Public Investment and Corruption in an Endogenous Growth Model*

Simge Tarhan†
University of Minnesota

First Version: August 2008
This Version: March 30, 2009
Latest version can be downloaded at: www.econ.umn.edu/~tarhan/research.html

Abstract

High capital spending is favored by economists and politicians for its beneficial effects on economic growth. However, there is empirical research associating high levels of public investment and low economic growth due to corruption. I provide an endogenous growth model with Ramsey taxation that is consistent with this empirical finding. In the model, government maximizes the weighted average of consumers utility and its own utility coming from expropriation of tax revenues. The weight determines the benevolence of the government. I show that a self-interested government sets a higher public-to-private-capital ratio than a benevolent one in order to increase the before-tax returns to private investment and hence increase tax revenues that can be expropriated. However, after-tax returns to private investment are lower and hence the growth rate is lower. Another result is that self-interested governments choose a high level of non-productive public investment, which provides a channel for the government to expropriate tax revenues for its private gain, thereby inflating total public investment.

Keywords: Corruption, Endogenous Growth, Public Investment, Ramsey Taxation.
JEL Classification Numbers: O40, H0, D73, E62.

*I am grateful to Larry E. Jones, V.V. Chari, and José-Víctor Ríos-Rull for their advice and encouragement. For their suggestions and comments, I thank Francesca Carapella, Roozbeh Hosseini, Facundo Piguillem, Evsen Turkay, and the members of the Chari-Jones Workshop, as well as the participants at the III Guanajuato Workshop for Young Economists and the Third Annual Graduate Student Conference at Washington University in St. Louis. All remaining errors are mine.

†Contact: 4-101 Hanson Hall, 1925 Fourth Street South, Minneapolis, MN 55455, USA. Email:*tarhan@umn.edu*.

1 Introduction

This paper studies the relationship between political corruption and public investment, and how economic growth in the long run is affected by this relationship. Political corruption, as defined by the *Transparency International*, is the abuse of entrusted power by political leaders for private gain, with the objective of increasing power or wealth. Given this definition, a benevolent government, whose sole purpose is to promote consumers' welfare, would never engage in corrupt activities. Hence, it is important to relax the assumption of a benevolent government in order to understand the link between political corruption, public investment, and growth. To this end, I write an endogenous growth model with a non-benevolent government deciding how much public investment to undertake. In the model I assume public investment to be financed through income taxes. Collecting taxes and deciding how to use the tax revenues give the government an opportunity to engage in corrupt activities for its own benefit. Using the model, I study the choices of the government and the behavior of consumers as a response to the government policies, all depending on how benevolent the government is.

In the model the government is assumed to maximize a weighted average of consumers' welfare and its own welfare coming from expropriated tax revenues. The weight on consumers' welfare determines how benevolent the government is. If the weight on consumers' welfare is zero, then the government is totally self-interested, and if the weight is one then the government is totally benevolent. The weight can be any number between 0 and 1, implying that the government can be partially benevolent. I show when the government is self-interested, the amount of productive public investment is low but the amount of expropriated tax revenues is high.

The government is assumed to be constrained by a period-by-period budget, which implies an upper bound on total embezzlement by the government at any period. This results in a dilemma for the corrupt politicians: they can either steal as much as they can at any period, leaving only a small amount of funds for the financing of the public capital, or they can invest in public capital so as to increase the productivity of private capital, and hence income, in the future. Increased income implies higher income tax revenues and more funds to embezzle in the future. Therefore, each type of government chooses an optimal growth rate through its policies that balances the cost of deferring expropriation of funds today and the benefit of increased tax revenues that can be embezzled in the future. This optimal growth rate is determined by the public-to-private capital ratio. I argue that a self-interested government chooses a higher public-to-private-capital ratio than a benevolent government and that this results in lower economic growth in the long run.

The model predicts low productive public investment and low growth in countries with self-interested governments. When testing the predictions of the model against data, benevolence of a government will be thought of as the degree of corruption in that country. Hence, a self-interested government in the model will be a counterpart of a highly corrupt government in the data. While the model distinguishes between productive public investment and expropriated tax revenues, it is hard to do so in the data. Expropriated tax revenues are recorded as part of government budget and affect several entries in the government budget. However, authors such as Tanzi and Davoodi (1997) and Keefer and Knack (2007) claim most of the corrupt activities of governments to be recorded as public investment[1]. Treating expropriated tax revenues as part of public investment in accordance with these studies, the model predicts that high levels of total public investment would be observed in countries with high corruption.

To the best of my knowledge, this paper is the first attempt to explain the interrelationship between political corruption, public investment, and economic growth through a model that analyzes the behavior of different types of government. Haque and Kneller (2008) undertake an empirical study to see the effects of corruption on public investment and economic growth. They find that corruption raises the level of public investment but lowers the returns to it, making it ineffective in promoting economic growth, which is consistent with the

[1]See next section for a more detailed discussion.

results of my model.

1.1 Background and Related Literature

The effect of public investment on growth has been debated extensively in the literature. Starting with Barro (1990), many researchers have tried to capture the effect of public investment on growth; however, a consensus on the empirical evidence has never been reached. There are studies claiming that public investment is not important for economic growth (e.g. Easterly and Rebelo (1993)) while others maintain that public investment has a substantial positive effect on growth (e.g. Aschauer (1989)). There are yet other papers which assert that only certain types of public investment are productive and that the effect of these on growth are different than the effect of non-productive public investment. For example, Devarajan, Swaroop, and Zou (1996) find that current expenditure has a positive effect on economic growth whereas capital spending of governments has a negative relationship with growth. They argue that developing countries have over-invested in public capital in expense of current spending.

The link between corruption and public investment has been explored mainly empirically. Tanzi and Davoodi (1997), for example, maintain that corrupt governments choose a higher public investment share of aggregate income. They claim that political corruption is often tied to capital projects. This is because the decisions regarding the budget and composition of capital are highly discretionary. Lack of competition in undertaking big capital projets and the difficulty in assessing the real cost and value of these projects make them a tool for corruption. The authors also argue that corruption reduces the productivity of public capital. Similarly, Keefer and Knack (2007) show that observed levels of public investment, as fractions of national income or of total investment, are higher in corrupt countries. These empirical findings are consistent with what my model predicts.

There have been many empirical studies trying to document a relationship between corruption and economic growth, especially after the well-known paper Mauro (1995). Mauro

(1995) maintains that corruption leads to lower economic growth and there are several studies confirming this paper's findings. (e.g. Tanzi and Davoodi (1997), Mauro (1997)) My results are consistent with these papers; high corruption and low growth go hand in hand.

1.2 Contribution of This Paper

This paper contributes to the literature on public investment and growth, corruption and growth, and corruption and public investment. Most of the work done in these areas are empirical and lack a theoretical basis. However, in order to fully understand the economic mechanism and provide policy suggestions it is important to have a model that captures the way benevolent and self-interested governments act. This paper provides such a model and fills in the theoretical gap in the literature. Within an optimal fiscal policy framework this paper explains the interdependency of public investment, corruption and growth.

This paper also contributes to the literature on optimal fiscal policy with linear taxes. Virtually all previous work in this literature assumes government to be benevolent. Jones, Manuelli, and Rossi (1993) extend the basic literature to endogenous growth models and Azzimonti-Renzo, Sarte, and Soares (2003) consider optimal choices of government in an environment with public capital. Contrary to these works, this paper allows the government to be self-interested and compares the behavior of self-interested and benevolent governments.

1.3 The Road Map

The rest of the paper is organized as follows: In Section 2, the model setup is introduced and competitive equilibrium is defined. Competitive equilibrium outcomes are for given government policies; however, the aim of this paper is to endogenize government policies. For this reason, another equilibrium concept, namely Ramsey equilibrium, is employed. Ramsey equilibrium outcomes include policy selections by the government and private allocations as best response to government policies. Competitive equilibrium outcomes are used to characterize Ramsey equilibrium, following Chari and Kehoe (1999). Next, balanced growth path allocations are characterized. These allocations depend on the type of the government, hence the relationship between public investment, corruption, and long-run growth can be studied. In Section 3, some empirical implications of the model are explained. These implications are consistent with previous empirical work described in the literature review above. However, not all empirical implications of the model have been studied before. Therefore I use the data set from Easterly and Rebelo (1993) to compare the results of the model with the data. In section 4, I describe the data I use and show that those implications of the model are also consistent with the data. Section 5 concludes.

