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Corruption Leading To Poorly Maintained Equipment and Infrastructure

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Abstract

This paper presents a simple model which explores the idea that corruption can result in inefficiently low levels of expenditure on maintaining infrastructure and equipment. In this model an official bargains with the supplier of a fleet of motor vehicles as to the size of the bribe (or kickback) that the supplier pays. The bribe is in return for the official using public funds to purchase the vehicles at an over inflated price. When the cost for the official of being caught is very low, the amount the official spends on vehicle maintenance is close to the non-corrupt level. When the cost of getting caught increases (for a given corrupt mark-up of the vehicle price) the level of expenditure on maintenance falls as the official mitigates the cost of being caught. If the cost of being caught is sufficiently high, the official will choose not to act corruptly.

Keywords: Corruption, Kickbacks, Maintenance, Development

1. Introduction

In this paper I consider the issue of poorly maintained publicly owned equipment and infrastructure in less developed countries. Rioja (2003) explains this with the aid of a neoclassical growth model. Rioja shows a suboptimal expenditure on maintenance occurs when new public infrastructure is financed by foreign aid, but the maintenance of such infrastructure is funded by taxation. In an empirical paper Tanzi and Davoodi (1997) conjecture that corrupt practices associated with purchasing equipment and infrastructure have the side effect of causing the level of maintenance expenditure to be smaller than it would have otherwise been. They contend that public officials are more likely to receive substantial bribes in return for commissioning new projects and investments, rather than, in return for paying contractors to properly maintain existing projects. While they are forced to use proxy data, they do find empirical support for low levels of maintenance being associated with corruption.

In this paper I present a simple analytic model to explore this idea that corruption can distort public expenditure on maintenance. In this model the official's choice of how much to spend on maintenance is distorted because the official wants to mitigate the cost of being caught. This fits in with one of the most important insights to come through from the economics of corruption literature. This is the idea that the desire for secrecy associated with corruption can lead to serious resource misallocation[1]. The specific situation considered in the model is where an official has a fixed budget to purchase and maintain a fleet of vehicles. There is only one supplier of the vehicles that the official can deal with. One justification for this assumption may be because the budget comes from tied aid[2]. Assuming one supplier allows us to focus on the bilateral relationship between the official and the supplier. If the official decides to act corruptly then the size of the bribe is determined by axiomatic Nash bargaining between these two parties. The use of the Nash bargaining methodology has now become widely accepted within the corruption literature; see Ades and Di Tella (1997), Campbell (2005) and Drugov (2010).

The remainder of this paper is arranged as follows. In Section II the basic model is set out and solved for the case when the official does not behave corruptly. In Section III corruption is introduced is into the model. Then the model is illustrated using a numerical example in Section IV. Finally, in Section V, there is the conclusion with some comment about the policy implications of this analysis.

2. The Model

We begin by considering a version of the model where the official does not act corruptly. Later we introduce corruption to the model. It will then be apparent that for certain parameter values, the official would make an expected loss from acting corruptly, and so the case where the official does not act corruptly is important. When not acting corruptly, the official only receives a fixed salary, which we normalise to zero.

The official has a fixed budget of R to purchase and maintain a fleet of vehicles. The official has only one supplier of vehicles that he can deal with. With vehicle maintenance we assume that there is a competitive market with many local maintenance providers. Thus the price of a unit of maintenance m (think of a person hour) has a parametric price of p_m. The life, in terms of kilometres, of an individual vehicle is a function of m. The convenient functional form we use is $k=m^{1/2}$. Note that both k and m refer to an individual vehicle. The cost of maintaining an individual vehicle is $m.p_m$. The number of vehicles purchased is denoted v. Hence the total expenditure on vehicle maintenance is $v.m.p_m$. From that it follows that we can write the official's budget constraint as $R=v.p_v + v.m.p_m$ where p_v denotes the price of a vehicle.

