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CORRUPTION, INVESTMENT, AND GROWTH IN DEVELOPING COUNTRIES

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Abstract

This paper extends the neoclassical model of economic growth to empirically investigate the impact of corruption on economic growth by examining the effect that corruption has on investment in human, private, and public capital and democratic governance. The impact of corruption on the level of private and public investment appears to be more ambiguous and, at any rate, less damaging than previously suggested in the literature. We, however, find that the impact of corruption on the accumulation of human capital is significantly more punitive than what has been previously found. We also find that the impact of corruption on governance is unambiguously negative, which further deters economic growth.

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Introduction

Corruption, commonly defined in the literature as the abuse of public power for private benefit, is a pervasive and universal phenomenon, and affects almost every culture to differing degrees. As witnessed throughout history, corruption can affect democratic and non-democratic countries, rich and poor countries, and corporations alike. In very recent times, corruption, or the allegation of corruption, has been instrumental in the reorganization of the political system in Italy, the change of governments in Indonesia, Japan, Peru and the Philippines, the collapse of governmental authority in Zaire, and the bankruptcies of Arthur Andersen, Enron, and MCI, among others. Corruption poses a threat to investment for a number of reasons: it reduces public and private sector efficiency when it enables people to assume positions of power through patronage rather than ability; distorts the financial economic and environment; and, at the limit, introduces instability and anarchy into the political process.

Previous examinations of the question of the influence of corruption on investment that use national income and product accounts (NIPA) data may, in fact, be biased. NIPA reports do not normally break down gross domestic investment into its private and public sector components, especially in the case of developing and transitional countries. When NIPA reports contain disaggregated investment data, private investment data often includes investment by state-owned enterprises (SOE) (Pfeffermann, Kisunko, and Sumlinski, 1997; Everhart and Sumlinski, 2001). Using the International Finance Corporation's definitions of public and private investment requires SOE investment be correctly identified as public investment, not private investment, unlike the current definitions used by most sovereigns for national income accounting.

In this paper we employ a new database using the IFC's definitions of public and private investment to theoretically and empirically investigate the influence of corruption on the accumulation of human, private, and public capital and the rate of economic growth. We explicitly allow for corruption to influence economic growth directly and indirectly through investment and governance channels. As we note below, many of the previous examinations of the impact of corruption either explore corruption's direct impact on economic growth or a specific area of interest (investment, human capital formation, rule of law, among others) but fail to examine the channels through which corruption may influence economic growth. In this paper, we extend the literature by explicitly modeling and empirically examine the direct and indirect influence of corruption on economic growth. While we find that the impact of corruption on the level of investment appears to be more ambiguous than previously suggested in the literature; corruption, not surprisingly, appears to negatively influence the accumulation of human capital and the pace of economic growth.

The paper is structured as follows. We first review the literature on corruption. We then develop a theoretical model of corruption in the third section that explicitly incorporates corruption's direct and indirect influences on economic growth. In the fourth section, we empirically investigate the hypothesized impacts of corruption and attempt to quantify the aggregate influence of corruption on investment and economic growth. In the last section, we conclude with a review of policy implications, highlight the shortcomings and strengths of our work, and suggest areas for further research.

Literature Review

Why do we care about the impact of corruption? A predictable economic environment is important for private investors. When investors are assured that the returns on enterprise and investment accrue to the entrepreneur and investor, investment is more likely to ensue. An environment where corruption and bribery are prevalent creates a situation where investment returns are difficult to predict. An unstable economic environment has two primary effects on private investment decisions: expected returns are lowered due to increased costs, and two, the dispersion of outcomes is larger, though manageable if the resources invested actually produce the desired result. (Johnson, Kaufmann, McMillian, and Woodruff, 2000). As noted initially in the seminal work of Mauro (1995, 1998), both effects serve to limit investment, which is critical to long-run, sustainable economic development. In this section we briefly review the arguments related to the impact of corruption on governance, investment, and growth.

Investigating the impact of corruption is not a new concept, yet quantifying the impact remains elusive (Tanzi 2002; Jain 2001; Rose-Ackerman, 1999; Theobald, 1990). A recent transitional country survey suggests that almost 40 percent of new enterprise expenses are consumed by informal payments (IMF, 2000). Only 13 percent of central government education transfers for non-wage expenditures in Uganda reached local governments during 1991-1995, the remainder were either appropriated for non-education purposes or corrupt activities (Reinikka and Svensson, 2004). While we must express a note of caution with respect to surveys that ask potential participants and victims of corrupt practices to report on the magnitude and frequency of such practices (Reinikka and Svensson, 2003; Svensson 2003); there appears to be sufficient consensus in the literature that less corruption might translate into more resources available for private investment. Moreover, strengthened public revenues as a result of less "leakage" due to corruption could translate into more public services or reduced taxes.

Although one might expect a broad consensus to exist concluding that corruption is bad, some authors have argued that under the proper circumstances, corruption may facilitate faster growth by serving as an "efficient grease" (Kaufmann and Wei 2000; Braguinsky 1996). Corruption can also be used to reverse errors in judgment by the government (Leff, 1989). Bribery may allow "better" firms to bypass red tape and thus reward market performance (Lui, 1985). Excessive regulation could be muted by bribery and, in some circumstances; corruption may be efficiency enhancing (Bardhan, 1997). Corruption incorporates otherwise alienated groups, integrates them, and provides them with an alternative to violence (Huntington, 1968). Finally, corruption among politicians may serve as the glue holding a country together, suggesting that corruption may lower the probability of conflict and indirectly enhance economic growth (Huntington, 2000; Graziano, 1980).

Despite these interesting perspectives on corruption, the economics literature generally disapproves of such practices. Firms that spend more management time with bureaucrats pay more in bribes and also pay a higher cost of capital (Kaufmann and Wei, 2000). Corruption may strain the linkages between taxes and public sector goods and services and thus promote tax evasion and the growth of the unofficial economy (Johnson, Kaufman, and Shleifer, 1997; Johnson, Kaufman, and Zoido-Lobaton, 1998; Loayza, 1996). Higher levels of corruption and bureaucratic inefficiency appear to positively influence the unofficial economy's share of GDP (Hellman, Jones, and Kaufmann, 2003; Frye and Zhuravskaya, 2000; Johnson, Kaufmann, McMillian, and Woodruff, 2000; Schneider, 2000; Alexeev and Pyle, 2003).

Corruption has been found to limit economic development by inhibiting growth in per capita income, child mortality, and literacy (Kaufmann, Kraay, and Mastruzzi, 2003; Mo, 2001). Corruption also appears to adversely affect public and private investment, although questions remain on the data and methodology employed in these studies (Habib and Zurawicki, 2002; Del Monte and Papagni, 2001; Tanzi and Hamid, 2000; Wei, 2000; Mauro 1995, 1998). Corruption may also affect economic policy by distorting the judgment of policymakers (Bai and Wei, 2000, 2001). Corruption cannot be assumed to be exogenous from the distortions it creates in the allocation of resources; distortions that create incentives for increased corruption. Although specific methodologies raise doubts about issues of causation, the consensus in the literature appears to suggest that corruption is negatively related to several crucial economic variables.

