Corruption and Supply-Side Economics

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Abstract

This paper develops a model of the effects of tax rates chosen optimally to promote growth and public welfare in the face of corruption. For a given level of corruption, public spending can promote growth but high tax rates in pursuit of various social goals have potentially significant supply-side economics effects that reduce income. Governments faced with rampant corruption optimally choose low tax rates, thus associating poor countries with low tax rates, and confounding the observed relation between tax rates and income. The model is estimated using cross-country data on income, tax rates, and corruption and is shown to match key features of the data. The chief contribution of this paper is to stress the importance of jointly considering the effects of corruption and taxation in documenting evidence in support of supply-side economics.

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1 Introduction

This paper develops a model of taxation with three key features: (1) some public spending is essential for growth, (2) excessive taxation reduces income, and (3) corruption/bribery competes with tax revenue in extracting resources. Governments choose tax rates optimally to promote growth and welfare, hence observed tax rates that additionally support social spending will tend to reduce income. However, corruption crowds out explicit taxation, hence poor countries with rampant corruption will tend to exhibit low rates of taxation, thereby confounding any observed relation between taxation and income. This paper uses cross-country data on income, tax rates, and corruption to estimate this model. The estimated model is shown to match key features of the data, including a robust negative relation between tax rates and income once corruption is taken into account.

Examples that highlight the key argument of this paper include a comparison of some wealthy, northern European countries with some poor countries in the rest of the world. The average GDP per capita (PPP) in 2018 for the northern European countries of Finland, Sweden, and Denmark is $61,710 and for the relatively poor countries of Syria, Afghanistan, and Guinea-Bissau is $2,736, despite the fact that tax rates in these northern European countries is much higher than for the poorer countries. The income tax rate for the highest earners in these northern European countries is on average 48 percent and their value-added tax is on average 25 percent, whereas the income tax rate for the highest earners in the poor countries is on average 21 percent and their value-added tax is on average 5 percent. Almost any measure of corruption (e.g., Transparency International) categorizes the northern European countries as low-corruption countries and the poorer countries as high-corruption. This paper argues that corruption crowds out explicit taxation, so governments saddled with rampant corruption that inhibits the creation of wealth find it optimal to tax at low rates. Nevertheless, for given levels of corruption, high rates of taxation also comes at the cost of lower levels of per-capita income.

In capturing the effects of corruption and bribery, this paper builds on previous empirical studies of the various channels by which corruption may affect a country's wealth. Mauro (1995), Johnson, et. al., (1997), Friedman, et. al., (2000), Alm, et. al., (2016) and Baum, et. al., (2017) documented various aspects of the relation between corruption, growth, tax evasion, and the size of the unofficial economy. Tanzi and Davoodi (1997) documented that corruption leads to a lower quality of public infrastructure. Mauro (1998) found that corruption is associated with lower levels of government spending on education. What's new is this paper is the documentation of a negative relation between corruption and the level of taxation. This is certainly not a channel by which corruption affects development, as if anything this channel goes in the wrong direction, but it is important to understand this relation to separate out the effects of corruption and tax rates on development, which is the focus of this paper.

A foundational premise of this paper is that corruption crowds out explicit taxation, which seems essential to explaining the negative relation between tax rates and corruption. This feature follows from the model in Shleifer and Vishney (1993), who refer to bribery and taxation as "sister" activities (p. 600). Evidence that corruption in the form of bribery extracts resources directly from private agents is provided by Transparency International's Global Bribery Rate, which reports that in 2017 on average 28 percent of people across countries reported paying a bribe in the last year to access public services such as education; judiciary; medical and health; police; registry and permit services; utilities; tax revenue and customs; and land service (Transparency International Global Corruption Barometer, 2017).

Models of corruption and taxation have been developed by Del Monte and Papagni (2001), Aghion, et. al., (2016), and others, but in these papers tax revenue generates resources that a corrupt government can extract.[1] Essentially, those papers think of corruption as stealing from the public coffers, whereas this paper thinks of corruption as rent-seeking behavior by corrupt government officials or other criminal elements in society that extract resources directly from the public, such as through bribery. This distinction provides significantly different incentives regarding a choice of tax rates for a given level of corruption, with the perspective of this paper designed to capture the negative relation between tax rates and measures of corruption as observed in the data.

The next section of this paper develops a model of tax rates in the face of corruption. This section solves for the fully dynamic equilibrium, which includes households that optimally choose their current and planned labor allocation and productivity-enhancing investments during their infinite lifetimes, and governments that solve a Ramsey problem by optimally choosing their current and planned tax and spending policy, taking full account how households are expected to respond to their choices over time. The following section summarizes key features of the data regarding the relation between corruption, tax rates, and income. Next is a section that develops a nonlinear least squares estimation strategy

[1] An insightful alternative approach is Acemoglu (2005), who modeled low taxes as stemming from weak, failed states (presumably corrupt) in which higher taxes would lead to an overthrow of the regime, and high taxes as stemming from either consensually strong states in which spending on public goods averts an overthrow of the regime or unilaterally strong states (also presumably corrupt) that do not fear an overthrow.

to estimate values of the unknown parameters, followed by a section that consider some experiments highlighting properties of the estimated model, along with results highlighting the predicted path of income and tax rates over time for a country that transitions from corrupt to non-corrupt. The final section concludes.

2 The Model

2.1 Setup

The model is a deterministic, infinite-horizon economy populated by two types of people. A fraction ω of the population are workers that produce goods and a fraction $1-\omega$ are rent-extractors that consume resources extracted from workers. The model will first be developed without sustained growth in per-capita income. The final subsection incorporates sustained growth. To simplify the analysis, specific functional forms will be assumed for preferences and production, but the resulting model will be sufficiently rich in capturing some key tradeoffs involving taxation and corruption.

Each worker is endowed with one unit of time each period that they can allocate to market and non-market production. Both markets produce the same good, but non-market production is less efficient than market production. Allocating n units of time to market production yields

$$y = An \tag{1}$$

units of a perishable consumption good, where labor productivity $A > 0$, and allocating m units of time to non-market production yields

$$A\left(m - \frac{\nu}{2}m^2\right),$$

units of the same good, where $0 < \nu < 1$,

$$n + m \leq 1, \tag{2}$$

and $0 \leq n, m \leq 1$. The assumption $\nu > 0$ captures the feature that non-market production is less efficient than market production, and the upper bound $\nu < 1$ is imposed so that the marginal productivity of labor in the non-market sector is never negative.

Workers pay a tax τ that is proportional to their market income to the government.

Workers must also pay an amount ξ that is proportional to their market income to the rent extractors. Both decrease disposable income the same way, so a time allocation (n, m) yields disposable income

$$A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right).$$

Although the amount ξ is meant to capture a variety of sources of private and public payment that is outside the "official" tax system, for simplicity I will refer to ξ as the bribery rate. The bribery rate ξ is assumed to differ across countries, but its determination is exogenous to the model. The essential difference between the tax rate τ and the bribery rate ξ is that tax revenue generated by τ must be used for public spending, but bribery income is diverted for personal gain by the rent-extractors. From an empirical standpoint, measured tax revenue will be associated with revenue generated by τ in the model. A chief premise of this paper is that most sources of bribery income, such as explicit bribes or other methods of rent extraction by a public authority, are not reflected in measured tax revenue. In this sense, this paper defines corruption as resources extracted from the private sector that is directly diverted to private gain by rent extractors.

Each worker chooses to divide their disposable income into consumption c and an investment z that enhances their future labor productivity, so that

$$c + z = A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2)\right). \tag{3}$$

Next period's labor productivity A' for each person depends on their own investment z as well as a per-capita investment H by the government in public infrastructure, such that

$$A' = D^{1-\gamma_h-\gamma_z} H^{\gamma_h} z^{\gamma_z}, \tag{4}$$

for $D > 0$, $0 < \gamma_h < 1$, $0 < \gamma_z < 1$ and $0 < \gamma_h + \gamma_z < 1$. Thus, a higher investment z by a household, or a higher investment H by the government, leads to a higher productivity A' next period. The parameter D captures the overall level of efficiency in translating private investment z or public investment H into future labor productivity. For this version of the model D is held fixed as a parameter, but in a later section D is assumed to growth at a fixed rate that leads countries to grow along a balanced growth path.