2 The model

2.1 Setup

In order to study the relationship between public investment and growth, an endogenous growth model with public capital is used. In this economy, there are a continuum of identical infinitely-lived individuals and a government. Each individual is born with an initial capital endowment of k_0. To keep the model simple, it is assumed that there is no labor market. There is a single nonstorable consumption good which is valued by the consumers. The representative individual maximizes her present discounted utility from consumption, where the discount rate $\beta \in (0, 1)$:

$$\sum_{t=0}^{\infty} \beta^t u(c_t) \tag{1}$$

Individuals rent capital, k, to firms and earn capital income at rate r, and pay income taxes at rate τ to the government. Therefore, their budget constraint is:

$$c_t + k_{t+1} - (1 - \delta_k)k_t = (1 - \tau_t)r_t k_t \qquad \forall t \tag{2}$$

where δ_k is the depreciation rate for private capital. Hence, given representative individual's initial capital endowment, k_0, sequence of rates of return to private capital, $\{r_t\}_0^\infty$, and sequence of tax rates, $\{\tau_t\}_0^\infty$, the representative consumer's problem can be written as:

Consumer's Problem

$$\max_{c_t, k_{t+1}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + k_{t+1} - (1 - \delta_k)k_t = (1 - \tau_t)r_t k_t \qquad \forall t$$

$$c_t \geq 0, \quad k_{t+1} \geq 0 \qquad \forall t$$

There are two factors of production in this economy: private capital and public capital. Each firm produces output, y_t, according to the following technology:

$$y_t = f(k_t, g_t) = Ak_t(\frac{g_t}{K_t})^\alpha \qquad \forall t \tag{3}$$

where $A > 0$, $0 < \alpha < 1$, g_t is the public capital stock, and K_t is the aggregate private capital stock. Individual private capital stock k and aggregate private capital stock K are differentiated to capture the effect of *congestion* on the marginal productivity of private capital. As the aggregate capital stock increases, public capital available per unit of private capital decreases, thereby reducing the marginal productivity of private capital. As argued in Barro and Sala-i Martin (1992), this functional form of production function refers to the case when public goods are rival but not excludable. According to these authors this type of public goods includes highways, water and sewer systems, airports and harbors, courts, and even national defense and police.

Note that this production function implies constant returns to private capital as long as the government maintains a constant congestion of public services, i.e. a constant $\frac{g}{K}$ ratio. However, the aggregate production function $Y_t = AK_t(\frac{g_t}{K_t})^\alpha$ exhibits diminishing returns to aggregate private capital K for given public capital stock g, and this is due to congestion.

This environment is similar to the one in Barro (1990) except that in the production function public services appear as stock variable, whereas in Barro (1990) they are treated as flow variable. Also, public services are assumed to be subject to congestion in this setup.

The government is allowed to be non-benevolent and is assumed to maximize a weighted average of consumers' welfare and the utility it gets from expropriated resources:

$$\sum_{t=0}^{\infty} \rho^t \{(1-\theta)u(C_t) + \theta v(E_t)\} \tag{4}$$

where $\rho \in (0,1)$ is the rate of time preference of the government, $\theta \in [0,1]$ is the type of the government, and E is the expropriation by the government.

Here θ denotes the degree of government's benevolence. If $\theta = 0$ the government is totally benevolent and it maximizes consumers' utility. If $\theta = 1$, then the government is totally self-interested and it maximizes the amount of resources it can divert from productive uses. θ is allowed to take on any value between 0 and 1, implying that the government can be partially benevolent. Type of the government is determined exogenously and does not change over time. Degree of benevolence of a government can depend on many institutional, sociological, historical, and economic factors. Studying these factors is outside the scope of this paper, and hence, type of the government will be treated as exogenously given. Moreover, indices measuring the extent of corruption show that there is persistence in the extent of corruption over time[2]. Corrupt countries tend to stay corrupt. Similarly, clean economies persistently stay free of corruption[3]. Hence, θ for any country will be taken as constant over time.

Note that the government's time preference, ρ, is allowed to be different than that of the consumers, β. This is to capture the idea that governments usually have a shorter lifespan than consumers due to elections, coups, revolutions, etc. The government levies distortionary

[2]For example, Corruption Perceptions Index values in 1995 and 2006 have a correlation coefficient equal to 0.93. See Appendix B for details.

[3]See Mauro (2004) for two models with multiple equilibria that explain the persistence phenomena and its effects on economic growth.

income taxes to finance public investment but it can expropriate part of the tax revenues for its own consumption. Hence, the government budget constraint at any time t can be written as:

$$E_t + g_{t+1} - (1 - \delta_g)g_t = \tau_t r_t K_t \tag{5}$$

where E is the amount of expropriation and δ_g is the depreciation rate of public capital. It is assumed that the government has a technology that converts tax revenues into public good. Also, it is assumed that $g_{t+1} \geq 0$ in every period. This implies that the maximum amount that can be expropriated at any time t equals total tax revenues at that period plus existing public goods net of depreciation.

A government policy is a sequence of tax rates, public capital levels, and amount of expropriation for all $t \geq 0$ and it is denoted by $\Pi = \{\tau_t, g_{t+1}, E_t\}_{t=0}^{\infty}$.

Finally, feasible allocations are described by the resource constraint:

$$C_t + K_{t+1} - (1 - \delta_k)K_t + g_{t+1} - (1 - \delta_g)g_t + E_t = AK_t \left(\frac{g_t}{K_t}\right)^{\alpha} \tag{6}$$

where C is the aggregate consumption in the economy.

2.2 Competitive Equilibrium

Competitive equilibrium describes the choices of consumers and firms as best response to government policies. Private agents' optimal choices along with the feasibility constraint and the government budget constraint are used to characterize the competitive equilibrium allocations and prices.

Definition 1 (Competitive Equilibrium) *For a given government policy* $\Pi = \{\tau_t, g_{t+1}, E_t\}_{t\geq 0}$*, and initial public and private capital stocks,* g_0 *and* k_0*, a competitive equilibrium for this economy is an allocation* $\{c_t, k_{t+1}, C_t, K_{t+1}\}_{t\geq 0}$*, and a price* $\{r_t\}_{t\geq 0}$ *such that:*

1. *Given prices and policy, the allocation solves the Consumer's Problem.*

2. *Price satisfies* $r_t = f_{kt} = A(\frac{g_t}{K_t})^\alpha$, $\forall t$.

3. *Government budget constraint (5) holds.*

4. *Resource constraint (6) is satisfied.*

2.2.1 Characterizing Competitive Equilibrium

Let λ_t be the Lagrange multiplier on the time-t Cons-BC. The following equations, including first-order conditions for consumer's problem and budget constraints, characterize the competitive equilibrium:

$$
\begin{array}{llcll}
\text{Cons-BC:} & C_t + K_{t+1} - (1-\delta_k)K_t & = & (1-\tau_t)r_tK_t & \forall t \\
\text{Cons-FOC1:} & \frac{\beta u'(c_{t+1})}{u'(c_t)} & = & \frac{\lambda_{t+1}}{\lambda_t} & \forall t \\
\text{Cons-FOC2:} & \lambda_{t+1}[(1-\tau_{t+1})r_{t+1} + 1 - \delta_k] & = & \lambda_t & \forall t \\
\text{Price:} & r_t & = & A\left(\frac{g_t}{K_t}\right)^\alpha & \forall t \\
\text{GBC:} & E_t + g_{t+1} - (1-\delta_g)g_t & = & \tau_t r_t K_t & \forall t \\
\text{Feasibility:} & C_t + K_{t+1} - (1-\delta_k)K_t + g_{t+1} - (1-\delta_g)g_t + E_t & = & AK_t\left(\frac{g_t}{K_t}\right)^\alpha & \forall t \\
\text{TVC1:} & \lim_{t\to\infty} \lambda_t K_t & = & 0 & \\
\text{TVC2:} & \lim_{t\to\infty} \lambda_t g_t & = & 0 &
\end{array}
$$

The following two propositions simplify the characterization of competitive equilibrium by reducing it down to two equations. These propositions will be used in the next section to describe Ramsey equilibrium allocations.

Proposition 1 *The allocations in a competitive equilibrium satisfy the following:*

$$C_t + K_{t+1} - (1-\delta_k)K_t + g_{t+1} - (1-\delta_g)g_t + E_t = AK_t\left(\frac{g_t}{K_t}\right)^\alpha \tag{7}$$

$$u'(C_t) = \beta u'(C_{t+1})[\frac{C_{t+1} + K_{t+2}}{K_{t+1}}] \tag{8}$$

Proof. Constraint (7) is part of the definition of competitive equilibrium. (8) is obtained by plugging GBC, Price, and Feasibility in Cons-FOC. See Appendix A for details. ∎

Equation (8) is called the *implementability constraint* because it describes the conditions government policies can be implemented, given the best response of consumers and firms to government's choices.