[1] Shleifer and Vishny (1993) give a lucid explanation of this idea using an example of a bottle making factory in Mozambique where the factory manager, looking for an opportunity to receive a bribe, wanted to buy an excessively sophisticated and expensive bottle-labelling machine rather than a generic bottle-labelling machine with a well-established and well-known market price.

[2] While not the focus of this paper, there is concern that tied aid can result in the purchasing of inappropriate equipment; see Africa Development Bank (2006, p. 49).

When the official is not acting corruptly, it is assumed that the official acts to maximise K the total number of kilometres the fleet of vehicles travelled ($K=v.k=v.m^{1/2}$). We are assuming that there is no cost, in terms of effort, in the official making the socially optimal choice.

The official and the supplier bargain over v and p_v. The return from not coming to an agreement for both parties is zero. Thus we can write the Nash bargaining problem as:

$$\operatorname*{Max}_{v,\,p_v}[v.m^{1/2}][v.(p_v - c_v)]$$

where c_v denotes the supplier's cost of producing an individual vehicle. Now we can rewrite our Nash bargaining problem by substituting for m using the official's budget constraint:

$$\operatorname*{Max}_{v,\,p_v}[v.(\frac{R}{v.p_m} - \frac{p_v}{p_m})^{1/2}][v.(p_v - c_v)].$$

From the first-order conditions we find:

$$p_v = 3c_v \text{ and } v = \frac{R}{4c_v}$$

From these it follows that:

$$m = \frac{c_v}{p_m},\ K = \frac{R}{4c_v^{0.5}p_m^{0.5}},\ v.(p_v - c_v) = \frac{R}{2}.$$

Here we can see the efficient level of maintenance per vehicle, m, is a function of the cost of producing a vehicle and the cost of a unit of maintenance.

3. The Model with Corruption

Now we go on to the version of the model where the parameter values are such that the official acts corruptly. Corruption takes the form of the official and supplier conspiring together to artificially inflate the supplier's gross surplus $v.(p_v - c_v)$. The official gets his share of this surplus by getting paid a bribe b. This corruption 'by itself' will not affect m. However, we suppose that the cost to the official of getting caught being corrupt, z, is affected by the size of the mark-up $z = \delta.(p_v - c_v)$. Under these circumstances we show that the level of m will be distorted when the official is acting corruptly, since the official wants to mitigate the cost of being caught. In the Appendix the case is shown where z is a fixed parameter. In that case corruption causes no distortion to the level of m.

Of course, when the official is acting corruptly, he is no longer acting to maximise K, the kilometres travelled by the fleet. It is necessary to introduce a constraint upon just how badly the official can do in terms of purchasing and maintaining the fleet of vehicle. Hence we use

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$\overline{K}$ to denote the minimum fleet kilometres that must come out of a deal that the official makes with the supplier. If we wish to, we can think of this in terms of the official facing some prohibitively high cost if he enters into an agreement with the supplier and fails to achieve $\overline{K}$.

Thus in our corrupt case, there are two constraints, the budget constraint and the minimum fleet kilometres constraint. This latter constraint, $\overline{K} = v.m^{0.5}$, can be rewritten as $m = (\overline{K}/v)^2$. Hence we can see that m is a function of v. With v and m having been determined, p_v simply falls out of the budget constraint.

The official and the supplier bargain over v and b. The probability of the official being caught is denoted using θ. The official being caught does not affect the payoff the supplier gets. Obviously, the official will not choose to come to an agreement if the parameter values are such that he will make an expected negative return. In such a case the official and the supplier would engage in non-corrupt bargaining (as shown above) with the official getting a payoff of zero (his normalised wage) and the supplier getting a payoff of $R/2$. Hence we can write the Nash bargaining problem for the corrupt case as:

$$\operatorname*{Max}_{v,b} \eta = [(1-\theta).b - \theta.\delta.(p_v - c_v) - 0]\left[v.(p_v - c_v) - b - {}^{R}/_{2}\right]$$

where $p_v = \frac{R}{v} - \frac{p_m \overline{K}^2}{v^2}$.