In eq. (4), H is measured in per-capita terms. An alternative assumption, explored in Barro (1990) and Glomm and Ravikumar (1999), is that H is measured as aggregate government spending, and hence government services could be thought of as non-rival. This difference would seem to have implications for the relation between country size (at least in a closed-economy setting) and productivity, but otherwise would not seem to be an important determinant of the relation between corruption and wealth. Whether a country is large or small, corruption would seem to lower per-capita income and crowd out explicit taxation along the same lines as in the current model.

People value a public good G provided by the government. For a sequence $\{c_t\}$ of consumption by a person and a sequence $\{G_t\}$ of the public good, preferences for each person are given by the discounted utility

$$\Sigma_{t=0}^{\infty}\beta^t \left(\log(c_t) + \eta \log(G_t)\right),$$

where $0 < \beta < 1$ and $\eta \geq 0$. The coefficient η captures preferences for the public good.

To describe actions taken by the government, denote the average level of market income by Y, so that average per-worker tax revenue is given by τY (in equilibrium each worker will generate the same market income). Tax revenue is divided into two types of spending, a per-capita amount H on goods that promote productivity, such as public education, an efficient judicial system, and public infrastructure, and a per-capita amount G on goods that are valued by households but do not promote productivity, such as military expenditure, environmental protection, and various social programs. Thus,

$$H + G = \tau Y.$$

H will be referred to as public infrastructure, G will be referred to as public goods, and the sum $H + G$ will be referred to as public spending. It is assumed that governments cannot borrow to finance public spending in excess of tax revenue. Governments are assumed to choose a tax and spend policy to maximize the welfare of workers. In making this decision, governments take into account how workers respond to taxes and public spending and that workers are subject to paying a bribe ξ that is beyond the policy makers control. In assuming that the government only values the welfare of workers, it is assumed that governments do not include the welfare of the rent extractors in making their decisions.

To complete the description of the model, per-worker bribery revenue is given by

$$B = \xi Y.$$

Bribery income gets allocated to the fraction $1 - \omega$ of the population that does nothing but consume this distribution, so that the per rent-extractor payment is

$$\frac{\omega B}{1-\omega}.$$

2.2 Optimal Time Allocation and Consumption

For some expectation of a recursive evolution of the aggregate variables (Y, τ, ξ, H, G), say $(Y', \tau', \xi', H', G') = \Omega(Y, \tau, \xi, H, G)$, each worker chooses sequences for their time allocation n and m, consumption c, and personal investment z to maximize their discounted utility, written recursively as the dynamic-programming problem

$$w(A) = \max_{n,m,z} \left\{ \log(c) + \eta \log(G) + \beta w(A') \right\},$$

subject to eq. (2), where c is given by eq. (3) and A' evolves according to eq. (4).

Let λ be the multiplier on the inequality constraint (2). The first-order conditions with respect to n, m, and z are given by

$$\begin{aligned} 1-(\tau+\xi) &\geq \lambda, \ w/eq.\ if\ \lambda > 0, \\ 1-\nu m &\geq \lambda, \ w/eq.\ if\ \lambda > 0, \\ n+m &\leq 1, \ w/eq.\ if\ \lambda > 0, \\ \frac{1}{A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right) - z} &= \beta\gamma_z w'(A')A'\frac{1}{z}. \end{aligned} \tag{5}$$

The envelope condition is

$$w'(A) = \frac{(1-\tau-\xi)n + m - \frac{\nu}{2}m^2}{A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right) - z}.$$

Substitution of the envelope condition into eq. (5) yields

$$\frac{1}{A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right) - z} = \beta\gamma_z \frac{A'\left((1-\tau'-\xi')n' + m' - \frac{\nu}{2}(m')^2\right)}{A'\left((1-\tau'\xi')n' + m' - \frac{\nu}{2}(m')^2\right) - z'}\frac{1}{z}.$$

The solution to this equation is

$$z = \beta\gamma_z A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right),$$

and hence also

$$c = (1-\beta\gamma_z)A\left((1-\tau-\xi)n + m - \frac{\nu}{2}m^2\right).$$

For a tax rate τ and bribery rate ξ in each period, if the boundary constraints for n and m are not binding, so that $n > 0$, $m > 0$, then $n + m = 1$ and the solutions for n and m are given by

$$m = \frac{\tau+\xi}{\nu}, \tag{6}$$

$$n = 1 - \frac{\tau+\xi}{\nu}. \tag{7}$$

Since m cannot exceed one and n cannot be negative, if $\tau + \xi \geq \nu$, then $m = 1$ and $n = 0$. Since it will clearly not be optimal for a government to choose a policy such that $n = 0$, for simplicity assume that $\tau + \xi \leq \nu$. This assumption will be verified as a feature of the solution.

To summarize the optimal behavior of households, define

$$P(\tau,\xi) = 1 - (\tau+\xi) + \frac{(\tau+\xi)^2}{2\nu}, \tag{8}$$

$$R(\tau,\xi) = \tau\left(1 - \frac{\tau+\xi}{\nu}\right). \tag{9}$$

Given the optimal time allocation and level of productivity, each worker's disposable income is given by AP and government public spending is given by AR, so that

$$z = \beta\gamma_z AP, \tag{10}$$

$$c = (1-\beta\gamma_z)AP, \tag{11}$$

$$H + G = AR. \tag{12}$$

At this solution, A' evolves according to

$$A' = D^{1-\gamma_h-\gamma_z} H^{\gamma_h} \left(\beta\gamma_z AP\right)^{\gamma_z}. \tag{13}$$

These equations completely summarize the behavior of households. Note that this is the optimal allocation for any recursive sequence of aggregate variables and hence is the fully dynamic solution to a person's utility optimization problem.

The following properties of P and R will be useful to study the equilibrium under an optimal government policy. Let P_τ be the derivative of P with respect to τ, and R_τ be the derivative of R with respect to τ, which are given by

$$P_\tau = -1 + \frac{\tau + \xi}{\nu}, \tag{14}$$

$$R_\tau = 1 - \frac{2\tau + \xi}{\nu}. \tag{15}$$

Lemma 1: For any τ such that $0 < \tau + \xi < \nu$, P is a strictly-decreasing function of τ.
Proof: Stated without proof. **Q.E.D.**

Lemma 2: For any τ such that $0 < \tau + \xi < \nu$, R is a strictly-positive, concave function of τ with peak at

$$\tau = \frac{\nu}{2}\left(1 - \frac{\xi}{\nu}\right).$$

Proof: Stated without proof. **Q.E.D.**

2.3 Optimal Government Policy and Equilibrium

Given optimizing worker behavior, the government is assumed to choose τ, H, and G to maximize the welfare of a typical worker, written recursively as the dynamic programming problem

$$v(A) = \max_{\tau,H} \left\{\log(c) + \eta \log\left(AR - H\right) + \beta v(A')\right\},$$

where c is given by eq. (11) with P given by eq. (14), R given by eq. (15), and A' given by eq. (13). In setting this up as a dynamic program, it is assumed that the government in choosing current actions takes future government reactions as given, and that future government choices are otherwise unconstrained by prior government choices. The first-order conditions with respect to H and τ can be written as

$$0 = -\eta \frac{1}{AR - H} + \beta \gamma_h v'(A') A' \frac{1}{H},$$

$$0 = \frac{P_\tau}{P} + \eta \frac{AR_\tau}{AR - H} + \beta \gamma_z v'(A') A' \frac{P_\tau}{P}.$$

The envelope condition is given by

$$v'(A) = \left(1 + \eta \frac{AR}{AR - H} + \beta \gamma_z v'(A') A'\right) \frac{1}{A}.$$

The solution to this system is

$$H = \left(\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta} \right) AR, \tag{16}$$

$$v(A) = \frac{1+\eta}{1-\beta\gamma_h-\beta\gamma_z} \log(A), \tag{17}$$

where τ must satisfy the equation

$$-\frac{P_\tau}{P} = \left(\frac{\beta\gamma_h + (1-\beta\gamma_z)\eta}{1-\beta\gamma_h+\beta\gamma_z\eta} \right) \frac{R_\tau}{R}. \tag{18}$$

At this solution, A evolves according to

$$A' = D^{1-\gamma_h-\gamma_z} \left(\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta} R \right)^{\gamma_h} (\beta\gamma_z P)^{\gamma_z} A^{\gamma_h+\gamma_z}, \tag{19}$$

and the solution for G is

$$G = \left(1 - \frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta} \right) AR,$$

Note that

$$\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta} < 1,$$

since $\beta\gamma_h + \beta\gamma_z < 1$.