Proposition 2 *Given allocations and period-0 policies that satisfy* (7) *and* (8)*, one can construct policies and prices which, together with the given allocations and period-0 policies, constitute a competitive equilibrium.*

Proof. See Appendix A. ∎

2.3 Ramsey Equilibrium

Competitive equilibrium allocations describe the behavior of private agents given government policy. To analyze the policy selection behavior of the government, the setup of the model will be reinterpreted as a game and additional assumptions regarding the timing of the game will be made. It will be assumed that the government moves first at time 0 and sets the stream of future policies for all time $t \geq 0$. Consumers make their decisions after they observe the government policy. This timing assumption implies that the government can fully commit to its policies at the beginning of the game and cannot change its actions after consumers have made their savings decisions. The equilibrium notion used in this case is called Ramsey equilibrium.

Definition 2 (Ramsey Equilibrium) *Given initial capital stocks,* g_0 *and* K_0*, a Ramsey equilibrium is a government policy* $\Pi = \{\tau_t, g_{t+1}, E_t\}_{t\geq 0}$*, an allocation rule* $\{C_t(\cdot), K_{t+1}(\cdot)\}_{t\geq 0}$*, and a price function* $\{r_t(\cdot)\}_{t\geq 0}$ *such that:*

1. *Government policy* Π *solves:*

$$\max_{\Pi} \sum_{t=0}^{\infty} \rho^t \{(1-\theta)u(C_t(\pi')) + \theta v(E_t)\}$$

subject to

$$E_t + g_{t+1} - (1-\delta_g)g_t = \tau_t r_t(\pi')K_t(\pi')$$

2. *For every policy π', the allocations $C(\pi')$ and $K(\pi')$, and the price system $r(\pi')$ constitute a competitive equilibrium.*

The resulting allocations in Ramsey equilibrium are called Ramsey allocations and the resulting policies are called Ramsey policies. Propositions 1 and 2 will be used to characterize the Ramsey equilibrium.

2.3.1 Characterizing Ramsey Equilibrium

Ramsey Problem, maximizing the government's objective function subject to the feasibility and implementability constraints, will be used to characterize the Ramsey Equilibrium, following Chari and Kehoe (1999). Proposition 3 extends the results of Chari and Kehoe (1999) to the case with non-benevolent governments.

Ramsey Problem with Non-Benevolent Government:

$$\max_{C_t, K_{t+1}, E_t, g_{t+1}} \sum_{t=0}^{\infty} \rho^t \{(1-\theta)u(C_t) + \theta v(E_t)\}$$

subject to

$$C_t + K_{t+1} - (1-\delta_k)K_t + g_{t+1} - (1-\delta_g)g_t + E_t = AK_t\left(\frac{g_t}{K_t}\right)^{\alpha} \quad (9)$$

$$u'(C_t) = \beta u'(C_{t+1})[\frac{C_{t+1}+K_{t+2}}{K_{t+1}}] \quad (10)$$

Proposition 3 *Ramsey allocations and policies solve the Ramsey Problem with Non-Benevolent Government.*

Proof. This is a corollary of Propositions 1 and 2. ■

Let $\rho^t\lambda_t$ and $\rho^t\mu_t$ be the Lagrange multipliers on (11) and (12), respectively. Then the following equations, which include first-order conditions and the constraints of the problem, characterize the Ramsey Equilibrium:

$$\begin{aligned}
\rho^t(1-\theta)u'_t + \rho^t\lambda_t + \rho^t\mu_t u''_t - \rho^{t-1}\mu_{t-1}\beta u''_t[\tfrac{C_t+K_{t+1}}{K_t}] - \rho^{t-1}\mu_{t-1}\beta u'_t\tfrac{1}{K_t} &= 0 \\
\rho^t\lambda_t - \rho^{t+1}\lambda_{t+1}[1-\delta_k + A(1-\alpha)\left(\tfrac{g_{t+1}}{K_{t+1}}\right)^{\alpha}] + \rho^t\mu_t\beta u'_{t+1}[\tfrac{C_{t+1}+K_{t+2}}{K_{t+1}^2}] - \rho^{t-1}\mu_{t-1}\beta\tfrac{u'_t}{K_t} &= 0 \\
\rho^t\theta v'_t + \rho^t\lambda_t &= 0 \\
\rho^t\lambda_t - \rho^{t+1}\lambda_{t+1}[1-\delta_g + A\alpha\left(\tfrac{g_{t+1}}{K_{t+1}}\right)^{\alpha-1}] &= 0 \\
C_t + K_{t+1} - (1-\delta_k)K_t + g_{t+1} - (1-\delta_g)g_t + E_t &= AK_t\left(\tfrac{g_t}{K_t}\right)^{\alpha} \\
\beta u'(C_{t+1})[\tfrac{C_{t+1}+K_{t+2}}{K_{t+1}}] &= u'(C_t)
\end{aligned}$$

These equations describe the optimal behavior of the government and consumers at all time periods.

2.4 Balanced Growth Path

Main focus of the paper is the long-run growth, so the balanced growth path will be analyzed[4]. On a balanced growth path, the following ratios must be constant: $\frac{C_{t+1}}{C_t} = \gamma_C$, $\frac{E_{t+1}}{E_t} = \gamma_E$, $\frac{K_{t+1}}{K_t} = \gamma_K$, and $\frac{g_{t+1}}{g_t} = \gamma_g$ for all t.

Assuming $u(\cdot) = log(\cdot)$ and $v(\cdot) = log(\cdot)$, balanced growth path can be solved analytically.

Proposition 4 *Given initial private and public capital stocks, K_0 and g_0, the Balanced Growth Path is characterized by the following:*

- $\dfrac{C}{K} = \dfrac{(1-\beta)}{\beta}\rho[1-\delta_g + A\alpha(\dfrac{g}{K})^{\alpha-1}]$
- $\dfrac{E}{K} = A(\dfrac{g}{K})^{\alpha} - (\dfrac{1}{\beta} + \dfrac{g}{K})\rho[1-\delta_g + A\alpha(\dfrac{g}{K})^{\alpha-1}] + (1-\delta_k) + (1-\delta_g)\dfrac{g}{K}$
- $\tau = 1 - \dfrac{\frac{\rho}{\beta}[1-\delta_g + A\alpha(\frac{g}{K})^{\alpha-1}] - (1-\delta_k)}{A(\frac{g}{K})^{\alpha}}$

[4]For the dynamic analysis of an endogenous growth model with public capital, see Futagami, Morita, and Shibata (1993).

- $\gamma_C = \gamma_K = \gamma_E = \gamma_g = \gamma \equiv \rho[1 - \delta_g + A\alpha(\frac{g}{K})^{\alpha-1}]$

where $\frac{g}{K}$ *satisfies:*

$$(1-\theta)\{A(\frac{g}{K})^{\alpha} - (\frac{1}{\beta} + \frac{g}{K})\rho[1-\delta_g + A\alpha(\frac{g}{K})^{\alpha-1}] + (1-\delta_k) + (1-\delta_g)\frac{g}{K}\} - \theta\frac{(1-\beta)}{\beta}\rho[1-\delta_g + A\alpha(\frac{g}{K})^{\alpha-1}] =$$

$$\theta\rho[\delta_k - \delta_g + A\alpha(\frac{g}{K})^{\alpha-1} - A(1-\alpha)(\frac{g}{K})^{\alpha}]$$

Proof. See Appendix A. ■

The key ratio for the balanced growth path is the public-to-private capital ratio, $\frac{g}{K}$; all other variables are determined according to this ratio. Notice that this ratio depends on a number of things, including depreciation rates of public capital and private capital (δ_g and δ_k), rate of time preference of consumers and the government (β and ρ), public capital elasticity of output (α), and the type of the government (θ). Moreover it is shown that on the balanced growth path all variables grow at the same rate and hence consumption-private capital ratio and expropriation-private capital ratio stay constant.

Proposition 5 *As the public-to-private capital ratio,* $\frac{g}{K}$*, increases growth rate decreases.*

This result is different than what one would get by looking at the competitive equilibrium. In a competitive equilibrium, growth rate would be given by:

$$\gamma^{CE} = \beta[1 - \delta_k + (1-\tau)A(\frac{g}{K})^{\alpha}] \tag{11}$$

So, in a competitive equilibrium the higher $\frac{g}{K}$ is, the higher the growth rate. Note that in competitive equilibrium case taxes are taken as given. In Ramsey equilibrium, however, taxes are not constant and they depend on $\frac{g}{K}$. In equilibrium the increase in τ more than offsets the increase in $\frac{g}{K}$ and the growth rate decreases as a result.

Case 1 (Full Depreciation) *Assume* $\delta_g = \delta_k = 1$.

