A Model of Corruption and Taxes

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Abstract

This paper develops and estimates a model of corruption and tax rates in which governments, faced with corruption, optimally choose tax rates to promote growth and public welfare. Governments faced with rampant corruption optimally choose low tax rates. The high overall distortion of corruption plus tax rates leads to lower growth, which is exacerbated by the reduced tax revenue that in part is necessary for government programs to promote growth. 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 estimated model exhibits significant growth effects from reducing corruption, even though optimal tax rates may rise over time.

JEL classification: H21, O43, P16

Keywords: Supply-side economics, Corruption, Optimal taxation.

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1 **Introduction**

This paper develops and estimates a model of corruption and tax rates in which governments, faced with corruption, optimally choose tax rates to promote growth and public welfare. Governments faced with rampant corruption optimally choose low tax rates. The high overall distortion of corruption plus tax rates leads to lower growth, which is exacerbated by the reduced tax revenue that in part is necessary for government programs to promote growth. The model is estimated using cross-country data on income, tax rates, and corruption and is shown to match key features of the data.

Models of corruption and growth have been developed by Del Monte and Papagni (2001), Aghion, et. al., (2016), and others. Both papers highlight a connection between corruption and public infrastructure that has important implications for growth, which is a feature incorporated into this model as well. The essential difference between those papers and this one is that in Del Monte and Papagni (2001) and Aghion, et. al., (2016) tax revenue generates resources that a corrupt government can extract, whereas in this paper tax revenue and rent extraction compete for private sector resources. 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 the optimal level of taxation for a given level of corruption, with the assumption of this paper designed to capture the negative relation between tax rates and measures of corruption as observed in the data. The assumption underlying this paper is much closer to the study of corruption in Shleifer and Vishney (1993), who refer to bribery and taxation as “sister” activities (p. 600), and argue that corruption is more distortionary than explicit taxation.¹

The next section of this paper develops a model of corruption and tax rates. 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

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¹An 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.
key features of the data regarding the relation between corruption, tax rates, and income along the lines documented by Coleman (2014). Next is a section that develops a nonlinear least squares estimation strategy 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 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 $\omega$ 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.

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

$$y = An$$

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 $0 < \nu < 1$,

$$n + m \leq 1,$$

and $0 \leq n, m \leq 1$. 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 $\tau$ that is proportional to their market income to the government. Workers must also pay an amount $\xi$ 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 \(\xi\) 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 \(\xi\) as the bribery rate. The bribery rate \(\xi\) is assumed to differ across countries, but its determination is exogenous to the model. The essential difference between the tax rate \(\tau\) and the bribery rate \(\xi\) is that tax revenue generated by \(\tau\) must be used for public spending, but bribery income is diverted for personal gain by the rent-extractors. From a modeling perspective this distinction is simply a labeling exercise regarding the use of funds. However, from an empirical standpoint, measured tax revenue will be associated with revenue generated by \(\tau\) 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.

Each worker chooses to divide their disposable income into consumption \(C\) and an investment \(Z\) that enhances their future labor productivity, so that

\[ C + Z = A \left( (1 - \tau - \xi) n + m - \frac{\nu}{2} m^2 \right). \]

Next period’s labor productivity \(A'\) for each person depends on their own investment \(Z\) as well as an investment \(H\) by the government in public infrastructure, such that

\[ A' = D^{1-\gamma_h-\gamma_z} H^\gamma_h Z^\gamma_z, \]

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.

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 \(\eta\) captures preferences for the public good.

To describe actions taken by the government, denote the average level of market
income by $\hat{y}$, so that average per-worker tax revenue is given by $\tau\hat{y}$ (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,

$$H + G = \tau\hat{y}.$$ 

$H$ 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 $\xi$ 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

$$B = \xi\hat{y}.$$ 

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 $(\hat{y}, \tau, \xi, H, G)$, say $(\hat{y}', \tau', \xi', H', G') = \Omega(\hat{y}, \tau, \xi, H, G)$, each worker choose 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

$$w(A) = \max_{n,m,z} \{\log(C) + \eta \log(G) + \beta w(A')\},$$
subject to eq. (2), where \( C \) is given by eq. (3) and \( A' \) evolves according to eq. (4).