The term on the left of eq. (18) is the utility cost of raising revenue by increasing the tax rate, and the term on the right is the utility gain by allocating tax revenue to public spending. The following result establishes the existence of a solution τ to this equation and also verifies the conjecture that $\tau + \xi \leq \nu$.

Proposition 1: For any ξ such that $0 \leq \xi < \nu$, there exists one, and only one, solution $\tau \leq \frac{\nu}{2}\left(1 - \frac{\xi}{\nu}\right)$ to eq. (18).
Proof: Define Q for $0 < \tau < \frac{\nu}{2}\left(1 - \frac{\xi}{\nu}\right)$ and $0 \leq \xi < \nu$ as

$$Q(\tau,\xi) = \frac{\tau\left(1 - \frac{\tau+\xi}{\nu}\right)^2}{\left(1-(\tau+\xi)+\frac{(\tau+\xi)^2}{2\nu}\right)\left(1-\frac{2\tau+\xi}{\nu}\right)} - \frac{\beta\gamma_h + (1-\beta\gamma_z)\eta}{1-\beta\gamma_h+\beta\gamma_z\eta}. \tag{20}$$

Given the functions P and R and their derivatives, the solution τ to eq. (18) is such that

$Q(\tau,\xi) = 0$. Q is a continuous function of τ. $Q(0,\xi) < 0$. $\lim_{\tau \to \frac{\nu}{2}\left(1-\frac{\xi}{\nu}\right)} Q(\tau,\xi) = \infty$ since $1 - \frac{2\tau+\xi}{\nu} = 0$ at $\tau = \frac{\nu}{2}\left(1 - \frac{\xi}{\nu}\right)$ and $1 - (\tau+\xi) + \frac{(\tau+\xi)^2}{2\nu}$ is a convex function of $\tau + \xi$ with minimum value $1 - \frac{\nu}{2} \geq 0$ at $\tau + \xi = \nu$. Thus, there exists a value $\tau < \frac{\nu}{2}\left(1 - \frac{\xi}{\nu}\right)$ such that $Q(\tau,\xi) = 0$. The derivative of Q with respect to τ is strictly positive, as by explicitly taking the derivative of Q with respect to τ, it can be shown to be the same sign as

$$\left(1 - (\tau+\xi) + \frac{(\tau+\xi)^2}{2\nu}\right)\left(1 - \frac{2\tau+\xi}{\nu}\right)\left(1 - \frac{2\tau}{\nu}\right) \tag{21}$$

$$+\tau\left(1 - \frac{\tau+\xi}{\nu}\right)\left(\left(1 - \frac{\tau+\xi}{\nu}\right)\left(1 - \frac{2\tau+\xi}{\nu}\right) + \left(1 - (\tau+\xi) + \frac{(\tau+\xi)^2}{2\nu}\right)\right), \tag{22}$$

which is strictly positive. Thus, there only exists one solution τ to $Q(\tau,\xi) = 0$. **Q.E.D.**

As η, ξ and consequently τ converge to steady state values, A converges to a steady-state value given by

$$A = D\left(\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta}R\right)^{\frac{\gamma_h}{1-\gamma_h-\gamma_z}} (\beta\gamma_z P)^{\frac{\gamma_z}{1-\gamma_h-\gamma_z}}. \tag{23}$$

The steady-state value for $y = An$ is given by

$$y = D\left(\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta}R\right)^{\frac{\gamma_h}{1-\gamma_h-\gamma_z}} (\beta\gamma_z P)^{\frac{\gamma_z}{1-\gamma_h-\gamma_z}} \left(1 - \frac{\tau+\xi}{\nu}\right). \tag{24}$$

A straightforward implication of Proposition 1 embodies a key feature of this paper: high levels of corruption lead to low tax rates and low output. The implication of the Proposition is that as ξ approaches its upper bound of ν, the optimal tax rate τ approaches zero, and from eq. (24) output approaches zero as well. This key feature of the model may explain the observed relation between per-capita GDP, tax rates, and measures of corruption in the data. In the data as well, observed high measures of corruption are related to low tax rates and low per-capita GDP.

2.4 Sustained Growth

In the model just presented, all countries converge to stead-state values of per-capita income, although potentially at different levels. To incorporate sustained growth in per-capita income, suppose an underlying world technology determines the evolution of D that is common across countries, so that for a current level of D, next period's level D' is given by

$$D' = (1+\theta)D,$$

for a constant $\theta \geq 0$ that is common across countries. Here, the determination of θ is exogenous to the model.[2] Define the following variables: $\hat{c} = c/D$, $\hat{z} = z/D$, $\hat{G} = G/D$, $\hat{A} = A/D$, and $\hat{H} = H/D$. Define also

$$\hat{D} = (1+\theta)^{-\frac{1}{1-\gamma_h-\gamma_z}}.$$

The set-up of this problem is identical to the problem just considered, with $\hat{c}$ replacing c, etc., and $\hat{D}$ replacing D. Here, countries converge to steady states with the same growth rate, but each country may be at a different level of per-capita income. Steady-state differences in per-capita income are completely determined by differences in the level of corruption and preference for public goods, along with difference policy choices by the government in each country.

3 Data Summary

This section establishes key relationships between income, tax rates, and corruption observed in the data. Various measures of income, tax rates, and corruption are defined to show that the key relationships are robust to alternative measures of these variables. Although the model is nonlinear, this section will include some linear regression results to capture some key relationships. Given potential endogeneity concerns, these regressions are chiefly meant to summarize some empirical relationships and are not meant to directly uncover an underlying structural relationship. The next section uses this data to estimate parameters of the model.

3.1 Income

This paper will compare income levels across countries at some recent point in time (2018), as opposed to comparisons of growth rates over time. As presented by Lucas (2009), low-growth countries are poor countries falling behind and high-growth countries are poor countries catching up, so growth comparisons would seem to focus more on policies to sustain a

[2]Aghion, et. al. (2016) provide a way to think about taxation, innovation and growth.

convergence path by which poor countries catch up to rich, industrial countries. Comparison of poor versus rich countries, and the persistent policies that led to this difference, would seem to be better suited to a comparison of levels of income. This approach, adopted in this paper, follows the lead of, e.g., Chari, Kehoe, and McGrattan (1997) and Hall and Jones (1999).

As a measure of aggregate income, I will use overall GDP, and as well following Hall and Jones (1999), GDP minus Natural Resource Rents,[3] as some countries experience high levels of GDP per capita due largely to the extraction of oil or other natural resources. As it regards a per person measure, I will use various measures, such as income per population (GdpPop for GDP and GdpXnrPop for GDP minus Natural Resource Rents), income per adult between 15 to 64 years of age (Gdp1564 and GdpXnr1564), and income per worker (GdpEmp and GdpXnrEmp). All comparisons will convert national incomes to U.S. dollars using a PPP exchange rate. Summary statistics for each variable, as well as those listed below, are reported in Table 1.

3.2 Tax Rate

Countries impose a variety of types of taxes to raise revenue, some relying on an income tax with varying degrees of importance assigned to personal versus corporate income, and some relying more on a consumption or value-added tax. In addition, countries differ by the degree to which tax rates are progressive, which creates a wedge between marginal and average tax rates. Here, I will consider three summary measures of a marginal tax rate: (1) one based only on the personal income tax, (2) a second that combines personal and corporate income tax rates, and (3) a third that adds the effect of a value-added tax to personal and corporate income tax rates.

