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Abstract:

In an endogenous growth model, the government officials are given the task of procuring public goods that are used as productive inputs in the production. Due to the information asymmetry between the government and the bureaucracy, the bureaucrats can falsely report of high quality-high cost procurement, while providing low quality-low cost product. This affects the productivity of the economy and hence reduces growth. Our analysis can show that corruption not only reduces the quality of public services that are necessary for production, but also inflates the public spending beyond the efficient level. In this way, we can explain why public investment fails to raise growth in the countries where corruption is endemic. We test our results empirically by improving the methodology on previous research on this topic by explicitly recognizing the role of simultaneity between public investment, corruption and growth and the possible biases arising from omission of correlated variables from the single reduced form equation based analysis. We use three-stage least squares method in a panel set up for a system of four equations on growth, public investment, corruption and private investment. Our primary results are twofold. First, corruption increases public investment. Second, corruption reduces the returns to public investment and makes it ineffective in raising economic growth.

JEL Classification: O10; H50

Keywords: Corruption, public investment, growth, three stage least squares

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1. Introduction

"Near where I live, there's a brand-new, eight-lane road that is peculiar in Manila, because there's hardly any traffic on it. There is no traffic, because the road goes nowhere. It is called President Diosdado Macapagal Boulevard, after a 1960s president. It just so happens that the incumbent president, Gloria Macapagal Arroyo is his daughter."

John McLean, BBC Manila Correspondent, 22nd October 2002

"… large craters in several important streets of Kolkata including Russel Street, Middleton Street, Sudder Street, Chowringhee Lane, Mirza Ghalib Street had been patched up with stone chips of such inferior quality that they turned to dust within two days of repair".

Statesman, 14 June 1993

In many developing countries corruption is pervasive, in particular in the projects involving the public sector. Reports of public sector corruption by the local or external press typically contain two elements: details of the exaggeration of the cost of public investment projects, or the use of inferior materials, and often both. Indeed such is the prevalence of anecdotes of this kind that virtually no study on corruption feels the need to draw upon the same set of examples (see for example Pritchett, 1996 for a list of alternative anecdotes). This paper is concerned by the issue typified by the above two quotations: corruption inflates the level of expenditure on public capital projects such as roads, but lowers the returns to that capital; in this case because they either go nowhere or they are of low quality. Both channels may lead to lower rates of economic growth: higher government spending must be financed, possibly through the use of distortionary taxation (Barro, 1990), while lower quality public inputs has a direct effect on the productivity of private capital.

Over the past two decades, a substantial volume of theoretical and empirical research has been directed towards identifying the elements of public expenditure that bear significant association with economic growth. Among the public expenditure elements, public investment, or in other words, productive public expenditure (at its aggregate and disaggregate levels) has been the prominent category in this literature. Following Barro (1990), many theoretical models[1] have been developed that show that by introducing both public capital and public services as inputs in the production of final goods, public investment generates higher growth in the long run. The general mechanism to raise growth in these models is as follows: public investment in infrastructure (e.g., roads and highways, water

[1] For example, Futagami et al (1993), Cashin (1995), Glomm and Ravikumar (1997), Ghosh and Roy (2004) among others.

supply, airports, etc.) and education raises private sector productivity (may be subject to congestion) thereby increasing growth.[2]

The empirical counterpart to these models has provided a more mixed set of findings, both for the level and composition effects of public investment expenditures. For example, Cashin (1995), Kocherlakota and Yi (1997), Fuente (1997), Kneller et al (1999) among others have found the level of public investment to have significant positive effect on growth in developed countries, while Bose et al (2007) find for developing countries that education expenditures and total public investment matter. In contrast, using more disaggregated expenditure functions Easterly and Rebelo (1993) find that only public investment in transport and communication generates positive effects on growth for a mixed sample of both developed and developing countries, whereas total public investment has no significant effect. Finally, Miller and Russek (1997) find that the same transport and communication expenditure variable has negative effect on growth in developing countries.

From the perspective of composition effects of public expenditures, Deverajan et al (1996) have shown public capital expenditure has a negative effect on growth for developing countries and the effect gets dramatically reversed if the sample is for developed countries. They explain their result by suggesting that “expenditures which are normally considered productive could become unproductive if there is an excessive amount of them” and concludes by saying that “developing country governments have been misallocating their resources” by excessive capital spending.[3] This result has been recently supported by Ghosh and Gregoriou (2007) in an optimal fiscal policy framework, again for developing countries. Interestingly as a suggestion for future work they posit a role for corruption in assuming away the possible positive returns from public investment in developing countries.

Formal support for the view that corruption impacts on public investment is easy to find in the literature. We focus on this component of government expenditure because, unlike much of current spending, capital spending is generally discretionary (in terms of size of the budget, the choice and the location of projects) and therefore more open to the influence of corrupt officials and political leaders. Simply put a unit of spending on public investment does not buy a unit worth of service. The classic example of this is the study on Ugandan school budgets by Ablo and Reinikka (1998), where on average only 13 per cent of the budget allocated to non-wage expenditures reached the schools. Public funds earmarked for vital

[2] The literature has also debated whether these effects are permanent or transitory (Turnovsky, 2004; Zagler and Durnecker, 2003 amongst others). Such concerns are outside of the scope of the current paper.
[3] Haque (2004) demonstrates the results from Devarajan et al. (1996) are sensitive to the use of panel data techniques that correct for non-stationarity in the variables.

areas of spending may simply go missing and never be reclaimed. Purchases of goods and services may be based on who offers the best kickbacks to officials, rather than who offers the best price-quality combination, or entire public programmes may be chosen more for their capacity to generate illegal income than for their potential to improve standards of living.

There also exists empirical evidence to suggest that corruption is, indeed, associated with a misallocation and misappropriation of public expenditures which are often inflated as a result.[4] Gupta et al. (2000) find that corruption has the effect of reducing the provision of education and health care, and of increasing infant mortality. Mauro (1997) presents evidence that corruption distorts public expenditures away from growth-promoting areas (like education and health) towards other types of project (e.g., infrastructure investment) that are less productivity-enhancing. In a similar vein, Tanzi and Davoodi (1997) find that corruption leads to a diversion of public funds to where bribes are easiest to collect, implying a bias in the composition of public spending towards low-productivity projects (e.g., large-scale construction) at the expense of value-enhancing investments (e.g., maintenance of the existing infrastructure). The same authors conclude that, as a result of corruption, the amount of public investment tends to rise, while the quality of this investment tends to fall, where the latter are measured for example by the number of paved roads in bad condition and power supply faults.

Finally, there is almost a limitless supply of anecdotal and case-study evidence to support the general hypothesis.[5] Abbott (1988) reports for example, the instance in Haiti when a prominent member of the Duvalier regime had 150 kilometres of rail track pulled up and sold for scrap metal, pocketing the proceeds for himself. Similarly, Hardin (1993) recounts the case of the Turkwell Gorge Dam project in Kenya, the final cost of which was more than double the amount of initial estimates due to the recoupment of bribe payments by the French contractor. Or Rose-Ackerman (1999) tells of the millions of dollars of non-existent stationary that was “purchased” by the Government Press Fund in Malawi, and describes how telephone specifications in another African country contained the useless requirement that the equipment must be robust to freezing temperatures (a requirement that could be satisfied by only one telephone manufacturer from Scandinavia).

