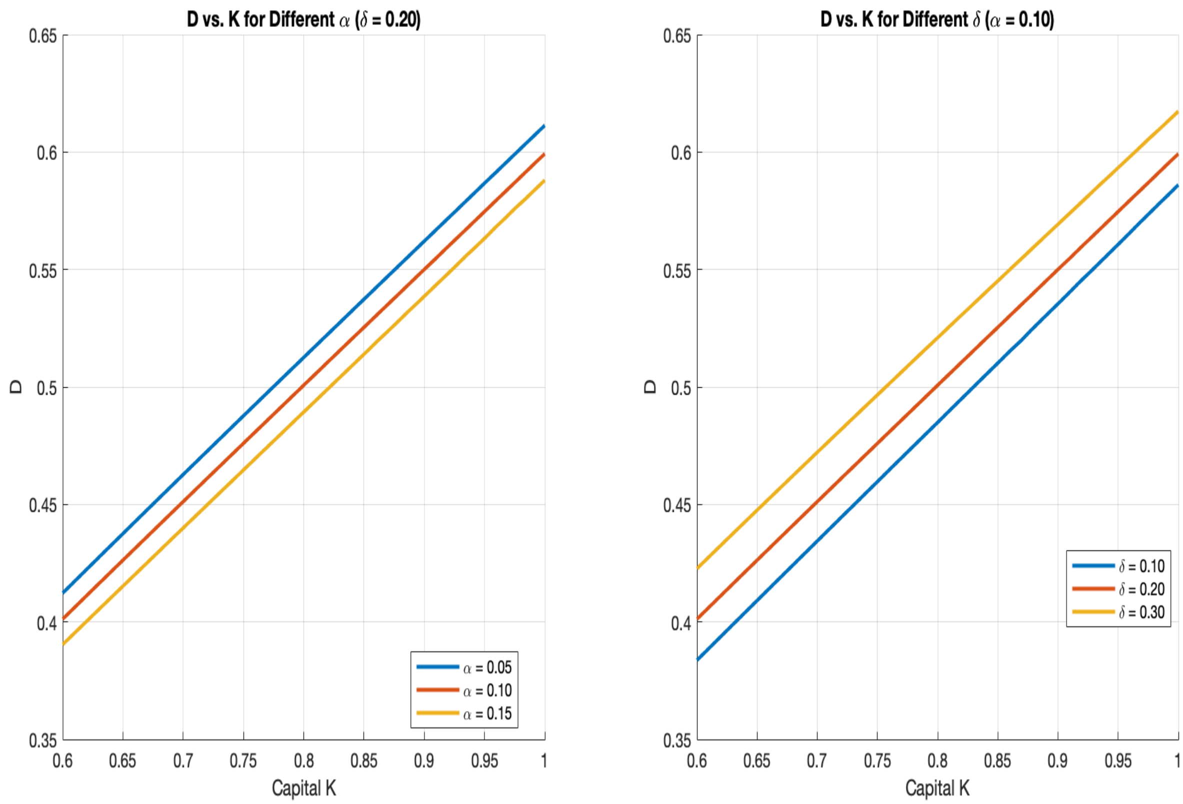

Figure 4: **Debt versus taxes and autocratic power**

emigration policy variable (δ) equaling 0 for no restrictions (formov = 2) and 1 otherwise.

The CIRIGHTS dataset is constructed using standardized coding of U.S. State Department annual country reports on human rights practices. Expert coders apply consistent criteria to these reports, ensuring comparability across countries and over time while minimizing subjective bias in the measurement of government emigration policies.

5.1.2 Sovereign Credit Default Swap Spreads

To measure market perceptions of sovereign default risk, we use credit default swap (CDS) spreads data from IHS Markit. We focus on 10-year USD-denominated contracts for senior foreign government debt from 2001 to 2022. CDS spreads represent the cost of insuring against sovereign default, with higher spreads indicating greater perceived risk.

We extract only government sector CDSs with 10-year tenors denominated in USD, specifically focusing on senior foreign debt (SNRFOR tier). We convert the percentage spreads to basis points by multiplying by 10,000, then calculate annual averages for each country. For our analysis, we use the natural logarithm of the mean annual spread (*Ln(Spreads)*) as our dependent variable, which helps normalize the distribution of spreads that can have extreme values.