For the marginal personal income tax rate, I will use estimates of the top personal income tax rate obtained from the Heritage Foundation's Index of Economic Freedom Database, which I will refer to as Tax0.

The Heritage Foundation database also includes the corporate income tax rate, which I combine with the personal income tax rate using the following method. Let W represent

[3] As defined by the World Bank: Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. The estimates of natural resources rents are calculated as the difference between the price of a commodity and the average cost of producing it. This is done by estimating the price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs. These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product (GDP).

Table 1: Summary Statistics

Variable	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Measures of Income						
GdpPop	191	21,982	22,676	5,065	14,210	31,527
GdpEmp	173	47,455	42,338	13,379	34,130	68,168
Gdp1564	191	33,316	32,750	8,449	21,648	47,245
GdpXnrPop	191	20,936	21,982	4,649	13,153	30,406
GdpXnrEmp	173	44,795	41,167	12,960	33,484	66,319
GdpXnr1564	191	31,775	32,047	8,068	20,672	45,888
Measures of Tax Rates						
Tax0	183	0.28	0.13	0.20	0.30	0.35
Tax1	183	0.33	0.14	0.24	0.36	0.42
Tax2	181	0.41	0.15	0.32	0.44	0.50
TaxZ	183	0.24	0.09	0.20	0.25	0.30
TaxV	214	0.14	0.07	0.10	0.15	0.19
Measures of Corruption						
VoiceAccount	202	0.003	1.00	−0.81	0.09	0.84
PoliticalStability	207	0.01	0.99	−0.58	0.08	0.85
GovtEffect	203	0.01	1.00	−0.66	−0.04	0.74
RegulatoryQuality	203	0.005	1.00	−0.72	−0.08	0.72
RuleofLaw	203	0.01	1.00	−0.70	−0.15	0.74
ControlofCorruption	203	0.01	1.00	−0.76	−0.16	0.69
CPI	179	43	19	29	38	57

Note: Gdp is adjusted by PPP. GdpPop = Gdp / Population, GdpEmp = Gdp / Employment, Gdp1564 = Gdp / Pop1564 (Pop1564 = Population older than 14 and younger than 65). GdpXnr = Gdp minus Natural Resource Rents. Tax0 = highest marginal personal income tax. TaxZ = corporate income tax. Tax1 = Tax0 + .2TaxZ. TaxV = value-added tax. Tax2 = (TaxV + Tax1)/(1 + TaxV). VoiceAccount = Voice and Accountability, PoliticalStability = Political Stability and Absence of Violence/Terrorism, GovtEffect = Government Effectiveness, RegulatoryQuality = Regulatory Quality, RuleofLaw = Rule of Law, and ControlofCorruption = Control of Corruption. CPI = Corruption Perception Index. Data Sources: World Bank World Development Indicators (Gdp, Population, Employment, Pop1564, TaxV), Heritage Foundation (Tax0, TaxZ), KPMG (TaxV if WDI TaxV is missing), Transparency International (CPI). Data are for 2018.

aggregate wage and salary income that is taxed at rate Tax0, and let Z represent aggregate corporate profits that is taxed at rate TaxZ. The tax rate on all of income $W + Z$, which I will refer to as Tax1, can then be derived from the following relation

$$(1 - Tax1)(W + Z) = (1 - Tax0)(W + (1 - TaxZ)Z).$$

Ignoring the interaction term $Tax0 \times TaxZ$, this relation can be approximated by

$$Tax1 \approx Tax0 + \frac{Z}{W + Z} TaxZ.$$

In the U.S., the Bureau of Economic Analysis estates that wage and salary income for 2020 is about \$8.9 trillion and corporate profits before tax is about \$2.3 trillion, so $Z/(W + Z)$ is approximately 0.2. The combined tax rate is thus approximately $Tax1 = Tax0 + 0.2TaxZ$, which I will refer to as the Total Income Tax (I will use this equation for all countries in the sample).

A country's value-added tax can be obtained from the World Bank World Development Indicators, supplemented by KPMG (2024) if the data was reported as missing. To incorporate a value-added tax, say TaxV, I will convert the value added tax to an equivalent income tax to define Tax2 given as

$$Tax2 = \frac{TaxV + Tax1}{1 + TaxV}.$$

I will refer to Tax2 as the Overall Tax Rate.

3.3 Corruption

Various agencies attempt to measure the degree of corruption in the public sector in different countries based on surveys that measure the perception of various forms of public corruption, ranging from bribery, diversion of public funds, using public office to pursue private gain, lack of transparency and accountability, and a wide variety of other features broadly associated with corruption. I will use 7 measures of the quality of governance and corruption. This list includes the following 6 from the World Governance Indicators: (1) Voice and Accountability, (2) Political Stability and Absence of Violence/Terrorism, (3) Government Effectiveness, (4) Regulatory Quality, (5) Rule of Law, and (6) Control of Corruption. Transparency International combines a variety of corruption measure into one Corruption Perception Index,

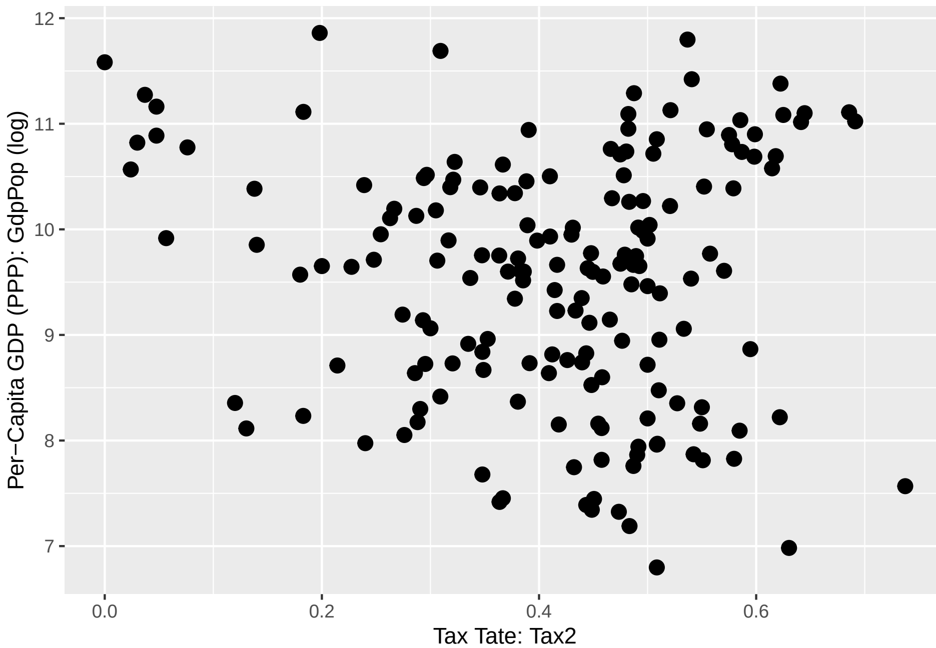

Figure 1: GDP and Tax Rate

which is included as well. Note that for all 7 measures of corruption, higher values of the index corresponds to lower levels of corruption.

3.4 Some Graphs

Fig. 1 graphs income as measured by per-capita GDP (PPP) (GdpPop) versus the tax rate as measured by Tax2 (robustness of the results to other measures of income, tax rates, and corruption are presented later in this paper). This graph does not exhibit any obvious and robust relationship between tax rates and GDP. The chief argument of this paper is that the degree of corruption impacts this relationship, so that low levels of corruption are associated with high levels of income and high levels of tax rates. Indeed, the correlation between Transparency International's Corruption Perception Index (CPI) and Tax2 is statistically significant at the 5% level, with correlation $r(171) = 0.21$ and $p = .0057$. Not controlling for corruption obfuscates any underlying structural relationship between tax rates and GDP.