If one accepts the current consensus in the literature that corruption negatively influences private and public sector outcomes, improving governance may be one way of combating corruption. Corruption thrives where states are too weak to control their own bureaucrats, to protect property and contract rights, and to provide the institutions that underpin an effective rule of law (Mauro, 2004; Brunetti and Weder, 2003; Eigen, 2002; Rivera-Batiz, 2002; Broadman and Recanatini, 2002). Improving political accountability appears, as this line of reasoning goes, to improve governance and reduce corruption. Accountability allows for the punishment of politicians who adopt bad policies and the limitation of bureaucratic monopoly power, thereby more closely aligning politicians' and bureaucrats preferences with those of the populace (Djankov, La Porta, Lopez-de-Silanes, and Shleifer, 2002; Laffont and Meleu, 2001; Rose-Ackerman, 1999, 1998). Democratic elections, parliamentary systems, political stability, fiscal decentralization, and freedom of the process all appear to be associated with lower levels of corruption (Martinez-Vazquez and McNab 2003; Tanzi, 2000; Andvig, 1999). Curiously, while the topics of corruption, investment, governance, and growth have garnered a significant amount of attention in the recent literature, there is a paucity of theoretical models of corruption that explicitly examine the outcomes of corruption. In many cases, models of corruption tend to focus on the causes and determinants of corruption rather than the outcomes of corruption (Ali and Isse, 2003; Persson, Tabellini, and Trebbi, 2003; Gyimah-Brempong, 2002; Shleifer and Vishny, 1993).

More recently, Pellegrini and Gerlaugh (2004), Papyrakis and Gerlaugh (2004), Mo (2000, 2001) empirically analyze the influence of corruption through various direct and indirect channels on economic growth. In general, these studies find that corruption retards economic growth, primarily through its detrimental impact on investment and international trade. Pellegrini and Gerlaugh, more importantly from the perspective of our study, note that there is not a statistically significant direct relationship between corruption and economic growth once other relevant factors are controlled for. While among the first studies attempting to examine the indirect channels through which corruption impacts economic growth, we note that these studies rely on a cross sectional approach and upon investment data that classifies SOE investment as private investment. Islam (2004) further argues that the unobserved fixed country effects and potential multicollinearity between explanatory variables are likely to bias the estimation of the impact of corruption on per capita GDP. With these findings in mind, we turn to the derivation of the theoretical model.

A Simple Model of Corruption, Investment, and Growth

While the potential influence of corruption on output through investment is not one of the conventional arguments for anti-corruption efforts, ignoring this potential effect, we believe, may inject *a priori* bias into our analysis. More importantly, by examining the impact of corruption within a neoclassical model of output, we can explore how corruption and governance influence investment and the tradeoffs between public and private investment.

Following Islam (1995), Mankiw, Romer, and Weil (1992), and Romer (1986), we assume a Cobb-Douglas production function for the economy such that production at time t is given by

$$Y_t = V_t K_t^{\alpha} G_t^{\beta} H_t^{\varphi} L_t^{\theta} \tag{1}$$

where $\alpha, \beta, \varphi, \theta > 0$ and $\alpha + \beta + \varphi + \theta \geq 1$. Y_t is output, V_t the level of technology and other institutional factors, K_t, G_t , H_t are the stocks of private, public and human capital, and L_t is labor at time t, respectively.[1] We define V_t as the product of the level of technology and other institutional factors at time t or

$$V_t = A_t C_t Z_t \tag{2}$$

where V_t is the exogenous level of technology, C_t the level of corruption, and Z_t is a row vector of exogenous variables that may influence output.[2] Note that C_t is synonymous with the direct effect of corruption on output. If corruption indirectly influences output through its impact on

[1] A complete derivation of the theoretical model is available upon request.

[2] At this time, for theoretical simplicity, we assume that corruption and the set of exogenous variables are uncorrelated.

investment, *certius paribus*, then it will indirectly influence economic output through either K_t, H_t, or G_t.

We further assume that output is subject to decreasing returns to scale with respect to physical and human capital. This implies that the economy, over the long-run, will tend to constant private capital-labor, human capital-labor, and public capital-labor ratios.[3] Once steady state output is achieved, additional increases in per capita output can only be achieved through increases in capital productivity or decreases in the level of corruption (assuming that the overall effect of corruption on economic growth is negative).[4] It is this perspective that interests us in this paper: corruption may affect output through two channels, a potential direct effect on output, and a series of potential indirect effects through the physical inputs in the production function.

To determine the influence of corruption on economic growth, we must first determine the steady state levels of the physical inputs in the production function. We assume that the same production function applies to all forms of reproducible capital and consumption so that one unit of capital can be freely transformed into one unit of consumption and vice versa. Labor is assumed to grow exogenously at rate n, technology at rate w, capital depreciates at rate δ, and corruption changes at rate c. Assuming decreasing marginal returns to all forms of reproducible capital; that no combination of capital inputs exhibits constant marginal returns; expanding V_t

[3] The growth model specified in Equation 1 can be either a Solow-augmented neoclassical growth model with constant returns to scale for all production factors ($\alpha + \beta + \varphi + \theta = 1$), or an endogenous growth model with increasing returns to scale for all production factors ($\alpha + \beta + \varphi + \theta \geq 1$). Also, if any combination of the capital inputs exhibits constant returns to scale ($\alpha + \beta = 1$, $\beta + \varphi = 1$, $\alpha + \varphi = 1$) then Equation (1) would similarly be characterized as an endogenous growth model. Senhadji (1999) noted that a large part of the empirical growth literature supports the assumption of decreasing returns to capital.

[4] While changes in resource endowments (the discovery of new resources or a cure for AIDS) may affect short-term capital-labor ratios, these changes would not necessarily affect the steady state capital-labor ratio unless these changes influenced capital productivity. Gerson (1998) argues that since the convergence to the new steady state may take years to occur, fiscal policy can still lead to higher output growth rates for a significant period of time, even though the neoclassical model might imply that these policies would affect only the level of output and not its long-run growth rate.

and taking the natural logarithm yields from (1) and (2) the steady state level of output per effective unit of labor[5] or

$$\ln\, y_t^* = \frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \frac{\beta}{1-\alpha-\beta-\varphi}\ln i_h + \frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_g - \frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+g+\delta+c) \qquad (3)$$

where i_k , $i_{g,}$ and i_h are the fractions of output invested in private, public, and human capital, respectively. Transforming (3) into differences in per capita output, noting that $\lambda = (n + g + \delta + c)(1 - \alpha - \beta - \varphi)$, and defining y_0 as the initial level of per capita output, the evolution of per capita output over time can be expressed as:

$$\dot{y} = (1-e^{-\lambda t})[\ln A_t + \ln C_t + \ln Z_t + \frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \frac{\beta}{1-\alpha-\beta-\varphi}\ln i_h + \frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_g - \frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+g+\delta+c) - \ln y_0 - e^{-\lambda t}\ln A(0) - e^{-\lambda t}\ln C(0) - e^{-\lambda t} Z(0)] \qquad (4)$$

We illustrate in (4) the direct and indirect influence of corruption on the evolution of per capita output over time. Corruption may directly influence per capita output, that is, increased levels of corruption *C* retard per capita output growth. Corruption may also indirectly influence per capita output growth by inhibiting the accumulation of public, private, and human capital. Efforts to lower corruption may have immediate direct and indirect positive influences on the evolution of per capita output over time.