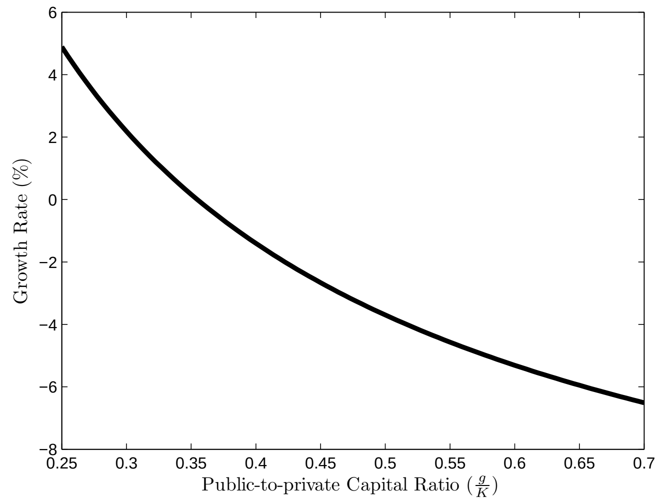


Figure 1: Growth and $\frac{g}{K}$. Parameter values are $A = \frac{1}{3}$, $\alpha = 0.25$, $\beta = \rho = 0.9$, and $\delta_k = \delta_g = 0.07$.

In this case the equation determining $\frac{g}{K}$ simplifies significantly:

$$\frac{g}{K} = \frac{\frac{\rho}{\beta}\alpha}{\theta(1-\rho) + \rho(1-\alpha)} \tag{12}$$

Proposition 6 *A self-interested government sets a higher public-to-private capital ratio for all $\rho < 1$.*

From the above expression for $\frac{g}{K}$, if the government is benevolent, i.e. $\theta = 1$, it chooses:

$$(\frac{g}{K})^{BEN} = \frac{\rho\alpha}{\beta(1-\rho\alpha)} \tag{13}$$

If the government is self-interested, i.e. $\theta = 0$, it chooses:

$$(\frac{g}{K})^{SELF-INT} = \frac{\alpha}{\beta(1-\alpha)} \tag{14}$$

Rate of time preference of the government does not matter for public-to-private capital ratio if the government is totally self-interested. If the government is benevolent, then as it becomes more patient it chooses a higher public-to-private capital ratio. However, this increase does not hurt the growth rate; growth rate still goes up as the government gets more patient.

Note that many endogenous growth models with public investment, starting with Barro (1990), find the optimal public investment-to-private capital ratio to be equal to the ratio of output elasticities of the two inputs, i.e. $\frac{\alpha}{1-\alpha}$. However, in the case of benevolent government in this model, the optimal choice of the government is lower than that ratio. This is because in this model, unlike Barro (1990) and others, public investment is taken as a stock variable rather than a flow variable and the government policy involves choosing next period's capital level rather than current investment. Hence, Barro (1990)'s golden rule is discounted by the rate of time preference of the government and consumers. As long as the consumers are at least as patient as the government, the optimal $\frac{g}{K}$ in this model is smaller than $\frac{\alpha}{1-\alpha}$. Impatience of consumers implies that a high public-to-private capital ratio is not desirable when public investment is financed by distortionary income taxes.

Proposition 7 (Government Policy) *When public and private capital fully depreciate*

(a) all types of governments set the same productive public investment share of output.

(b) total public investment increases as a government gets less benevolent.

(c) tax rate increases as a government gets less benevolent.

First consider productive public investment as a share of income. Given that there is full depreciation of productive public capital, this share is equal to $\frac{g_{t+1}}{Y_t}$. Moreover, $g_{t+1} = \gamma \cdot g_t$. Hence, by simple algebra:

$$\frac{g_{t+1}}{Y_t} = \frac{i_g}{Y} = \rho\alpha \tag{15}$$

Notice that this value is independent of θ, so all types of governments choose the same share of public investment.

So, in countries with high $\frac{g}{K}$, i.e. countries with self-interested governments, productive private investment share is smaller than in countries with benevolent governments. Total public investment, on the other hand, does depend on the type of the government and it can easily seen that $\frac{\partial \frac{i_g+E}{Y}}{\partial \theta} < 0$.

$$\frac{i_g + E}{Y} = \rho\alpha + (1-\theta)(1-\rho) \tag{16}$$

Now consider the tax rate:

$$\tau = \rho\alpha + (1-\theta)(1-\rho) \tag{17}$$

When the government is benevolent, i.e. $\theta = 1$:

$$\tau^{BEN} = \rho\alpha \tag{18}$$

When the government is totally self-interested, i.e. $\theta = 0$:

$$\tau^{SELF-INT} = 1 - \rho + \rho\alpha \tag{19}$$

Notice that when the government is totally benevolent all of the tax revenues are used for financing the productive public investment. A self-interested government uses only part of the tax revenues for the productive public investment and provides the same amount of productive public investment. The government engages in more non-productive activities as it becomes less patient, i.e. $\frac{\partial \frac{E}{Y}}{\partial \rho} < 0$.

Proposition 8 *When public and private capital fully depreciate*

(a) private investment decreases as a government gets less benevolent.

(b) growth rate of the economy decreases as a government gets less benevolent.

Share of private investment in total output can be calculated as below. Note that as θ decreases, $\frac{i_k}{Y}$ decreases.

$$\frac{k_{t+1}}{Y_t} = \frac{i_k}{Y} = \beta[\theta(1-\rho) + \rho(1-\alpha)] \tag{20}$$

Growth rate is given by:

$$\gamma = A(\rho\alpha)^{\alpha} \left(\beta[\theta(1-\rho) + \rho(1-\alpha)]\right)^{1-\alpha} \tag{21}$$

It is easy to show that the growth rate increases with θ. This is consistent with the results that private investment and productive public investment increase with θ.

Case 2 (Less Than Full Depreciation) *Assume* $0 < \delta_g < 1$, $0 < \delta_k < 1$.

In this case there is no way to simplify the formulas presented above. However, it is still possible to see how a benevolent government is different than a self-interested one. Table 1 shows public investment share of output, private investment share of output, public-to-private capital ratio, and growth rate corresponding to different degrees of benevolence. These figures are calculated for $A = \frac{1}{3}$, $\beta = 0.9$, $\rho = 0.9$, $\alpha = 0.25$, $\delta_k = 0.07$, and $\delta_g = 0.07$.

Table 1: **Balanced Growth Path Values**

θ	**0**	**0.10**	**0.25**	**0.50**
g/K	0.28	0.30	0.33	0.40
g/Y	1.17	1.22	1.32	1.52
K/Y	4.12	4.05	3.95	3.77
i^g/Y	0.12	0.11	0.10	0.08
E/Y	0	0.06	0.15	0.30
τ	0.12	0.18	0.25	0.38
i^k/Y	0.41	0.37	0.31	0.21
Growth Rate	3%	2.1%	1%	-1.5%

Public investment share of output is again roughly the same across different types of government but private investment share is much higher in countries with benevolent governments. Growth rate is also higher in these countries while tax rate is lower.

3 Empirical Implications of the Model

The theory has implications about the total public investment and economic growth. A self-interested government chooses a high level of public investment, and the increased taxes to finance that investment causes the private investment to fall, hence the low growth rate. If countries are lined up according to their total public investments, the model predicts that those would high levels of public investment would have low growth rates.

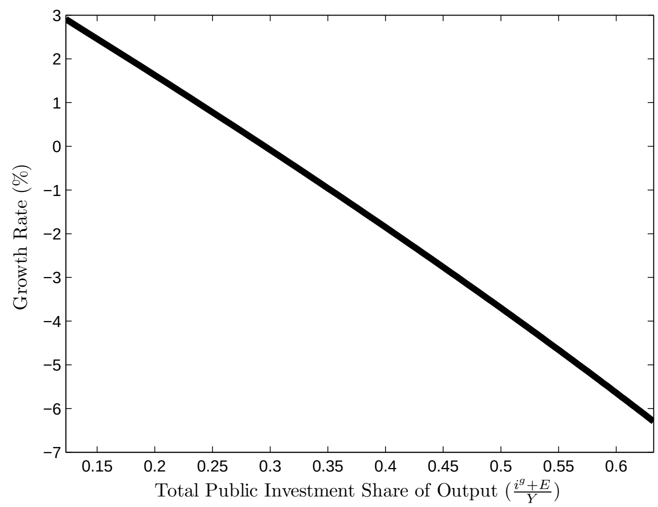


Figure 2: Total Public Investment and Growth. Parameter values are $A = \frac{1}{3}$, $\alpha = 0.25$, $\rho = \beta = 0.9$, $\delta_k = \delta_g = 0.07$.

Another implication of the model is that the total public-to-private investment ratio is inversely related with growth rate. Figure 3 depicts the relationship of public-to-private investment ratio and economic growth implied by the model.