5.1.3 Expropriation Risk

Although we would have preferred to use data from `https://cirights.com/`, they don't code expropriation risk. Our expropriation risk measure is instead derived from U.S. State Department Country Reports on Human Rights Practices (2016-2018), accessed directly from their official website. We implemented a systematic evaluation process using Claude-3-Haiku to analyze the text of each country report, specifically assessing respect for property rights on a 10-point scale (1=strong property rights, 10=weak). The model extracted numerical scores based on explicit mentions of property rights violations, nationalization threats, government seizures, compensation practices, and enforcement of property laws, while also capturing supporting text evidence for each score. For countries with multiple years of data, we calculated an average expropriation score, providing a comprehensive cross-sectional measure of property rights protection that complements our time-varying emigration policy variable.

5.1.4 Debt-to-Capital Ratio

To construct a measure of debt financing of infrastructure, we obtain data on public capital stock from the IMF Investment and Capital Stock Dataset (Xiao, Amaglobeli, and Matsumoto, 2021). We combine this data with the data on general government debt from the World Economic Outlook Database to construct debt-to-capital ratios for countries in our sample.

5.1.5 Macroeconomic Controls

We include key macroeconomic indicators as control variables in our analysis. Central government debt as a percentage of GDP is obtained from the International Monetary Fund (IMF) Global Debt Database, accessible at `https://www.imf.org/external/datamapper/CG_DEBT_GDP@GDD`. This measure provides a standardized indicator of sovereign debt burden across countries, capturing the extent of government borrowing relative to economic output and serving as a critical control when examining sovereign default risk.

For economic size and development, we use the natural logarithm of GDP per capita (Ln(GDP)) from the World Bank's World Development Indicators database, available at `https://data.worldbank.org/indicator/NY.GDP.PCAP.CD`. This transformation normalizes the distribution of GDP values and allows for appropriate comparison across economies of different scales. GDP per capita serves as a proxy for overall economic development and institutional quality, both of which may influence sovereign risk perceptions independent of specific policy choices.

To account for differences in countries' ability to repay debt driven by differences in population size, we control for log of population. Additionally, following existing literature examining the determinants of sovereign spreads, we also control for differences in inflation across countries, measured using natural log of inflation. Population and inflation data are obtained from the World Economic Outlook Database of the International Monetary Fund, available at `https://www.imf.org/en/Publications/WEO/weo-database/2025/april`.

Finally, remittances could also affect a country's ability to repay debt. To control for differences in remittances, we include remittances as a percent of GDP as a control variable. Remittance data are obtained from the World Bank World Development Indicator database, available at `https://databank.worldbank.org/source/world-development-indicators/Series/BX.TRF.PWKR.DT.GD.ZS`.

5.2 Empirical Analysis

5.2.1 Credit Spreads

In this section, we formally test the main predictions of the theoretical model. We start by testing the prediction that autocratic powers — emigration restrictions and expropriation power — influence the sovereign's ability and willingness to repay, thereby affecting credit spreads. We estimate several specifications to examine these relationships.

Our baseline specification examines the relationship between restrictive emigration policies and sovereign spreads:

$$\text{Log Spread}_{it} = \beta_1\, \delta_{it} + X_{it}'\gamma + \mu_i + \lambda_t + \varepsilon_{it} \tag{14}$$

where Log Spread$_{it}$ is the natural logarithm of the mean annual spread on 10-year USD-denominated CDS contracts for country i at time t, δ_{it} is our binary indicator for restrictive emigration policies in country i at time t (equal to 0 for no restrictions and 1 otherwise), X_{it}' is a vector of macroeconomic controls including the natural logarithm of GDP per capita, central government debt as a percentage of GDP, natural logarithm of population, natural logarithm of inflation, and remittances as a share of GDP, μ_i represents country fixed effects, λ_t represents year fixed effects, and ε_{it} is the error term.

We then extend our analysis to consider how economic downturns might interact with emigration restrictions, estimating:

$$\text{Log Spread}_{it} = \beta_1\, \delta_{it} + \beta_2\, DT_{it} + \beta_3\, (\delta_{it} \times DT_{it}) + X_{it}'\gamma + \mu_i + \lambda_t + \varepsilon_{it} \tag{15}$$

where DT_{it} is an indicator for economic downturn, defined as negative GDP growth (i.e., $\Delta\text{GDP}_{it} < 0$).