From the first of the first-order conditions $(\frac{\partial \eta}{\partial v}=0)$ we can write:

$$-2\theta.\delta.p_m.\overline{K}^2.v^{-3} + \left(\theta.\delta.R + (1-\theta).p_m.\overline{K}^2\right).v^{-2} - (1-\theta).c_v = 0 \qquad (1)$$

Since (1) is a polynomial we cannot straightforwardly write down an analytical solution for v. However, if we work with a numeric example (that is, select parameter values, as we do in the next section) then we can use this polynomial to find values for v (and, hence, those

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variables that are dependent on *v*). It is worthwhile noting that if δ=0 then from (1) we have

$v = \frac{p_m^{0.5}\overline{K}}{c_v^{0.5}}$ and we can use this by substituting for *v* in $m = \frac{\overline{K}^2}{v^2}$ to get $= \frac{c_v}{p_m}$. Thus, if there is a zero penalty for getting caught, maintenance per vehicle will be at the same level as in the non-corrupt case.

From the second of the first-order conditions $(\frac{\partial\eta}{\partial b}=0)$ we can write an expression for *b* as a function of *v*:

$$b = \frac{1}{2}\left[\frac{R}{2} - p_m.\overline{K}^2.v^{-1} - c_v v\right] + \frac{\theta\delta}{2(1-\theta)}\left[R.v^{-1} - p_m.\overline{K}^2.v^{-2} - c_v\right] \qquad (2)$$

So, we can see that *b*, p_v and *m* are all simply functions of *v*.

4. A Numeric Example

For our numeric example we use the following parameter values:

R=\$100 000, $\overline{K}$=500, c_v=\$10, p_m=\$1, θ=0.1.

Throughout the following discussion we consider various selected values of δ. Remember that there is a positive linear relationship between this parameter and the cost to the official of being caught $z = \delta.(p_v - c_v)$.

First we compare when δ=1 and when δ=100.

When δ=1: *v*=161, p_v=\$609.67, $v.p_v$=\$98451.87.

When δ=100: *v*=367, p_v=\$270.71, $v.p_v$=\$99318.55.

When δ=1, the cost of getting caught is trivial. When δ=100, the cost of getting caught is obviously much larger. Here the official will bargain for more vehicles to be supplied. This is because with a higher *v*, p_v will be lower and hence the mark-up $(p_v - c_v)$ will be smaller – and this will, to some extent, mitigate the increase in the cost of being caught.

Now we compare the maintenance per vehicle.

When δ=1: m=9.59.

When δ=100: m=1.86.

Remember that the efficient level of m is c_v/p_m (10 for our example). So when the cost of getting caught is very small, δ=1, maintenance is close to the efficient level. At δ=100 the official has less R left to spend on overall maintenance and he purchases a greater number of vehicles. Thus m (the maintenance level on each vehicle) falls away dramatically. What we have is a distortion in the allocation of resources to maintenance stemming from the desire to mitigate the cost of being caught. The distortion is towards buying an excessive number of vehicles.

We go on now to considering when δ=7698 and δ=7699.

At δ=7698 the expected payoff for the official is:

$$(1-\theta).b-\theta.\delta.(p_v-c_v)$$

$$=(0.9)(20650.50)-(0.1)(7698)(34.14-10)=0.3140.$$

At δ=7699 this expected payoff for the official is negative and so the official chooses not to act corruptly and instead to bargain over v and p_v with the supplier (as outlined previously).

At δ =7698 the payoff for the supplier approaches from above R/2=$100000/2=$50000 which is the payoff the supplier gets in the non-corrupt case (i.e. the payoff the supplier gets if δ=7699). The value of the supplier's payoff at δ=7698 is:

$$v.(p_v-c_v)-b$$

$$=(2926.37)(34.14-10)-20650.50=50000.35$$

At the core of the corrupt deal between the supplier and the official is the conspiracy to make the supplier's gross surplus artificially large (the official, of course, gets his share of this surplus in the form of the bribe (a kickback)). Here we compare the surplus when corruption is taking place with the surplus when corruption is not taking place.