The model also implies that productive public investment and expropriated tax revenues are inversely correlated (see Figure 4). A benevolent government would choose a high productive public investment share of output and would not embezzle resources for its own use. A self-interested government, on the other hand, would choose a lower productive public investment and uses a big part of tax revenues for non-productive purposes. This means that if the total public investment observed is high, then it is likely that most of this public investment is non-productive, aimed at providing private returns for politicians. Figure 5

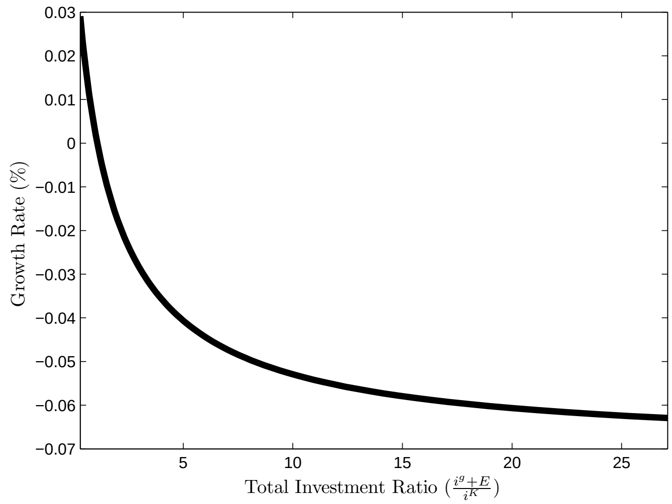


Figure 3: Total Public-to-private Investment Ratio and Growth. Parameter values same as in Figure 2.

depicts this relationship.

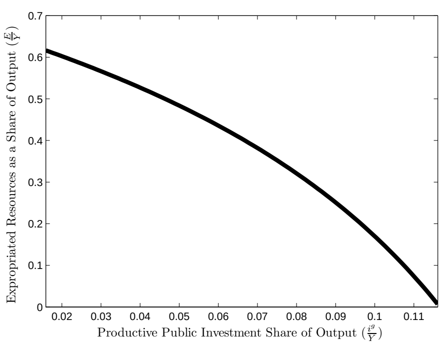


Figure 4: Productive Public Investment and Expropriated Resources as a Share of Output. Parameter values same as in Figure 2.

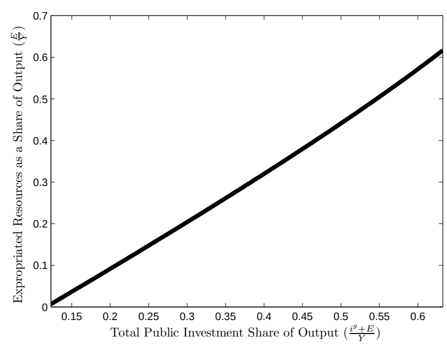


Figure 5: Total Public Investment Share of Output and Expropriated Resources as a Share of Output. Parameter values same as in Figure 2.

Moreover, according to the model, private investment is lower in countries with self-interested governments, while total public investment is higher. As a result, the public-to-private investment ratio in corrupt countries is higher (see Figure 6). This is consistent with the findings of Tanzi and Davoodi (1997), Mauro (1995) and Mauro (1995). Mauro (1995) finds that corruption decreases private investment, while Tanzi and Davoodi (1997) maintain that corruption increases public investment.

Finally, the model predicts that economic growth would be lower in countries with high corruption. This is also consistent with empirical work pioneered by Mauro (1995).

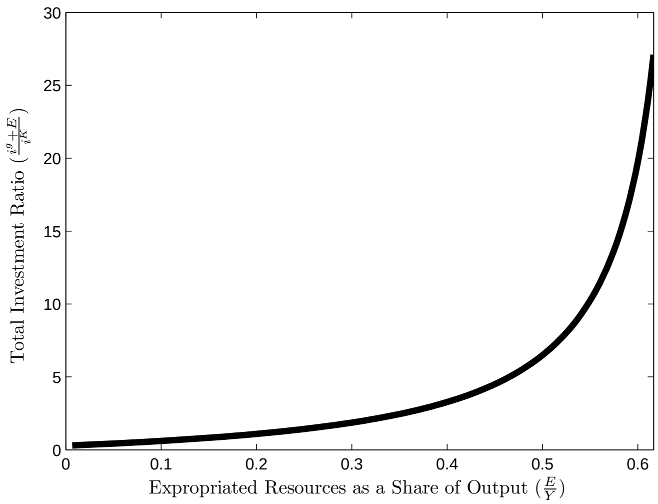


Figure 6: Expropriated Resources and Total Public-to-private Investment Ratio. Parameter values same as in Figure 2.

While there is empirical evidence supporting the implications of the model regarding share of public investment, corruption, and growth there are no studies examining how public-to-private capital ratio differ across countries. In the next section I present data and compare it with the implications of the model regarding public-to-private capital.

4 Data

I took the public investment and private investment data from Easterly and Rebelo (1993) data set. This data is gathered from sources including World Bank country reports, United Nation's national accounts data, and World Bank's annual *World Development Report*. It includes more than 100 countries and covers 1970 through 1988. The authors calculate private investment by subtracting public investment from total investment. However their data set lacks private investment figures for many advanced countries. I used OECD data to complement the Easterly-Rebelo data set and I calculated decade averages of public and private investment in 1980s as a fraction of GDP.

Public capital stock and private capital stock data are not readily available. As a proxy for these variables, I used public investment and private investment data obtained from the (extended) Easterly-Rebelo data set. Note that as long as public capital and private capital depreciate at the same rate, the ratio of the two capitals $\frac{g}{K}$ would equal to the ratio of the investments $\frac{i^g}{i^k}$. Therefore, using investment ratio rather than capital ratio would be a good proxy if the two capitals depreciate at similar rates.

I took the growth rates from Heston, Summers, and Aten (2006) and I calculated the average growth rate of real GDP per capita in year 2000 constant prices for 1980-1990.

The measure of corruption is obtained from Transparency International's Corruption Perceptions Index (CPI) for 2006. The CPI ranks countries by their perceived levels of public sector corruption, as determined by expert assessments and opinion surveys. It scores countries on a scale from zero to ten, with ten indicating a highly clean country and zero indicating a highly corrupt country. Note that the CPI values are from 2006 whereas other data are for 1980-1990. There is no CPI for that decade as the earliest CPI is collected in 1995. However, there is persistence in this index; countries that are corrupt in 1995 seem to stay corrupt in 2006. The correlation coefficient for 1995 CPI and 2006 CPI for countries that are reported in both is 0.93. See Appendix B for details. Hence, 2006 CPI would be a good enough measure for perceived corruption in 1980s.

There are 86 countries in the whole sample and the complete list of countries included is in Appendix B. Table 2 presents descriptive statistics of the variables analyzed.

Figure 7a shows the relationship between public-to-private investment ratio and growth rate. The correlation coefficient is -0.23 and it is significantly different than 0. Note that the correlation is not driven by the extreme points. If we take out countries[5] whose public-to-private investment ratio is higher than 5 the correlation coefficient decreases to -0.29. This case is shown in Figure 7b. While there is more dispersion of growth rates at low levels of public-to-private investment ratio, growth rate is never too high when the investment ratio

[5]These countries are Ethiopia, Hungary, Mauritania, Jamaica, Burundi, Mozambique, Poland, and Niger.