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[4] In general, the incentives and opportunities to engage in corruption are greatest in areas of public procurement that involve large-scale expenditures, complex technologies and monopolistic power. For example, purchases of military hardware (specialised, high technology goods produced by a limited number of firms) offer greater scope for rent-seeking than purchases of medical supplies (standardised products sold in open markets by a large number of firms).

[5] The single most extensive source of evidence is the World Bank’s web-site, www.worldbank.org/publicsector/anticorrupt. For a particularly perplexing account of the experiences of many African countries, see also www.freeafrica.org.

In analysing the effect of corruption on the varying relationship between public investment and growth for different sets of countries, we draw upon the literature relating corruption and growth pioneered by Mauro (1995). On the basis of cross-country data Mauro finds a significant negative relation between a corruption index, and the rate of economic growth.[6] According to his findings, policies to fight corruption could be beneficial to growth. According to his estimates "a country that improves its standing on the corruption index, say, 6 to 8 (0 being the most corrupt, 10 the least) , will experience a 4 percentage point increase in its investment rate and a 0.5 percentage point increase in its annual GDP growth rate." Others have found similar evidence of an adverse effect of corruption on growth (e.g., Mauro 1997, Tanzi and Davoodi 1997, Keefer and Knack 1997, Knack and Keefer 1995, Li et al 2000, Sachs and Warner 1997).

The second strand of the literature has investigated the reverse causality between corruption and growth: bureaucratic rent-seeking not only influences, but is also influenced by, the level of development. In a thorough and detailed study Treisman (2000) finds that rich countries are generally rated as having less corruption than poor countries, which as much as 50 to 73 percent of the variations in corruption indices being explained by variations in per capita income levels. These findings, are supported by Ades and di Tella (1999), Fisman and Gatti (2002), Paldam (2002), and Rauch and Evans (2000).

In this paper, first we develop an endogenous growth model in which public agents (bureaucrats) are delegated the responsibility of procuring pubic goods on behalf of the government along with collecting taxes from households. Bureaucrats have the opportunity to embezzle public funds by falsifying the information about the true quality and cost of the goods they are procuring. Bureaucrats may be tempted to deceive the government by claiming to deliver goods of high-quality at high cost when they are actually providing goods of low-quality and low-cost. By doing this, bureaucrats inflate (artificially) the amount of public funds that must be raised and allow themselves an opportunity to embezzle some of these funds. Such behaviour is costly for society because it reduces capital accumulation and growth.

In the second part, we test the hypothesis empirically. Given the interdependency of corruption, public investment and growth summarised above, we depart from the single-equation reduced form that is typical of the empirical growth literature and instead estimate the model as a system of equations using three stage least squares. This methodology is the same as that used by Wacziarg (2001) to study the relationship between openness to international trade and growth. This methodology also allows us to model the offsetting relationships between corruption, public investment and investment that might be hidden in a reduced form approach.

Our analysis using simultaneous equation system is valuable from the policy perspective. Our results for differences in the growth effects of public investment driven by corruption prevailing in the economy give rise to information that is particularly useful for developing countries, which are resource constrained. In this regard, our main contribution is the finding that the corruption inflates the level of public spending, but the effect of public investment on growth is lower where corruption is high This result is novel and strengthens previous findings that take care of the biases arisen from omission of correlated variables from the single reduced form equation based analysis.

The remainder of the paper is organised as follows. In Section 2 we develop a neoclassical growth model to show how increase in corruption leads to increase in the amount of public investment but reduces the quality of the service from those investments, and thereby reduces growth. In Section 3, we describe the data and methodology. In Section 4, we present our main set of results, while Section 5 shows us the robustness of our analysis by bringing the other determinants of our dependent variables in different equations and by running OLS regressions separately with single equation setup to see the biases created there in. Section 6 concludes.

2. The Model

Time is discrete and indexed by $t = 0, .., \infty$. There is a constant population of two-period-lived agents belonging to overlapping generations of dynastic families. Agents of each generation are divided into two groups of citizens – private individuals (or households), of whom there are m, and public servants (or bureaucrats), of whom there are $n < m$.[7] All agents are risk neutral, working only when young and consuming only when old. Households work for firms in the production of output, while bureaucrats work for the government in the administration of public policy. Public policy consists of a programme of taxes and expenditures designed to

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[6] Mauro compiled the index by using information assembled from Business International in 68 countries in 1980-83.

[7] We assume that agents are differentiated at birth according to their abilities and skills. A population of m agents lack the skills necessary to become bureaucrats, while a population of n agents possess these skills. The latter are induced to become bureaucrats by an allocation of talent condition established below. Thus, as in other analyses (e.g., Ehrlich and Lui 1999; Sarte 2000), we abstract from issues relating to occupational choice. In doing so we are able to simplify the analysis by not having to consider possible changes in the size of the bureaucracy and possible changes in the level of corruption that may result from this.

make available public goods and services which contribute to the efficiency of output production.

We assume that households are endowed with $\lambda > 1$ units of labour and are liable to pay taxes of τ_t, and thus a household can save $(\lambda w_t - \tau_t)$. Taxes are collected by bureaucrats on behalf of the government, which requires funding for public expenditures. Corruption arises from the incentive of a bureaucrat to appropriate public funds by falsifying information to the government. We assume that a fraction, $\mu \in (0,1)$, of bureaucrats are corruptible in this way, while the remaining fraction, $1-\mu$, are non-corruptible, with the identity of a bureaucrat being unobservable by the government.[8] Firms, of which there is a unit mass, hire labour from households and rent capital from all agents in perfectly competitive markets.

2.1 The Private Sector

Each firm combines *lt* units of labour with k_t units of capital to produce y_t units of output according to

$$y_t = Al_t^{\alpha} k_t^{1-\alpha} G_t^{\alpha}, \quad A > 0, \alpha \in (0,1)) \tag{1}$$

where k_t denotes the aggregate stock of capital and G_t denotes the aggregate quality of public goods and services.[9] The firm hires labour and rents capital at the competitively-determined wage rate w_t and rental rate r_t respectively. Profit maximisation implies, $w_t = \alpha A l_t^{\alpha-1} k_t^{1-\alpha} G_t^{\alpha}$ and $r_t = \alpha A l_t^{\alpha} k_t^{-\alpha} G_t^{\alpha}$. Since, in equilibrium $l_t = l = \lambda m$ (the fixed supply of labour), we may write this condition as

$$w_t = \alpha A l^{\alpha-1} k_t^{1-\alpha} G_t^{\alpha} \equiv w(k_t, G_t) \tag{2}$$

$$r_t = (1-\alpha) A l^{\alpha} k_t^{-\alpha} G_t^{\alpha} \equiv r(k_t, G_t) \tag{3}$$

Thus the equilibrium wage and the rate of return to capital are functions of both capital stock and the aggregate quality of public services.

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[8] This assumption may be thought of as capturing differences in the propensities of bureaucrats to engage in corruption, whether due to differences in proficiencies at being corrupt or differences in moral attitudes towards being corrupt (e.g., Acemoglu and Verdier 2000; Besley and McLaren 1993; Tirole 1996). The main purpose of the assumption is to allow us to determine the wages of bureaucrats in a relatively straightforward way that does not demand additional assumptions about how public sector pay is determined. In fact, all we need for this purpose is that there be at least one bureaucrat who is non-corruptible - all other bureaucrats may well be potential transgressors.