Finally, we examine the relationship between expropriation risk and sovereign spreads:

$$\text{Log Spread}_{it} = \beta_1 \, \alpha_i + X_{it}'\gamma + \lambda_t + \varepsilon_{it} \tag{16}$$

where α_i is our measure of expropriation risk for country i. Since our expropriation measure is time-invariant (calculated as the average score over 2016-2018), we omit country fixed effects in this specification to avoid perfect collinearity. We estimate all equations using robust standard errors clustered at the country level to account for potential heteroskedasticity and serial correlation in the error terms.

5.2.2 Debt-to-Capital Ratio

Our theoretical framework predicts that autocratic powers influence not only credit spreads but also the composition of infrastructure financing, particularly the reliance on debt versus taxes. Specifically, restrictions on emigration (δ) increase a sovereign's ability to maintain a stable tax base during downturns, making debt financing more feasible and attractive. In contrast, higher expropriation risk (α) reduces the amount of output available for repayment and lowers the credibility of future payments, thereby making tax financing relatively more attractive. To test the effect of migration restrictions on debt financing of infrastructure, we estimate the following regression:

$$\text{DebtCapital}_{it} = \beta_1 \delta_{it} + X_{it}'\gamma + \mu_i + \lambda_t + \varepsilon_{it} \tag{17}$$

where DebtCapital_{it} is the debt-to-capital ratio for country i at time t, δ_{it} is the emigration restriction indicator, and X_{it}' includes the same macroeconomic controls used in the empirical analysis in section 5.2.1. As before, we include year fixed effects (λ_t) and country fixed effects (μ_i).

We then test how expropriation affects debt financing of infrastructure. To do this, we estimate the following regression:

$$\text{DebtCapital}_{it} = \beta_1 \alpha_i + X_{it}' \gamma + \lambda_t + \varepsilon_{it} \tag{18}$$

where α_i is our measure of expropriation risk for country i. Since our expropriation measure is time-invariant (calculated as the average score over 2016-2018), we omit country fixed effects in this specification to avoid perfect collinearity. We estimate all equations using robust standard errors clustered at the country level to account for potential heteroskedasticity and serial correlation in the error terms.

6 Results

Tables 1 and 2 present results from our empirical analysis examining the relationship between autocratic restrictions on emigration, expropriation risk, sovereign credit spreads, and debt financing of infrastructure. Our empirical findings provide strong support for the key predictions of our theoretical model.

6.1 Emigration Restrictions and Sovereign Spreads

Columns (1) and (2) of Table 1 show that the baseline effect of emigration restrictions (δ) on sovereign spreads is negative, and the effect is statistically significant in column (2) once we control for country-level characteristics that can affect sovereign spreads. This is consistent with our model's prediction that countries with higher restrictions on emigration should face lower credit spreads, as restricted emigration enhances a sovereign's ability to repay debt by maintaining the tax base during economic stress.

The critical test of our theory, however, is captured in column (3), which examines how emigration restrictions interact with economic downturns. The interaction term ($\delta \times \mathbb{1}_{\Delta GDP<0}$) is negative and statistically significant, indicating that emigration restrictions are particularly valuable for reducing spreads during economic contractions. This

Table 1: **Migration Restriction, Expropriation, and Credit Spreads**

This table presents estimates from Equations (14), (15), and (16) for 2001–2022. The dependent variable is the log of country i's CSD spread at time t. Our key explanatory variables are δ_{it}, which is a binary indicator of emigration restrictions and captures how these restrictions affect credit spreads, $\delta_{it} \times \mathbb{1}_{\Delta GDP<0}$, which interacts emigration restrictions (δ_{it}) with an indicator for negative GDP per capita growth ($\mathbb{1}_{\Delta GDP<0}$) and captures how emigration policies affect sovereign spreads specifically during economic contractions, and α, which measures expropriation risk. All specifications include year fixed effects, while columns (1)–(3) also include country fixed effects. Columns (4)–(5) include expropriation risk, which is a cross-sectional measure, and therefore cannot include country fixed effects. Standard errors clustered at the country level are reported in parentheses. ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