Fig. 2 graphs the same relationship, but here countries are placed into three categories based on their level of CPI. The "Low" category consists of countries below the first quartile for CPI, the "Mid" category consists of countries between the first and third quartiles, and the "High" category consists of countries above the third quartile. Here it is clear that

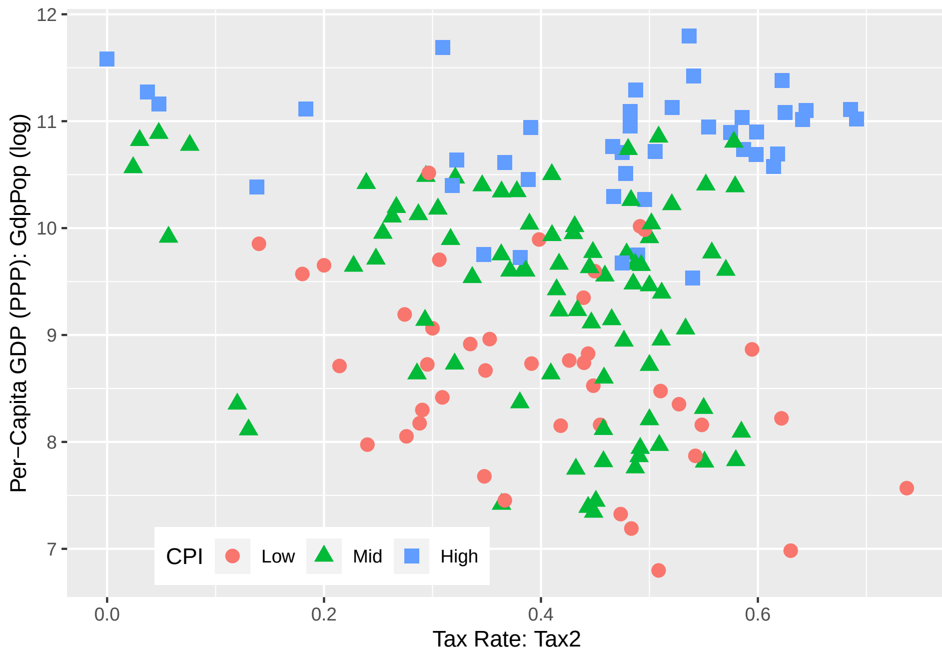

Figure 2: GDP and Tax Rate with Corruption

within a category there appears to exist a robust, negative association between per-capita GDP and the tax rate. Categories associated with a higher level of corruption (a lower value of CPI), tend to exhibit lower levels of GDP. From this graph it seems clear that conditional on a level of corruption as measured by CPI, there exists a robust negative relation between per-capita GDP and tax rates.

Table 2 (Regression 1) displays results of regressing per-capita GDP (PPP) on the CPI index of corruption. Fig. 3 graphs the residuals from that regression against the tax rate Tax2. This figure exhibits a pronounced negative association between the residual and the tax rate, suggesting that the tax rate captures an additional influence on income.

3.5 Regression Result

Table 2 (Regression 2) displays results of regressing per-capita GDP (PPP) on the tax rate Tax2 and the CPI index of corruption. Both the measure of the tax rate and corruption are very significant in Regression 2, suggesting that tax rates and corruption are both important determinant of a country's wealth.

Table 3 summarizes the magnitude of the relationship documented in Table 2 (Regression 2). Quantitatively, real, per-capita GDP depends significantly on both corruption

Table 2: Regression: GdpPop

	Dependent variable:	
	GdpPop (log)	
	(1)	(2)
CPI	4.481***	4.736***
	(0.327)	(0.266)
Tax2		−1.872***
		(0.391)
Constant	7.561***	8.231***
	(0.156)	(0.187)
Observations	169	167
R^2	0.529	0.574
Adjusted R^2	0.526	0.569
Residual Std. Error	0.805 (df = 167)	0.764 (df = 164)
F Statistic	187.571*** (df = 1; 167)	110.633*** (df = 2; 164)

Note: GdpPop = GDP (PPP) / Population. CPI = Corruption Perception Index, Tax2 = tax rate that incorporates the personal income tax, corporate income tax, and value-added tax. *p<0.1; **p<0.05; ***p<0.01.

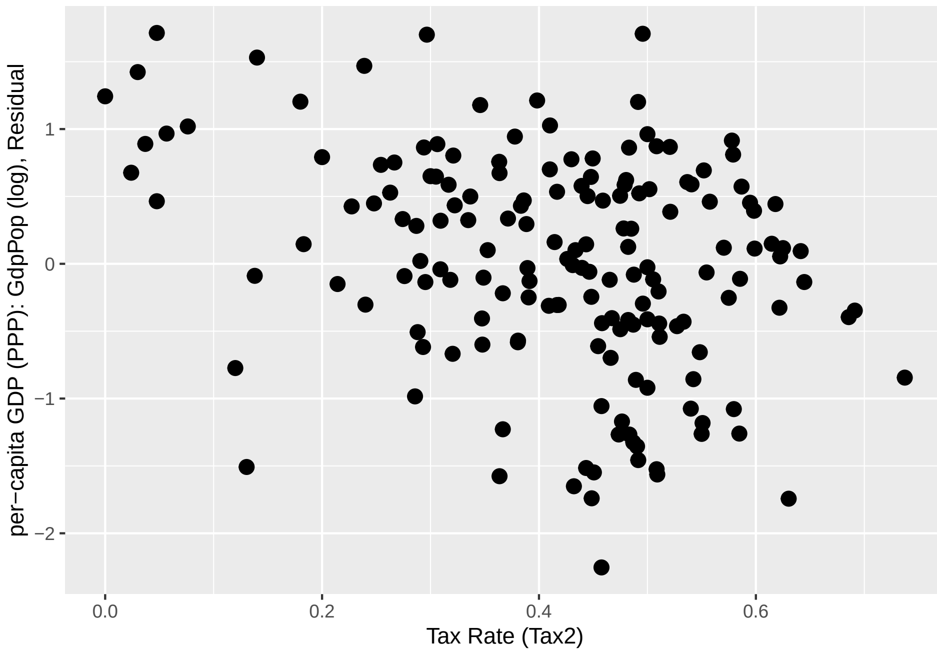

Figure 3: GDP on Corruption Residual and Tax Rate

and tax rates. For a tax rate of 40 percent, as the CPI index falls from 66 to 10 (the median plus and minus the interquartile range), real, per-capita GDP falls from $40,456 to $2,852 (a 70 percent decline). For a CPI Index of 38 (the median value), as the income tax rate rises from 20 to 60 percent, real per-capita GDP falls from $15,620 to $7,387 (a 53 percent decline). Both tax rates and corruption seem to be related to real, per-capita GDP in a quantitatively important way.

Table 3: Real, per-capita GDP Predictions
(from fitted regression in Table 2, Regression 2)

	Tax Rate		
CPI	20%	40%	60%
66	58,827	40,456	27,821
38	15,620	10,742	7,387
10	4,147	2,852	1,961

3.6 Alternative Regression Results

This section reports regression results using different measures of income, tax rates, and measures of the quality of governance. Table 4 displays regression results using different measures of income. Table 5 displays regression results using different measures of the tax rate. Table 6 displays regression results using different measures of corruption and the quality of governance. In almost every regression, both the measure of the tax rate and the measure of corruption continue to be very significant. The one exception is the regression with Political Stability in Table 6, in which case the coefficient on the tax rate becomes insignificantly different from zero, likely because Political Stability is a poor measure of corruption.