2.2 The Public Sector

The objective of the government is to provide public goods and services which function as inputs to private production. The government demands $g_t = \theta y_t$ amount of these goods and delegates the task of procuring them to bureaucrats.[10] In return for his services, a bureaucrat is paid a salary which is determined as follows. Any bureaucrat (whether corruptible or non-corruptible) can work for a firm to receive an income equal to the wage paid to households. Any bureaucrat who is willing to accept a salary less than this wage must be expecting to receive compensation through some form of malpractice and is therefore immediately identified as being corrupt. As in other analyses (e.g., Acemoglu and Verdier, 1998), we assume that a bureaucrat who is discovered to be corrupt is fined the full amount of his legal and illegal income. Given this, then no corruptible bureaucrat would ever reveal himself in the way described above. As such, the government can minimise its labour costs, while ensuring complete bureaucratic participation, by setting the salaries of all bureaucrats equal to the wage paid by firms to households.[11] Against this background, the government keeps a check on bureaucratic behaviour using an imprecise monitoring technology. This technology implies that a bureaucrat who is corrupt faces a probability, $p \in (0, 1)$, of avoiding detection, and a probability, $1 - p$, of being found out.

The government finances its expenditures each period by running a continuously balanced budget. Its revenues consist of the taxes collected by bureaucrats from households, plus any fines imposed on bureaucrats who are caught appropriating government fund.

Each bureaucrat is charged with the responsibility for procuring $\frac{g_t}{n}$ units of public goods using whatever public funds are allocated to him. A public good may be of either high-quality or low-quality and may be procured at either high-cost or low-cost. One unit of a high-quality good yields 1 unit of productive service, while one unit of a low-quality good yields $\beta < 1$ units of productive service. The cost of the former is a random variable which we assume to be identically and independently distributed, and to take the value of 1 unit of output with

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[9] This is essentially the production technology used by Barro (1990), where public services, G_t, enter as labour-augmenting inputs which create externality effects and produce constant returns to the accumulable factors of production.

[10] Bureaucrats are also responsible for the collection of taxes, an activity that may also be open to abuse in the form of bribery and tax evasion. This does not arise in our model because all households have the same income and are subject to same tax liability.

[11] This has the same interpretation as the allocation of talent condition in Acemoglou and Verdier (2000). The government cannot force any of the n potential bureaucrats to actually take up public office, but it is able to induce all of them to do so by paying what they would earn elsewhere.

probability $q \in (0, 1)$ and the value of $\phi > 1$ units of output with probability $1 - q$. The cost of the latter is 1 unit of output with certainty.[12] Corruption is made possible due to informational asymmetries between bureaucrats and the government as a consequence of the delegation of duties by the latter to the former. It is bureaucrats who evaluate public goods in terms of their cost and quality, and who supply the government with information on which to base decisions. By falsifying this information, a bureaucrat may be able to enrich himself through the appropriation of public funds. More precisely, we assume that only bureaucrats are informed about the true cost and quality of public goods. All that the government knows is that a public good may be of high quality or low-quality, and that the per unit cost of any high-quality good is 1 or ϕ. Given this state of affairs, the government instructs each bureaucrat to maximise public good quality per unit of expenditure. For a high-quality good, there is an upper value and a lower value of this, as given by 1 and $\frac{1}{\phi}$, respectively. For a low-quality good, the value is β. We confine our attention to the case in which $\frac{1}{\phi} > \beta$. Under such circumstances, the government will always demand high-quality goods, whatever their alleged cost.

A bureaucrat, when young, is endowed with one unit of labour which he supplies inelastically to the government to earn a salary of w_t. For simplicity, we assume that bureaucrats have no other source of legal income and are exempt from paying any taxes.[13] By definition, a bureaucrat who is not corrupt abides fully by the government's instructions for providing public goods. Such a bureaucrat procures $\frac{g_t}{n}$ units of goods at a true total cost of $\frac{g_t}{n}$ or $\phi\left(\frac{g_t}{n}\right)$ and a true total quality of $\frac{g_t}{n}$. The final wealth of a non-corrupt bureaucrat is $(1+r_t)w_t$. In contrast, a bureaucrat who is corrupt pursues his own hidden agenda which conflicts with the interests of the government. Such a bureaucrat engages in deception by procuring low-quality public goods at low-cost, while claiming that the goods are of high-quality and high-cost. Although the quantity of each good is still $\frac{g_t}{n}$, the quality is only $\beta\left(\frac{g_t}{n}\right)$, and although

[12] As indicated earlier, the effect of corruption in our model is that public goods are provided at a lower overall quality but greater total expense. The latter result is due to the variability in cost of high-quality goods. The former result prevails regardless of this assumption.

[13] The fact that bureaucrats have only one unit of labour (as opposed to λ units) may be used to justify this assumption.

the bureaucrat claims $\phi\left(\frac{g_t}{n}\right)$ in public funds, he spends only $\left(\frac{g_t}{n}\right)$. Thus $(\phi-1)\left(\frac{g_t}{n}\right)$ is the amount of funds that a bureaucrat may be able to embezzle by misleading the government.

In general, corrupt bureaucrats may try to remain inconspicuous by hiding their illegal income, by investing this income differently from legal income and by altering their patterns of expenditure.[14] These activities typically entail costs in one form or another. For the purposes of the present analysis, we make the simple assumption that a bureaucrat who is corrupt needs to spend resources, C_t, on trying to conceal his behaviour if he is to stand any chance of not being caught. It is plausible to imagine that more resources must be spend the greater is the amount of illegal income that a bureaucrat appropriates and the greater also is the number of other bureaucrats who are behaving in the same way. The presumption in both cases is that corruption would be more visible and less easy to conceal, implying extra costs for a bureaucrat in trying to avoid detection. We model these features by specifying C_t to be an increasing function of the total illegal income of a bureaucrat from falsifying the information about the public goods, $(\phi-1)\left(\frac{g_t}{n}\right)$ and the total population of bureaucrats who appropriate public funds, $\varepsilon_t\mu n$. A convenient formulation of this cost function is

$$C_t = (\varepsilon_t\mu n)^{\delta}(\phi-1)\left(\frac{g_t}{n}\right); \qquad (\delta > 0) \tag{4}$$

With probability p, a corrupt bureaucrat succeeds in his deception and saves the amount $w_t + (\phi-1)\left(\frac{g_t}{n}\right) - C_t$. With probability $(1-p)$, the bureaucrat is apprehended and punished his legal income. Like all households, all bureaucrats save their entire income at the rate of interest r_t in order to finance retirement consumption. Accordingly, we may write the expected income of each corruptible bureaucrat as

$$\left.\begin{array}{ll} w_t(1+r_{t+1}); & \text{if he chooses not to be corrupt;} \\ \left[pw_t + (\phi-1)\left(\frac{g_t}{n}\right) - C_t\right](1+r_{t+1}); & \text{if he chooses to be corrupt;} \end{array}\right\} \tag{5}$$

[14] It may even be the case that income from corruption at onel level is used to foster corruption at other levels (e.g., to ensure non-interference from the legal authorities). Discussions of these issues can be found in Rose-Ackerman (1996) and Wade (1985), among others.