Dependent Variable:			**Ln(Spreads)**		
	(1)	(2)	(3)	(4)	(5)
δ	-0.049	-0.162**	-0.123		
	(0.101)	(0.081)	(0.081)		
$\delta \times \mathbb{1}_{\Delta GDP<0}$			-0.189**		
			(0.078)		
α				0.464***	0.184***
				(0.066)	(0.060)
$\mathbb{1}_{\Delta GDP<0}$			0.240***		
			(0.076)		
Log GDP		-2.226***	-2.163***		-0.838***
		(0.411)	(0.409)		(0.091)
Central Government Debt, % of GDP		0.014***	0.014***		0.008***
		(0.003)	(0.002)		(0.002)
Remittances, % of GDP		0.022	0.023		-0.012
		(0.019)	(0.018)		(0.013)
Log Population		-0.513	-0.507		-0.213***
		(0.332)	(0.318)		(0.046)
Log Inflation		-0.382*	-0.418*		0.029***
		(0.219)	(0.230)		(0.007)
Observations	1,472	1,340	1,340	1,355	1,245
Adjusted-R^2	0.77	0.86	0.86	0.42	0.67
Year FE?	Yes	Yes	Yes	Yes	Yes
Country FE?	Yes	Yes	Yes	No	No

strongly supports Result III from our theoretical model, which predicts that credit spread sensitivity to economic shocks is dampened for autocracies with higher migration costs. Specifically, during economic downturns (when $\mathbb{1}_{\Delta GDP<0} = 1$), a one-unit increase in emigration restrictions is associated with approximately 19% lower credit spreads, a substantial economic effect.

The positive coefficient on the economic downturn indicator in column (3) confirms that, as expected, negative GDP growth generally increases sovereign spreads. However, this effect is substantially mitigated for countries that maintain tight restrictions on emigration, demonstrating how autocratic control over human capital can serve as a commitment device for debt repayment.

6.2 Expropriation Risk and Sovereign Spreads

Columns (4) and (5) of Table 1 examine the relationship between expropriation risk and sovereign spreads. The coefficient on expropriation risk is positive and statistically significant in both specifications, confirming Result II from our theoretical model, which predicts that credit spreads are increasing in expropriation risk (α). This relationship remains robust even after macroeconomic control variables in column (5), although the magnitude of the effect decreases.

These findings support our theoretical mechanism that while restrictions on emigration enhance debt repayment capacity by securing the tax base, expropriation risk undermines it by reducing the proportion of output available for debt servicing. A one-unit increase in our expropriation risk measure is associated with approximately 18-46% higher credit spreads, depending on the specification.

The coefficients on control variables also align with our theoretical predictions. Log GDP per capita has a strong negative relationship with spreads, confirming that economic development reduces default risk. Central government debt as a percentage of GDP is positively associated with spreads, consistent with standard sovereign risk models where

Table 2: **Migration Restriction, Expropriation, and Debt Financing of Infrastructure**

This table presents estimates from Equation (18) for 2001–2022. The dependent variable is the ratio of debt financing to capital stock of country i at time t. Our key explanatory variables are δ_{it}, which is a binary indicator of emigration restrictions and α, which measures expropriation risk. All specifications include year fixed effects, while columns (1) and (2) also include country fixed effects. Columns (3)–(4) include expropriation risk, which is a cross-sectional measure, and therefore cannot include country fixed effects. Standard errors clustered at the country level are reported in parentheses. ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

Dependent Variable:	**Debt-to-Capital**			
	(1)	(2)	(3)	(4)
δ	0.039	0.024		
	(0.039)	(0.031)		
α			-0.135***	-0.103**
			(0.043)	(0.041)
Log GDP		0.158		0.009
		(0.172)		(0.062)
Central Government Debt, % of GDP		0.012***		0.011***
		(0.001)		(0.002)
Remittances, % of GDP		-0.001		0.016**
		(0.013)		(0.007)
Log Population		0.623**		0.064*
		(0.311)		(0.035)
Log Inflation		-0.082		-0.017***
		(0.074)		(0.006)
Observations	1,180	1,091	1,074	1,004
Adjusted-R^2	0.85	0.94	0.12	0.61
Year FE?	Yes	Yes	Yes	Yes
Country FE?	Yes	Yes	No	No