An advantage of our theoretical specification over the models used in previous papers is our explicit examination of the out-of-steady-state dynamics. In addition, we also make explicit the difference between the bounded institutional factors in the production function and the physical inputs in the production function. The bounded institutional factors directly influence economic growth while the physical inputs are weighted by the ratio of their output share to

[5] The effective unit of labor is the technology augmented unit of labor; see Islam (1995).

labor's share of output. Finally, we explicitly capture the unobservable initial conditions in the theoretical model. Empirically, equation (4) suggests that corruption is an explanatory variable in the evolution of private, public, and human capital over time. When investigating the evolution of per capita output, corruption may enter directly as an explanatory variable or indirectly as an interaction term with other variables of interest.

Two problems may arise with our derivation of the steady state production function and the equation for the convergence to the steady state output level. First, if countries have permanent differences in technology, then these differences would enter as part of the error term and be positively correlated with initial per capita output. Permanent variations in technology could bias the estimated coefficient on initial per capita output toward zero. Second, while countries may not have permanent variations in technology, they may have permanent variations in their institutional factors (colonial legacy, legal system, climate, geographical region) that would also enter as part of the error term. We address these issues below.

Data

Accepting the various limitations of measures of corruption discussed in the literature, we utilize the corruption index from Political Risk Service's International Country Risk Guide (ICRG) which has been previously employed in the economics literature (Rajkumar and Swaroop, 2002; Tanzi and Davoodi, 2002; Knack, 2001; Knack and Keefer, 1995). The ICRG attempts to measure corruption by investigating whether high-ranking government officials are likely to demand special payments and if illegal payments are generally expected in lower levels of government and has been used in the economics literature.[6] For convenience, we rescale the ICRG 0 (most corruption) to 6 (least corrupt) index to a 0 (absence of corruption) to 1 (completely corruption). Unlike other, perhaps more complete datasets that also attempt to measure corruption, the ICRG database has monthly ratings for over 100 countries from 1984 to present.[7] We follow a similar approach in employing the ICRG index of bureaucratic quality as our proxy for institutional quality and the strength of the public service.[8]

Turning the question of public and private investment, we define private investment as the difference between total gross domestic investment and consolidated public investment.[9] This approach is necessary, we argue, to remove the potential bias of SOE and other types of public investment that are normally reported as private investment in the national accounts data. Consolidated public investment data for each country were compiled primarily from World Bank Country Economic Memoranda, Public Investment Reviews, Public Expenditure Reviews, and other World Bank and IMF country reports. Where World Bank data were not available, country data obtained from government officials and websites were used. Sixty-three countries are represented in the investment data.[10]

When we merge the investment data with the corruption and governance measures, our sample falls to fifty countries. We do, however, believe that this is still the largest panel of public and private investment data to date for developing and transitional economies. Our final sample covers fifty countries for the period 1984-1999 with a total of 684 observations.[11] We must note that our sample data is limited to developing and transitional countries due to the scope of the original work.

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[6] For additional information on the International Country Risk Guide, see http://www.icrgonline.com.

[7] We choose not to employ Transparency International's Corruption Perceptions Index due to the short length of the time series and the variability in the measurement methodologies over time. We also choose not to employ the World Bank's 2000 World Business Environment Survey (http://info.worldbank.org/governance/wbes) as we wished to investigate the evolution of corruption, investment, and growth across time. We do note, however, that the ICRG index correlates highly with the Transparency International's Corruption Perceptions Index for the 1996-2002 periods.

[8] The precise ICRG definition of their measure is as follows: the institutional strength and quality of the bureaucracy is another shock absorber that tends to minimize revisions of policy when governments change. Therefore, high points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. In these low-risk countries, the bureaucracy tends to be somewhat autonomous from political pressure and to have an established mechanism for recruitment and training.

[9] For a detailed discussion of the investment data employed in this research, see Everhart and Sumlinski (2001).

[10] See Appendix A for the countries included in the sample used for this study.

[11] See Appendix B for the variables included in the sample.

Econometric Model and Empirical Issues

We must first note that, unlike our study which employs panel data, the majority of the research on corruption has been done with cross-sectional data. In addition, much of the work on investment in emerging markets has also relied on cross-sectional data. Those time-series analyses that do exist are largely country-specific. As for our data sample, comparable data for developed countries are not available at this time. Future research could focus on developing similar measures for developed countries.

Our empirical strategy is straightforward. We first examine whether serial correlation is present using a Durbin-Waston test for OLS regressions and a Bhargava, Franzini, and Narendranathan (BFN) (1982) test based upon the residuals of the Within estimator for the panel data regressions. If serial correlation is present, we first difference the data and test whether serial correlation is present in residuals from the estimations employing first differenced data. We then test for hetoerskedasticity using Breusch-Pagan (1980) for the OLS estimations as suggested by Koenker and Bassett (1982). For panel data estimators, we employ the Koenker and Bassett (1982) test using the Within or GLS residuals, as appropriate. To correct for heteroscedasticity, if present, we use the White (1980) heteroskedastic consistent covariance estimator. Baltagi (1995) points out that even if we have homoskedastic errors, there is no penalty associated with the incorrect use of the White heteroskedastic consistent covariance estimator for the OLS or Within models. Thus, even if there are other models we have incorrectly diagnosed as being heteroskedastic when they are not, the parameter estimates are not adversely affected.

For questions of endogeneity, we follow Hausman (1978), Hausman and Taylor (1981), and Baltagi (1995). To calculate a Hausman test statistics, we must have a sufficient number of independent regressors. One difficulty is the number of available instruments that are independent. Anderson and Hsiao (1981) present a ready solution when using panel data in differences. In the case of first-differenced panel data, an appropriate instrument is the second-period lagged *level* of the regressor in question. Anderson and Hsiao assert that the choice of instruments should be correlated with the endogenous variable but not with the contemporaneous value of the dependent variable and the second-period lagged level of the regressor in question typically meets these requirements. It is this lack of available instruments that precludes us from estimating the following equations as a system.

What is the impact of corruption on private investment? To investigate the influence of corruption, we employ the pooled OLS estimator, one-way country-specific error components estimator, the one-way time-effects errors component estimator and the two-way error components estimator.[12] We hypothesize that private investment is a function of public investment, the quality of governance, and, among other things, corruption, or

$$I_{it}^{P} = \beta_1 C_{it} + \beta_2 (C_{it} I_{it}^{G}) + \beta_3 I_{it}^{P} + \beta_4 Q_{it} + \beta_5 Z_{it} + \mu_i + \lambda_t + \nu_{it} \qquad (5)$$

where I^{P}_{it} is private investment, C_{it} is corruption, I^{G}_{it} is public investment, Q_{it} is the governance, $C_{it} * I^{G}_{it}$ is the interaction between corruption and public investment, and Z represents an array of conditioning variables. The error term is composed of μ_I, the unobservable country specific effect, λ_t, the unobservable time specific effect, and the white-noise stochastic disturbance term, ν_{it}. The subscripts *i* and *t* refer to country *i* during year *t*, respectively. We note the presence of serial correlation in the error terms when the base estimation equation is estimated in levels and thus specify the equation in first differences (Table 1).[13]

Testing for the presence of endogeneity of public investment in (5)[14], we fail to reject the null hypothesis of exogeneity for private investment with respect to the public investment.[15] We

[12] The full set of estimation results is available upon request.