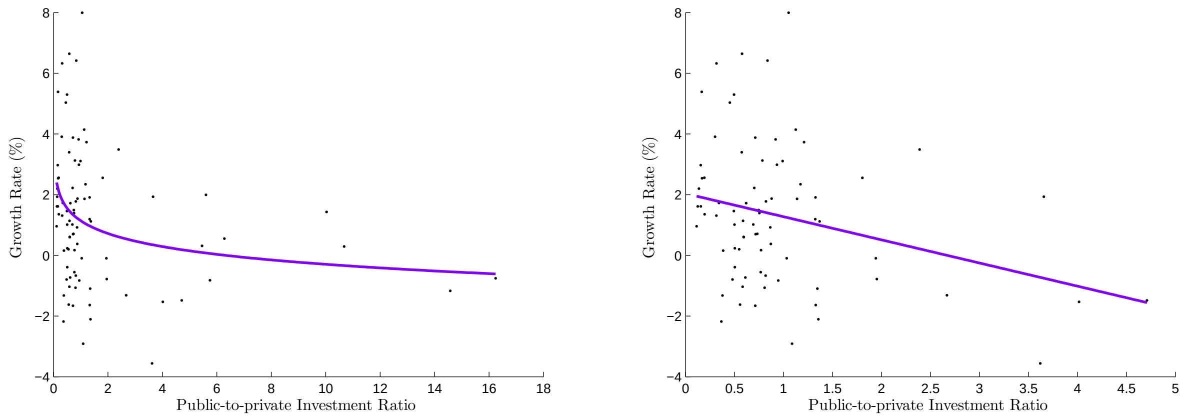
Table 2: **Descriptive Statistics**

	Mean	**Std. Dev.**	**Minimum**	**Maximum**
Whole Sample (86 Countries)				
Public Investment Share	0.10	0.05	0.02	0.27
Private Investment Share	0.11	0.06	0.005	0.29
Public-to-private Capital Ratio	1.72	2.90	0.11	16.24
Growth Rate (%)	1.22	2.25	-3.56	8.00
Corruption Perceptions Index	3.92	2.08	1.80	9.60
Advanced Countries[a] (14 Countries)				
Public Investment Share	0.05	0.03	0.02	0.13
Private Investment Share	0.20	0.08	0.12	0.29
Public-to-private Capital Ratio	0.26	0.21	0.11	0.84
Growth Rate (%)	2.94	2.02	0.20	6.41
Corruption Perceptions Index	7.69	1.83	4.40	9.60
Developing Countries[a] (72 Countries)				
Public Investment Share	0.11	0.05	0.04	0.27
Private Investment Share	0.10	0.06	0.005	0.25
Public-to-private Capital Ratio	2.00	3.05	0.30	16.24
Growth Rate (%)	0.88	2.15	-3.56	8.00
Corruption Perceptions Index	3.18	1.12	1.80	7.30
Least Corrupt Countries[b] (11 Countries)				
Public Investment Share	0.04	0.03	0.02	0.13
Private Investment Share	0.22	0.10	0.10	0.29
Public-to-private Capital Ratio	0.22	0.16	0.11	0.62
Growth Rate (%)	2.49	1.46	0.95	5.38
Corruption Perceptions Index	8.60	0.78	7.30	9.60
Most Corrupt Countries[b] (10 Countries)				
Public Investment Share	0.08	0.03	0.05	0.13
Private Investment Share	0.08	0.03	0.04	0.12
Public-to-private Capital Ratio	1.37	1.00	0.58	3.62
Growth Rate (%)	-0.26	1.91	-3.56	3.93
Corruption Perceptions Index	2.07	0.14	1.80	2.20

[a] *According to the classification of the IMF. See Appendix B for the list of advanced countries.*

[b] *Top and bottom 10 countries according to the Corruption Perceptions Index (2006). See Appendix B for the list of these countries.*

is high. The dispersion of growth rates at low levels can be explained by this theory through changes across countries in public capital elasticity of output (α), rate of time preference of the government ρ, and that of consumers. The model predicts, keeping the type of the government constant, a higher public capital elasticity of output, a more patient government,



(a) All Countries

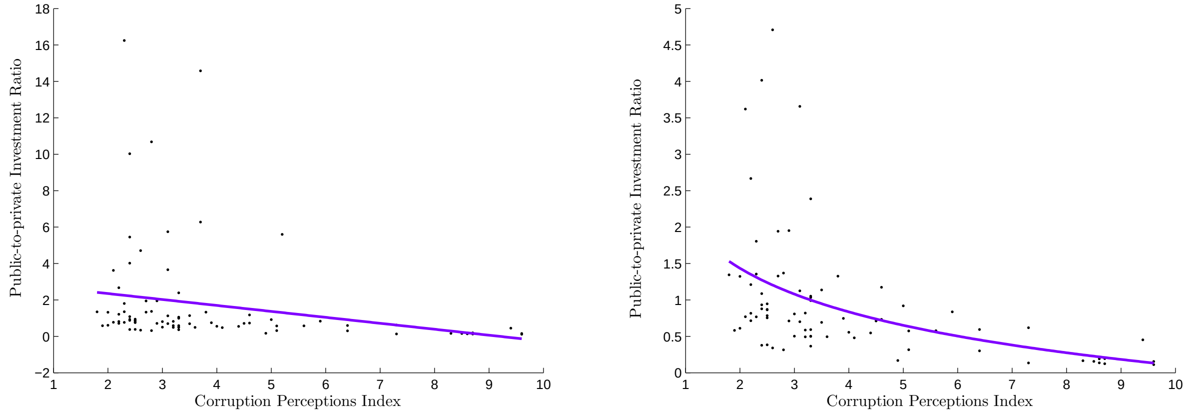
(b) Countries with $X \leq 5$

Figure 7: Public-to-private Investment Ratio and Growth in the data.

and less patient consumers result in higher investment ratios.

As Figure 8a shows, corruption and public-to-private investment ratio are positively related. Recall that high numbers in Corruption Perceptions Index refer to low corruption. The correlation coefficient between X and Corruption Perceptions Index is -0.24 and it is significantly different than 0. Again, extreme points do not derive this relationship. If we take out countries whose public-to-private investment ratios are above 5, the correlation coefficient would decrease to -0.43. This case is shown in Figure 8b. This result is one of the main arguments in this paper. Several authors have maintained that corruption causes public investment as a share of output or of total investment to be high (e.g. Tanzi and Davoodi (1997) and Keefer and Knack (2007)). What is shown here is that with high corruption, public capital per private capital is too high. Self-interested governments distort the capital mix and reduce the productivity of private capital.

Figure 9 depicts the relationship between Corruption Perceptions Index and Public Investment Share of Output. The correlation coefficient is -0.33 and it is statistically significant. This is in line with the model's results. Corrupt governments inflate the amount of public investment by reducing the productive public investment and increasing the amount of funds expropriated. Keefer and Knack (2007) find a similar result and claim that public



(a) All Countries

(b) Countries with $X \leq 5$

Figure 8: Corruption and Public-to-private Investment Ratio in the data.

investment reported should not be used for policy suggestions because the reported public investment data is an overestimation of the actual productive public investment.

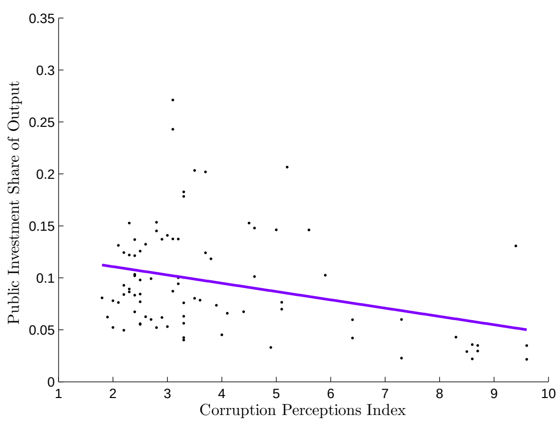


Figure 9: Corruption and Public Inv. in the data.

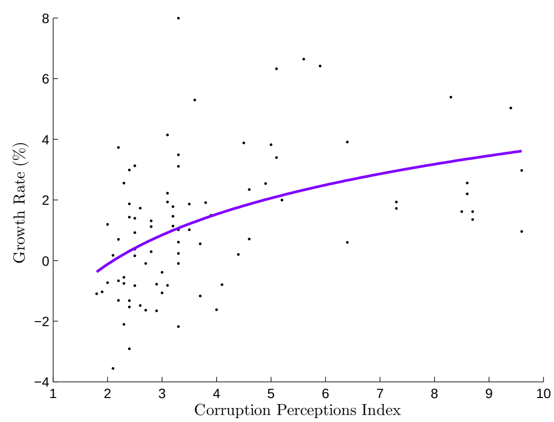


Figure 10: Corruption and Growth in the data.

Finally, Figure 10 demonstrates the relationship between corruption and growth. The correlation coefficient is 0.43 and it is significantly different than 0. This concurs not only the implication of the model but also what other scholars have argued (see Mauro (1995), Tanzi and Davoodi (1997)).

Table 3 summarizes the correlation coefficients for all the variables. Recall that countries with high CPI values are relatively clean economies. Hence, a negative correlation of a variable with CPI means that variable is high in corrupt countries.

Table 3: **Correlation Coefficients**

	$\mathbf{i^g/Y}$	$\mathbf{i^k/Y}$	**g/K (all)**	**g/K (≤ 5)**	**Growth Rate**	**CPI**
$\mathbf{i^g/Y}$	1					
$\mathbf{i^k/Y}$	-0.11*	1				
g/K (all)	0.45	-0.58	1			
g/K(≤ 5)	0.59	-0.58	-	1		
Growth Rate	0.16*	0.55	-0.23	-0.29	1	
CPI	-0.33	0.51	-0.24	-0.43	0.43	1

**Not significant.*

5 Concluding remarks

In many macroeconomic models that deal with government choices, the government is assumed to be benevolent. When the government is totally benevolent one would not expect to see political corruption in the economy. In this paper the assumption of a benevolent government is relaxed and a simple model that tries to explain the interaction between political corruption, public investment, and economic growth is developed. In line with many other studies, one result of the model is that corruption is detrimental to economic growth. A self-interested government chooses a high productive public-to-private capital ratio, thereby increasing the returns to private capital. However, this increase in the capital ratio requires the tax rates to go up, causing the after-tax returns to be lower. The net effect on growth is negative. Also, part of the tax revenues are expropriated by the government, so the share of output that goes to productive public investment in corrupt countries is low.

An interesting extension of the model would be to consider the case when the government does not have access to a commitment technology and compare the result to those of Azzimonti-Renzo, Sarte, and Soares (2003).