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

\[
1 - (\tau + \xi) \geq \lambda, \quad w/eq. \text{ if } \lambda > 0, \\
1 - \nu m \geq \lambda, \quad w/eq. \text{ if } \lambda > 0, \\
n + m \leq 1, \quad w/eq. \text{ if } \lambda > 0, \\
\frac{1}{A((1 - \tau - \xi) n + m - \frac{\nu}{2} m^2) - Z} = \beta \gamma_z w'(A') A' \frac{1}{Z}.
\]

The envelope condition is

\[
w'(A) = \frac{(1 - \tau - \xi) n + m - \frac{\nu}{2} m^2}{A((1 - \tau - \xi) n + m - \frac{\nu}{2} m^2) - Z}.
\]

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

\[
\frac{1}{A((1 - \tau - \xi) n + m - \frac{\nu}{2} m^2) - Z} = \beta \gamma_z w'(A') A' \frac{1}{Z}.
\]

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 \( \tau \) and bribery rate \( \xi \) 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

\[
m = \frac{\tau + \xi}{\nu}, \quad (6) \\
n = 1 - \frac{\tau + \xi}{\nu}. \quad (7)
\]

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

\[ P(\tau, \xi) = 1 - (\tau + \xi) + \frac{(\tau + \xi)^2}{2\nu}, \]  

\[ R(\tau, \xi) = \tau \left( 1 - \frac{\tau + \xi}{\nu} \right). \]  

(8)  

(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

\[ Z = \beta \gamma_z AP, \]  

\[ C = (1 - \beta \gamma_z) AP, \]  

\[ H + G = AR. \]  

(10)  

(11)  

(12)

At this solution, \( A' \) evolves according to

\[ A' = D^{1-\gamma_h-\gamma_z} H^{\gamma_h} (\beta \gamma_z AP)^{\gamma_z}. \]  

(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 \( P_\tau \) be the derivative of \( P \) with respect to \( \tau \), and \( R_\tau \) be the derivative of \( R \) with respect to \( \tau \), which are given by

\[ P_\tau = -1 + \frac{\tau + \xi}{\nu}, \]  

\[ R_\tau = 1 - \frac{2\tau + \xi}{\nu}. \]  

(14)  

(15)

**Lemma 1:** For any \( \tau \) such that \( 0 < \tau + \xi < \nu \), \( P \) is a strictly-decreasing function of \( \tau \).

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

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

\[ \tau = \frac{\nu}{2} \left( 1 - \frac{\xi}{\nu} \right). \]
2.3 Optimal Government Policy and Equilibrium

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

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

where $C$ is given by eq. (11) with $P$ given by eq. (14), $R$ given by eq. (15), and $A'$ given by eq. (13). The first-order conditions with respect to $H$ and $\tau$ 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

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

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

where $\tau$ must satisfy the equation

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

At this solution, $A$ evolves according to

$$A' = D^{1 - \gamma_h - \gamma_z} \left(\frac{\beta \gamma_h (1 + \eta)}{\beta \gamma_h + (1 - \beta \gamma_z) \eta} R\right)^{\gamma_h} (\beta \gamma_z P)^{\gamma_z} A^{\gamma_h + \gamma_z},$$
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 $\tau$ to this equation and also verifies the conjecture that $\tau + \xi \leq \nu$.

**Proposition 1:** For any $\xi$ 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

$$Q(\tau, \xi) = \frac{\tau (1 - \frac{\tau + \xi}{\nu})^2}{\left(1 - (\tau + \xi) + \frac{(\tau + \xi)^2}{2\nu}\right)(1 - \frac{2\tau + \xi}{\nu})} - \frac{\beta \gamma h + (1 - \beta \gamma z) \eta}{1 - \beta \gamma h + \beta \gamma z \eta}. \quad (20)$$

Given the functions $P$ and $R$ and their derivatives, the solution $\tau$ to eq. (18) is such that $Q(\tau, \xi) = 0$. $Q$ is a continuous function of $\tau$. $Q(0, \xi) < 0$. $\lim_{\tau \to \frac{\nu}{2} \left(1 - \frac{\xi}{\nu}\right)} Q(\tau, \xi) = \infty$ 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 $\tau$ is strictly positive, as by explicitly taking the derivative of $Q$ with respect to $\tau$, it can be shown to be the same sign as

