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Endogenous corruption in a neoclassical growth model

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Abstract

The following paper presents a simple neoclassical growth model where corruption is an endogenous result of competition between a public agent and a private agent. The model provides a simple theoretical framework in which the level of corruption as well as the effects of corruption on income, consumption, and growth are identifiable. Bureaucratic red-tape is then added to the model. The results suggest that, a priori, corruption is neither efficiency enhancing nor efficiency detracting with respect to growth but always results in some income redistribution. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Corruption and the public sector are intimately related. When government officials mismanage vast amounts of resources, the temptation faced by otherwise

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responsible agents within that institution is great. Corruption, although unethical, may be perfectly rational from the individual's frame of reference.

Public sector corruption, as defined here, is the illegal profiteering by a public agent from her position as a representative of the government.[1] For example, consider the customs official who charges her own extra duty on top of the actual tariff, or perhaps the official charges the correct tariff but pockets the money. Then there is the payment to an official to get a 'public' service to which one may already be entitled. Corruption can therefore take place in any economic transaction involving the public sector. As in any economic transaction, both parties mutually benefit.

Governments have a natural monopoly over the provision of public goods. Ideally, a government should provide its services to the private sector as efficiently as possible. Public goods are produced by governments for exactly this reason; production of types of goods is inefficient if left in the hands of the private sector. In a world without corruption, the public sector would provide its goods at the marginal cost. Thus, the most goods are available at the least cost. Instead, what if government personnel, whether officials or employees, are corruptible?

Consider a public sector that is self-seeking. In other words, suppose the government assumes its role in the production process, but does so with its own welfare maximization in mind. The government therefore exploits the monopoly power that it has over the provision of public goods. The obvious result is that less public goods are provided at a higher price.

The underlying assumption in this paper is that the government, through its agents, is self-seeking. This is modeled as follows. Public agents, acting as representatives of the government, recognize the necessary role of public goods and services in the production process. They are also cognizant of the monopoly rents available from provision of 'public' goods and services. The public sector's monopoly profits represent corruption. The limitations on the extent of corruption depend on the ability of the private sector to exert control over government activity.

The concept that public goods may be provided by self-seeking agents is not new. Niskanen (1971) and later, Niskanen (1994), develop a theory of supply by bureaus. In particular, the analysis bears on the supply of public services by bureaus. The typical bureaucrat is assumed to face a set of possible actions, to have personal preferences among the outcomes of the possible actions, and to choose the action within the possible set that he most prefers.

I present a simple neoclassical endogenous growth model where the public sector's monopoly position is explicitly considered. I find that, as compared to

[1] I have adopted the definition of corruption as presented in Shleifer and Vishny (1993). There is although a significant body of literature that describes other variations corruption and its effects. Alam (1989, 1990), Geddes and Neto (1992), Kurer (1993), and Lapalombara (1994) constitute a sample.

the ideal where public goods are provided competitively, the corruption equilibrium is defined by lower growth rates and by sub-optimal levels of private sector income. Although full monopoly rents are unattainable, the middle ground between perfect competition and monopoly can still provide significant real income to corrupt public agents. Thus, corruption implies some degree of income redistribution.

I show that a stable balanced growth equilibrium can exist where public goods are provided at a profit for the government. As expected, less public goods are provided at a higher price relative to the competitive ideal. The monopoly rents represent the endogenous level of corruption within the economy. I also show that if the public sector is subject to significant bureaucratic red-tape that is present within the competitive ideal and corruption alleviates that red-tape, then the corruption equilibrium can be preferred by all agents within the economy. Red-tape represents the waste within the public sector production process. For example, it is quite possible that the total value of public sector output is less than the total value of the inputs simply due to public inefficiency in the production process. The resulting equilibrium in an economy that is sufficiently plagued by red-tape is defined by comparatively higher growth rates and comparatively greater income to the private sector. The income redistribution associated with corruption results from the transfer of resources that would have otherwise been lost to bureaucracy. Thus, even with the resulting income redistribution, the corruption equilibrium is Pareto superior to the bureaucracy plagued competitive equilibrium.

There are several endogenous growth models that examine the role of the public sector. Zeisemer (1991), Hartwick (1992), and Glomm and Ravikumar (1992) constitute a sample.[2] I have adopted the work of Barro (1990) as the cornerstone of this paper. He presents a simple constant returns to scale model of economic growth. There is one composite good that is a function of capital and a public good, which is trivially produced from tax revenues. The simplicity of the model is useful to highlight corruption as defined here.

2. Endogenous corruption

A self-interested government may be modeled as a situation where individual actors within the state use their positions to profit from the sale of public goods. This theory is presented in Shleifer and Vishny (1993).

[2] Other pieces of endogenous growth literature that address the public sector's role are Devereux and Mansoorian (1992), King (1992), King and Rebelo (1990), and Rebelo (1991). Endogenous growth models that address rent seeking include Pecorino (1992), and Grossman and Helpman (1991, 1994).

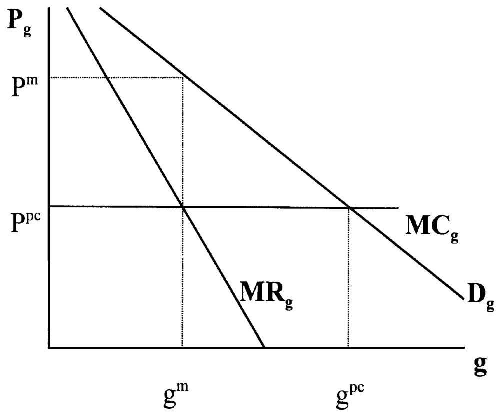

Fig. 1.

Their model is illustrated in Fig. 1. D_g is the demand curve for the public good g, and MR is its associated marginal revenue curve. MC_g is the marginal cost to the government agent of providing g.

The MC_g might or might not be associated with the cost of actually producing g. That is to say, it could be the case that the corrupt official sells the public good with little concern for its actual value. The marginal cost of providing the good is therefore strictly a function of the probability of detection of the public agent's illegal activities. On the other hand, the corrupt official might be keenly aware of the public good's real worth. She 'owns' the government and runs it like a good business. The marginal cost of providing g would therefore be a function of the corrupt agent's likelihood of detection as well as the actual cost of producing g.

There are three possible cases to be considered in the model. If there is no corruption whatsoever, the price of the public good, g, is $P^{pc} = MC_g$ and the quantity provided is g^{pc}. The public good is provided as if by a perfect competition. If the government official is empowered to sell the public good without probability of detection, she would optimally choose to charge a premium on the good such that the price of the public good is $P^{m} \mid MR_g = MC_g > P^{pc}$. Obviously, the amount of g provided by the monopolistic government agent would be some $g^{m} < g^{pc}$. The third possibility is that the government agent can provide the stolen public goods at no cost to herself, in other words with no likelihood of detection and irrespective of production costs. The marginal cost of the public good to the corrupt agent is zero and the rational corrupt agent would price the good accordingly. Under such circumstances, it might easily be the case that at $MC_g = 0$ the price charged by the agent is $P < P^{pc}$. In such a case, the corruption could be efficiency enhancing. Suppose the red tape involved in the public sector causes the competitive price of g to be so high

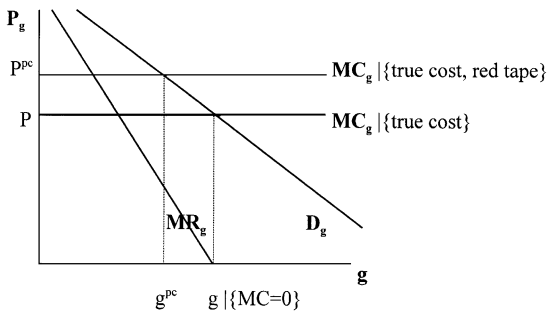

Fig. 2.

that agents can cut through it by being corrupt. Fig. 2 illustrates this third possibility.