When δ=7698 (corruption taking place)

Surplus=2926.37($34.14 -$10)=$70650.85

When δ=7699 (corruption not taking place)

Surplus=R/2=$100000/2=$50000

So while a 'marginal shift' in δ, that causes corruption to switch to non-corruption, does not cause a 'jump' in the respective payoffs, there is a downward jump in the surplus.

With corruption a very small level of *m* can be 'gotten away with' because *K* will be at the minimal 'allowable level' $(K = \overline{K} = 500)$. Without corruption *K* jumps to:

$$K = \frac{R}{4c_v^{0.5} p_m^{0.5}} = \frac{100000}{4(3.1623)(1)} = 7905.694$$

Now, finally, let's look at the jumps in *v*, p_v and *m* associated with the shift to non-corruption.

$v = 2926$ when δ=7698

$v = \frac{R}{4c_v} = \frac{100000}{4(10)} = 2500$ when δ=7699

$p_v = \$34.14$ when δ=7698

$p_v = 3c_v = 3(\$10) = \$30$ when δ=7699

$m = (\overline{K}/v)^2 = (500/2926)^2 = 0.0292$ when δ=7698

$m = c_v/p_m = 10/1 = 10$ when δ=7699

What we have here is fewer vehicles being purchased and each one being purchased at a somewhat lower price. This leaves more of *R* left to spend on maintenance and there are fewer vehicles to maintain. Hence, the amount of maintenance per vehicle, *m*, jumps upward dramatically.

The above analysis is summarised in the following two propositions:

Proposition 1. *A case can be shown where if* δ *is increased by a sufficient amount, the official will switch from acting corruptly to not acting corruptly. At this switch there will be an upward jump in m (maintenance per vehicle) and K (the total number of kilometres travelled by the fleet of vehicles).*

Proposition 2. *A case can be shown where if* δ *is increased by an amount that is not sufficient to cause a switch away from corruption, then this will cause a reduction in m.*

5. Policy Implications and Conclusion

If government can, in some way, increase δ, there is the possibility that this could be counterproductive. If δ can be increased enough to cause a shift from corruption to non-corruption, then m will be provided at the efficient level and the total fleet kilometres K will be maximised. However, if δ is increased, but not by enough to shift away from corruption, then m will be pushed further downward. So here we have a case of where weak anti-corruption measures are worse than no anti-corruption measures. The weak anti-corruption measures simply cause the corrupt parties to misallocate resources so as to mitigate the impact of such anticorruption measures.

Overall, the results from this paper endorse the intuition in Tanzi and Davoodi (1997). That is the analysis shows that an official receiving kickbacks from a supplier, acting perfectly rationally, may choose to spend a very low amount on maintenance. It is somewhat surprising that there has not been more attention in the literature devoted to this subject. This might be partly explained by a lack of international data on maintenance expenditure. It also might be partly explained by the widely-held notion that less-developed countries invest in inappropriate technology. This contention may be more appealing to a number of scholars than the story told here where the technology is appropriate and the problem is that it is under-maintained.

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Appendix

He we consider our corrupt bargaining story, but with *z*, the cost of being caught, being simply a fixed parameter. Under these circumstances, it is simple to show that the level of *m* will be efficient. We can write the Nash bargaining problem for this case as:

$$\underset{v,b}{\mathrm{Max}}\,\eta = [(1-\theta).b - \theta.z - 0]\left[v.(p_v - c_v) - b - {}^{R}/_{2}\right]$$

where $p_v = \frac{R}{v} - \frac{p_m \overline{K}^2}{v^2}$.

From the first of the first-order conditions $\left(\frac{\partial \eta}{\partial v} = 0\right)$ we have $= \frac{p_m^{0.5}\overline{K}}{c_v^{0.5}}$.

Using this we substitute for *v* in $m = \frac{\overline{K}^2}{v^2}$ to get $= \frac{c_v}{p_m}$. So here the maintenance per vehicle level is the same as the non-corrupt case.