In this model the type of government is taken as given and the reasons as to why some governments are more self-interested than others are not explored. The type of government in any country might depend on the historical, cultural, institutional, and macroeconomic environment in that country. My aim for future research is to explore the macroeconomic determinants of corruption.

Appendix A - Proofs of Propositions

Proof of Proposition 1

The first constraint, the feasibility constraint, is part of the definition of CE. The second one is obtained by plugging GBC, Price, and Feasibility in Cons-FOC.

$$\begin{aligned}
u'(C_t) &= \beta u'(C_{t+1})[(1-(\frac{E_{t+1}+g_{t+2}-(1-\delta_g)g_{t+1}}{r_{r+1}K_{t+1}}))r_{t+1}+1-\delta_k] \\
u'(C_t) &= \beta u'(C_{t+1})[A(\frac{g_{t+1}}{K_{t+1}})^\alpha-(\frac{E_{t+1}+g_{t+2}-(1-\delta_g)g_{t+1}}{A(\frac{g_{t+1}}{K_{t+1}})^\alpha K_{t+1}})A(\frac{g_{t+1}}{K_{t+1}})^\alpha+1-\delta_k] \\
u'(C_t) &= \beta u'(C_{t+1})[\frac{A(\frac{g_{t+1}}{K_{t+1}})^\alpha K_{t+1}-E_{t+1}-g_{t+2}+(1-\delta_g)g_{t+1}}{K_{t+1}}+1-\delta_k] \\
u'(C_t) &= \beta u'(C_{t+1})[\frac{C_{t+1}+K_{t+2}-(1-\delta_k)K_{t+1}}{K_{t+1}}+1-\delta_k] \\
u'(C_t) &= \beta u'(C_{t+1})[\frac{C_{t+1}+K_{t+2}}{K_{t+1}}]
\end{aligned}$$

Proof of Proposition 2

Aggregate allocations $\{C_t, K_t\}_{t\geq 0}$, initial conditions g_0 and K_0, and first-period policies g_1, τ_0 and E_0 are given. Prices $\{r_t\}_{t=0}^\infty$ and policies $\{\tau_t, E_t, g_{t+1}\}_{t=1}^\infty$ need to be constructed. To this end first-order conditions will be used. Given the assumptions on the utility function of consumers, the first-order conditions are both necessary and sufficient for consumer and firm maximization.

The following four equations can be used to construct r_t, τ_t, E_t, and g_{t+1} at each time t:

$$r_t = A\left(\frac{g_t}{K_t}\right)^\alpha \tag{22}$$

$$\tau_{t+1} = 1-\left[\frac{u'_t}{\beta u'_{t+1}}-1+\delta_k\right]\frac{1}{A\left(\frac{g_{t+1}}{k_{t+1}}\right)^\alpha} \tag{23}$$

$$C_t+K_{t+1}-(1-\delta_k)K_t+g_{t+1}-(1-\delta_g)g_t+E_t = AK_t\left(\frac{g_t}{K_t}\right)^\alpha \tag{24}$$

$$g_{t+1}-(1-\delta_g)g_t+E_t = A(1-\tau_t)K_t\left(\frac{g_t}{K_t}\right)^\alpha \tag{25}$$

Proof of Proposition 4

As shown in the main discussion, Ramsey Problem is characterized by the following equations:

$$\rho^t\frac{(1-\theta)}{C_t}+\rho^t\lambda_t-\rho^t\frac{\mu_t}{C_t^2}+\rho^{t-1}\beta\frac{\mu_{t-1}}{C_t^2}[\frac{C_t+K_{t+1}}{K_t}]-\rho^{t-1}\beta\frac{\mu_{t-1}}{C_tK_t} = 0 \quad (26)$$

$$\rho^t\lambda_t-\rho^{t+1}\lambda_{t+1}[1-\delta_k+A(1-\alpha)\left(\frac{g_{t+1}}{K_{t+1}}\right)^{\alpha}]+\rho^t\beta\frac{\mu_t}{C_{t+1}}[\frac{C_{t+1}+K_{t+2}}{K_{t+1}^2}]-\rho^{t-1}\beta\frac{\mu_{t-1}K_t}{C_t} = 0 \quad (27)$$

$$\rho^t\frac{\theta}{E_t}+\rho^t\lambda_t = 0 \quad (28)$$

$$\rho^t\lambda_t-\rho^{t+1}\lambda_{t+1}[1-\delta_g+A\alpha\left(\frac{g_{t+1}}{K_{t+1}}\right)^{\alpha-1}] = 0 \quad (29)$$

$$C_t+K_{t+1}-(1-\delta_k)K_t+g_{t+1}-(1-\delta_g)g_t+E_t = AK_t\left(\frac{g_t}{K_t}\right)^{\alpha} \quad (30)$$

$$\frac{\beta}{C_{t+1}}[\frac{C_{t+1}+K_{t+2}}{K_{t+1}}] = \frac{1}{C_t} \quad (31)$$

On a balanced growth path, the following ratios must be constant: $\frac{C_{t+1}}{C_t}=\gamma_C$, $\frac{E_{t+1}}{E_t}=\gamma_E$, $\frac{K_{t+1}}{K_t}=\gamma_K$, and $\frac{g_{t+1}}{g_t}=\gamma_g$ for all t.

Plug (28) in (29):

$$\frac{E_{t+1}}{E_t}=\rho[1-\delta_g+A\alpha\left(\frac{g_{t+1}}{K_{t+1}}\right)^{\alpha-1}]$$

In order for this ratio to be constant over time, $\frac{g_t}{K_t}$ must be constant for all t. Denote this ratio by $X=\frac{g}{K}$. Then:

$$\gamma_E=\rho[1-\delta_g+A\alpha X^{\alpha-1}]$$

Equation (31) on balanced growth path implies:

$$\frac{C_t}{K_t}+\gamma_K=\frac{\gamma_C}{\beta}$$

So $\frac{C_t}{K_t}$ is a constant for all t, hence $\gamma_C=\gamma_K$. So, on balanced growth path:

$$\frac{C}{K}=(\frac{1-\beta}{\beta})\gamma_K \quad (32)$$

Rewrite equation (30):

$$\frac{C_t}{K_t}+\frac{K_{t+1}}{K_t}-(1-\delta_k)+\frac{g_{t+1}}{K_t}-(1-\delta_g)\frac{g_t}{K_t}+\frac{E_t}{K_t}=A\left(\frac{g_t}{K_t}\right)^{\alpha}$$

On balanced growth path:

$$(\frac{1-\beta}{\beta})\gamma_K+\gamma_K-(1-\delta_k)+X\gamma_K-(1-\delta_g)X+\frac{E_t}{K_t}=AX^{\alpha}$$

So, $\frac{E_t}{K_t}$ is a constant for all t; hence $\gamma_E = \gamma_K$ and:

$$\frac{E}{K} = AX^{\alpha} - (\frac{1}{\beta} + X)\gamma_K + (1-\delta_k) + (1-\delta_g)X \tag{33}$$

Now consider (26). Plug (28) in (26):

$$\frac{\rho(1-\theta)}{C_t} - \frac{\rho\theta}{E_t} - \frac{\rho\mu_t}{C_t^2} + \frac{\beta\mu_{t-1}}{C_t^2}[\frac{C_t + K_{t+1}}{K_t}] - \frac{\beta\mu_{t-1}}{C_t}\frac{1}{K_t} = 0$$

Multiply it by K_t and consider the balanced growth path:

$$\frac{\rho(1-\theta)K}{C} - \frac{\rho\theta K}{E} - \frac{\rho\mu_t K}{C_t C} + \frac{\beta\mu_{t-1}K}{C_t C}[\frac{C_t + K_{t+1}}{K_t}] - \frac{\beta\mu_{t-1}}{C_t} = 0$$

Rewrite it:

$$\frac{\rho(1-\theta)K}{C} - \frac{\rho(1-\gamma)K}{E} - \rho\frac{\mu_t}{C_t}\frac{K}{C} + \frac{\mu_{t-1}}{C_{t-1}}\beta\left(\frac{K}{\gamma_K C}[\frac{C}{K} + \gamma_K] - \frac{1}{\gamma_K}\right) = 0 \tag{34}$$

Now consider (27). Plug (28) and (29) in (27):

$$-\left(\rho\gamma_K - \rho^2[1-\delta_k + A(1-\alpha)\left(\frac{g_{t+1}}{K_{t+1}}\right)^{\alpha}]\right)\frac{\theta}{E_{t+1}} + \frac{\mu_t\beta\rho}{C_{t+1}}[\frac{C_{t+1} + K_{t+2}}{K_{t+1}^2}] - \mu_{t-1}\frac{\beta}{C_t K_t} = 0$$

