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Economic growth with endogenous corruption: an empirical study

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Abstract The effect of corruption on the rate of economic growth for a panel of countries during 1984–2007 is investigated using recent improvements in dynamic panel data techniques to control for the endogeneity of corruption and investment. Corruption has a significant effect on the growth rate of real per capita income. This effect is non-linear.

Keywords Corruption · Growth · Panel data

1 Introduction

Corruption generally is defined as the use of public office for private gains (Bardhan 1997). The main forms of corruption are bribes received by public officials, embezzlement by public officials of resources they are entrusted to administer, fraud in the form of manipulating information to further public officials' personal goals, extortion, and favoritism (Andvig and Fjeldstad 2001). Corruption by the highest political decision makers is known as *political* or *grand* corruption. Political corruption involves relatively large bribes paid to influence policy formulation and major contract awards tailored to favor private interests. *Bureaucratic* and *judicial* corruption is corruption by bureaucrats and judicial officials involved in implementing existing policies in their daily interaction with the citizens of the country. Given that corrupt behavior of public officials affects the cost and incentive structures faced by the firms and households, economists have long been interested in analyzing how corruption affects the performance of an economy, particularly the rate of growth of an economy.

In our detailed review of the current literature, we find that the conclusions on the effect of corruption on the rate of growth of an economy are hesitant and qualified at best. This is because the interaction between growth and corruption presents four estimation challenges that have yet to be taken into account simultaneously: First, time invariant heterogeneity among

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countries in terms of religion, culture, and institutions has an important role in explaining cross country differences in corruption (Treisman 2000) as well as the rate of growth (Islam 1995). Since the particular nomenclature of such time invariant heterogeneity in a country 'selects' the event to be explained (the rate of growth) and the explanatory variable of interest (the level of corruption), there is a omitted variable problem (Heckman 1979; Woolridge 2002) and cross-sectional ordinary least-squares (OLS) models lead to biased estimates. Second, corruption and investment are endogenously determined in the sense that they are both correlated with exogenous shocks that affect the rate of economic growth. The quality of the instruments used to control for the endogeneity, therefore, has a bearing on the bias and consistency of the estimate of corruption's partial effect on the rate of growth of an economy. Third, the rate of economic growth has persistence, i.e., the current growth rate is correlated with its own lagged value. This leads to an additional endogeneity problem when using a cross-sectional model that has lagged growth rate as a right-hand regressor. Lagged growth rate is correlated with the error term because the latter includes time invariant country specific factors.

A higher incidence of corruption means a larger number of occurrences of corrupt activities in the case of all commonly used measures of corruption. This means that for any two points in a corruption scale the number of participants in the market for corruption is different and the effect of corruption on growth may depend on how these participants are organized. The fourth estimation challenge arises from this fact. Shleifer and Vishny (1993), e.g., show that when corrupt public officials work as independent monopolists seeking respective bribes, corruption is pervasive and output is driven down by corruption to a very low level. On the other hand, when public officials work jointly as a multi-plant monopolist, the number of times a bribe is sought and, therefore, the perception of corruption is low, and the loss of output is smaller. In a similar vein, Olson (2000) argues that when each corrupt official is one of many with a narrow stake in the society, the negative effect of corruption is at its highest compared to a situation when the corrupt officials work together because of an encompassing interest in how much is produced. Thus, as we move along a corruption scale, the organization of corruption may be changing as well and this may lead to a non-linearity in the effect of corruption on output which existing works have ignored.

The aim of this paper is to examine the effect of corruption on the rate of growth of real GDP per capita after allowing for unobserved country fixed effects (FE), the endogeneity of corruption and investment, the persistence of growth and differences in how the market for corruption is organized. We find that the direct effect of corruption on the rate of growth of real per capita income is economically and statistically significant, and that the effect is non-linear.

The paper is organized as follows. Section 2 presents an overview of the literature on the effect of corruption on growth. Section 3 details the empirical strategy. Section 4 presents the data used to implement the strategy. Section 5 presents and discusses the empirical results. Section 6 concludes.