higher debt burdens increase default probability. Overall, these empirical results provide strong support for our theoretical framework, demonstrating that autocratic powers have differential effects on sovereign credit risk. Restrictions on emigration enhance commitment to repay and reduce spreads, particularly during economic downturns, while expropriation power undermines this commitment and increases spreads. These findings help explain the nuanced relationship between autocracy and sovereign borrowing costs observed in the "democracy advantage" literature, showing how specific dimensions of autocratic control can either mitigate or exacerbate sovereign risk.

6.3 Debt Financing of Infrastructure

Columns (1) and (2) of Table 2 examine the effect of emigration restrictions on debt-to-capital ratio. We find that emigration restrictions are positively associated with higher debt-to-capital ratios, consistent with our model's prediction that tighter migration controls raise sovereign debt capacity. Countries with higher migration barriers rely more heavily on debt to finance infrastructure, as they can credibly commit to tax-based repayment without the risk of labor flight.

Conversely, results in columns (3) and (4) show that expropriation risk is negatively associated with the debt share of infrastructure finance, reflecting creditor concerns over future repayments. This supports the theoretical mechanism by which expropriation weakens the link between productive output and debt servicing capacity, inducing greater reliance on tax-based or internally financed investment.

7 Conclusion

In this study we have explored the role of autocratic power on the financing of a nation's infrastructure. While the term autocracy is often associated with restrictions of several rights and freedoms, we focus on two specific restrictions; restrictions on the ability to leave a country and restrictions on ownership of economic output through expropriation. We show theoretically that greater restrictions on migration result in lower credit spreads and higher use of debt financing. Moreover, in the event of sovereign default, more of national output is devoted to repayment of debt when migration restrictions are larger. The power to expropriate output has the opposite affect; credit spreads increase, debt financing is more restricted and less is repaid in the event of a sovereign default. Preliminary empirical evidence supports the predictions of our model.

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Appendices

A Proofs

A.1 Proof of Proposition 1

Proof of Proposition 1. First, we have

$$\frac{\partial \bar{F}}{\partial \delta} = (1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{1-\gamma}}\beta_\tau^{1-\gamma} z_t K^\gamma \bar{\tau}_t^{1-\gamma}\frac{\partial \bar{\tau}_t}{\partial \delta} \;= (1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{1-\gamma}}\beta_\tau^{1-\gamma} z_t K^\gamma \bar{\tau}_t^{1-\gamma}\frac{\beta_\delta}{\beta_\tau} \;>\; 0\,.$$

Similarly,

$$\begin{aligned} \frac{\partial \bar{F}}{\partial \alpha} &= \; -\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_\tau^{1-\gamma} z^\sigma K^\gamma \bar{\tau}_t^{2-\gamma} \;<\; 0 \\ \text{and} \quad \frac{\partial \bar{F}}{\partial K} &= \gamma(1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_\tau^{1-\gamma} z^\sigma K^{\gamma-1} \bar{\tau}_t^{2-\gamma} \;>\; 0\,. \end{aligned}$$

□

A.2 Proof of Proposition 2

Proof of Proposition 2. We have

$$\frac{\partial CS}{\partial x} \;= -\frac{1-\rho}{\rho K}\frac{\partial \bar{F}^d}{\partial x} \quad \text{for} \quad x \in \{\delta, \alpha\}\,.$$

In addition, we know from Result I that

$$\frac{\partial \bar{F}^d}{\partial \delta} \;>\; 0 \quad \text{and} \frac{\partial \bar{F}^d}{\partial \alpha} \;<\; 0\,,$$

which directly yields the comparative statics with respect to δ and α. The last result is obtained by differentiation. □

A.3 Proof of Proposition 3

Proof of Proposition 3.

$$
\begin{aligned}
CS = & \frac{1-\rho}{\rho}\left[1 - \frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_\tau^{1-\gamma} z_t K^{\gamma-1}\bar{\tau}_t^{2-\gamma}\right] \\
= & \frac{1-\rho}{\rho}\left[1 - \frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}}\beta_\tau^{1-\gamma} K^{\gamma-1} z_t \left(\frac{L_{t-1} + \beta_z z_t + \beta_\delta \delta}{\beta_\tau}\right)^{2-\gamma}\right] .
\end{aligned}
$$