Multiply by K_{t+1} and consider the balanced growth path:

$$-\left(\rho\gamma_K - \rho^2[1-\delta_k + A(1-\alpha)X^{\alpha}]\right)\theta\frac{K}{E} + \frac{\mu_t\beta\rho}{\gamma_K C_t}[\frac{C}{K} + \gamma_K] - \mu_{t-1}\frac{\beta\gamma_K}{\gamma_K C_{t-1}} = 0$$

Rewrite it:

$$-\rho\left(\gamma_K - \rho[1-\delta_k + A(1-\alpha)X^{\alpha}]\right)\theta\frac{K}{E} + \frac{\mu_t}{C_t}\frac{\beta\rho}{\gamma_K}[\frac{C}{K} + \gamma_K] - \beta\frac{\mu_{t-1}}{C_{t-1}} = 0 \tag{35}$$

(34) and (35) are difference equations for $\frac{\mu}{C}$. They have to be satisfied at the same time. Hence, this condition can be used to find X. The X that satisfies both (34) and (35) is given by:

$$\frac{\rho(\frac{(1-\theta)K}{C} - \frac{\theta K}{E})}{\frac{K}{C}} = \rho\left(\rho[1-\delta_g + A\alpha X^{\alpha-1}] - \rho[1-\delta_k + A(1-\alpha)X^{\alpha}]\right)\theta\frac{K}{E} \tag{36}$$

Once $\frac{C}{K}$ and $\frac{E}{K}$ are substituted from equations (32) and (33), one can solve for X using (36).

Now consider the Euler equation from the consumer's problem:

$$\frac{C_{t+1}}{C_t} = \beta[(1-\tau_{t+1})r_{t+1} + 1 - \delta_k]$$

From the government's problem:

$$\frac{C_{t+1}}{C_t} = \rho[1 - \delta_g + A\alpha X^{\alpha-1}]$$

Equating the two:

$$\tau = 1 - \frac{\frac{\rho}{\beta}[1-\delta_g + A\alpha X^{\alpha-1}] - (1-\delta_k)}{AX^\alpha}$$

Then the balanced growth path is characterized as follows:

- $\frac{C}{K} = \frac{(1-\beta)}{\beta}\rho[1-\delta_g + A\alpha X^{\alpha-1}]$
- $\frac{E}{K} = AX^\alpha - (\frac{1}{\beta} + X)\rho[1-\delta_g + A\alpha X^{\alpha-1}] + (1-\delta_k) + (1-\delta_g)X$
- $\frac{g}{K} = X$
- $\tau = 1 - \frac{\frac{\rho}{\beta}[1-\delta_g+A\alpha X^{\alpha-1}]-(1-\delta_k)}{AX^\alpha}$
- $\gamma_C = \gamma_K = \gamma_E = \gamma_g = \rho[1-\delta_g + A\alpha X^{\alpha-1}]$

where X satisfies:

$$(1-\theta)\{AX^\alpha - (\frac{1}{\beta}+X)\rho[1-\delta_g+A\alpha X^{\alpha-1}] + (1-\delta_k) + (1-\delta_g)X\} - \theta\frac{(1-\beta)}{\beta}\rho[1-\delta_g+A\alpha X^{\alpha-1}] =$$

$$\theta\rho[\delta_k - \delta_g + A\alpha X^{\alpha-1} - A(1-\alpha)X^\alpha]$$

Appendix B - Data

List of countries included in the sample

Algeria, Argentina, Australia, Austria, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Finland, Gabon, Ghana, Greece, Grenada, Guinea, Haiti, Honduras, Hong Kong, Hungary, India, Indonesia, Italy, Jamaica, Kenya, South Korea, Lesotho, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Rwanda, Senegal, Sierra Leone, Singapore, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syria, Taiwan, Thailand, Togo, Tunisia, Turkey, UK, Uruguay, USA, Venezuela, Zambia, and Zimbabwe.

Advanced countries included in the sample

Australia, Austria, Canada, Finland, Greece, Hong Kong, Italy, Netherlands, New Zealand, Singapore, South Korea, Taiwan, UK, and USA.

Least corrupt countries included in the sample

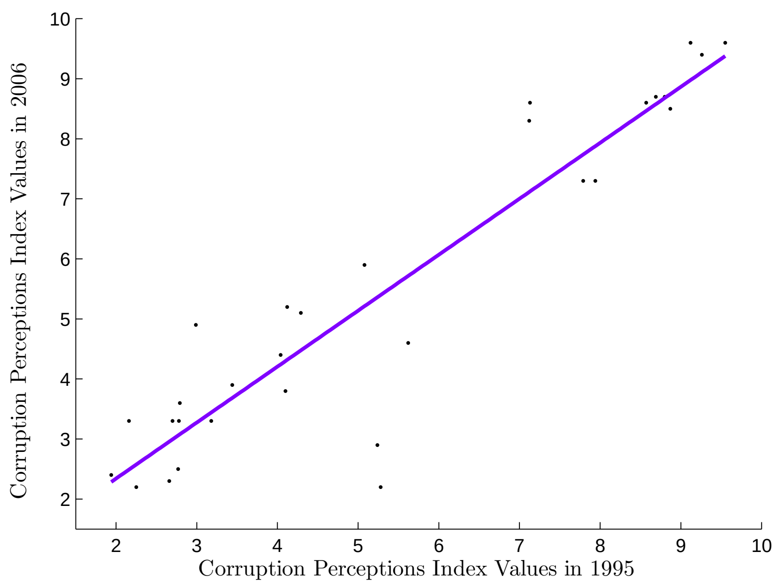
Australia, Austria, Canada, Chile, Finland, Hong Kong, Netherlands, New Zealand, Singapore, UK, and USA.

Most corrupt countries included in the sample

Bangladesh, Côte d'Ivoire, Equatorial Guinea, Guinea, Haiti, Kenya, Nigeria, Pakistan, Sierra Leone, and Sudan.

Corruption Perceptions Index in 1995 and 2006

Only 30 countries in the sample have CPI values in 1995. These countries are Argentina, Australia, Austria, Brazil, Canada, Chile, China, Colombia, Finland, Greece, Hong Kong, Hungary, India, Indonesia, Italy, Malaysia, Mexico, Netherlands, New Zealand, Pakistan, Philippines, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey, UK, USA, and Venezuela. The correlation coefficient between 1995 CPI values and 2006 CPI values for these countries is 0.93.



References

Aschauer, D. A. (1989): "Is Public Expenditure Productive?," *Journal of Monetary Economics*, 23, 177–200.

Azzimonti-Renzo, M., P.-D. G. Sarte, and J. Soares (2003): "Optimal public investment with and without government commitment," Working Paper 03-10, Federal Reserve Bank of Richmond.

Barro, R. J. (1990): "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy*, 98, S103–S125.

Barro, R. J., and X. Sala-i Martin (1992): "Public Finance in Models of Economic Growth," *Review of Economic Studies*, 59(4), 645–661.

Chari, V., and P. J. Kehoe (1999): "Optimal fiscal and monetary policy," vol. 1 of *Handbook of Macroeconomics*, chap. 26, pp. 1671–1745. Elsevier.

Devarajan, S., V. Swaroop, and H.-F. Zou (1996): "The composition of public expenditure and economic growth," *Journal of Monetary Economics*, 37(2-3), 313–344.

Easterly, W., and S. Rebelo (1993): "Fiscal Policy and Economic Growth," *Journal of Monetary Economics*, 32, 417–458.

Futagami, K., Y. Morita, and A. Shibata (1993): "Dynamic Analysis of an Endogenous Growth Model with Public Capital," *Scandinavian Journal of Economics*, 95(4), 607–25.

Haque, M. E., and R. Kneller (2008): "Public Investment and Growth: The Role of Corruption," Centre for Growth and Business Cycle Research Discussion Paper Series 98, Economics, The University of Manchester.

Heston, A., R. Summers, and B. Aten (2006): *Penn World Table Version 6.2*Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Jones, L. E., R. E. Manuelli, and P. E. Rossi (1993): "Optimal Taxation in Models of Endogenous Growth," *Journal of Political Economy*, 101(3), 485–517.

Keefer, P., and S. Knack (2007): "Boondoggles, Rent-Seeking, and Political Checks and Balances: Public Investment under Unaccountable Governments," *The Review of Economics and Statistics*, 89(3), 566–572.

Mauro, P. (1995): "Corruption and Growth," *The Quarterly Journal of Economics*, 110(3), 681–712.

——— (1997): "The Effects of Corruption on Growth, Investment, and Government Expenditure," in *Corruption and the Global Economy*, ed. by K. A. Elliott. Institute of International Economics, Washington D.C.

——— (2004): "The Persistence of Corruption and Slow Economic Growth," *IMF Staff Papers*, 51(1).

Tanzi, V., and H. R. Davoodi (1997): "Corruption, Public Investment, and Growth," IMF Working Papers 97/139, International Monetary Fund.