2.4 Incentive to be corrupt

A corruptible bureaucrat will embezzle public funds if his expected payoff from doing so is no less than his payoff from not doing so. Using (5), we may state this condition as $\left[pw_t + (\phi-1)\left(\frac{g_t}{n}\right) - C_t\right](1+r_{t+1}) \geq w_t(1+r_{t+1})$.

Substituting the value of C_t from (4) in (5), and rearranging, this condition becomes,

$$(\phi-1)\left(\frac{g_t}{n}\right)\left[1-(\varepsilon_t \mu n)^{\delta}\right] \geq (1-p)w_t \tag{6}$$

Intuitively, a bureaucrat is more likely to be corrupt the more he stands to gain in illegal income and the less he expects to lose in legal income if he is caught. When holding with equality the condition determines a critical value of $\phi = \phi^*$, above which a (corruptible) bureaucrat will choose to be corrupt and below which he will choose not to be corrupt. Using the assumption $g_t = \theta y_t$ and w_t from (2) in condition (6), this critical value becomes

$$\phi^* = 1 + \frac{(1-p)\alpha n}{\lambda m\left[1-(\varepsilon_t \mu n)^{\delta}\right]\theta} \tag{7}$$

Crucially, this is increasing in ε_t and μ. Intuitively, if an economy has more corruptible bureaucrats and/or, if more of its bureaucrats become corrupt, each bureaucrat at his individual level needs to inflate the cost of procuring public services more in order to attain higher income from being corrupt as opposed to choosing not to be corrupt.

5. Public Finance, Public Investment and Growth

Our model economy displays a unique balanced growth equilibrium in which all real variables grow at the same constant rate. This growth rate is determined from the capital market equilibrium condition which states that the total demand for capital must equal the total supply of savings. To determine how corruption affects savings, it is necessary to consider how corruption affects public finances since the state of the government's balance sheet dictates the level of taxes required to maintain budget balance. In conducting our analysis, we appeal to the law of large numbers to replace probabilistic events at the individual level by actual outcomes at the aggregate level. Thus p (1 − p) is understood to be a measure of corrupt bureaucrats who succeed (fail) in their illegal profiteering, while q (1 − q) is understood to be a measure of high-quality public goods that have low (high) cost.

Consider the case in which ε_t proportion of corruptible bureaucrats become corrupt. In this case, *G* is determined as $G = [1-\varepsilon_t \mu(1-\beta)]g_t$ since only non-corruptible bureaucrats procure high-quality public goods (yielding total services of $(1-\mu)n\left(\frac{g_t}{n}\right)$, while among the corruptible bureaucrats ε_t proportion procure low-quality public goods (yielding total services of $\varepsilon_t \mu n\beta\left(\frac{g_t}{n}\right)$ but $(1-\varepsilon_t)$ proportion do not find it optimal to be corrupt and hence procure similar as non-corrupt bureaucrats (yielding total services of $(1-\varepsilon_t)\mu n\left(\frac{g_t}{n}\right)$)These bureaucrats, of whom there are $\varepsilon_t \mu n$, make bogus claims on public funds by pretending to procure high-quality public goods at high-cost (when the opposite is true). The total value of these claims is $\varepsilon_t \mu n\phi\left(\frac{g_t}{n}\right)$. Non-corruptible bureaucrats, of whom there are $(1-\mu)n$, behave truthfully as above, claiming $(1-\mu)nq\left(\frac{g_t}{n}\right)$ and $(1-\mu)n(1-q)\phi\left(\frac{g_t}{n}\right)$ in public funds. The corruptible bureaucrats who find it optimal to be non-corrupt also behave truthfully, claiming total cost of $(1-\varepsilon_t)\mu n[q+(1-q)\phi]\left(\frac{g_t}{n}\right)$. Summing all we get the aggregate amount of resources that the government now allocates to public goods provision, i.e.,

$$\text{Public investment spending} = [q+(1-q)\phi+\varepsilon_t \mu q(\phi-1)]g_t \quad (8)$$

The above equation (8) shows that if the proportion of bureaucrats who are corrupt increases, each bureaucrat is supposed to inflate their claims from public investment spending more. Added to this is nw_t, expenditures on bureaucrats' salaries.

Revenues for the government comprise the tax income from households, $m\tau_t$, plus the value of fines imposed on corrupt bureaucrats who are caught, $(1-p)\varepsilon_t \mu n w_t$. From the government's budget constraint, the value of τ_t is deduced as

$$m\tau_t = \{q+(1-q)\phi+\varepsilon_t \mu q(\phi-1)\}g_t + [1-(1-p)\varepsilon_t \mu]nw_t \quad (8)$$

As above, total savings by households amount to $m(\lambda w_t - \tau_t)$. Total savings by bureaucrats consist of the savings by non-corruptible bureaucrats, $(1-\mu)nw_t$, plus the savings of corruptible bureaucrats who chose not to be corrupt, $(1-\varepsilon_t)\mu n w_t$ and the savings of those who chose to be corrupt, $\varepsilon_t \mu \left[p n w_t + (\phi - 1)\left\{1 - (\varepsilon_t \mu n)^{\delta}\right\} g_t \right]$.

Substituting the value of G and using the assumption $g_t = \theta y_t$ in (1) and (2), we may write the growth of capital accumulation (which is equal to the growth of output), γ, as

$$\gamma = \frac{k_{t+1}}{k_t} = a\left[\alpha - \left\{q + (1-q)\phi^* + \varepsilon_t \mu (\phi^* - 1)\left[(\varepsilon_t \mu n)^{\delta} - (1-q)\right]\right\}\right]\left[1 - \varepsilon_t \mu (1-\beta)\right]^{\alpha} \qquad (9)$$

The above equation shows us, if either ε_t and μ increases, growth rate of output or capital in the economy declines. This happens through increasing the public investment spending but reducing the total public services the government can provide by such spending. In the following empirical section of the paper, we would like to test this hypothesis.

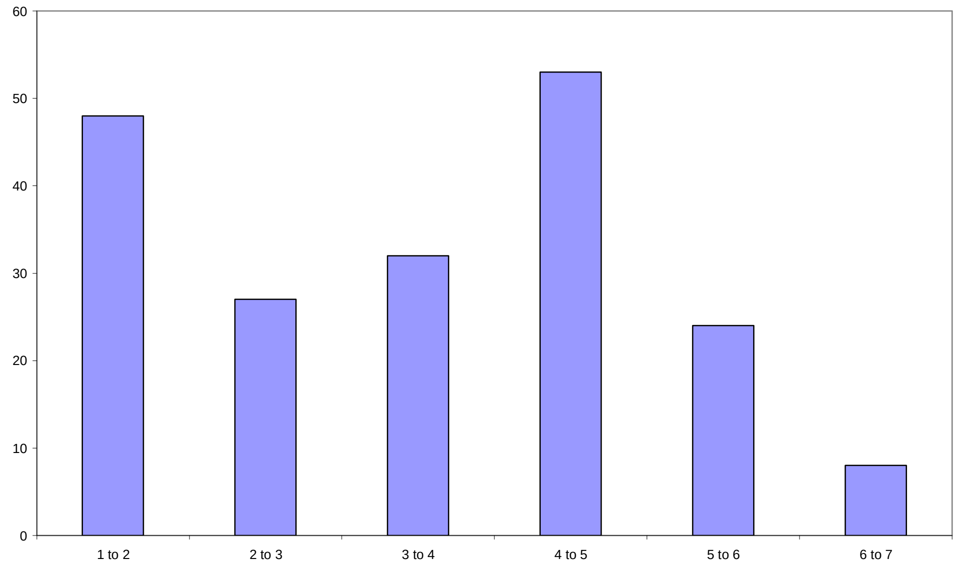
3. Methodology and Data:

In this section, we briefly describe the workings of a model of growth that includes public investment. We do not claim any particular innovation in this and use it only to provide some motivation for the empirical analysis. In addition, we describe our data set.