Table 4: Regression: Various Measures of Income

	Dependent variable:				
	GdpEmp (log)	Gdp1564 (log)	GdpXnrPop (log)	GdpXnrEmp (log)	GdpXnr1564 (log)
	(1)	(2)	(3)	(4)	(5)
CPI	3.975^{***}	4.409^{***}	4.911^{***}	4.147^{***}	4.586^{***}
	(0.274)	(0.250)	(0.255)	(0.263)	(0.239)
Tax2	-1.521^{***}	-1.738^{***}	-1.616^{***}	-1.263^{***}	-1.479^{***}
	(0.383)	(0.366)	(0.398)	(0.393)	(0.373)
Constant	9.340^{***}	8.670^{***}	7.972^{***}	9.081^{***}	8.408^{***}
	(0.187)	(0.178)	(0.189)	(0.188)	(0.180)
Observations	165	168	167	165	168
R^2	0.497	0.573	0.588	0.514	0.589
Adjusted R^2	0.490	0.567	0.583	0.508	0.584
Residual Std. Error	0.749	0.714	0.767	0.751	0.715
F Statistic	79.897^{***}	110.527^{***}	117.094^{***}	85.777^{***}	117.992^{***}

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

4 Estimating the Parameters

The unknown parameters of the model will be estimated with nonlinear least squares (NLS). As developed in this paper, the perspective regarding the data is that per-capita income differences across countries are due to cross-country differences in corruption, the preference for public goods and the resulting different policy choice made by governments in each country. The nonlinear relationship between real per-capita GDP, tax rates, and corruption that will be used to estimate the parameters is eq. (24), with eq. (18) used to relate η to τ

Table 5: Regression: Various Measures of Tax Rates

	Dependent variable:	
	GdpPop (log)	
	(1)	(2)
CPI	4.755^{***}	4.708^{***}
	(0.278)	(0.272)
Tax0	-1.911^{***}	
	(0.451)	
Tax1		-1.849^{***}
		(0.418)
Constant	7.991^{***}	8.083^{***}
	(0.166)	(0.174)
Observations	167	167
R^2	0.566	0.571
Adjusted R^2	0.560	0.566
Residual Std. Error (df = 164)	0.772	0.767
F Statistic (df = 2; 164)	106.771^{***}	109.211^{***}
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 6: Regression: Various Measures of Corruption

	Dependent variable:					
	GdpPop (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
VoiceAccount	0.722^{***}					
	(0.090)					
PoliticalStability		0.711^{***}				
		(0.081)				
GovtEffect			1.033^{***}			
			(0.046)			
RegulatoryQuality				0.997^{***}		
				(0.063)		
RuleofLaw					0.951^{***}	
					(0.053)	
ControlofCorruption						0.861^{***}
						(0.054)
Tax2	-2.388^{***}	-0.898	-1.585^{***}	-1.666^{***}	-1.880^{***}	-1.877^{***}
	(0.665)	(0.548)	(0.327)	(0.360)	(0.385)	(0.415)
Constant	10.550^{***}	9.976^{***}	10.192^{***}	10.211^{***}	10.343^{***}	10.340^{***}
	(0.297)	(0.239)	(0.147)	(0.154)	(0.171)	(0.181)
Observations	171	171	171	171	171	171
R^2	0.305	0.334	0.717	0.653	0.589	0.523
Adjusted R^2	0.296	0.326	0.714	0.649	0.584	0.517
Residual Std. Error (df = 168)	0.971	0.951	0.619	0.686	0.746	0.804
F Statistic (df = 2; 168)	36.814^{***}	42.051^{***}	213.211^{***}	158.298^{***}	120.498^{***}	92.104^{***}

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

and ξ. Use eq. (18) to derive

$$\eta = \frac{-\frac{P_\tau R}{PR_\tau}(1-\beta\gamma_h) - \beta\gamma_h}{\left(\frac{P_\tau R}{PR_\tau} - 1\right)\beta\gamma_z + 1}. \tag{25}$$

and use this relation to show

$$\frac{\beta\gamma_h(1+\eta)}{\beta\gamma_h + (1-\beta\gamma_z)\eta} = \beta\gamma_h\left(1 - \frac{PR_\tau}{P_\tau R}\right).$$

This result can be used to show that the steady-state value of A is

$$A = D\left(\beta\gamma_h\left(R - \frac{PR_\tau}{P_\tau}\right)\right)^{\frac{\gamma_h}{1-\gamma_h-\gamma_z}}(\beta\gamma_z P)^{\frac{\gamma_z}{1-\gamma_h-\gamma_z}}.$$

The steady-state value of y, written in log form and with an error term, can then be written as

$$\begin{aligned}\log y \quad = \quad & d + \frac{\gamma_h}{1-\gamma_h-\gamma_z}\log\left(\beta\gamma_h\left(R - \frac{PR_\tau}{P_\tau}\right)\right) \\ & + \frac{\gamma_z}{1-\gamma_h-\gamma_z}\log(\beta\gamma_z P) + \log\left(1 - \frac{\tau+\xi}{\nu}\right) + \epsilon,\end{aligned} \tag{26}$$

where $d = \log D$. This equation involves the five parameters β, d, ν, γ_h, and γ_z. This nonlinear relationship between y, τ, and ξ will be used to estimate the parameters of the model via NLS.

To estimate the model, I will relate Transparency International's CPI index of corruption to the bribery rate ξ featured in the model. Although it is reasonable to conjecture they are monotonically related, there is no reason to expect they are measured in the same units, or even linearly related. Here I will assume the following relation

$$\xi = (1 - CPI/100)^\alpha, \tag{27}$$

for some parameter $\alpha > 0$. Low values of CPI, which are associated with high levels of corruption, are thus associated with high levels of ξ. The parameter α will shift the distribution of ξ to either lower or higher values, but with $\alpha > 0$ the range of ξ will be from zero to one. Using eq. (27) to relate the CPI corruption index to the model's bribery variable ξ will add the parameter α to the list of parameters that need to be estimated.

The variable $Tax2$ constructed from the data is based in part on measurement of the highest marginal tax rate on income, and is thus likely an overestimate of the effective marginal tax rate for the economy. Here I will assume there is a monotonic relation between the measured tax rate $Tax2$ and the marginal tax rate τ in the model of the following form:

$$\tau = \zeta * Tax2, \tag{28}$$

where $0 < \zeta \leq 1$. Using eq. (28) to relate the measured tax rate $Tax2$ to the models marginal tax rate τ will add the parameter ζ to the list of parameters that need to be estimated.

Some observations of $Tax2$ and CPI along with implied values of τ and ξ may not satisfy eq. (18) for any value of $\eta \geq 0$. Observed tax rates are simply too low to support an optimal infrastructure spending H as well as any positive spending on public goods G as implied by the model. As it regards implications for market output, for these observation the model will be solved for $G = 0$ and thus $H = AR$. The relation between y, τ, and ξ, for these observations and parameter values, becomes

$$\begin{aligned} \log y &= d + \frac{\gamma_h}{1 - \gamma_h - \gamma_z} \log (R) \\ &\quad + \frac{\gamma_z}{1 - \gamma_h - \gamma_z} \log (\beta \gamma_z P) + \log \left(1 - \frac{\tau + \xi}{\nu}\right) + \epsilon. \end{aligned} \tag{29}$$

The model's prediction for GDP is thus either eq. (26) or (29) depending on whether or not the model predicts $G > 0$ or $G = 0$.

The discount factor β will be set to .95 to anchor the model in a time horizon that seems relevant for political turnover (roughly 5 years for a 1 percent annual discount rate). The unknown parameters to be estimated are thus given by d, γ_h, γ_z, ν, α, and ζ. The results of NLS estimation are reported in Table 7. Model 1 imposes the constraint $\nu \leq 1$, which turns out to be a binding constraint. Model 2 relaxes this constraint and finds that the unconstrained parameter estimates are not too different from those for Model 1.[4] One interesting feature of the parameter estimates is that the exponent parameter for public infrastructure is estimated to be significantly lower than the estimate for the exponent for private investment. Also, the point estimate $\zeta = .347$ suggests that the economy-wide marginal tax rate is about 40 percent of the marginal tax rate based on the highest rate in a progressive tax structure. Fig. 4 graphs the fitted vs. observed values of per-capita GDP

[4] It turns out not to be binding, but if $\nu > 1$ then an additional condition $n = 0$ if $\tau + \xi > 1$ needs to be added as a property of an equilibrium.

(for Model 1). As can be seen from this figure, the model captures a significant amount of the variation of per-capita GDP as it relates to corruption and tax rates.