[13] We reject the null hypothesis of no serial correlation at the 1% significance level using a Durbin-Watson test for serial correlation. Re-specifying the model in first differences, we fail to reject the null hypothesis.

14 We fail to reject the null hypothesis of exogeneity with a Hausman test statistic of 0.08 with 565 degrees of freedom .

also note the presence of heteroskedasticity (Table 2). We then examine whether the random effects GLS estimator or fixed effects Within estimator is more appropriate for the estimation of (5). While we would prefer to use the random effects estimator to avoid the loss of degrees of freedom associated with the use of the Within estimator, we reject the null hypothesis that the regressors and effects are uncorrelated. As this result suggests that the random effects estimator is inconsistent, we use the fixed effects estimator for the estimation of the relationship between private investment, public investment, and corruption. Finally, we examine whether the fixed effects are jointly significant, that is, whether the time and country specific effects are significant. Curiously, the time and country specific effects are insignificant, regardless of the set of conditioning variables, suggesting the pooled OLS estimator is the most efficient estimator.

From this paper's perspective, the most important result is that the corruption interaction term is relatively large and statistically significant with the expected negative sign, as is public investment (Table 3). This result holds when we re-estimate (5) without the statistically insignificant quality of bureaucracy variable and under various alternative specifications. This result appears to suggest that crowding-out appears to be present among the sample countries during the observed periods. Curiously, corruption by itself is statistically insignificant, thus suggesting that corruption does not directly influence private investment, but through its impact on public investment. This result compliments the cross-sectional results of Dreher and Herzfeld (2005) who also fail to detect a statistically significant direct effect for corruption, although for aggregate investment only.

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[15] We employ different alternatives of conditioning variables to examine whether this result is robust and conclude that we fail to reject the null hypothesis with the given set of countries, time periods, and explanatory variables. We also fail to reject the null hypothesis of exogeneity for corruption, the interactive term, and the conditioning variables, to include Current Account Balance as a percentage of GDP, Broad Money as a percentage of GDP, and External Trade as a percentage of GDP.

What is the impact of corruption on public investment? Turning to the question of the impact of corruption on public investment, we employ the same methodology as with respect to the question of the impact of corruption on private investment. Following the theoretical model, we allow corruption to directly influence the accumulation of public capital and indirectly through its influence on the quality of the bureaucracy and the accumulation of private investment. Using the same variable notation as in (5), the base estimation equation for the change in public investment is

$$I_{it}^{G} = \beta_1 C_{it} + \beta_2 (C_{it} I_{it}^{P}) + \beta_3 I_{it}^{P} + \beta_4 Q_{it} + \beta_5 Z_{it} + \mu_i + \lambda_t + \nu_{it} \tag{6}$$

Again, we note the presence of serial correlation in the error terms when the base estimation equation is estimated in levels and thus specify the equation in first differences.[16]

Testing again for the presence of endogeneity of private investment in (5)[17], we fail to reject the null hypothesis of exogeneity for private investment with respect to the public investment.[18] When investigating whether the random effects GLS estimator is more appropriate than the fixed effects Within estimator, we again reject the null hypothesis that the regressors and effects are uncorrelated and thus employ the fixed effects estimator. Lastly, when we examine whether the fixed effects are jointly significant, we find the time-specific effects to be statistically significant and thus employ the one-way time-specific fixed effects error components estimator.

From this paper's perspective, the most important result is that the corruption is not statistically significant, whether its direct effect or its indirect effect through private investment

[16] We reject the null hypothesis of no serial correlation at the 1% significance level using a Durbin-Watson test for serial correlation. Respecifying the model in first differences, we fail to reject the null hypothesis of no serial correlation.

17 We fail to reject with a Hausman test statistic of 2.07 with 678 degrees of freedom.

[18] We employ different alternatives of conditioning variables to examine whether this result is robust and conclude that we fail to reject the null hypothesis with the given set of countries, time periods, and explanatory variables. We also fail to reject the null hypothesis of exogeneity for corruption, the interactive term, and the conditioning variables, to include Current Account Balance as a percentage of GDP, Broad Money as a percentage of GDP, and External Trade as a percentage of GDP.

(Table 4). This result is striking and contrary to the results of the majority of the previous literature, with the previously noted exception of Dreher and Herzfeld (2005). This result holds when we re-estimate (6) without the statistically insignificant quality of bureaucracy variable and under various alternative specifications. The estimated coefficient for the quality of the bureaucracy is quite fragile with respect to the inclusion of the time-specific effects, suggesting that previous results may merely be capturing a proxy effect. The crowding out effect noted in the estimation of (5) appears again, suggesting that crowding out does occur in the sample countries and time periods.

We must caution, however, that another explanation exists for the lack of significance of the quality of bureaucracy and corruption variables. We are estimating with panel data in first differences, not in levels or cross-section as with previous analyses in the literature. Another explanation of the lack of significance is also related to our estimating panel data in differences. When estimating in differences we are attempting to determine if the changes in bureaucratic quality and corruption induce changes in the level of investment. We are not smoothing the data as is often the case with cross-section analysis; we are attempting to capture unobserved time and country-specific effects. We do consider the insignificance of the estimated coefficients, given our *a priori* hypotheses, somewhat disappointing and consider it an area in need of future research, perhaps with other proxies.

What is the impact of corruption on human capital? Measuring the potential impact of corruption on the accumulation of human capital is, understandably, a difficult task. As with measuring corruption, we must employ imperfect proxies for human capital. Given our desire to investigate the influence corruption across countries and time, school-based measures of human capital are unavailable to us.[19] We, however, can employ an outcome based measures of human

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[19] A number of authors have used education as a proxy for human capital in growth regressions, and we investigated this route for our research as well. However, education data for such a broad *panel* of emerging market economies is not available. However, we merged the education dataset from Lee and Barro (2001) with our panel for the

capital accumulation, infant mortality per 1,000 live births, to investigate the relationship between corruption and the accumulation of human capital. Our estimating equation for the change in human capital, *H*, is:

$$H_{it} = \beta_1 C_{it} + \beta_2 y_{it} + \beta_3 Q_{it} + \beta_4 Z_{it} + \mu_i + \lambda_t + \nu_{it} \qquad (7)$$

where *y* is the change in per capita GDP. We add public health expenditures as a percentage of GDP as a conditioning variable for these regressions. Again, we note the presence of serial correlation in the error terms when the base estimation equation is estimated in levels and thus specify the equation in first differences.[20] Testing for the presence of endogeneity of corruption in (7)[21], we fail to reject the null hypothesis of exogeneity.[22] When investigating whether the random effects GLS estimator is more appropriate than the fixed effects Within estimator, we again reject the null hypothesis that the regressors and effects are uncorrelated and thus employ the fixed effects estimator.