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

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

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

As $\eta$, $\xi$ and consequently $\tau$ converge to steady state values, $A$ converges to a steady-
state value given by

\[
A = D \left( \frac{\beta \gamma_h (1 + \eta)}{\beta \gamma_h + (1 - \beta \gamma_z) \eta} \right)^{1 - \gamma_h - \gamma_z} (\beta \gamma_z P)^{1 - \gamma_h - \gamma_z} \cdot (23)
\]

The steady-state value for \( y = An \) is given by

\[
y = D \left( \frac{\beta \gamma_h (1 + \eta)}{\beta \gamma_h + (1 - \beta \gamma_z) \eta} \right)^{1 - \gamma_h - \gamma_z} (\beta \gamma_z P)^{1 - \gamma_h - \gamma_z} \left( 1 - \frac{\tau + \xi}{\nu} \right) \cdot (24)
\]

A straightforward implication of Proposition 1 is that as \( \xi \) approaches \( \nu \), the optimal tax rate \( \tau \) approaches zero, and from eq. (24) output approaches zero as well: high levels of corruption lead to low tax rates and low output. This is a key feature of the model that may explain the observed relation between per-capita GDP, tax rates, and measures of corruption in the data.

### 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 \( \theta \) is exogenous to the model.\(^2\) Define the following variables: \( c = C/D, \ g = G/D, \ z = Z/D, \ a = A/D, \) and \( h = H/D. \) Define also

\[
b = (1 + \theta)^{-1 - \gamma_h - \gamma_z}.
\]

The set-up of this problem is identical to the problem just considered, with \( c \) replacing \( C, \) etc., and \( b \) 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

\(^2\)Aghion, et. al. (2016) provide a way to think about taxation, innovation and growth.
preference for public goods, along with difference policy choices by the government in each country.

3 Data

Coleman (2014) considers various measures of income, tax rates, corruption and documents a robust negative relation between tax rates and income after controlling for corruption. The measure of income used here is simply per-capita GDP (PPP), obtained from the World Bank World Development Indicators. The measure of tax rates used here is Tax2 as defined in Coleman(2014), which is based on Tax0 (personal income tax), TaxZ (corporate income tax), and TaxV (value-added tax) (obtained from the Heritage Foundation, the World Bank, and KPMG) such that

\[
\begin{align*}
    \text{Tax}_1 &= \text{Tax}_0 + 0.2\text{Tax}_Z, \\
    \text{Tax}_2 &= \frac{\text{Tax}_V + \text{Tax}_1}{1 + \text{Tax}_V}.
\end{align*}
\]

The measure of corruption is Transparency International’s Corruption Perception Index (CPI). All data are for 2018.

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 \( \eta \) to \( \tau \) and \( \xi \). Use eq. (18) to derive

\[
\eta = \frac{-\frac{P_r R}{P_{R^*}} (1 - \beta \gamma_h) - \beta \gamma_h}{\left(\frac{P_r R}{P_{R^*}} - 1\right) \beta \gamma_z + 1}.
\]
and use this relation to show

\[
\frac{\beta \gamma h(1 + \eta)}{\beta \gamma h + (1 - \beta \gamma z) \eta} = \beta \gamma h \left(1 - \frac{P R_T}{P_T}\right).
\]

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

\[
A = D \left(\beta \gamma h \left(R - \frac{P R_T}{P_T}\right)\right)^{\frac{\gamma h}{1 - \gamma h - \gamma z}} \left(\beta \gamma z P\right)^{\frac{\gamma z}{1 - \gamma h - \gamma z}}.
\]

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

\[
\log y = d + \frac{\gamma h}{1 - \gamma h - \gamma z} \log \left(\beta \gamma h \left(R - \frac{P R_T}{P_T}\right)\right) + \frac{\gamma z}{1 - \gamma h - \gamma z} \log (\beta \gamma z P) + \log \left(1 - \frac{\tau + \xi}{\nu}\right) + \epsilon,
\]

where \(d = \log D\). This equation involves the five parameters \(\beta, d, \nu, \gamma h,\) and \(\gamma z\). This nonlinear relationship between \(y, \tau,\) and \(\xi\) 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 \(\xi\) 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

\[
\xi = (1 - CPI/100)^\alpha,
\]

for some parameter \(\alpha > 0\). Low values of \(CPI\), which are associated with high levels of corruption, are thus associated with high levels of \(\xi\). The parameter \(\alpha\) will shift the distribution of \(\xi\) to either lower or higher values, but with \(\alpha > 0\) the range of \(\xi\) will be from zero to one. Using eq. (27) to relate the \(CPI\) corruption index to the model’s bribery variable \(\xi\) will add the parameter \(\alpha\) 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 $\text{Tax}2$ and the marginal tax rate $\tau$ in the model of the following form:

$$\tau = \zeta \ast \text{Tax}2,$$

where $0 < \zeta \leq 1$. Using eq. (28) to relate the measured tax rate $\text{Tax}2$ to the models marginal tax rate $\tau$ will add the parameter $\zeta$ to the list of parameters that need to be estimated.