Table 7: Nonlinear Regression

		Parameter Estimates	
Parameter	Description	(1)	(2)
β	time preference	$0.95^{\dagger}$	$0.95^{\dagger}$
d	overall productivity	12.947	12.977
		(1.000)	(1.116)
γ_h	infrastructure exponent	0.015	0.014
		(0.060)	(0.068)
γ_z	private investment exponent	0.735	0.735
		(0.091)	(0.095)
ν	non-market production cost	1.000	1.093
		(0.101)	(0.169)
α	corruption adj	1.747	1.698
		(0.545)	(0.198)
ζ	marginal tax adj	0.347	0.387
		(0.107)	(0.118)
Observations		136	136
DF		130	130
SSE		93.897	91.745
RMSE		0.850	0.840

†Not estimated. Model 1: $\nu \leq 1$. Model 2: ν unconstrained.

5 Some Experiments

At the estimated parameter values, Fig. 5 captures the core features of the supply-side underpinnings of the model. For two values of the bribery rate ξ, Panel A displays the relation between market output and the level of tax rates and Panel B displays the relation between tax revenue and the level of tax rates. In depicting this relation, households optimally choose their time allocation (n, m) and private investment Z in response to the tax rate, and the government optimally chooses to allocate total tax revenue between public good G and

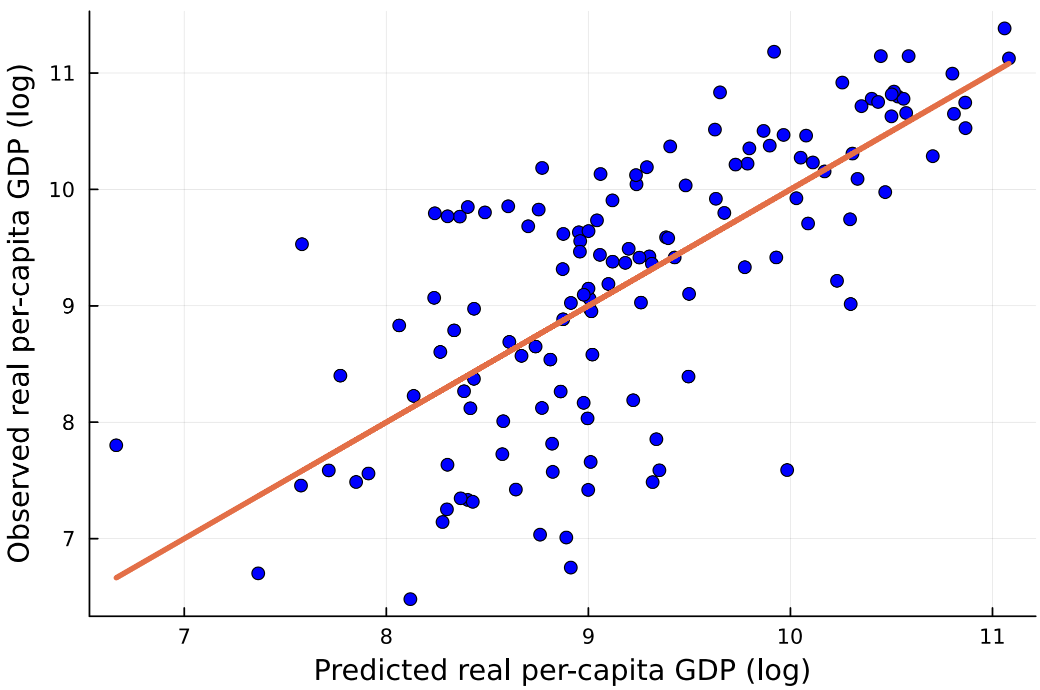

Figure 4: **Predicted vs Observed real per-capita GDP**

public infrastructure H expenditures. Because of the essential nature of public infrastructure, market output is zero if tax rates are zero, but quickly rises as tax rates begin to rise and generate tax revenue. At some point output begins to fall with a continued rise in tax rates, as the disincentive effect of tax rates outweigh the benefits of additional infrastructure. Higher levels of corruption as captured by ξ tend to lower tax revenue and market output at any level of the tax rate.

Fig. 6 shows the dependence in the model of market output y (Panel A) and tax rate τ (Panel B) on the bribery rate ξ, where now the government is assumed to choose the tax rate optimally. As the bribery rate rises, the tax rate falls, and market output falls. The magnitudes are quantitively significant: as the bribery rate rises from 0 to 40 percent, market output falls roughly by a factor of 6. As ξ rises even further, market output approaches zero. In addition, as the bribery rate rises from 0 to 85 percent, the tax rate falls by a factor of 3 (from 15 to 5 percent), although most of this fall occurs at higher rates of bribery. As captured by the model, this reduction in tax rates is insufficient to compensate for the increased distortion due to corruption. The overall rise in the distortion provides a disincentive to work in the market, and the rise in corruption diverts resources away from

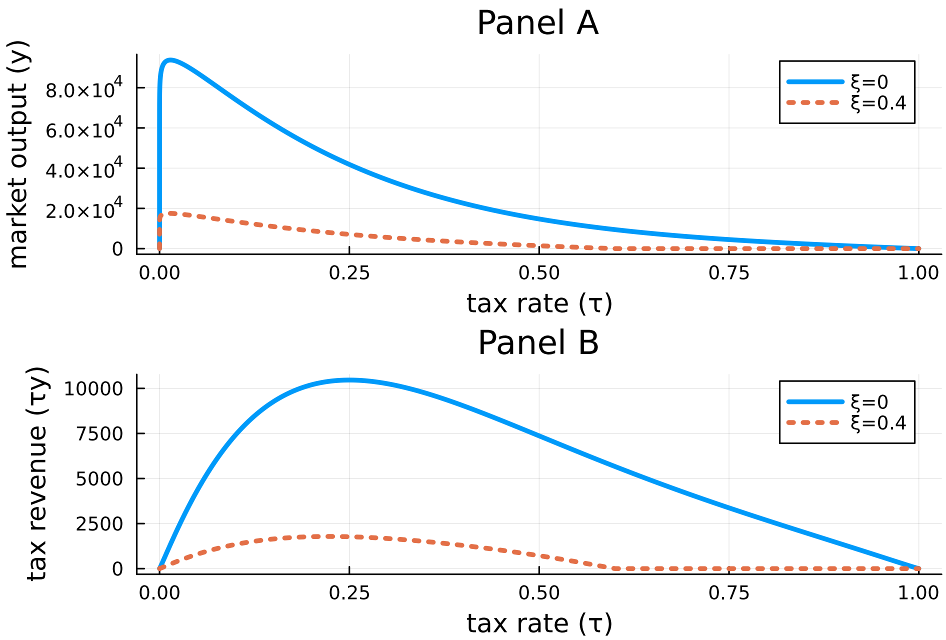

Figure 5: **Estimated Model and Tax Rate**. **Panel A:** Plot of market output y and tax rate τ. **Panel B:** Plot of tax revenue τy and tax rate τ. Other parameter: $\eta = 1.0$.

public infrastructure, the combined effect of which is to greatly reduce output.

Fig. 7 shows the dependence in the model of market output y (Panel A) and tax rate τ (Panel B) on the preference for the non-productive public good as measured by η. Here we see that a higher value for the public good leads to a rise in the tax rate and a consequent fall in market output. That is, as more revenue is required to finance the non-productive public good and tax rates rise by about 20 percentage points, output falls roughly in half. As these results show, variation across countries in the preference for public goods will tend to lead to an inverse association between tax rates and real per-capita GDP.

Fig. 8 shows the estimated path of market output for a country in which corruption is rampant ($\xi = .7$) to transition to zero corruption ($\xi = 0$). Recall that $\beta = .95$, so every period in the model is assumed to be 5 years. The rise in output is significant, rising slightly more than 10 fold from about \$3,000 (per-capita) to about \$60,000. Achieving the full rise in output takes some time, estimated to be about 60 years, with half the gain achieved in about 25 years.