From this paper's perspective, the most important result is the fragility of the corruption variable to different specifications. In the most parsimonious specification, without public health expenditures as a percentage of GDP, corruption is positive and statistically significant. Including public expenditures as a percentage of GDP does reduce the number of observations significantly and the estimated coefficient on corruption is insignificant. Finally, re-specifying the equation to investigate whether corruption directly and indirectly influences the accumulation of human capital, we find that direct effect of corruption is 1/3 that of the parsimonious equation

overlapping years and countries to investigate whether infant mortality and education were related. Using data for 35 of our countries for the years 1985, 1990, and 1995, we find a correlation of .71 between the two series, leading us to conclude that much of the informational content in an education proxy is also contained in our primary proxy for human capital, infant mortality.

[20] We reject the null hypothesis of no serial correlation at the 1% significance level using a Durbin-Watson test for serial correlation. Re-specifying the model in first differences, we fail to reject the null hypothesis of no serial correlation.

21 We fail to reject with a test statistic of 0.2127 with 652 degrees of freedom.

[22] We employ different alternatives of conditioning variables to examine whether this result is robust and conclude that we fail to reject the null hypothesis with the given set of countries, time periods, and explanatory variables. We also fail to reject the null hypothesis of exogeneity for public health expenditures as percentage of GDP.

and that the indirect effect through public investment is positive and significant. The message is clear, however, corruption does have a human cost. These results echo those of Mo (2001) who notes that corruption lowers average schooling (a viable proxy in cross-sectional samples) by 0.25 years. Dreher and Herzfeld (2005) also note that an increase in the corruption index by one point appears to lower school enrollment and life expectancy by five percentage points and 2.5 years, respectively.

What is the impact of corruption on governance? While recent empirical evidence suggests that governance positively and significantly influences economic growth, the evidence is far from conclusive. *A priori*, one would expect the relationship to exhibit to be negative. As with our previous estimations, we hypothesize that there exists a series of direct and indirect effects of corruption on governance. We estimate the following equation:

$$Q_{it} = \beta_1 C_{it} + \beta_2 C_{it} * I_{it}^G + \beta_3 y_{it} + \beta_4 Z_{it} + \mu_i + \lambda_t + \nu_{it} \qquad (8)$$

Again, we note the presence of serial correlation in the error terms when the base estimation equation is estimated in levels and thus specify the equation in first differences.[23] Testing for the presence of endogeneity of corruption in (8)[24], we fail to reject the null hypothesis of exogeneity.[25] When investigating whether the random effects GLS estimator is more appropriate than the fixed effects Within estimator, we again reject the null hypothesis that the regressors and effects are uncorrelated and thus employ the fixed effects estimator.

Not surprisingly, both corruption's direct effect and the interaction term between corruption and public investment prove significant and have the expected negative sign. The explanatory power of this equation is among the highest of any we report in this note. Further,

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[23] We reject the null hypothesis of no serial correlation at the 1% significance level using a Durbin-Watson test for serial correlation. Re-specifying the model in first differences, we fail to reject the null hypothesis of no serial correlation.

24 We fail to reject with a test statistic of 04875 with 684 degrees of freedom.

[25] We employ different alternatives of conditioning variables to examine whether this result is robust and conclude that we fail to reject the null hypothesis with the given set of countries, time periods, and explanatory variables.

this relationship is robust to the inclusion of various conditioning variables in the Z matrix. Hence we conclude that increases in corruption are associated with declines in the quality of the bureaucracy.

What is the impact of corruption on economic growth? We turn now to the question of whether corruption significantly influences economic growth. As suggested by equation (4) of the theoretical model, GDP growth is a function of human and physical capital, and macroeconomic conditions, as the literature suggests, but also corruption and governance. Thus, we specify the estimation equation for GDP growth as

$$y_{it} = \beta_1 C_{it} + \beta_2 I_{it}^{G} + \beta_3 I_{it}^{P} + \beta_4 Q_{it} + \beta_5 H_{it} + \beta_5 Z_{it} + \mu_i + \lambda_t + \nu_{it} \qquad (9)$$

Again, we note the presence of serial correlation in the error terms when the base estimation equation is estimated in levels and thus specify the equation in first differences.[26] Testing for the presence of endogeneity of corruption in (8)[27], we fail to reject the null hypothesis of exogeneity.[28] When investigating whether the random effects GLS estimator is more appropriate than the fixed effects Within estimator, we again reject the null hypothesis that the regressors and effects are uncorrelated and thus employ the fixed effects estimator.

Curiously, corruption appears to be insignificant with respect to growth in GDP per capita, regardless of the estimated used to investigate this hypothesis. This result compliments the cross-sectional findings of Dreher and Herzfeld (2005) and Pellegrini and Gerlaugh (2004) who also fail to detect a statistically significant direct effect of corruption on economic growth. We investigated alternative specifications, to include interacting corruption with the stocks of private and public investment, yet these variables are also insignificant. We must caution that

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[26] We reject the null hypothesis of no serial correlation at the 1% significance level using a Durbin-Watson test for serial correlation. Re-specifying the model in first differences, we fail to reject the null hypothesis of no serial correlation.

27 We fail to reject with a test statistic of 1.541 with 680 degrees of freedom for the OLS model.

[28] We employ different alternatives of conditioning variables to examine whether this result is robust and conclude that we fail to reject the null hypothesis with the given set of countries, time periods, and explanatory variables.

we are examining whether the change in corruption influences the rate of growth in GDP; a much more difficult association to detect than that previously examined in the literature, that is, whether levels of GDP per capita are associated with levels of corruption. Thus, our *a priori* hypothesis that corruption appears to directly influence economic growth is not supported by the empirical evidence at this point in time.

In contrast, the expected positive impact of quality of the bureaucracy is statistically significant. The coefficient is quite large, implying that a 1% change in governance (as proxied by quality of the bureaucracy), elicits a 3.6% change in the GDP growth rate. This finding is consistent with the literature and suggests that corruption may indirect influence economic growth through its negative influence on governance. Also consistent with the literature is private investment's positive impact on economic growth which is positive and statistically significant. Curiously, public investment and human capital (as proxied by infant mortality) fail to test significant in any of the models we report. The finding on human capital is somewhat surprising and contrasts with a number of works found in the literature. Our finding on public capital is consistent with the country-specific literature that breaks down public investment by type. We must again caution that our findings are limited to our sample countries and time periods but suggest that these findings warrant further investigation.

In summary, private investment appears to be important for growth, as does governance. Public and human capital flows do not appear to influence growth, though we must caution that our measure of human capital leaves much to be desired. Corruption's impact on public and private investment is not as unambiguous as previous cross-section and country-specific time series studies suggest. We find that, for our sample countries, corruption does not appear to directly influence economic growth but does so indirectly via its interaction with public investment and governance quality. We recognize that much work needs to be done in this area, however, and merely suggest a proper accounting of corruption's influence may need to more robustly examine the indirect rather than the direct linkages between corruption and economic growth.