The function

$$
x(a+x)^{2-\gamma}
$$

is strictly increasing and convex in x for $x > 0$. Thus, CS is increasing in expected z_t. Moreover,

$$
\frac{\partial CS^2}{\partial z_t \partial \delta} = -\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{1-\gamma}} K^{\gamma-1}\beta_\delta \left[L_{t-1} + (1-\gamma)\beta_z z_t + \beta_\delta \delta\right]\left[L_{t-1} + \beta_z z_t + \beta_\delta \delta\right]^{-1-\gamma} .
$$

□

B Numerical Solution

We write all the components of the utility function as a function of τ_0 and the exogenous parameters (with the focus on K), using the optimal τ_σ for Period 2.

- Initial population:

$$L_0(\tau_0, \delta) \;=\; N_0 + \beta_z z_0 - \beta_\tau \tau_0 + \beta_\delta \delta\,.$$

- GDP:

$$Y_0(\tau_0, K, \delta) \;=\; z_0 (L_0(\tau_0, \delta))^{1-\gamma} K^\gamma$$

- Debt:

$$D(\tau_0, K, \alpha, \delta) \;=\; K - (1-\alpha)\tau_0 Y_0(\tau_0, K, \delta)$$

- $\bar{\tau}_2$

$$\bar{\tau}_2(\tau_0, \delta) \;=\; \frac{L_0(\tau_0, \delta) + \beta_z z_2 + \beta_\delta \delta}{\beta_\tau}$$

- $\bar{F}$:

$$\bar{F}(\tau_0, K, \alpha, \delta) = \;(1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}} \beta_\tau^{1-\gamma} z_2 K^\gamma \left(\frac{L_0(\tau_0, \delta) + \beta_z z_2 + \beta_\delta \delta}{\beta_\tau} \right)^{2-\gamma}\,.$$

- F :

$$F(\tau_0, K, \alpha, \delta) \;=\; \frac{1}{\rho}\left[D(\tau_0, K, \alpha, \delta) - (1-\rho)\bar{F}^d(\tau_0, K, \alpha, \delta)\right]$$

- $\tau^*_{2,d}$:

$$\tau^*_{2,d} \;=\; \frac{1}{2-\gamma}\bar{\tau}_2(\tau_0, \delta)$$

- $\tau^*_{2,d}$: It is the lowest solution to the equation

$$\tau\left[\bar{\tau}_{2,u}(\tau_0, \delta) - \tau\right]^{1-\gamma} = \;\frac{K + F(\tau_0, K, \alpha, \delta)}{(1-\alpha)\beta_\tau^{1-\gamma} z_2^u K^\gamma}\,. \tag{19}$$

The LHS of the equation is independent of K but the RHS depends on K, and is increasing in K. Thus, existence of a solution restricts possible values of *alpha* and/or K.

- L_2

$$L_2(\tau_0, \delta) \;=\; N_0 + \beta_z z_0 - \beta_\tau \tau_0 + \beta_\delta \delta + \beta_z z_2 - \beta_\tau \tau_2^* + \beta_\delta \delta$$

- Y_2

$$Y_2(\tau_0, K, \delta) \;=\; z_2 L_2^{1-\gamma}(\tau_0, \delta) K^\gamma \,.$$

- $L_2 U_2$:

$$L_2 U_2 \Big|_{(\tau_0, K, \alpha, \delta)} \;=\; (1-\alpha)\beta_\tau (1 - \tau_2^*(\tau_0, K, \alpha, \delta))(\bar{\tau}_2(\tau_0, K, \alpha, \delta) - \tau_2^*(\tau_0, K, \alpha, \delta))$$

Notice that we have all relevant equilibrium quantities in closed-form except $\tau_{2,d}^*$. We ensure existence of a solution by examining the LHS and RHS of Equation (20). Since the LHS of the equation is independent of K, we first select all parameters other than K, and then use this equation the determine the range of values of K for which a solution exists. However, this creates a challenge for exposition of the results since this range will depend on both α and δ.