The Shleifer and Vishny model assumes that the marginal cost in the above graph represents the marginal cost of providing the public good in terms of the likelihood and cost of detection. Thus the higher is the probability of detection, the higher is the marginal cost of providing the public good by the corrupt individual.

Consider instead a public good that uses real resources, i.e. capital. The provision of the public good would imply a social marginal cost associated with the allocation of capital between the private sector, $y = F(k_2, g)$, and the public sector, $g = H(k_1)$. The total amount of capital that is available at any given time is k where $k = k_1 + k_2$. Capital is mobile between g and y, therefore the rental rate of capital must be the same in the productions y and g. The government accepts bribes above and beyond the actual price of g. But businesses view the corruption premium as a production cost and therefore the effective price of g is above the otherwise market price.

One would expect corruption of this kind to be an institutional aspect of the economy in question. For businesses to accept the corrupt price implies that corruption is not a secret. Either the populace has grown to accept public sector corruption as a form legitimate income or they are just powerless to stop it.

Consider the production of output, $y = F(k_2, g)$, where F is linearly homogenous in k_2 and g. The demand for k_2 (Fig. 3) at any given time is equal to the partial derivative of F with respect to k_2, $F_{k_2} = D_{k_2}(P_g, r)$, and the demand for g (Fig. 4) at any given time is equal to the partial derivative of F with respect to g, $F_g = D_g(P_g, r)$. The marginal revenue of g (Fig. 4) is the partial derivative of the total revenue in the production of g with respect to g. Furthermore, since g is function k_1, it is possible to express the demand for g indirectly in terms of k_1 (Fig. 5). In this scenario, the production function of g is linearly homogenous in k_1. It is defined as $g = H(k_1) = vk_1$, where v is the inverse red tape coefficient. Therefore the demand for g in terms of k_1 is simply vD_g.

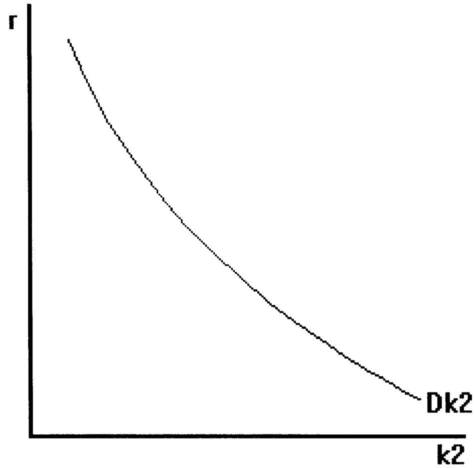

Fig. 3.

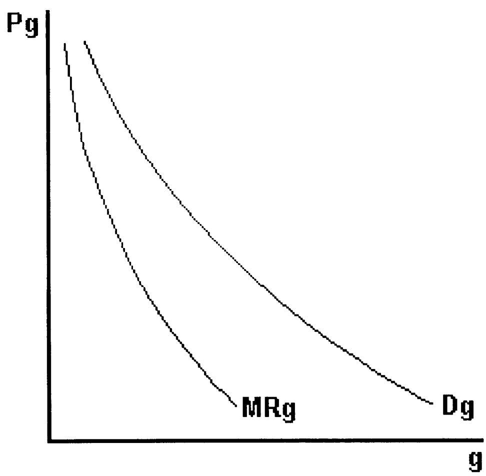

Fig. 4.

Fig. 3 may be superimposed upon Fig. 4 to show that capital has only two choices with regard to where it is used (Fig. 6). Capital may be allocated toward the production of g or toward the production of y. Notice that the social marginal cost of k_1 is exactly equal to the demand for k_2. This is because more g requires more k_1, which in turn leaves less k_2 to produce y, thereby implying the increasing marginal cost of k_1.

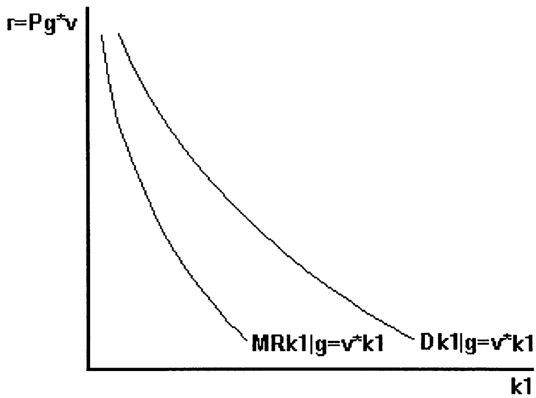

Fig. 5.

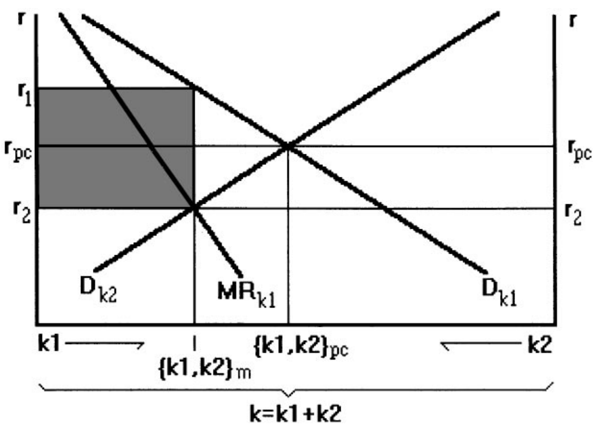

Fig. 6.

$\{k_1, k_2\}_{pc}$ represents the competitive equilibrium for both y and g. Corruption is zero thus the corrupt public agent ceases to exist. The economy wide rental rate of capital at the competitive equilibrium is r_{pc}. In the absence of red tape, the competitive equilibrium is the most efficient and subsequently corresponds to the greatest balanced growth rate possible (see Table 1).

The shaded area of Fig. 6 represents the monopoly rents available to a corrupt public sector. If the public official had the market power, she would theoretically charge $P_g = r_1/v \mid \{k_1, k_2\}$ thereby maximizing rents from the sale of public goods as a monopolist. But extorting complete monopoly rents implies no detection costs.