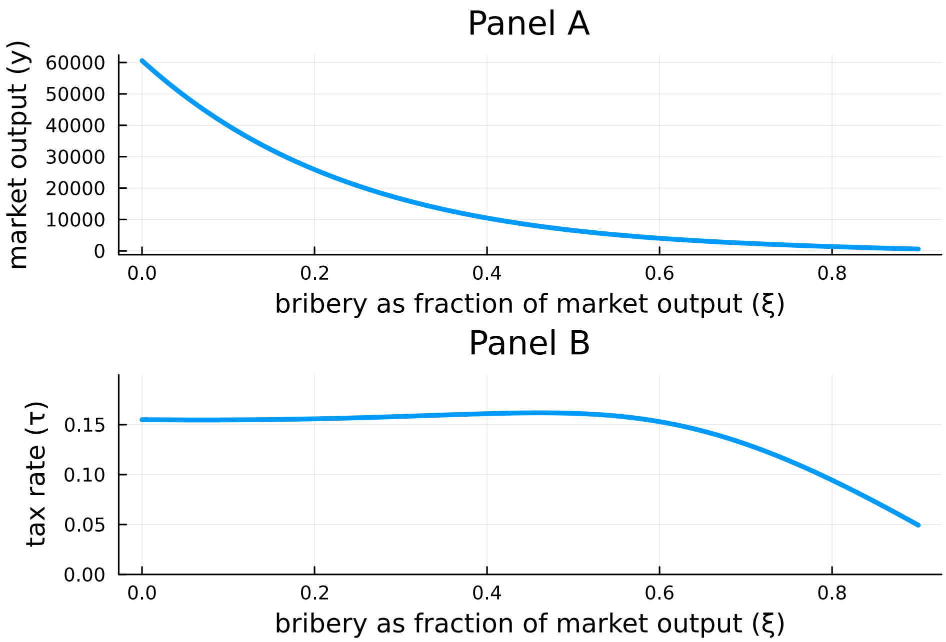

Figure 6: **Estimated Model and Corruption**. **Panel A:** Plot of log market output ($\log y$) and bribery rate (ξ). **Panel B:** Plot of tax rate (τ) and bribery rate (ξ). Other parameters: $\eta = 1$.

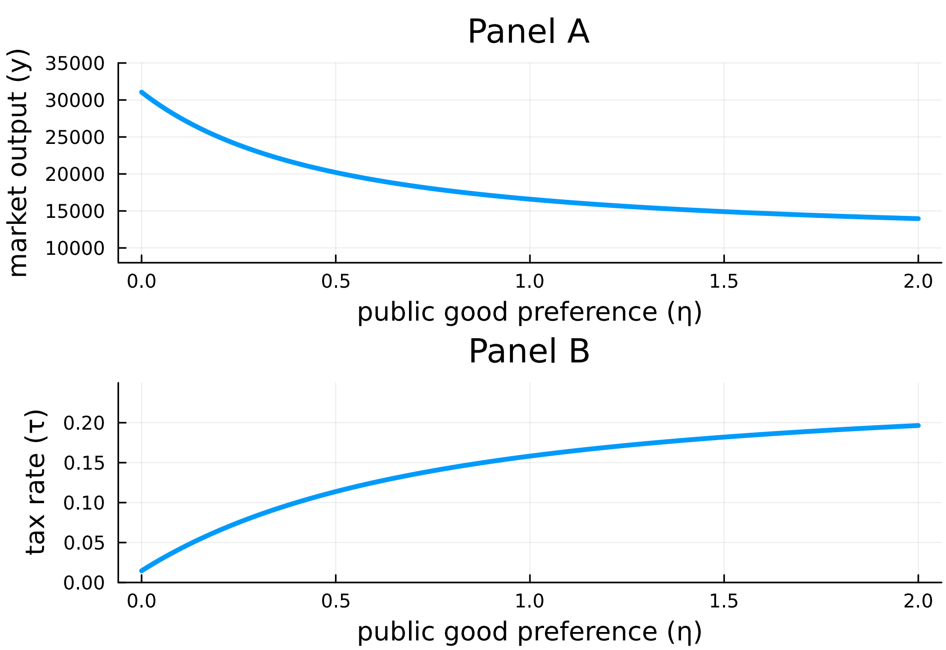

Figure 7: **Estimated Model and Public Goods**. **Panel A:** Plot of market output $\log y$ and public good preference η. **Panel B:** Plot of tax rate τ and η. Other parameter: $\xi = .3$.

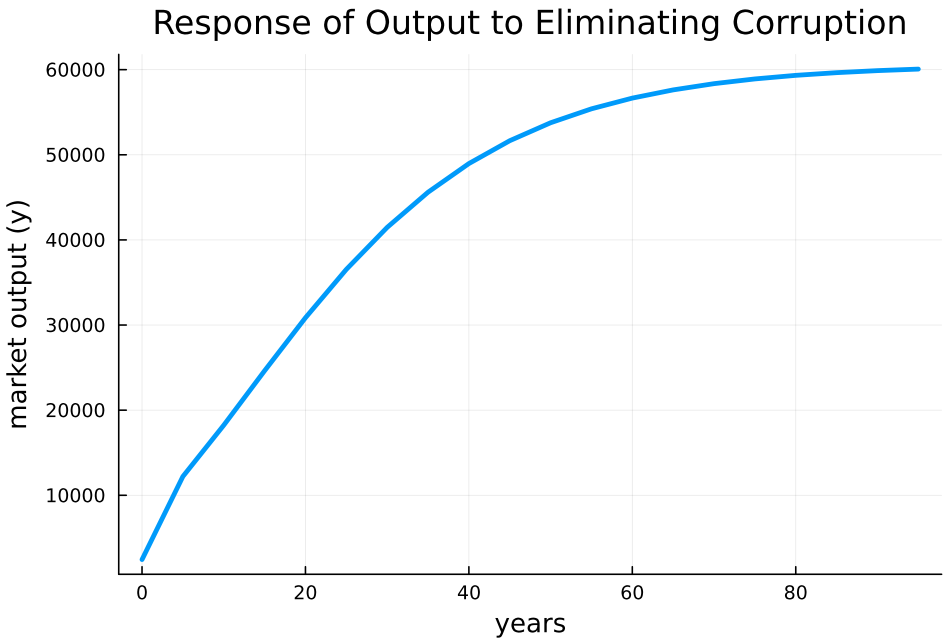

Figure 8: **Estimated Path of Output from Eliminating Corruption**. ξ reduced from 0.7 to 0. Other parameter: $\eta = 1.0$.

6 Summary

The goal of this paper was to propose a structural model of taxation and corruption to interpret the observed relation between income, taxation, and corruption. Across countries, there is a robust negative relation between rates of taxation and per-capita income after controlling for measures of corruption. Corrupt countries tend to have low levels of per-capita income and tend to impose low rates of taxation, thereby confounding a simple bi-variate relation between taxation and per-capita income. To explain this, a model was developed in which taxation and corruption have similar supply-side disincentive effects on the economy, but revenue extracted via corruption is diverted to personal gain, whereas revenue raised via taxation is in part spent on investment that enhances productivity. Corruption thus has the additional effect of starving the economy of public resources useful to enhancing productivity. Governments take the disincentive effects of corruption into account when optimally choosing tax rates to promote public welfare, and as a consequence choose low tax rates when corruption is rampant. Nevertheless, governments that choose high tax rates to support public spending that does not promote productivity do so at the expense of a lower per-capita income.

As in Prescott (2004), this paper argues that differences in tax rates across countries are an important determinant of differences in income across countries. The chief contribution of this paper is to argue that extending such a study to include countries with vastly different levels of per-capita income requires understanding the relation between taxation and corruption. This paper did not address the reason why corruption differs across countries, but adds to the body of research that motivates a deeper understanding of this important issue. In the context of this paper, it is estimated that a country in which corruption is rampant could achieve a more than 10 fold increase in market per-capita income within about 20 years by eliminating corruption, even though tax rates would optimally rise during this period.

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