B.1 Range for K

B.1.1 Restriction 1: $\bar{F}^d \;\leq\; F \;\leq\; \bar{F}^u$

In equilibrium, we need

$$\bar{F}^d \;\leq\; F \;\leq\; \bar{F}^u \,.$$

This requirement implies that

$$F \;>\; D, \quad F \;>\; 0, \quad \text{and} \quad D \;>\; 0\,,$$

since

$$\bar{F}^d(\tau_0, K, \alpha, \delta) \ > \ 0 \quad \forall \tau_0, K, \alpha, \delta\,.$$

Returning to the requirement, it follows that

$$\begin{aligned}
\rho \bar{F}^d \leq \ & K - (1-\alpha)\tau_0 Y_0(\tau_0, K, \alpha, \delta) - (1-\rho)\bar{F}^d(\tau_0, K, \alpha, \delta) \ \leq \ \rho \bar{F}^u \\
\Leftrightarrow 0 \leq \ & K - (1-\alpha)\tau_0 Y_0(\tau_0, K, \alpha, \delta) - \bar{F}^d(\tau_0, K, \alpha, \delta) \ \leq \ \rho(\bar{F}^u - \bar{F}^d) \\
\Leftrightarrow K^0_{\alpha,\delta}(\tau_0) \leq \ & K^{1-\gamma} \ \leq \ K^1_{\alpha,\delta}(\tau_0)\,,
\end{aligned}$$

where

$$K^0_{\alpha,\delta}(\tau_0) \ \equiv \ (1-\alpha)\tau_0 z_0 (L_0(\tau_0, \delta))^{1-\gamma} + \frac{\bar{F}^d(\tau_0, K, \alpha, \delta)}{K^\gamma} \quad \text{and} \quad K^1_{\alpha,\delta}(\tau_0) \ \equiv \ K^0_{\alpha,\delta}(\tau_0) + \rho \frac{(\bar{F}^u - \bar{F}^d)}{K^\gamma}\,.$$

Neither $K^0_{\alpha,\delta}$ nor $K^1_{\alpha,\delta}$ depends on K, so we have a restriction on K. Moreover, both constants are positive as long as

$$L_0(\tau_0, \delta) > \ 0 \quad \Longleftrightarrow \quad \tau_0 \ < \ \frac{N_0 + \beta_z z_0 + \beta_\delta \delta}{\beta_\tau}\,.$$

The last inequality holds since

$$\tau_0 \ \leq \ \tau_{0,L} \ \leq \frac{N_0 + \beta_z z_0 + \beta_\delta \delta}{\beta_\tau}\,.$$

B.1.2 Restriction 2: Existence of $\tau^*_{2,d}$

$\tau^*_{2,d}$: It is the lowest solution to the equation

$$\tau \left[\bar{\tau}_{2,u}(\tau_0, \alpha, \delta) - \tau\right]^{1-\gamma} = \ \frac{K + F(\tau_0, K, \alpha, \delta)}{(1-\alpha)\beta_\tau^{1-\gamma} z_2^u K^\gamma}\,. \tag{20}$$

The LHS of the equation is independent of K, while the RHS increases in K. Thus, the existence of a solution restricts the possible values of K given $\{\alpha, \delta, \cdots\}$. Let

$$C(\tau_0, \alpha, \delta) \;=\; \max_{\tau} \tau(\bar{\tau}_{2,u}(\tau_0, \alpha, \delta) - \tau)^{1-\gamma} \;=\; \frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}} \bar{\tau}_{2,u}^{2-\gamma}(\tau_0, \alpha, \delta)\,.$$

A solution exists iff

$$(1-\alpha)\beta_{\tau}^{1-\gamma} z_2^u K^{\gamma} C(\tau_0, \alpha, \delta) \geq \; K + F(\tau_0, K, \alpha, \delta)\,,$$

Note that

$$\bar{F}^u(\tau_0, K, \alpha, \delta) \;=\; (1-\alpha)\beta_{\tau}^{1-\gamma} z_2^u K^{\gamma} C(\tau_0, \alpha, \delta)$$