Table 1

		Balanced growth with endogenous corruption	Perfect competition in the production of g	% Change from PC
1	γ = growth rate	0.026	0.031	– 16.9
2	k_1 = capital in g	0.143	0.250	– 42.9
3	k_2 = capital in y	0.857	0.750	14.3
4	v = red tape coef. (inverse)	1.000	1.000	0.0
5	y = total output	0.318	0.330	– 3.9
6	g = public good	0.143	0.250	– 42.9
7	ψ = total corruption	0.040	0.000	NA
8	$y - \psi$ = legitimate income	0.278	0.330	– 15.9
9	c_1 = consumption 1	0.036	0.000	NA
10	c_2 = consumption 2	0.255	0.299	– 14.7
11	$c_1/\psi = c_2/(y-\psi)$ = cons. rate	0.919	0.906	1.4
12	$s_1/\psi = s_2/(y-\psi)$ = saving rate	0.081	0.094	– 13.6
13	ψ/y = corruption rate	0.125	0.000	NA

Note: The table shows only selected values. The complete table is printed in Appendix B, Table 5.

Compare the two benchmarks, $\{k_1, k_2\}_{\mathrm{m}}$ and $\{k_1, k_2\}_{\mathrm{pc}}$. One implies unrestrained corruption and the other implies no corruption at all. If there exists some likelihood of detection and an associated penalty to the corrupt agent for getting caught, then the corrupt equilibrium must lie somewhere in the interior between the two benchmarks.

3. Corruption and growth: Efficiency decreasing endogenous corruption

Corruption is generally thought to have only negative effects on economic growth. Regardless of how one analyzes corruption, the common theme is that it entails the misallocation of productive resources. Therefore corruption, by this reasoning, must lead to sub-optimal growth rates. In the following model, corruption's only result is income redistribution. Consequently, efficiency measured in terms of the growth rate, suffers.

Consider agent 1, the 'public agent'. She receives her income by exercising the market power associated with her position as a public official. She receives monopoly rents by maximizing the difference in the competitive value rental rate of public sector capital, $(r_2^* k_1)$, and the value marginal product of public sector capital, $(r_1^* k_1)$. The true value of capital is exactly what demanders of g are willing to pay. The monopoly rents are paid in final goods c_{1t}. She maximizes the following utility function:

$$\text{Max } U_1 = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t} u(c_{1t})\,\mathrm{d}t = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t}\left(\frac{c_{1t}^{1-\sigma}-1}{1-\sigma}\right)\mathrm{d}t \tag{1}$$

subject to

$$\psi_t = (r_{1t} - r_{2t})k_{1t} = P_g g_t - r_{2t}k_{1t}, \tag{2}$$

$$B_t = \left\langle \begin{array}{c|c} G\left(\dfrac{\psi_t}{y_t}\right) & G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle = \left\langle \begin{array}{c|c} \left|\ln\left(1 - \dfrac{\psi_t}{y_t}\right)\right| - \beta & 0 \leq \beta \leq 1, G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle, \tag{3}$$

$$(1 - B_t)\psi_t + B_t(-2\psi_t) = c_{1t} + s_{1t}, \tag{4}$$

$$g_t = H(k_{1t}) = vh(k_{1t}) = vk_{1t}, \tag{5}$$

$$\dot{k}_t = s_{1t} + s_{2t}, \tag{6}$$

$$k_t = k_{1t} + k_{2t}. \tag{7}$$

The variables are defined as follows:
y_t = total output at time t,
g_t = public good at time t,
P_g = price of the public good at time t (time subscript omitted for clarity),
v = inverse productivity factor = coefficient of red tape, $0 \leq v \leq 1$,
c_{it} = agent i's consumption at time t,
s_{it} = agent i's saving at time,
ψ_t = corruption at time t,
B_t = the probability of detection,
G_t = the detection function,
β = constant in the detection function,
r_{1t} = the marginal product of capital in the public sector,
r_{2t} = the marginal product of capital in the private sector,
k_{1t} = capital used in the public sector at time t,
k_{2t} = capital used in the public sector at time t,
ρ = the pure rate of time preference,
σ = the coefficient of relative risk aversion.

The public agent's growth path is defined by

$$\gamma_1 = \frac{\dot{c}_{1t}}{c_{1t}} = \frac{1}{\sigma}\left[(r_{1t} - r_{2t}) - \rho\right] \tag{8}$$

where γ_1 is her growth rate of consumption.

Notice that the cost of detection is a function of the probability of detection B and the fine associated with detection, $2\psi_t$.[3] B is determined by the detection function, G, which is directly related to the corruption rate.[4] Given the constant β, the detection cost is a wedge such that the maximum rents attainable is at an equilibrium below complete monopoly rents. The result is that the corrupt agent maximize rents by selling the public good for highest price above the competitive rate such that the probability of detection is zero.[5]

The two agents engage in a simple game. At any given time, say $t = 0$, there exists some amount of capital $k_{t=0}$. Agent 1, the public agent, goes first by choosing the amount of $k_{1t=0}$ that she needs to produce her desired amount of $g_{t=0}$. She limits the amount of $g_{t=0}$ available to the economy in order to raise its price. She maximizes her utility by choosing $k_{1t=0}$ such that $P_g = r_1/v$ and ψ is maximized given the probability of detection, B. Corruption income is paid in final goods, $\psi_{t=0}$. The corrupt agent may devote her income toward consumption, $c_{1t=0}$, or toward saving, $s_{1t=0}$.

Agent 2, the private agent, derives revenue and utility from standard production and consumption of the composite good c_{2t}. He is faced with the following maximization problem:

$$\text{Max } U_2 = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t} u(c_{2t})\,\mathrm{d}t = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t}\left(\frac{c_{2t}^{1-\sigma} - 1}{1-\sigma}\right)\mathrm{d}t \tag{9}$$

subject to

$$y_t = F(k_{2t}, g_t) = k_{2t} f\left(\frac{g}{k_{2t}}\right) = k_{2t}\, A\left(\frac{g_t}{k_{2t}}\right)^{\alpha}, \tag{10}$$

$$y_t = P_g g_t + r_{2t} k_{2t}, \tag{11}$$

$$g_t = H(k_{1t}), \tag{12}$$

$$y_t - \bar{\psi}_t = c_{2t} + s_{2t}, \tag{13}$$

[3] The fine for getting caught is twice the value of how much the agent steals. It is a proxy for the legal ramifications associated with such illegal corruption.

[4] The greater the corruption rate, the more likely is detection. Intuitively, the idea is simple. A public employee that is driving a luxury car is more likely to draw attention to her corrupt activities.

[5] Although this is restrictive, it does set a natural limitation to the scope of corruption. The probability of detection along with the penalty for getting caught are constructed such that the agent cannot extort full monopoly rents, but must settle for something less. In particular, the optimum occurs at $B = 0$.

$$\dot{k}_t = s_{1t} + s_{2t}, \tag{14}$$

$$k_t = k_{1t} + k_{2t}. \tag{15}$$

The private agent accepts the amount of g_t provided by the public agent and pays the corresponding monopolistically set price, P_g. Given this amount of public good, he does the best he can by devoting all of the remaining capital, k_{2t}, to the production of y. His growth path is defined by

$$\gamma_2 = \frac{\dot{c}_{2t}}{c_{2t}} = \frac{1}{\sigma}[f(1-\alpha) - \rho] \tag{16}$$

where γ_2 is his growth rate of consumption.