Conclusions and Policy Implications

In this paper a number of noteworthy issues have been explored. Some of our conclusions run counter to the conventional wisdom and evidence provided in the literature. Much of the previous work in corruption and investment has been constrained by empirical limitations more stringent than ours, and often the motivations seem ad hoc. In addition, previous works tend to rely on cross-sectional or country-specific time series, utilizing investment datasets that do not necessarily reflect reality. Our results, however, do appear to support the more recent findings (although reliant on cross-sectional data) that corruption does not directly influence economic growth.

Among the more interesting empirical findings is that there exists an interaction effect associated with public investment that dampens private investment. Corruption's impact on public investment manifests itself in such a way as to repel private investment in the presence of corruption. Private investors have objective functions which are generally different than those of persons charged with allocating public investment. Return on investment is very often not the primary concern of those involved with public investment. On the other hand, private investors demand a return and will direct their investments where they anticipate the highest return with the least variance. Undoubtedly corruption adds uncertainty to the returns. Couple this notion with the fact that numerous authors have shown private investment to be more important than public investment for economic growth, and the path to a virtuous circle becomes clear.

The impact of reduced corruption on public investment is less clear. The proxies we employ for physical public investment are less than satisfactory. Measuring the quality of other types of public investment such as military bases and education has proven difficult. However, if we consider the estimation we have already performed using infant mortality as proxy for human capital, and instead view infant mortality rates as measuring the quality of healthcare infrastructure, then we already have our answer: reduced corruption is associated with lower infant mortality rates. If one accepts the notion that infant mortality rates can serve as a valid proxy for the quality of healthcare infrastructure, then the returns to public investment from lower corruption could also be quite high.

Appendix A

Investment Sample

Country	Period	Country	Period
Argentina	1984-1999	Azerbaijan	1998-1999
Bangladesh	1984-1999	Bolivia	1987-1999
Brazil	1984-1998	Bulgaria	1990-1999
Chile	1984-1999	China	1984-1999
Colombia	1984-1999	Costa Rica	1984-1998
Cote d'Ivoire	1986-1999	Dominican Rep.	1984-1999
Ecuador	1984-1999	Egypt	1984-1999
El Salvador	1984-1999	Estonia	1998-1999
Guatemala	1984-1999	Guinea-Bissau	1987-1999
Guyana	1987-1999	Haiti	1984-1999
India	1984-1999	Indonesia	1984-1999
Iran	1984-1999	Kazakhstan	1998-1999
Kenya	1985-1999	Korea Republic	1984-1999
Lithuania	1998-1999	Madagascar	1984-1999
Malawi	1984-1999	Malaysia	1984-1999
Mexico	1984-1999	Morocco	1984-1999
Namibia	1990-1999	Nicaragua	1990-1999
Pakistan	1984-1999	Panama	1985-1999
Papua New Guinea	1984-1998	Paraguay	1984-1999
Peru	1984-1999	Philippines	1984-1999
Poland	1989-1999	Romania	1991-1999
South Africa	1984-1999	Thailand	1984-1999
Trinidad & Tobago	1984-1999	Tunisia	1984-1999
Turkey	1984-1999	Uruguay	1984-1999
Venezuela	1984-1999	Yugoslavia	1998-1999

Appendix B
Variable Appendix

	Description and Source
Bureaucratic Quality	Quality of the bureaucracy: re-scaled from 0 = Inept to 6 = Totally Competent to 0 = Inept to 1 = Totally Competent Source: International Country Risk Guide
Corruption	Corruption index: re-scaled from 0 = Inept to 6 = Totally Competent to 0 = Inept to 1 = Totally Competent Source: International Country Risk Guide
Private Investment	Public investment to Gross Domestic Product Source: Author created
Public Investment	Private investment to Gross Domestic Product Source: Author created
GDP Per Capita	Gross Domestic Product per Capita Source: World Development Indicators 2002
Current Account	Current Account Balance as a percentage of GDP Source: World Development Indicators 2002
Aid	International aid as a percentage of central government expenditures Source: World Development Indicators 2002
External Debt	External debt as a percentage of GDP Source: Global Development Finance 2002
Trade	Exports + Imports as a percentage of GDP Source: World Development Indicators 2002
Infant Mortality	Deaths per 1,000 live births Source: International Database, U.S. Census 2002
Population	Total population Source: World Development Indicators 2002

Table 1
Testing For Serial Correlation – Data in Levels

Dependent Variable N= number of observations	Durbin Watson OLS	BFN One Way Fixed Effects-Country	BFN One Way Fixed Effects-Time	BFN Two Way Fixed Effects
Private Investment / GDP N = 684	.4319	.0468	.2108	.2326
Public Investment / GDP N = 684	.3131	.0632	.0549	.1519
Quality of Bureaucracy N = 684	.4875	.0206	.0187	.3199
GDP Growth N =680	1.541	.7945	1.063	1.508
Human Capital- Infant Mortality N = 652	.2127	.0023	.0031	.0048

Table 2
Testing For Heteroscedasticity

Dependent Variable N= number of observations	B-P OLS	K-B One Way Fixed Effects-Country	K-B One Way Fixed Effects-Time	K-B Two Way Fixed Effects
Private Investment / GDP N = 684	18.36	23.36	3.04	10.73
Public Investment / GDP N = 684	16.85	427.73	397.56	230.99
Quality of Bureaucracy N = 684	28.27	2.13	.26	7.23
GDP Growth N =680	35.36	647.77	647.91	647.88
Human Capital- Infant Mortality N = 652	27.78	602.04	606.66	607.55
Human Capital- Life Expectancy N = 381	20.15	597.95	597.60	597.61

Table 3
Estimation Results

	Dependent Variable			
Explanatory Variables	Private Investment / GDP	Private Investment / GDP	Public Investment / GDP	Public Investment / GDP
Interaction: C*(Pub Inv/GDP)	-.466 (.242) *	-.455 (.241) *		
Quality of Bureaucracy	.767 (1.36)		-.488 (1.94)	1.96 (1.62)
Public Investment / GDP	-.342 (.066) ***	-.343 (.065) ***		
Current Account Balance / GDP	-.265 (.035) ***	-.266 (.035) ***		-.154 (.042) ***
Trade / GDP	.099 (.011) ***	.993 (.012) ***	.045 (.010) ***	.055 (.015) ***
Broad Money / GDP	.085 (.019) ***	084 (.019) ***		
Private Inv / GDP			-.099 (.059) *	-.256 (.075) ***
Corruption			.822 (1.88)	2.53 (1.71)
Constant	.031 (.097)	.024 (.095)		
R^2	.359	.358	.107	.258
df	565	566	678	601
Estimator	Pooled OLS	Pooled OLS	Within 1-way Time Effects	Within 1-way Time Effects

*Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. White corrected standard errors are reported.*