Data Sources and Characteristics

The key variables in our analysis are a measure of public investment expenditures and data on measures of corruption. We measure public investment using data for Central Government Capital Expenditure for 1970 – 2000 for 66 countries, as reported in Government Finance Statistics (GFS) published by the International Monetary Fund (IMF). Corruption indices are from International Country Risk Guide (ICRG), which are spread from 1 (least corrupt) to 6 (most corrupt). These data are available for a panel of 63 countries for the period 1980 – 2003. We have tested the robustness of our findings to alternative such as the Corruption Perception Index (CPI) data collected by Transparency International (TI) and the results are essentially the same. The remaining data used are from World Bank Development Indicators (WDI). The distribution of the corruption scores for the final sample used for estimation is shown in Figure 1. As this figure makes clear there are two clear groups of countries within the corruption data, those with low corruption (a score of less than 4) and those with medium to high corruption (a score of 4 or above). We use this information within the subsequent empirical analysis.

Figure 1: Corruption Scores



Notes: This figure is based on 192 observations, covering 58 countries.

In this paper we focus our attention on their medium term growth impacts of public investments and corruption. For this reason the data are averaged over 5-year periods. As is typically argued in the empirical growth literature this also helps to reduce the effect of the business cycle on any correlations between the variables of interest. The five-year periods for public investment data considered are 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99, while the corruption data are 1980-84, 1985-89, 1990-94, 1995-99, and 2000-03. To maximise the number of available data points we employ the lag of public investment variable (the data for this variable ends in 2000 compared to 2003 for corruption) in the regressions. After accounting for missing data on some of the variables used in the estimation, the dataset we use for estimation has 192 observations. This data covers 58 different countries covering Europe, the Americas, Africa, Asia and Oceania, with on average three observations per country.

Table 1 provides the summary statistics for our main variables. Based on the evidence in Figure 1 we have split the sample between the countries with corruption higher than 4 and lower than 4. The evidence in the Table would tend to support the view that corruption results in lower levels of economic development. For countries where corruption is higher, the average growth is lower (0.50% per annum) compared to less corrupt countries (1.81% per annum) and they are on average also poorer (measured by GDP per capita), less open to international trade and invest a lower proportion of GDP. The public investment variable however shows support for our hypotheses. Public investment as a proportion of GDP is higher (5.03%) in high corrupt countries compared to low corruption countries (2.72%).

Table 1: Summary Statistics

		Growth	Public Invest/ GDP	GDP per capita	Corruption	Openness /GDP	Private Invest/ GDP
Total Sample	average	1.23	3.74	8.31	3.23	65.84	18.37
(obs=192)	stdev	2.41	3.10	1.60	1.59	54.13	5.41
Corruption<4	average	1.81	2.72	9.31	2.06	73.66	19.85
(obs=107)	stdev	1.95	1.74	1.16	0.95	68.26	5.37
Corruption>4	average	0.50	5.03	7.04	4.70	56.00	16.51
(obs=85)	stdev	2.72	3.88	1.09	0.81	24.62	4.88

Methodology

In Barro (1990) some types of government expenditures are assumed to enter the production function of firms. These expenditures are taken to be exogenous by the individual firm such that when the model is solved at the aggregate level the growth rate is both sustainable and endogenous (in a manner akin to the learning-by-doing model of Romer, 1986). These productive expenditures contrast with those expenditures that enter utility function of the representative household (and which we label non-productive expenditure). Such expenditures, because they have no effect on the investment decision, have no effect on the growth rate unless financed by some form of distortionary taxation. We briefly describe a simple Cobb-Douglas version of that model which we extend to include non-productive expenditures.

The output of firm i is assumed to be produced using C-D production technology given by equation (1) below, where Y_i is the output of firm i, K_i is aggregate private capital of firm i, A represents a constant technology parameter and a form of non-rival, non-excludable public good G_Y. As in Barro (1990) the individual firm takes the level of government inputs to be exogenous and therefore aggregate output can be expressed as.

(A) $$Y = AK^{\alpha} G_Y^{\beta}$$

If $\beta = 1-\alpha$ we have a similar model to Barro in the sense that there is sustainable endogenous growth that is determined in part by public investment, while if $\beta < 1-\alpha$ then we have a version of the neoclassical model in which expenditures affect the level but not the growth of output (assuming exogenous technical progress).[15]

[15] Iφ $\beta + \lambda > 1-\alpha$ then the growth rate explodes towards infinity. As is typical in these types of model the results rest on a knife-edge.

We assume that the elasticity of output with respect to public investment, the β term, is dependent upon the level of corruption in society such that the return to public investment is equal to $\beta = \gamma(1-\eta)$, where η is increasing in the level of corruption. In the absence of corruption, $\eta = 0$, then $\beta = \gamma$, while under this specification at the highest level of corruption the returns to investment are bounded at zero, $\beta = 0$. The choice of zero bound is motivated in part by the empirical evidence presented in Sections 3 and 4 of the paper, where we see that public investment's effect on growth becomes insignificantly different from zero in the presence of higher corruption.

Differentiating the production function with respect to time yields the following,

(B) $$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha \frac{\dot{K}}{K} + \gamma(1-\eta)\frac{\dot{G}_Y}{G_Y}$$

Following Wacziarg (2001) we then augment this list of growth determinants. To this list we add openness to international trade to capture the effects of technology transfer (Coe, Helpman and Hoffmeister, 1997), but also because of the relationship between openness and government spending discussed in Rodrik (1998). As Wacziarg (2001) writes the estimated model moves away from reduced form empirics typical in the growth literature, but is short of a fully structural model, for example we do not consider differences in the method of financing public investment. Corruption is allowed to enter the regressions for each of these channel variables and the growth regression directly. To specifying each of the channel equations we draw upon the existing literature discussed in the introduction.

Three stage least squares is preferred to two-stage least squares estimation when there is significant correlation across equations. The estimates presented in this paper use a method first employed in a cross-country growth context by Tavares and Wacziarg (2001) to analyze the effects of democracy on growth. The underlying econometric theory is an extension of the three-stage-least-squares method of Zellner and Theil (1962) to panel data. This method achieves consistency by appropriate instrumenting, and efficiency through optimal weighting. It combines features of instrumental variables, random effects, and generalized least squares models. In this setting, both cross-period and cross-equation error correlations are allowed to differ from zero. This ensures the efficiency of the estimates. Taking cross-period error correlations into account is similar to assuming that the error terms contain country-specific effects uncorrelated with the right-hand-side variable. The flexibility of the error covariance matrix allows for substantial efficiency gains relative to estimating each equation separately (that is, assuming zero cross-equation error covariances).