Balanced growth occurs in the model only at the equilibrium growth rate $\gamma_1 = \gamma_2$. This implies that $f{\cdot}(1-\alpha) = (r_1 - r_2)$ or that $r_1 = 2r_2$. The equilibrium is optimal to agent 1 given the existence of a probability of detection and the fine for getting caught. The equilibrium represents the notion that all members of society have the same average relative saving rate. Just because one's income stems from corruption does not drive the agent to save and thereby invest more. The economy in this model adopts one saving rate and assumes that rate applies to all members of society. Nonetheless, the balanced growth equilibrium represents a unique economy wide savings rate. Intuitively, this result implies that an economy that is subject to this type of institutional corruption has natural limitations. In other words, it is impossible for there to be a long-run dynamic balanced growth equilibrium where the public sector extorts full monopoly rents from the private sector. But some degree of economic rent is possible for a corrupt government to achieve over the long run. A corrupt economy can therefore exist in a long-run dynamic equilibrium. It is widely observed across the globe, corrupt economies do persist and there is no reason to believe that corruption per se is a short-run phenomenon that self-corrects itself. This model allows long-run corruption to exist as well as be identifiable.

The graphic interpretation is quite simple. Consider Fig. 7 below. Point a represents the competitive equilibrium in which there is no corruption. Notice the rental rate of capital is at its highest possible point implying the highest possible growth rate. Point b represents the monopoly optimum for a corrupt public sector. Since corruption is paid in final goods, the revenue from corruption must come from the economy's productive capacity. Therefore the shadow price of output is equal to the shadow price of corruption (i.e. $\lambda = \mu$ in Appendix A). If the value of corruption is equal to $\psi = k_1(r_1 - r_2)$ (i.e. the light gray area of Fig. 7) and it must be paid for one to one out of production, then the cost of corruption in terms of final goods is equal to $\psi = (r_2 k_1)$ (i.e. the dark gray area of Fig. 7). r_2 characterizes the growth rate of consumption of agent 2 and $(r_1 - r_2)$ characterizes the growth rate of consumption of agent 1. If $r_2 = (r_1 - r_2)$ then a balanced growth equilibrium is achieved.

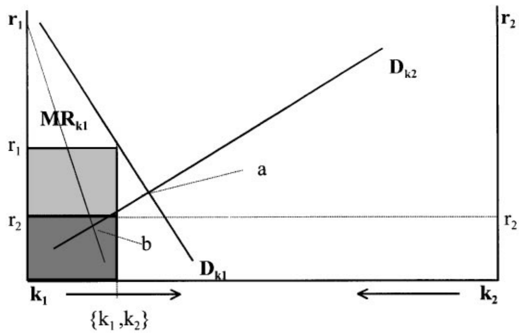

Fig. 7.

If there is no corruption, there are no illegal goods to consume and $c_{1t} = \psi_t = 0$. A 'clean' economy in the above model may be thought of as one that is run by a central planner whose objective it is to maximize economic growth with no concern for the welfare of agent 1. In the absence of red tape, a clean economy is the most efficient when g is provided competitively. As might be expected, the optimal government size when the public good is provided competitively is $g = \alpha$.[6]

Table 1 compares the simulation results for two scenarios. The two columns compare a corrupt economy, $\psi > 0$ in row 7, at the balanced growth equilibrium with a clean economy, $\psi = 0$ in row 7, at the balanced growth equilibrium. The two economies are identical in every respect except one; the corrupt economy has a self-seeking public sector that exerts market power as aforementioned, while the clean economy produces public goods at the traditional competitive ideal. Note that $v = 1$ in row 4 of both scenarios, implying there is no bureaucratic 'red-tape' in the production of g.

The model simulation assumes the following values.

α = the coefficient on g in the production of $y = 0.25$,

v = the inverse red tape coefficient in the production of $g = 1$,

ρ = the discount factor = 0.02,

σ = the intertemporal elasticity of substitution = 10,

β = the constant in the detection probability function = 0.1335.

[6] This result follows Barro (1989) in his analysis of public goods within endogenous growth models.

Table 2

	Balanced growth with endogenous corruption	Perfect competition in the production of g	% Change from PC
c_1/y = econ. wide cons. rate 1	0.115	0.000	NA
c_2/y = econ. wide cons. rate 2	0.804	0.906	− 11.3
s_1/y = econ. wide save. rate 1	0.010	0.000	NA
s_2/y = econ. wide save. rate 2	0.071	0.094	− 24.4

Efficiency that is measured in terms of growth (row 1), γ, falls 17% due to corruption. That is to say, the corrupt economy theoretically grows at a rate 17% below that of the clean economy, ceteris paribus. This loss is attributed to corruption. Total production (row 5), y, falls 4%. Legitimate consumption (row 9), c_2, falls 15% while the consumption rate (row 11) rises 1% and the saving rate (row 12) falls 14% due to corruption. Lower growth implies higher current consumption and less saving. The relative value of the public sector is constant, equal to the coefficient on g in the production function. But the amount of available g falls 43% due to corruption.

Table 1 suggests that there is significant loss in efficiency as well as in total wealth due to corruption. But the clean economy is an unrealistic benchmark. Corruption exists, to at least some extent, in every economy. Therefore, if the clean benchmark economy is unavailable, the corrupt equilibrium may represent a second best equilibrium that among other things has strong income redistribution qualities.

There is only one class of agent in the clean economy, while there are two classes in the corruption economy. The recipients of corruption do not produce anything extra but they account for a significant portion of total economy-wide wealth. Since the economy is closed and all of the wealth is accounted for, the result is that corruption is a mechanism that redistributes wealth from one group and to another.

Table 2 compares the economy wide consumption and saving rates. Note that in Table 1 the consumption rates are relative to each agent's income. In Table 2, consumption rates are relative to the total output of the entire economy. Agent 2 suffers an 11% loss in relative consumption and a 24% loss in relative saving due to corruption. In the clean economy, agent 2 did 100% of the saving. In the corrupt economy, she does only 87% of the economy's saving because there exists an agent 1 to save the rest.

The above model suggests a strong correlation between the level of corruption and α, the coefficient on g in the production function. (see Table 5 in Appendix B). Theoretically, this result implies a simple relationship between the elasticity of y with respect g, the growth rate, and the corruption rate. The more important public goods are to final production, the lower is the growth rate, and the higher is the corruption rate. In other words, the more necessary is the public sector to private production, the more corruption opportunities exist for the unscrupulous public agent. Furthermore, the endogenous corruption rate, ψ/y, in Table 1, row 13 is 13%. That means that 13% of total output, a significant portion of total wealth, is redistributed to the corrupt sector. Keep in mind that this segment of society would have otherwise gotten nothing.

4. Corruption and growth: Efficiency enhancing endogenous corruption

This section considers the possibility of efficiency enhancing corruption. For corruption to be efficiency enhancing, there must be present an institutional hurdle that may be circumvented by corrupt agents. Suppose the economy is plagued by bureaucratic 'red tape'. The corrupt official overcharges for her services to maximize her welfare. Producers, who are intent on maximizing profit, pay her a gratuity in order to avoid the bureaucracy. This type of bribery is often referred to as 'speed money' and is quite common in many less developed economies.