Table 4
Estimation Results

	Dependent Variable				
Explanatory Variables	Human Capital: Infant Mortality	Human Capital: Infant Mortality	Quality of Bureaucracy (Governance Proxy)	Growth	Growth
Quality of Bureaucracy	12.50 (13.45)			3.60 (1.72) **	3.86 (1.60) **
Public Investment / GDP				.141 (.151)	.066 (.174)
Private Investment / GDP				.269 (.093) ***	.400 (.115) ***
Budget Deficit as % GDP					.242 (.094) **
Interaction: corruption*aid as % government expenditures		1.40 (.574) **			
Interaction: corruption*public investment/GDP		12.83 (5.73) **	-.019 (.015) *		
Corruption	22.73 (11.15) **	7.79 (4.77) *	-.124 (.057) **	-2.41 (2.38)	-2.79 (2.43)
Aid as % of Imports					-.083 (.094) ***
Per Capita GDP	-.008 (.001) ***	-.0088 (.003) ***			
Human Capital Proxy: Infant Mortality				.031 (.023)	
Constant				.016 (.224)	-.124 (.234)
R^2	.457	.46	.653	.04	.075
df	572	364	568	582	431
Estimator	Within 1-way Time Effects	Within 1-way Country Effects	Within 1-way Time Effects	Pooled OLS	Pooled OLS

*Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. White corrected standard errors are reported*

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Not for Publication Theoretical Appendix

We assume a Cobb-Douglas production function for the economy such that production at time t is given by $Y_t = A_t K_t^{\alpha} G_t^{\beta} H_t^{\varphi} L_t^{\theta}$ where $\alpha, \beta, \varphi, \theta > 0$ and $\alpha + \beta + \varphi + \theta = 1$. Y_t is output, K_t, H_t, and G_t are private, human, and public capital, and L_t is labor at time t. Labor is assumed to grow exogenously at rate n. We augment the standard term for exogenous technical progress, A_t to include exogenous technical progress, T_t, the level of governance, GOV_t, and a matrix of exogenous variables that may influence output, Z_t. We assume T grows exogenously at rate w.

We assume governance to be a function of the level of corruption, C_t, and the quality of the bureaucracy, Q_B. We define A_t and GOV_t as $A_t = T_t \cdot GOV_t \cdot Z_t$ and $GOV_t = f(Q_B, C_t)$. Assuming that private investment, public investment, human capital formation, and labor force participation is a function of corruption and a broad array of other variables, Z, leads to the following: $K_t = h(C_t, Z_K)$, $G_t = i(C_t, Z_G)$, $H_t = j(C_t, Z_H)$, $L_t = k(C_t, Z_L)$.

We assume that physical and human capital inputs in the aggregate production function are subject to decreasing returns to scale, thereby implying that the economy will tend toward constant private capital-labor, public capital-labor, and human capital-labor ratios in the long-run. Following Mankiw et al. (1992), we define i_k, i_g, and i_h to be the fractions of output invested in private, public, and human capital, respectively, then $k_t = (K_t / A_t L_t)$, $g_t = (G_t / A_t L_t)$, and $h_t = (H_t / A_t L_t)$, are the stocks of private, public, and human capital per effective unit of labor. We assume further that the same production function applies to all forms of reproducible capital and consumption, so that one unit of capital can be transformed into one unit of consumption without cost, and vice versa. Recalling that labor and technology grow exogenously at rates n and w, and assuming that all capital depreciates at a uniform rate δ, we now define c to be a measure of the rate of change in C_t, the level of corruption. The growth of output is dictated over time by

$$\dot{k}_t = i_k y_t - (n + w + \delta + c) k_t \qquad [16]$$
$$\dot{g}_t = i_g y_t - (n + w + \delta + c) g_t$$
$$\dot{h}_t = i_h y_t - (n + w + \delta + c) h_t .$$

Assuming decreasing marginal returns to all forms of reproducible capital and that no combination of capital inputs exhibits constant marginal returns, the evolution of private-capital stock per effective worker over time is given by

$$\dot{k}_t = i_k y_t - (n + w + \delta + c) k_t \qquad [17]$$
$$\dot{k}_t = i_k k_t^{\alpha} g_t^{\beta} h_t^{\varphi} - (n + w + \delta + c) k_t .$$

In steady-state, the change in the rate of accumulation of private-capital stock per effective worker is zero, i.e., $\dot{k}_t = 0$, so we restate equation (17) as

$$i_k k^{*\alpha} g^{*\beta} h^{*\varphi} = (n + w + \delta + c) k^* , \qquad [18]$$

where k^*, g^*, and h^* are the steady-state stocks of private, public, and human capital stock per effective unit of labor, respectively. Noting that $g^* = \frac{i_g}{i_k} k^*$ and $h^* = \frac{i_h}{i_k} k^*$, equation (18) becomes,

$$i_k k_t^{*\alpha} \left(\frac{i_g}{i_k} k_t^*\right)^{\beta} \left(\frac{i_h}{i_k} k_t^*\right)^{\varphi} = (n + w + \delta + c) k_t^* , \qquad [19]$$

$$i_k k_t^{*\alpha} i_g^{\beta} i_k^{-\beta} k_t^{*\beta} i_h^{\varphi} i_k^{-\varphi} k_t^{*\varphi} = (n + w + \delta + c) k_t^* \qquad [20]$$
$$\text{or,} \quad i_k^{1-\beta-\varphi} i_g^{\beta} i_h^{\varphi} k_t^{*\alpha+\beta+\varphi} = (n + w + \delta + c) k_t^*$$

allowing us to solve for k^*, the steady-state level of capital stock per effective unit of labor:

$$k_t^* = \left[\frac{i_k^{1-\beta-\varphi} i_g^{\beta} i_h^{\varphi}}{(n+w+\delta+c)} \right]^{\frac{1}{1-\alpha-\beta-\varphi}} \quad . \qquad [21]$$

Following the same algebraic process we can solve for the steady-state levels of public and human capital per effective unit of labor,

$$g_t^* = \left[\frac{i_g^{1-\alpha-\varphi} i_k^{\alpha} i_h^{\varphi}}{(n+w+\delta+c)} \right]^{\frac{1}{1-\alpha-\beta-\varphi}} \quad , \qquad [22]$$

$$h_t^* = \left[\frac{i_h^{1-\alpha-\beta} i_k^{\alpha} i_g^{\beta}}{(n+w+\delta+c)} \right]^{\frac{1}{1-\alpha-\beta-\varphi}} \quad . \qquad [23]$$

The key insights provided by equations (21), (22), and (23) are that corruption lowers the steady-state levels of all three types of capital, i.e., as *c* increases, k^*, g^*, and h^*, are each lower than with no corruption present.