Thus, a solution exists iff

$$\begin{aligned}
\bar{F}^u(\tau_0, K, \alpha, \delta) \geq & \; K + \frac{1}{\rho}\left[D(\tau_0, K, \alpha, \delta) - (1-\rho)\bar{F}^d(\tau_0, K, \alpha, \delta)\right] \\
\iff \rho\bar{F}^u(\tau_0, K, \alpha, \delta) \geq & \; (1+\rho)K - (1-\alpha)\tau_0 Y_0(\tau_0, K, \alpha, \delta) - (1-\rho)\bar{F}^d(\tau_0, K, \alpha, \delta) \\
\iff K^{1-\gamma} \leq & \; \frac{1}{1+\rho} K^1_{\alpha,\delta}(\tau_0)\,.
\end{aligned}$$

B.1.3 Equilibrium

An economically meaningful equilibrium exists if

$$\begin{aligned}
K^0_{\alpha,\delta}(\tau_0) \leq & \; \frac{1}{1+\rho} K^1_{\alpha,\delta}(\tau_0) \\
\Leftrightarrow K^0_{\alpha,\delta}(\tau_0) \leq & \; \frac{(\bar{F}^u - \bar{F}^d)}{K^{\gamma}} \\
\Leftrightarrow K^0_{\alpha,\delta}(\tau_0) \leq & \; (1-\alpha)\frac{(1-\gamma)^{1-\gamma}}{(2-\gamma)^{2-\gamma}} \beta_{\tau}^{1-\gamma}\left(z_2^u \bar{\tau}_{2,u}^{2-\gamma}(\tau_0, \alpha, \delta) - z_2^d \bar{\tau}_{2,d}^{2-\gamma}(\tau_0, \alpha, \delta)\right)
\end{aligned}$$

At $\tau_0 = 0$, this inequality becomes

$$
\begin{aligned}
2z_2^d \bar{\tau}_{2,d}^{2-\gamma}(\tau_0, \alpha, \delta) \leq &\ z_2^u \bar{\tau}_{2,u}^{2-\gamma}(\tau_0, \alpha, \delta) \\
\Longrightarrow \frac{\bar{\tau}_{2,u}(\tau_0, \alpha, \delta)}{\bar{\tau}_{2,d}(\tau_0, \alpha, \delta)} \geq &\ \left(\frac{2z_2^d}{z_2^u}\right)^{\frac{1}{2-\gamma}} \\
\Longrightarrow 1 + \frac{\beta_z(z_2^u - z_2^d)}{N_0 + \beta_z(z_0 + z_2^d) + 2\beta_\delta\delta} \geq &\ \left(\frac{2z_2^d}{z_2^u}\right)^{\frac{1}{2-\gamma}} \ = \ 2\left(1 - \frac{z_2^u - z_2^d}{z_2^u}\right)^{\frac{1}{2-\gamma}}
\end{aligned}
$$

Suppose that

$$
z_2^i = iz_0 \quad \text{and} \quad z_0 \ = \ \rho z_2^u + (1-\rho)z_2^d; \quad \Longrightarrow \quad u \ = \ \frac{1-(1-\rho)d}{\rho}.
$$

$$
\Longrightarrow \left[\frac{(u-d)}{\left(\frac{2d}{u}\right)^{\frac{1}{2-\gamma}} - 1} - (1+d)\right]\beta_z z_0 > \ N_0 + 2\beta_\delta\delta\,.
$$

B.2 Range for τ_0

We know that

$$
\frac{N_0 + \beta_z z_0 + \beta_\delta\delta + \beta_z z_t + \beta_\delta\delta - (2-\gamma)\beta_\tau}{\beta_\tau} \ < \ \tau_0 \ < \ \frac{N_0 + \beta_z z_0 + \beta_\delta\delta + \beta_z z_t + \beta_\delta\delta - \frac{2(2-\gamma)}{(1-\gamma)}}{\beta_\tau}\,.
$$

This requires that

$$
\beta_\tau \ \geq \ \frac{2}{(1-\gamma)}
$$

and

$$
\frac{2}{(1-\gamma)} \ \leq \ \frac{N_0 + \beta_z z_0 + \beta_\delta\delta + \beta_z z_t + \beta_\delta\delta}{(2-\gamma)} \ \leq \ \beta_\tau\,.
$$