An important consideration with respect to red-tape and corruption deals with the question, which comes first, red-tape or corruption? It is an underlying assumption of this analysis that red-tape precedes corruption. Even when the red-tape is endogenous, as it is in the end of this section, I assume that red-tape is, a priori, a hurdle that corruption emerges in response to.

This is a somewhat limiting assumption. It is possible that red-tape is a result of institutional corruption. It is possible that in an economy in which government corruption is sanctioned or at least tolerated, public agents create red-tape.[7] These agents see the corruption rents available from circumventing the bureaucracy that they themselves previously instituted. In such a case, red-tape and corruption are simultaneously endogenous to each other.

I have attempted to capture this at the end of this section when corruption is efficiency enhancing in the presence of red-tape. In my analysis, red-tape is endogenous to the level of corruption and to the relative size of the public sector. Regardless though, corruption is *in response* to red-tape and not vice versa. In other words, corruption only exists because red-tape exists. From an institutional perspective, this means that the corrupt public agents create red-tape in light of future revenue possibilities. Only after the bureaucracy is in place can they reap the benefits of corruption. Higher red-tape leads to more corruption, which in turn leads to less red-tape. Therefore, in the resulting equilibrium, lower red-tape is associated with higher corruption.

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[7] See Desoto (1989) for examples of this type of behavior in Peru.

Table 3

	Balanced growth with endogenous corruption	Perfect competition in the production of g with red tape	% Change from PC
γ = growth rate	0.026	0.026	0.0
v = red tape coef. (inverse)	**1.000**	**0.500**	100.0
y = total output	0.318	0.278	14.3
g = public good	0.143	0.125	14.3
ψ = total corruption	0.040	0.000	NA
$y-\psi$ = legitimate income	0.278	0.278	0.0
c_1 = consumption 1	0.036	0.000	NA
c_2 = consumption 2	0.255	0.252	1.3
$c_1/\psi = c_2/(y-\psi)$ = cons. rate	0.919	0.907	1.3
$s_1/\psi = s_2/(y-\psi)$ = saving rate	0.081	0.095	– 14.7
ψ/y = corruption rate	0.125	0.000	NA

An interesting idea for analysis would be to reverse the situation by making red-tape the dynamic result of corruption. This concern is beyond the scope of the present research but is a topic for future investigation.

If the balanced growth equilibrium with corruption that is described above is the threshold where corruption may persist, then there exists some level of red-tape such that agent 2 is at least indifferent between living with the red-tape and paying the corruption premium to circumvent the red tape.

Table 3 compares two distinct balanced growth equilibria. The left column represents the economy with corruption and no red-tape. Thus, the inverse red-tape coefficient is $v = 1$. The right column represents a clean economy with a significant amount of bureaucratic red-tape. Thus, the inverse red-tape coefficient is $v = 0.5$ (see Appendix B, Table 6, for complete simulation results). $v = 0.5$ implies that half of the total worth of the public sector is lost in red-tape. If red-tape accounts for that large a loss, it would be no wonder that corruption equilibrium is preferable.

Agent 2 is indifferent between corruption and clean with red tape only so far as growth is concerned. Total output, y, and production of g are each 14% higher in the corrupt economy. Because there is another agent to share in the total saving in the corrupt economy, agent 2 is relatively better off with marginally more absolute consumption and a marginally higher consumption rate than in the clean economy. Beyond the social implications of a long-run corrupt equilibrium, the corruption scenario is likely preferable to one with excessive red tape. At least under corruption, real output is not wasted by an ineffective public sector instead it is essentially redistributed.

The above analysis compares two separate balanced growth equilibria. In each, the coefficient of red tape, v, is exogenous. Consider instead a coefficient of red-tape that is endogenous. In particular, assume that v is a function of the relative size of the government and the corruption rate. I assume that red-tape is more likely the larger is the government sector. Furthermore, since corruption is partially in response excess red-tape, as corruption grows, red-tape diminishes. It is important to note that v is a long-run index which is driven by the relative values of government and corruption. v is not dynamic and is therefore unaffected by economic growth. v is a long-run index that emerges given the long-run equilibrium levels of g, y and ψ.

The model is the same as before except for the new specification of v in agent 1's maximization problem.

$$\text{Max } U_1 = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t} u(c_{1t})\,\mathrm{d}t = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t}\left(\frac{c_{1t}^{1-\sigma}-1}{1-\sigma}\right)\mathrm{d}t \tag{17}$$

subject to

$$\psi_t = (r_{1t} - r_{2t})k_{1t} = P_g g_t - r_{2t}k_{1t}, \tag{18}$$

$$B_t = \left\langle \begin{array}{c|c} G\left(\dfrac{\psi_t}{y_t}\right) & G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle = \left\langle \begin{array}{c|c} \left|\ln\left(1 - \dfrac{\psi_t}{y_t}\right)\right| - \beta & 0 \leq \beta \leq 1,\, G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle, \tag{19}$$

$$(1 - B)\psi_t + B(-2\psi_t) = c_{1t} + s_{1t}, \tag{20}$$

$$g_t = H(k_{1t}) = vh(k_{1t}) = vk_{1t}, \tag{21}$$

$$v = J\left(\frac{\psi_t}{y_t}, \frac{P_g g_t}{y_t}\right) = 2\left(\exp\left(1 - \frac{P_g g_t}{y_t} + \frac{\psi_t}{y_t}\right) - 2\right), \tag{22}$$

$$\dot{k}_t = s_{1t} + s_{2t}, \tag{23}$$

$$k_t = k_{1t} + k_{2t}. \tag{24}$$

Agent 2 maximization problem is specified exactly as before.

$$\text{Max } U_2 = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t} u(c_{2t})\,\mathrm{d}t = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t}\left(\frac{c_{2t}^{1-\sigma}-1}{1-\sigma}\right)\mathrm{d}t \tag{25}$$

subject to

$$y_t = F(k_{2t}, g_t) = k_{2t} f\left(\frac{g_t}{k_{2t}}\right) = k_{2t} A\left(\frac{g_t}{k_{2t}}\right)^{\alpha}, \tag{26}$$

$$g_t = H(k_{1t}), \tag{27}$$

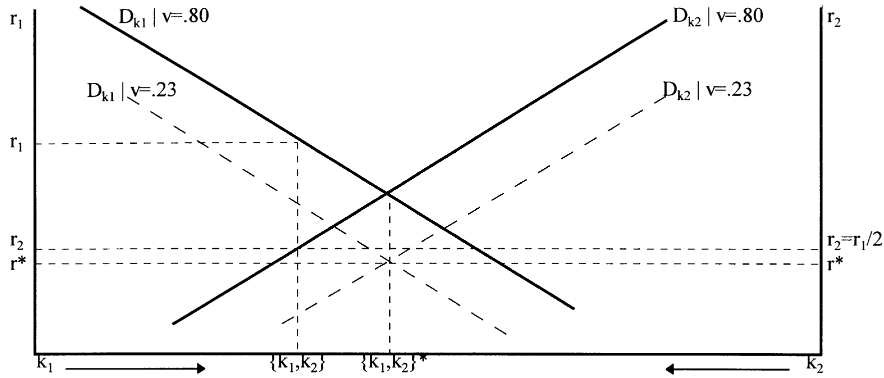

Fig. 8.