We now turn to the task of solving for the steady-state level of output per effective unit of labor. If we substitute equations (21), (22), and (23) into (1), and note that

$y^* = Y^* / (A_t L_t)$, we find

$$y_t^* = \left[\frac{i_k^{1-\beta-\varphi} i_g^{\beta} i_h^{\varphi}}{(n+w+\delta+c)} \right]^{\frac{\alpha}{1-\alpha-\beta-\varphi}} \left[\frac{i_g^{1-\alpha-\varphi} i_k^{\alpha} i_h^{\varphi}}{(n+w+\delta+c)} \right]^{\frac{\beta}{1-\alpha-\beta-\varphi}} \left[\frac{i_h^{1-\alpha-\beta} i_k^{\alpha} i_g^{\beta}}{(n+w+\delta+c)} \right]^{\frac{\varphi}{1-\alpha-\beta-\phi}} \quad . \qquad [24]$$

Reorganizing equation (24) yields

$$y_t^* = \left(\frac{1}{n+w+\delta+c}\right)^{\frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}} \left(i_k\right)^{\frac{\alpha}{1-\alpha-\beta-\varphi}} \left(i_g\right)^{\frac{\beta}{1-\alpha-\beta-\varphi}} \left(i_h\right)^{\frac{\varphi}{1-\alpha-\beta-\varphi}} \quad . \qquad [25]$$

Equation (25) makes the potential impact of corruption readily apparent, any reduction in *c* also improves the steady state level of output per effective unit of labor and vice-versa. This result suggests that actions to lower C_t (negative c) results in a higher level of steady state output per effective unit of labor.

Let $\hat{y}$ be actual output per effective worker at time t, then approximating about the steady state we define the rate of convergence as

$$\frac{\partial \ln \hat{y}(t)}{\partial t} = \lambda\left[\ln(y^*) - \ln \hat{y}(t)\right] \qquad [26]$$

where $\lambda = (n + w + \delta + c)(1 - \alpha - \beta - \varphi)$.

If we let t_1 and t_2 be points in time, $t_2 > t_1$, and define $\tau = (t_2 - t_1)$, then equation (26) implies that

$$\ln \hat{y}(t_2) = (1 - e^{-\lambda\tau})\ln y^* + e^{-\lambda\tau} \ln \hat{y}(t_1) \qquad [27]$$

where $\hat{y}(t_1)$ is income per effective worker.

Then,

$$\begin{aligned} \ln \hat{y}(t_2) - \ln \hat{y}(t_1) &= (1 - e^{-\lambda\tau})\ln y^* + e^{-\lambda\tau} \ln \hat{y}(t_1) - \ln \hat{y}(t_1) \\ &= (1 - e^{-\lambda\tau})(\ln y^* - \ln \hat{y}(t_1)) \end{aligned} \qquad [28]$$

Since we cannot observe steady state output in equation (28), we substitute for y^* using equation (25) to get output per effective unit of labor:

$$\begin{aligned} \ln \hat{y}(t_2) - \ln \hat{y}(t_1) = {} & (1 - e^{-\lambda\tau})\ln\left[\left(\frac{1}{n + w + \delta + c}\right)^{\frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}} (i_k)^{\frac{\alpha}{1-\alpha-\beta-\varphi}} (i_g)^{\frac{\beta}{1-\alpha-\beta-\varphi}} (i_h)^{\frac{\varphi}{1-\alpha-\beta-\varphi}} \right] \\ & - (1 - e^{-\lambda\tau})\ln \hat{y}(t_1) \end{aligned} \qquad [29]$$

Expanding and taking logs,

$$\ln\hat{y}(t_2) - \ln\hat{y}(t_1) = \quad [30]$$

$$(1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + (1-e^{-\lambda\tau})\frac{\beta}{1-\alpha-\beta-\varphi}\ln i_h + (1-e^{-\lambda\tau})\frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_g$$

$$-\frac{\alpha+\beta+\varphi}{n+w+\delta+c}(1-e^{-\lambda\tau})\ln(n+w+\delta+c) - (1-e^{-\lambda\tau})\ln\hat{y}(t_1)$$

Note, however, that equation (30) this is expressed in output per effective unit of labor and Mankiw et al. (1992) and Islam (1995) use output *per capita*. We can, therefore, re-express this equation by noting that output per effective unit of labor is $\hat{y}(t) = Y(t)/A(t)L(t)$. Thus,

$$\ln\hat{y}(t) = \ln(Y(t)/L(t)) - \ln A(t) \quad [31]$$

$$\ln\hat{y}(t) = \ln y(t) - \ln A(t)$$

where *ln y(t)* is the log of output per capita and *A(t)* is defined as before.

Substituting $\hat{y}(t)$ into equation (29) yields the typical "growth – initial level" equation,

$$\ln y(t_2) - \ln A(t_2) - (\ln y(t_1) - \ln A(t_1)) = (1-e^{-\lambda\tau}) \cdot \quad [32]$$

$$\left[\frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \frac{\beta}{1-\alpha-\beta-\varphi}\ln i_g + \frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_h - \frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+w+\delta+c)\right]$$

$$-(1-e^{-\lambda\tau})(\ln y(t_1) - \ln A(t_1))$$

Thus,

$$\ln y(t_2) - \ln y(t_1) = (1-e^{-\lambda\tau}) \cdot \quad [33]$$

$$\left[\frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \frac{\beta}{1-\alpha-\beta-\varphi}\ln i_g + \frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_h - \frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+w+\delta+c)\right]$$

$$-(1-e^{-\lambda\tau})\ln y(t_1) + (1-e^{-\lambda\tau})\ln A(t_1) + \ln A(t_2) - \ln A(t_1)$$

or,

$$\ln y(t_2) - \ln y(t_1) = (1-e^{-\lambda\tau}) \cdot \quad [34]$$

$$\left[\frac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \frac{\beta}{1-\alpha-\beta-\varphi}\ln i_g + \frac{\varphi}{1-\alpha-\beta-\varphi}\ln i_h - \frac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+w+\delta+c)\right]$$

$$-(1-e^{-\lambda\tau})\ln y(t_1) + \ln A(t_2) - e^{-\lambda\tau}\ln A(t_1)$$

This is a useful result: we have an equation where the difference in per capita output is a function of the difference in *A*. We have stated per capita output in terms of the change of *A(t)* and other factors. Following Islam (1995), we note that if $A(t_1)$ represents the initial conditions, then $A(t_1)$ is unobserved and $e^{-\lambda\tau} A(t_1)$ is the unobserved country-specific effect. To see this, note that we do not observe *T(0), GOV(0),* or *Z(0)*.

We thus have a model for the change in per capita output that illustrates the role of governance and corruption on the convergence path and other things, or

$$\ln y(t_2) - \ln y(t_1) = (1-e^{-\lambda\tau}) \cdot \left[\begin{array}{l} \ln T(t_2) + \ln GOV(t_2) + \ln Z(t_2) + \dfrac{\alpha}{1-\alpha-\beta-\varphi}\ln i_k + \dfrac{\beta}{1-\alpha-\beta-\varphi}\ln i_g \\ \qquad + \dfrac{\varphi}{1-\alpha-\beta-\varphi}\ln i_h - \dfrac{\alpha+\beta+\varphi}{1-\alpha-\beta-\varphi}\ln(n+w+\delta+c) - \ln y(t_1) \\ \qquad\qquad \underline{\underline{-e^{-\lambda\tau}T(t_1) - e^{-\lambda\tau}\ln GOV(t_1) - e^{-\lambda\tau}\ln Z(t_1)}} \end{array} \right] \quad [35]$$

Note that the term with the double underline is our unobservable initial conditions.