The effect of corruption on the returns to public investment and growth is clear in the above model. To capture the second part of the main hypothesis we also include corruption in the regression for public investment. Within this regression we also include GDP per capita, to capture Wagner's law, openness to international trade, the size of the population and a measure of the size of the urban population, all of which can be found in the previous literature. Of these perhaps the most controversial is the measure of openness. Here we follow Rodrik (1998) who argues that trade liberalisation is only accepted by the electorate with corresponding increases in government expenditures. The literature on the effect of trade on fiscal policy is again an area of research not without disagreement however. Alesina & Waziarg (1998) argue that the openness and government size relationship found by Rodrik (1998) is generated by an omitted variable bias, the exclusion of an indicator of country size. The link between government size and country size is negative (there are economies of scale in the provision of government goods and services) as is the correlation between trade openness and country size (as suggested by the gravity equation). When country size is omitted and trade openness included in a regression of the determinants of government expenditure levels the openness variable proxies for the country-size government-size relationship generating a positive coefficient. If both size and openness are included in the regression the significant relationship between openness and government size disappears. We include both variables to control for such effects.

The variables chosen for inclusion in the corruption equation draw upon the tests of robustness conducted in Treisman (2000). According to the results in that paper corruption is most strongly correlated with the level of GDP per capita. Indeed this variable alone is capable of explaining between 50 to 75 per cent of the variation in the corruption index (depending on the measure of corruption used). Treisman also shows that history plays an important role in determining current levels of corruption, and more so than the current policy climate. Therefore, as in that paper, we include measures of whether the country has an established democratic system and whether it is a former British Colony. In the case of the latter La Porta et al. (1999) interpret a similar result as suggesting the superiority in terms of governance of the common law system. Finally, Ades and Di Tella (1999) have previously argued that openness to international trade reduces corruption because it opens economies, and its government, to greater competition from abroad.

To model the determinants of investment we draw on Wacziarg (2001). The investment GDP ratio is dependent upon wealth, measured by GDP per capita in period t-1, characteristics of the population (the size and the dependency ratio), the level of corruption and public investment. We include corruption to test whether private capital investment is influenced in the same way by corruption as public investment, that it is raises the costs of investment. Public investment is included to capture possible crowding out effects from this variable.

With this in mind, we use a panel set-up in which we have four equations in the systems. The dependent variables are growth rate in real GDP per capita (gr_{it}), log of public investment/GDP ($lpigdp_{it}$), corruption ($corr_{it}$), and log of private investment/GDP ($lprigdp_{it}$). The equations for baseline regression system are as follows:

$$gr_{it} = \alpha_0 + \alpha_1(corr_{it}) + \alpha_2(lpigdp_{it}, if\ corr < 4) + \alpha_3(lpigdp_{it}, if\ corr > 4) + \alpha_4(\lg dp_{it}) + \alpha_5(lprigdp_{it}) + \alpha_6(lopen_{it}) + u_{1,it} \quad (3.1)$$

$$lpigdp_{it} = \beta_0 + \beta_1(corr_{it}) + \beta_2(\lg dp_{it}) + \beta_3(lopen_{it}) + \beta_4(lpop_{it}) + \beta_5(urb_{it}) + u_{2,it} \quad (3.2)$$

$$corr_{it} = \gamma_0 + \gamma_1(\lg dp_{it}) + \gamma_2(lopen_{it}) + \gamma_3(dem_{it}) + \gamma_4(br_{it}) + u_{3,it} \quad (3.3)$$

$$lprigdp_{it} = \delta_0 + \delta_1(corr_{it}) + \delta_2(lpigdp_{it}) + \delta_3(\lg dp_{it}) + \delta_4(lpop_{it}) + \delta_5(dep_{it}) + u_{4,it} \quad (3.4)$$

Where, *lgdp* = log of initial GDP per capita; *lopen* = log of openness; *urb* = urbanisation; *lpop* = log of population; dem = democracy; br = british colony; dp = dependency ratio.

Here, instead of using interaction term, we use break point of corruption as our corruption values are dummy variable. Tanzi and Davoodi (1997) were able to use interaction term as they used continuous variables for quality of public investment. We break the sample by corruption from above or below 4. We have checked with corruption from above or below 2 or 3 and the results essentially remain the same.

We also report in the table the Sargan overidentifying restrictions test (along with the p-value). This is a test of the joint null hypothesis that the excluded instruments are valid instruments. That is, they are uncorrelated with the error term and correctly excluded from the estimated equation. In this case rejection of the null suggests that the instruments are not valid. As can be seen we cannot reject the null in any of the reported regressions.

4. Results

In Table 2 we report the results from our baseline set of equations. In this regression we compare the effect of public investment on growth using the median value for corruption in the sample (3.38). The results from this regression are consistent with a number of the hypotheses tested in this paper, and are supportive of others found within the literature. Concerning the two main hypotheses, that corruption raises the level of public investment but lowers the returns to this investment, we find support. The corruption term is significant and negative in the regression for public capital, while the public capital term is significant in the growth equation. The coefficients suggest only a very slight difference between the effect of public capital on rates of growth according to whether the level of corruption lies above or below the mean however. Public investment having marginally stronger growth effects when corruption is lower. Using the system of equations these results would suggest that a one standard deviation increase in corruption (1.59) would raise public investment by 0.74 percentage points. This would increase tend to increase growth in countries with corruption below a score of 4 by 2.3 percentage points and by 2.2 percentage points when corruption was above this. In both cases this would be offset by the negative direct effect of corruption, which would reduce growth by just over 5 percentage points. The negative direct effect of corruption on growth is consistent with Mauro (1995), although here this effect is offset by the growth enhancing increasing in public investment.

Tanzi and Davoodi (1997) include an interaction term between corruption and the level of public spending in a regression for the quality of roads (measured by the percentage of roads in good condition). They find that while the interaction term is of the right sign and close to statistical significance its inclusion has the effect of making the direct effect of corruption and public investment both insignificant. Rajkumar and Swaroop (2002) use a similar specification in a model of health outcomes (infant mortality rates) for 90 countries. Here corruption has no direct effect but when interacted with health spending it is significant. Corruption reduces the positive effect of increased health spending on child mortality rates. A similar effect on education quality is also found.

We also find an interesting effect of public investment and corruption on the investment rate. In accordance with Aschauer (1989) we find significant evidence of crowding out of private investment by public investment, albeit where significance is at the 10 per cent level. A number of explanations might be put forward to explain this result. These include the idea that the public sector bids up the price of goods and services making the marginal private investment unprofitable. Alternatives include that these investments are financed by taxes that distort investment decisions, or by deficit financing which raises the interest rate. Corruption has a similar effect on the level of private investment as public investment. Corruption tends to raise the level of private investment in the economy, perhaps reflecting any bribes that are required to 'grease the wheels'. A similar positive correlation is found by Lambsdorff (2002).