$$y_t - \bar{\psi}_t = c_{2t} + s_{2t}, \tag{28}$$

$$\dot{k}_t = s_{1t} + s_{2t}, \tag{29}$$

$$k_t = k_{1t} + k_{2t}. \tag{30}$$

Notice how v is specified. It is an inverse coefficient, thus a low value for v implies more red-tape. Red-tape is directly proportional to the relative worth of the government and inversely proportional to the corruption rate.[8]

A graphic interpretation is presented in Fig. 8. Given the same coefficient values as before, $\alpha = 0.25$, $\rho = 0.02$, $\sigma = 10$, and $\beta = 0.1335$, when corruption is zero, the endogenous coefficient of red tape is $v = 0.23$ and the competitive interest rate is r^*. When corruption is allowed to reduce red tape, $v = 0.80$ and the interest rate is $r_1 = 2r_2$. Note that $r_2 > r^*$, therefore the economy wide growth rate with corruption is higher than without corruption.

The simulation results are presented in Table 4 (for the complete simulation results see Appendix B, Table 7). Note that the corruption scenario is more efficient in terms of growth as well as preferable to the private agent in terms of output and consumption. The model shows that an economy sufficiently plagued by bureaucratic red tape can be made better off by corruption and is also capable of higher sustained growth rates because of that corruption.

The corrupt equilibrium is the global optimum. In the previous section, a central planner would not allow any corruption because the competitive provision of public good is superior to corrupt provision of public goods. But

[8] This is not the only possible specification of v. It simply serves the purpose by providing a concave function with a solution between 0 and 1 that is endogenous to the model.

Table 4

	Corruption	pc		Corruption	pc
γ = growth rate	0.024	0.021	$k_{t+1} = s_1^*\gamma + s_2^*\gamma$	1.025	1.021
v	0.798	0.234	c_1	0.034	0.000
y	0.300	0.230	c_2	0.241	0.209
g	0.114	0.059	$c_1/\psi = c_2/(y-\psi)$	0.919	0.909
r_1	0.525	0.230	s_1	0.003	0.000
r_2	0.263	0.230	s_2	0.021	0.021
$\psi = c_1 + s_1$	0.038	0.000	$s_1/\psi = s_2/(y-\psi)$	0.081	0.091
$y - \psi = c_2 + s_2$	0.263	0.230	ψ/y	0.125	0.000

now, the corrupt equilibrium is the long-run Pareto optimum. Because the competitive provision of the public good implies more red-tape, the central planner could do no better in the long run than to choose the corrupt equilibrium thereby reducing red tape.

5. Conclusion

I have created a simple scenario where a formally defined concept of public sector corruption may be introduced to a neoclassical growth model. The model theoretically shows how corruption may exist within an economy. It further goes to show how corruption can be efficiency enhancing.

I assume balanced growth, which implies that there must exist an economy wide interest rate that everyone shares. Since I defined two agents, there exists a unique equilibrium such that both agents' saving rates match and the economy experiences the unique growth rate.

I show that corruption is sustainable within a long-run dynamic equilibrium. Section 4 shows that corruption can also be efficiency enhancing if the economy suffers from excessive bureaucratic red-tape. All agents find that corruption is preferable to business as usual, when business as usual entails accepting the public sector bureaucracy.

It is always the case that corruption redistributes income. Only through corruption does the public agent gain real revenues. Furthermore, the income redistribution, at least on a theoretical level, implies a better use of resources. In other words, it is better that rents go to a corrupt public agent who will in turn spend the money within the economy than it being lost to bureaucratic red-tape, which is nothing more than drain on the entire economy.

The endogenous growth model depicts a common economic scenario faced by countries the world over. Governments are indispensable but often abuse their powers. In many places, public sector corruption is not only accepted but actually expected. Firms take into account the realities of dealing with the government. If paying a bribe is the accepted protocol faced by a firm, then that firm will pay a bribe. Regardless, the firm is willing to pay the bribe so long as its marginal benefits are greater than the bribe's marginal costs. Furthermore, these same economies that are rife with corruption are not necessarily worse off because of it. The income redistribution due to corruption does not necessarily preempt a rich and powerful elite that leaches off the masses. Regardless of the coefficients that one chooses, the model does not imply unbounded public sector graft. At worst, when the coefficient on g is $\alpha = 0.35$, corruption represents only 17.5% of total wealth (see Table 5).

An interesting proposition is that agents living off the public dole may form a sort of middle class, especially in poorer nations.[9] These people view the opportunity to use the public sector, which is ineffectual anyway, as a real and legitimate source of income. If there exists a public perception that the government is a self-seeking agent, then there is going to be competition and it necessarily implies that corruption will become an acceptable and perhaps justifiable economic institution.

Appendix A. Endogenous corruption in a simple endogenous growth model

A.1. Agent 1

$$\text{Max } U_1 = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t} u(c_{1t})\,\mathrm{d}t = \int_{t=0}^{\infty} \mathrm{e}^{-\rho t}\left(\frac{c_{1t}^{1-\sigma}-1}{1-\sigma}\right)\mathrm{d}t$$

subject to

$$\psi_t = (r_{1t} - r_{2t})k_{1t} = P_g g_t - r_{2t}k_{1t},$$

$$B_t \left\langle \begin{array}{c|c} G\left(\dfrac{\psi_t}{y_t}\right) & G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle = \left\langle \begin{array}{c|c} \left|\ln\left(1 - \dfrac{\psi_t}{y_t}\right)\right| - \beta & 0 \leq \beta \leq 1,\ G \geq 0 \\ 0 & G < 0 \end{array} \right\rangle,$$

$$(1 - B)\psi_t + B(-2\psi_t) = c_{1t} + s_{1t} \quad : \mu,$$

$$g_t = H(k_{1t}) = vh(k_{1t}) = vk_{1t}$$

[9] This is certainly the case in Paraguay where the government is the nations largest employer. Government jobs there are highly prized specifically because of the corruption opportunities that come with public employment. See Barreto (1996) for an institutional analysis of corruption in Paraguay.