Some observations of $\text{Tax}2$ and $\text{CPI}$ along with implied values of $\tau$ and $\xi$ 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 $y$, $\tau$, and $\xi$, for these observations and parameter values, becomes

$$\log y = d + \frac{\gamma_h}{1 - \gamma_h - \gamma_z} \log (R) + \frac{\gamma_z}{1 - \gamma_h - \gamma_z} \log (\beta \gamma_z P) + \log \left(1 - \frac{\tau + \xi}{\nu}\right) + \epsilon.$$  (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 $\beta$ 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 $d$, $\gamma_h$, $\gamma_z$, $\nu$, $\alpha$, and $\zeta$. The results of NLS estimation are reported in Table 1. 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.\(^3\) 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. 1 graphs the fitted vs. observed values of per-capita GDP (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.

\(^3\)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.
<table>
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<th>Description</th>
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<td></td>
<td>(0.545)</td>
<td>(0.198)</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>marginal tax adj</td>
<td>0.347</td>
<td>0.387</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.107)</td>
<td>(0.118)</td>
</tr>
</tbody>
</table>

| 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: $\nu$ unconstrained.
Figure 1: Predicted vs Observed real per-capita GDP

5 Some Experiments

At the estimated parameter values, Fig. 2 captures the core features of the supply-side underpinnings of the model. For two values of the bribery rate $\xi$, 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 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 $\xi$ tend to lower tax revenue and market output at any level of the tax rate.

Fig. 3 shows the dependence in the model of market output $y$ (Panel A) and tax rate $\tau$ (Panel B) on the bribery rate $\xi$, 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 quantitatively significant: as the bribery rate rises from 0 to 40 percent, market output falls roughly by a factor of 6. As $\xi$ 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 public infrastructure, the combined effect of which is to greatly reduce output.

Fig. 4 shows the dependence in the model of market output $y$ (Panel A) and tax rate $\tau$ (Panel B) on the preference for the non-productive public good as measured by $\eta$. 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. 5 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
Figure 3: **Estimated Model and Corruption.** **Panel A:** Plot of log market output ($\log y$) and bribery rate ($\xi$). **Panel B:** Plot of tax rate ($\tau$) and bribery rate ($\xi$). Other parameters: $\eta = 1$.

Figure 4: **Estimated Model and Public Goods.** **Panel A:** Plot of market output log $y$ and public good preference $\eta$. **Panel B:** Plot of tax rate $\tau$ and $\eta$. Other parameter: $\xi = .3$. 
Figure 5: Estimated Path of Output from Eliminating Corruption. $\xi$ reduced from 0.7 to 0. Other parameter: $\eta = 1.0$.

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.

6 Summary

This paper has bolstered the argument that supply-side forces are important determinants for wealth creation. Across countries, there is a robust negative relation between rates of taxation and per-capita income. The chief contribution of this paper is establishing the importance of controlling for corruption when documenting this negative relation. 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 pre-capita income. A robust empirical relation documented in this paper is that both excessive taxation and corruption are negatively associated with per-capita income. This relation holds up to various measure of taxation and corruption, and as well holds to using various instruments to deal with a potential confounding relation between corruption and income.
To explain the effects of corruption and the relation between corruption and taxation documented in the data, this paper viewed the effects of corruption through a similar supply-side lens as explicit taxation. Rents are extracted in corrupt countries through the use of bribes that have a similar private disincentive effect as explicit taxation. Corruption thereby destroys wealth. Moreover, bribery competes with explicit taxation, so countries saddled with high rates of corruption find it optimal to impose low rates of taxation. Thus, in addition to the direct effect of corruption in reducing the private incentive to accumulate wealth, the low rate of taxation starves a country from necessary productivity-enhancing public expenditures. The model thus provides a simple supply-side argument as to how corruption destroys wealth in a way that also explains why corruption is inversely associated with explicit rates of taxation. 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.
References