Table 2: Three stage least squares regression: Baseline

	(1)	(2)	(3)	(4)
Dependent Variable	**Growth**	**Log(Public Investment/GDP)**	**Corruption**	**Log(private Investment/GDP)**
Corruption	-3.251 (3.58)**	0.466 (6.57)**		0.094 (2.72)**
Log(PubInvest/GDP)	3.124			
if corruption <4	(4.61)**			
Log(PubInvest/GDP) if corruption >4	3.002 (6.56)**			
Log(Public Investment/GDP)				-0.057 (1.72)
Log(Initial GDP)	-3.733 (7.64)**	0.240 (3.05)**	-0.690 (9.62)**	0.116 (3.29)**
Log(Private Investment/GDP)	20.063 (13.94)**			
Log(Openness)	-1.650 (3.03)**	0.562 (5.02)**	0.100 (0.80)	
Log(population)		0.063 (1.34)		-0.025 (1.83)
Urbanisation		0.000 (0.08)		
Democracy			-0.699 (2.71)**	
British Colony			-0.251	
			(1.55)	
Dependency ratio				-0.350 (2.02)*
Observations	192	192	192	192
Hansen J-test for over identifying restrictions X^2 (p-value)	2.132 (0.34)			

Notes: numbers in parenthesis are t-statistics. **, * and + denote significance at the 1%, 5% and 10% of statistical significance respectively. All regressions are based on the reg3 command in stata and additional include fixed regional dummies as well as fixed time effects for each 5-year period. The regions used are Middle East and North Africa, Western Europe, East Asia and Pacific, Sub-Saharan Africa, Eastern & Central Asia, Latin America and Caribbean and South Asia. The time periods used in the estimation are 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99.

Of the additional regressors and estimated equations we find much to support existing work. In the public investment equation the level of spending is increasing in the level of GDP per capita but is in openness to international trade. In light of Wagner's law the former might be interpreted as suggesting that the income elasticity of public investment is greater than one, while the latter is consistent with Rodrik (1998) who argues that openness to international trade raises the level of government expenditures.

Table 3: Three stage least squares regression with corruption affecting public investment at a cut-off point of 4

	(1)	(2)	(3)	(4)
Dependent Variable	**Growth**	**Log(Public Investment/GDP)**	**Corruption**	**Log(private Investment/GDP)**
Corruption	-0.627 (1.79)			-0.034 (1.19)
Corruption <4		0.049 (1.50)		
Corruption >4		0.083 (2.85)**		
Log(PubInvest/GDP) if corruption <4	0.353 (2.02)*			
Log(PubInvest/GDP) if corruption >4	0.211 (1.11)			
Log(Public Investment/GDP)				0.112 (2.45)*
Log(Initial GDP)	-1.829 (6.02)**	0.083 (1.08)	-0.688 (9.61)**	0.063 (1.96)
Log(Private Investment/GDP)	16.399 (12.91)**			
Log(Openness)	-0.466 (1.27)	0.658 (5.89)**	0.035 (0.28)	
Log(population)		0.114 (2.30)*		-0.001 (0.10)
Urbanisation		-0.008 (2.06)*		
Democracy			-0.782 (2.86)**	
British Colony			-0.150 (0.85)	
Dependency ratio				-0.231 (1.17)
Observations	192	192	192	192
Hansen J-test for over identifying restrictions X^2 (p-value)	2.156 (0.32)			

Notes: numbers in parenthesis are t-statistics. **, * and + denote significance at the 1%, 5% and 10% of statistical significance respectively. All regressions are based on the reg3 command in stata and additional include fixed regional dummies as well as fixed time effects for each 5-year period. The regions used are Middle East and North Africa, Western Europe, East Asia and Pacific, Sub-Saharan Africa, Eastern & Central Asia, Latin America and Caribbean and South Asia. The time periods used in the estimation are 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99.

Unlike Alesina and Wacziarg (1998) we find that this result is not affected by the inclusion of a measure of population. We also find no evidence of economies of scale in the rate of public investment from greater urbanisation of the population. As expected, corruption is strongly negatively correlated with GDP per capita and a measure of democracy. Like Treisman

(2000) we also find that openness to international trade plays no significant role as does British Colonial status. Also, as in standard empirical growth literature, we find convergence and highly positive and significant effect of private investment on growth.

The results in Table 2 are supportive of the hypotheses of the paper, but they do not offer complete support. This is largely because of the similarity of the coefficients on productive expenditures split by the level of corruption in the growth equation. One suggestion for this might be that observations are being incorrectly categorised as high corruption using the median to partition countries and this is tending to inflate the effect of public investment on growth in high corruption countries. In Table 3 we search this possibility by changing the point at which firms are classed as high or low corruption. We find from Table 3 evidence in support of this, when we choose a corruption score of 4 as the appropriate cut-off value we now find that public capital has a positive effect on growth only in countries with low corruption levels. In high corruption countries public capital has a poorly defined effect on growth.

In Table 3 we also consider whether the effect of corruption on public investment differs at the same point. In column 2 of Table 3 we find that corruption is significantly related to increases in public investment only when corruption rises above 4 on the index. By allowing varying effects of corruption on public investment, we find the effect of corruption on private investment in column 4 to become insignificant, but public investment still remains positive and significant, i.e., crowding in private investment. Table 3 also suggests, as in Alesina and Wacziarg (1998), that countries that are more open and have more population spends more on public investment.

The results in Table 4 suggest an interesting outcome from an increase in corruption. According to the results in column 2 a one standard deviation increase in corruption would induce an increase in the level of public investment in countries with a corruption score greater than 4 of 0.13 percentage points and have no effect on the public investment to GDP ratio in countries with corruption levels lower than this. The change in growth from this would then be zero in both cases; it leads to an increase in public investment that has no growth impact in high corruption countries and no change in public investment in low corruption countries. In both cases the effect is therefore equal to the direct impact of corruption on economic growth equal to close to 1 percentage point per annum over the 5-year period (1.59*-0.627=-0.99). This effect of course contrasts with a non-corruption induced increase in public investment, where the effect would be positive only in low corruption countries. For example a one-standard deviation increase in public investment would, according to these estimates, increase growth by 1 percentage point per annum over a 5-year period.

Table 4: Three stage least squares regression with corruption affecting public investment at a cut-off point of 4 and taking education into consideration

Dependent Variable	Growth	Log(Public Investment/GDP)	Corruption	Log(private Investment/GDP)
Corruption	-0.491 (1.26)			-0.077 (2.66)**
Corruption <4		0.053 (1.71)+		
Corruption >4		0.064 (2.22)*		
Log(PubInvest/GDP) if corruption <4	0.400 (2.32)*			
Log(PubInvest/GDP) if corruption >4	0.029 (0.15)			
Log(Public Investment/GDP)				0.140 (3.20)**
Secondary School Enrolment	0.007 (0.76)			
Log(Initial GDP)	-1.587 (4.38)**	0.006 (0.08)	-0.765 (10.64)**	0.032 (0.96)
Log(Private Investment/GDP)	17.968 (14.37)**			
Log(Openness)	-0.522 (1.44)	0.645 (6.00)**	-0.073 (0.62)	
Log(population)		0.131 (2.72)**		0.005 (0.34)
Urbanisation		-0.009 (2.50)*		
Democracy			-0.782 (3.16)**	
British Colony			-0.072 (0.44)	
Dependency ratio				-0.189 (1.07)
Observations	186	186	186	186
Hansen J-test for over identifying restrictions X^2 (p-value)	0.790 (0.67)			

Notes: numbers in parenthesis are t-statistics. **, * and + denote significance at the 1%, 5% and 10% of statistical significance respectively. All regressions are based on the reg3 command in stata and additional include fixed regional dummies as well as fixed time effects for each 5-year period. The regions used are Middle East and North Africa, Western Europe, East Asia and Pacific, Sub-Saharan Africa, Eastern & Central Asia, Latin America and Caribbean and South Asia. The time periods used in the estimation are 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99.