optional endogenous red-tape coefficient:

$$v = J\left(\frac{\psi_t}{y_t}, \frac{P_g g_t}{y_t}\right) = 2\left(\exp\left(1 - \frac{P_g g_t}{y_t} + \frac{\psi_t}{y_t}\right) - 2\right),$$

$$\dot{k}_t = s_{1t} + s_{2t} \quad : \pi,$$

$$k_t = k_{1t} + k_{2t} \quad : \eta,$$

$$L_1 = H_1 + \mu_t(\psi_t - c_{1t} - s_{1t}) + \eta_t(k_t - k_{1t} - k_{2t}),$$

$$L_1 = U_{1t} + \pi_t(s_{1t} + s_{2t}) + \mu_t(\psi_t - c_{1t} - s_{1t}) + \eta_t(k_t - k_{1t} - k_{2t}),$$

$$\frac{\partial L_1}{\partial c_{1t}} = u'(c_{1t}) - \mu_t = 0,$$

$$u'(c_{1t}) = \mu_t,$$

$$u''(c_{1t})\dot{c}_{1t} = \dot{\mu}_t,$$

$$\frac{\dot{\mu}_t}{\mu_t} = \frac{u''(c_{1t})}{u'(c_{1t})}\dot{c}_{1t} = \frac{u''(c_{1t})}{u'(c_{1t})}c_{1t}\frac{\dot{c}_{1t}}{c_{1t}} = -\sigma\frac{\dot{c}_{1t}}{c_{1t}},$$

$$\frac{\dot{c}_{1t}}{c_{1t}} = -\frac{1}{\sigma}\frac{\dot{\mu}_t}{\mu_t},$$

$$\frac{\partial L_1}{\partial k_{1t}} = \mu_t\frac{\partial \psi_t}{\partial k_{1t}} - \eta_t = 0,$$

$$\mu_t\frac{\partial \psi_t}{\partial k_{1t}} = \eta_t,$$

$$\frac{\partial \psi_t}{\partial k_{1t}} = (r_{1t} - r_{2t}),$$

$$\frac{\eta_t}{\mu_t} = (r_{1t} - r_{2t}),$$

$$\frac{\partial L_1}{\partial s_{1t}} = \frac{\partial H_1}{\partial s_{1t}} - \mu_t = 0,$$

$$\pi_t - \mu_t = 0,$$

$$\pi_t = \mu_t,$$

$$\frac{\partial L}{\partial k_t} = \frac{\partial H}{\partial k_t} - \eta_t = 0,$$

$$\pi_t\rho - \dot{\pi}_t - \eta_t = 0,$$

$$\eta_t = \pi_t \rho - \dot{\pi}_t,$$

$$\frac{\eta_t}{\pi_t} = \rho - \frac{\dot{\pi}_t}{\pi_t}.$$

And since $\pi_t = \mu_t$,

$$\frac{\eta_t}{\mu_t} = \frac{\eta_t}{\pi_t} = (r_{1t} - r_{2t}) = \rho - \frac{\dot{\mu}_t}{\mu_t},$$

$$-\frac{\dot{\mu}_t}{\mu_t} = (r_{1t} - r_{2t}) - \rho.$$

Hence

$$\gamma_1 = \frac{\dot{c}_{1t}}{c_{1t}} = -\frac{1}{\sigma}\frac{\dot{\mu}_t}{\mu_t} = \frac{1}{\sigma}[(r_{1t} - r_{2t}) - \rho].$$

A.2. Agent 2

$$\text{Max } U_2 = \int_{t=0}^{\infty} e^{-\rho t} u(c_{2t})\,dt = \int_{t=0}^{\infty} e^{-\rho t}\left(\frac{c_{2t}^{1-\sigma} - 1}{1-\sigma}\right) dt$$

subject to

$$y_t = F(k_{2t}, g_t) = k_{2t} f\left(\frac{g_t}{k_{2t}}\right) = k_{1t} A\left(\frac{g_t}{k_{2t}}\right)^{\alpha},$$

$$g_t = H(k_{1t}),$$

$$y_t - \bar{\psi}_t = c_{2t} + s_{2t} \quad : \lambda_t,$$

$$\dot{k}_t = s_{1t} + s_{2t} \quad : \varphi_t,$$

$$k_t = k_{1t} + k_{2t} \quad : \theta_t,$$

$$L_2 = H_2 + \lambda_t(y_t - \bar{\psi}_t - c_{2t} - s_{2t}) + \theta_t(k_t - k_{1t} - k_{2t}),$$

$$L_2 = U_{2t} + \varphi_t(s_{1t} + s_{2t}) + \lambda_t(y_t - \bar{\psi}_t - c_{2t} - s_{2t}) + \theta_t(k_t - k_{1t} - k_{2t}),$$

$$\frac{\partial L_2}{\partial c_{2t}} = u'(c_{2t}) - \lambda_t = 0,$$

$$u'(c_{2t}) = \lambda_t,$$

$$u''(c_{2t})\dot{c}_{2t} = \dot{\lambda}_t,$$

$$\frac{\dot{\lambda}_t}{\lambda_t} = \frac{u''(c_{2t})}{u'(c_{2t})}\dot{c}_{2t} = \frac{u''(c_{2t})}{u'(c_{2t})}c_{2t}\frac{\dot{c}_{2t}}{c_{2t}} = -\sigma\frac{\dot{c}_{2t}}{c_{2t}},$$

$$\frac{\dot{c}_{2t}}{c_{2t}} = -\frac{1}{\sigma}\frac{\dot{\lambda}_t}{\lambda_t},$$

$$\frac{\partial L_2}{\partial k_{2t}} = \lambda_t\frac{\partial y_t}{\partial k_{2t}} - \theta_t = 0,$$

$$\lambda_t\frac{\partial y_t}{\partial k_{2t}} = \theta_t,$$

the Cobb–Douglas technology $\Rightarrow \partial y_t/\partial k_{2t} = f(1-\alpha)$,

$$\frac{\theta_t}{\lambda_t} = f(1-\alpha),$$

$$\frac{\partial L_2}{\partial s_{2t}} = \frac{\partial H_2}{\partial s_{2t}} - \lambda_t = 0,$$

$$\varphi_t - \lambda_t = 0,$$

$$\varphi_t = \lambda_t,$$

$$\frac{\partial L_2}{\partial k_t} = \frac{\partial H_2}{\partial k_t} - \theta_t = 0,$$

$$\varphi_t\rho - \dot{\varphi}_t - \theta_t = 0,$$

$$\theta_t = \varphi_t\rho - \dot{\varphi}_t,$$

$$\frac{\theta_t}{\varphi_t} = \rho - \frac{\dot{\varphi}_t}{\varphi_t}.$$

Since $\varphi_t = \lambda_t$,

$$\frac{\theta_t}{\lambda_t} = \frac{\theta_t}{\varphi_t} = f(1-\alpha) = \rho - \frac{\dot{\varphi}_t}{\varphi_t},$$

$$-\frac{\dot{\varphi}_t}{\varphi_t} = f(1-\alpha) - \rho.$$

Hence

$$\gamma_2 = \frac{\dot{c}_{2t}}{c_{2t}} = -\frac{1}{\sigma}\frac{\dot{\varphi}_t}{\varphi_t} = \frac{1}{\sigma}[f(1-\alpha) - \rho].$$

A.3. Balanced growth equilibrium

Balanced growth implies that

$$\frac{\dot{c}_{1t}}{c_{1t}}=\frac{\dot{c}_{2t}}{c_{2t}}= -\frac{1}{\sigma}\frac{\dot{\mu}_t}{\mu_t}= -\frac{1}{\sigma}\frac{\dot{\varphi}_t}{\varphi_t}.$$

Hence

$$\gamma_1=\gamma_2=\frac{\dot{c}_{1t}}{c_{1t}}=\frac{\dot{c}_{2t}}{c_{2t}}=\frac{1}{\sigma}[(r_{1t}-r_{2t})-\rho]=\frac{1}{\sigma}[f(1-\alpha)-\rho].$$

The condition for a balanced growth equilibrium is therefore $f(1-\alpha)=(r_{1t}-r_{2t})$ and since $f(1-\alpha)=r_{2t}$ it must be the case that $r_{1t}=2r_{2t}$.

Appendix B.

Table 5

		Balanced growth with endogenous corruption	Perfect competition in the production of g	% Change from PC
1	γ = growth rate	0.026	0.031	– 16.9
2	k_1 = capital in g	0.143	0.250	– 42.9
3	k_2 = capital in y	0.857	0.750	14.3
4	$k = k_1 + k_2$ = total capital	1.000	1.000	0.0
5	v = red tape coef. (inverse)	1.000	1.000	0.0
6	y = total output	0.318	0.330	– 3.9
7	g = public good	0.143	0.250	– 42.9
8	ψ = total corruption	0.040	0.000	#DIV/0!
9	$y - \psi$ = legitimate income	0.278	0.330	– 15.9
10	r_1 = marg. prod. of k_1	0.556	0.330	68.2
11	r_2 = marg. prod. of k_2	0.278	0.330	– 15.9
12	$P_g = r/v$ = price of g	0.556	0.330	68.2
13	$P_g^* g/y$ = relative worth of g	0.250	0.250	0.0
14	c_1 = consumption 1	0.036	0.000	#DIV/0!
15	c_2 = consumption 2	0.255	0.299	– 14.7
16	s_1 = savings 1	0.003	0.000	#DIV/0!
17	s_2 = savings 2	0.023	0.031	– 27.3
18	$c_1/\psi = c_2/(y-\psi)$ = cons. rate	0.919	0.906	1.4
19	$s_1/\psi = s_2/(y-\psi)$ = saving rate	0.081	0.094	– 13.6
20	ψ/y = corruption rate	0.125	0.000	#DIV/0!

Table 6

Growth with endogenous corruption

α = coefficient on g	**0.050**	**0.150**	**0.250**	**0.350**
γ = growth rate	0.044	0.032	0.026	0.022
k_1 = capital in g	0.026	0.081	0.143	0.212
k_2 = capital in y	0.974	0.919	0.857	0.788
$k = k_1 + k_2$ = total capital	1.000	1.000	1.000	1.000
v = red-tape coef. (inverse)	1.000	1.000	1.000	1.000
y = total output	0.471	0.370	0.318	0.289
g = public good	0.026	0.081	0.143	0.212
r_1 = marg. prod. of k_1	0.918	0.685	0.556	0.476
r_2 = marg. prod. of k_2	0.459	0.342	0.278	0.238
c_1 = consumption 1	0.011	0.025	0.036	0.047
c_2 = consumption 2	0.416	0.313	0.255	0.220
s_1 = savings 1	0.001	0.002	0.003	0.004
s_2 = savings 2	0.043	0.030	0.023	0.018
ψ = total corruption	0.012	0.028	0.040	0.051
$y - \psi$ = legitimate income	0.459	0.342	0.278	0.238
$P_g = r/v$ = price of g	0.918	0.685	0.556	0.476
$P_g^*\ g/y$ = relative worth of g	0.050	0.150	0.250	0.350
$c/y = (c_1 + c_2)/y$ = consumption rate	0.907	0.913	0.919	0.924
$c_1/\psi = c_2/(y - \psi)$ = cons. rate	0.907	0.913	0.919	0.924
$s_1/\psi = s_2/(y - \psi)$ = saving rate	0.093	0.087	0.081	0.076
ψ/y = corruption rate	0.025	0.075	0.125	0.175
$(y - \psi)/y$ = legitimate production rate	0.975	0.925	0.875	0.825
c_1/y = econ. wide cons. rate 1	0.023	0.068	0.115	0.162
c_2/y = econ. wide cons. rate 2	0.884	0.844	0.804	0.763
$s_1^*\gamma/y$ = econ. wide save. rate 1	0.002	0.007	0.010	0.013
$s_2^*\gamma/y$ = econ. wide save. rate 2	0.091	0.081	0.071	0.062

Table 7

	Balanced growth with endogenous corruption	Perfect competition in the production of g with red tape	% Change from PC
γ = growth rate	0.026	0.026	0.0
k_1 = capital in g	0.143	0.250	– 42.9
k_2 = capital in y	0.857	0.750	14.3
$k = k_1 + k_2$ = total capital	1.000	1.000	0.0
v = red-tape coef. (inverse)	**1.000**	**0.500**	100.0
y = total output	0.318	0.278	14.3
g = public good	0.143	0.125	14.3
ψ = total corruption	0.040	0.000	#DIV/0!
$y - \psi$ = legitimate income	0.278	0.278	0.0
r_1 = marg. prod. of k_1	0.556	0.278	100.0
r_2 = marg. prod. of k_2	0.278	0.278	0.0
$P_g = r/v$ = price of g	0.556	0.556	0.0
$P_g^* g/y$ = relative worth of g	0.250	0.250	0.0
c_1 = consumption 1	0.036	0.000	#DIV/0!
c_2 = consumption 2	0.255	0.252	1.3
$c_1/\psi = c_2/(y-\psi)$ = cons. rate	0.919	0.907	1.3
$s_1/\psi = s_2/(y-\psi)$ = saving rate	0.081	0.095	– 14.7
ψ/y = corruption rate	0.125	0.000	#DIV/0!
c_1/y = econ. wide cons. rate 1	0.115	0.000	#DIV/0!
c_2/y = econ. wide cons. rate 2	0.804	0.907	– 11.4
s_1/y = econ. wide save. rate 1	0.010	0.000	#DIV/0!
s_2/y = econ. wide save. rate 2	0.071	0.095	– 25.4

Table 8

	Corruption	pc		Corruption	pc
γ = growth rate	0.024	0.021	$\psi = c_1 + s_1$	0.038	0.000
k_2	0.857	0.750	$y - \psi = c_2 + s_2$	0.263	0.230
k_1	0.143	0.250	$P_g = r/v$	0.658	0.982
k	1.000	1.000	$P_g^* g/y$	0.250	0.250
v	0.798	0.234	$c/y = (c_1 + c_2)/y$	0.919	0.909
y	0.300	0.230	$c_2/(y-\psi)$	0.919	0.909
g	0.114	0.059	c_1/ψ	0.919	#DIV/0!
r_2	0.263	0.230	$s_2/(y-\psi)$	0.081	0.091
r_1	0.525	0.230	s_1/ψ	0.081	#DIV/0!
c_2	0.241	0.209	ψ/y	0.125	0.000
c_1	0.034	0.000	$y - \psi/y$	0.875	1.000
s_2	0.021	0.021	c_2/y	0.804	0.909
s_1	0.003	0.000	c_1/y	0.115	0.000
$s_2^* \gamma$	0.022	0.021	s_2/y	0.071	0.091
$s_1^* \gamma$	0.030	0.000	s_1/y	0.010	0.000
$k_{t+1} = s_1^* \gamma + s_2^* \gamma$	1.025	1.021			

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