4. Robustness

Now, we add education as it is one of the most important factors for growth and see whether our results are affected. Table 4 shows the results for the system that includes education. The results are in general robust. These results do not change when we use other measures of education, which are in all cases insignificant.

Table 5: OLS regressions treating all equations separately

	(1)	(2)	(3)	(4)
Dependent Variable	**Growth**	**Log(Public Investment/GDP)**	**Corruption**	**Log(private Investment/GDP)**
Corruption	-0.279 (1.22)			0.039 (1.74)+
Corruption <4		0.044 (1.23)		
Corruption >4		0.078 (2.54)*		
Log(PubInvest/GDP) if corruption <4	0.159 (1.00)			
Log(PubInvest/GDP) if corruption >4	0.249 (1.63)			
Log(Public Investment/GDP)				-0.070 (2.03)*
Log(Initial GDP)	-0.390 (1.79)+	0.037 (0.46)	-0.681 (9.02)**	0.119 (3.27)**
Log(Private Investment/GDP)	2.334 (3.98)**			
Log(Openness)	0.648 (2.21)*	0.551 (4.59)**	0.043 (0.32)	
Log(population)		0.065 (1.25)		-0.000 (0.02)
Urbanisation		-0.006 (1.45)		
Democracy			-0.830 (2.86)**	
British Colony			-0.153 (0.82)	
Dependency ratio				0.032 (0.12)
Observations	192	192	192	192

Notes: numbers in parenthesis are t-statistics. **, * and + denote significance at the 1%, 5% and 10% of statistical significance respectively. All regressions include fixed regional dummies as well as fixed time effects for each 5-year period. The regions used are Middle East and North Africa, Western Europe, East Asia and Pacific, Sub-Saharan Africa, Eastern & Central Asia, Latin America and Caribbean and South Asia. The time periods used in the estimation are 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99.

Moreover, we find that corruption significantly reduces private investment after allowing the effect of education within the system. This result is more convincing in the sense that it is in conformity with what Mauro (1995) has suggested, i.e., corruption affects growth negatively through reducing private investment.

We have mentioned earlier that due to the interdependency between corruption, public investment and growth, the use of three stage least squares regression with a system of equations should give sufficient flexibility of the error covariance matrix that would allow for substantial efficiency gains relative to estimating each equation separately as used in standard literatures on public investment, corruption and growth. Now we test whether it had made really any difference by estimating the equations separately.

Table 5 estimates the equations separately as in standard literature (i.e., assuming zero cross-equation error covariances). The results we see is dramatically different from what we find from three-stage least squares regressions. We find that public investment does not affect growth whether the countries have high or low corruption, though the result of higher corruption raising public investment in equation 2 still remains. Hence, we can conclude that by using three stage least squares regression, we can identify the significant positive effect of public investment on growth for low corrupt countries. In Appendix A we also show that the same conclusion is reached when we use a two-stage least squares methodology, where these lie somewhere between the results for OLS and three stage least squares.

In a final test of the robustness of the results we follow Wacziarg (2001) and provide a test of exhaustiveness of the system calculated by regressing the residuals vector obtained from the system estimates of the growth equation against our measure of public investment, corruption and their interaction. A significant correlation in this regression may suggest that an important channel has been omitted from the system. The results are based on the system reported in Table, although the results are identical for the other system regression reported in the paper. Reassuringly we find no evidence of misspecification, the point estimates on the three terms in the regression on the residuals from the growth regression are all statistically insignificant at conventional levels. The t-statistic on public investment is 0.06, that on corruption is 0.97 and that on the interaction term is 1.29.[16]

5. Conclusion:

This paper is a first attempt, in a cross-country context, to evaluate empirically the effects of public investment on growth that is affected by the presence of corruption in an economy. In order to take the interdependency between public investment, corruption and growth we have formulated a system of four equations where growth, public investment, corruption and private investment were dependent variables in equations and explanatory variables in other equations. In so doing we have combined three distinct literatures on "corruption and growth", "public investment and growth", and "corruption and public investment" to capture the effect of one on the other.

Theoretically, we have developed a neoclassical growth model where the government officials are given the task of procuring public goods that are used as productive inputs in the production. Due to the information asymmetry between the government and the bureaucracy, the bureaucrats can falsely report of high quality-high cost procurement, while providing low quality-low cost product. This affects the productivity of the economy and hence reduces growth. Our analysis can show that corruption not only reduces the quality of public services that are necessary for production, but also inflates the public spending beyond the efficient level. In this way, we can explain why public investment fails to raise growth in the countries where corruption is endemic.

Econometrically, we have used three stage least squares regression in a panel set up that allowed us to consider non-zero correlations across equations. Taking cross-period error correlations into account is similar to assuming that the error terms contain country-specific effects uncorrelated with the right-hand-side variables. The flexibility of the error covariance matrix allows for substantial efficiency gains relative to estimating each equation separately (that is, assuming zero cross-equation error covariances).

The empirical evidence provided in the study suggests that corruption increases public investment but reduces its effect on economic growth. In other words, only the countries with lower corruption can enjoy the efficient return on public investment such that it raises growth. But in high corrupt countries, the returns from public investment are reduced by the corrupt agents in the economy and hence public investment fails to generate higher growth. In addition to its direct negative impact and indirect impact through reducing the returns to public investment, corruption has another indirect negative effect on growth through reducing private investment. These results suggest that the policies to deter corruption and to increase the efficiency of public investment could give very positive impulses to economic growth. Based on these insights, we view our analysis as a promising step towards understanding an issue that is dominating the international development arena.

[16] The same result holds if we replace the interaction term with the measure of public investment split above and below a corruption value of 4. Here the t-statistic on public investment is 0.75 when corruption is below 4, 0.65

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when it is above 4, while that on corruption is -0.28.

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Appendix A

Table A1: Two stage least squares

	(1)	(2)	(3)	(4)
Dependent Variable	**Growth**	**Log(Public Investment/GDP)**	**Corruption**	**Log(private Investment/GDP)**
Corruption	-0.242 (0.59)			-0.002 (0.06)
Corruption <4		0.044 (1.23)		
Corruption >4		0.078 (2.54)*		
Log(PubInvest/GDP) if corruption <4	0.275 (1.14)			
Log(PubInvest/GDP) if corruption >4	0.479 (2.16)*			
Log(Public Investment/GDP)				0.010 (0.19)
Log(Initial GDP)	-1.098 (3.22)**	0.037 (0.46)	-0.681 (9.02)**	0.118 (3.15)**
Log(Private Investment/GDP)	9.375 (5.55)**			
Log(Openness)	0.018 (0.04)	0.551 (4.59)**	0.043 (0.32)	
Log(population)		0.065 (1.25)		0.009 (0.52)
Urbanisation		-0.006 (1.45)		
Democracy			-0.830 (2.86)**	
British Colony			-0.153 (0.82)	
Dependency ratio				0.199 (0.72)
Observations	192	192	192	192