2 The current literature

2.1 Change in measures to reduce corruption vs. change in the incidence of corruption

An important qualification to note is that the incidence of corruption is not a variable that policy makers control directly. What policy makers control are measures aimed at changing the incidence of corruption. These measures vary widely in their nature and effectiveness.

Also, there is evidence that the implementation of such measures (e.g., making the economy more open) do not produce immediate growth effects. Hausman et al. (2005), e.g., report that most instances of economic reform[1] do not produce growth acceleration and Giavazzi and Tabellini (2005) report that reforms affect growth positively after a lag of 4 years and the perception of the quality of governance (corruption) after a lag of 3 years. In the discussion that follows, our focus is on the effect of a change in the incidence of corruption that has already taken place on the rate of growth of real per capita GDP without any reference to how the change came about.[2]

2.2 Predictions from the theoretical literature

In the theoretical literature on the effect of corruption on economic growth, human capital generally is identified as the engine of growth. Public officials create opportunities for bribes through discretionary changes and/or enforcement of the incentive regime framed by public policies. Firms expend some of their endowments as bribes in rent seeking or the avoidance of rent destruction instead of augmenting human capital. As a result, the accumulation of human capital is affected adversely, and consequently, the rate of growth is lower (Murphy et al. 1991; Pecorino 1992). For a given exogenously determined amount of rent in an economy, the growth reducing effect of corruption is larger in countries with a low level of human capital, typically low income countries (Ehrlich and Lui 1999).

Assuming that human capital accumulation always carries a positive return, the above perspective implies that corruption is always growth reducing and the optimal level of corruption is zero. Opponents of this view argue that when public policies create opportunities for rent, they may do so by restricting competition among firms and, therefore, by restricting aggregate output. Corruption weakens the restriction on output by greasing the wheels of government for firms burdened by controls and, therefore, corruption is growth enhancing (Leff 1964; Huntington 1968; Friedrich 1972; Nye 1989). Thus, in a second best world with public policy restrictions on output leading to opportunities for rent, the growth maximizing incidence of corruption is non-zero.

Rose-Ackerman (1997) disputes the existence of a stable growth enhancing equilibrium level of corruption. She argues that corruption will always escalate to ever higher levels. Indeed, Kaufman (1998) and Kaufman and Wei (2000) find that in economies where corruption is high and more bribes have to be paid, managers end up allocating more time with public officials and less time in productive work.

Aidt (2003) points out that the case for a growth-maximizing non-zero level of corruption is based on the following problematic assumptions: Public officials care about the maximization of output,[3] not bribes; real resources are not expended in the search for partners in corruption and in keeping the transactions secret; the diversion of tax revenue from the treasury to the corrupt officials does not create an excess burden of taxation; corrupt contracts are all enforceable; and the distortions from government interventions that corruption

[1] Measured by the degree of openness of an economy.

[2] Policy makers can institute measures to reduce corruption; however, the change in the incidence of corruption occurs with a lag as all decision makers—including the policy makers—adjust their respective *private* behavior (including grand corruption) in response to the change. Our paper examines how growth is influenced by the aggregate of all economic agents' choice of corruption consequent to their respective private utility maximizing behavior *ex post*.

[3] In Olson's (2000: 4) terminology, the public officials have an encompassing interest in the economy.

is supposed to smooth are exogenous. Be that as it may, in a second best world with opportunities to seek bribes, the optimal incidence of corruption may still work out to be non-zero because prevention of corruption by public officials needs close monitoring which is costly (Acemoglu and Verdier 1998; Klitgaard 1988).

2.3 The empirical literature—findings and methodology

Mauro (1995) is the seminal empirical work which investigates the interaction between corruption and growth. Mauro reports that much of corruption's effect on growth takes place through the effect on investment. In subsequent works, Mo (2001) and Pelligrini and Gerlagh (2004) identify human capital, political stability, and trade openness as additional channels through which corruption affects growth. These authors use cross-sectional models with the average rate of economic growth as the dependent variable and a set of control variables (commonly initial GDP, investment, primary and secondary education enrollment rates, population growth rate, political stability, government expenditure) following Barro (1991) and Levine and Renelt (1992). Mauro treats the endogeneity of corruption and the endogeneity of investment separately. Both Mo and Pelligrini and Gerlagh treat investment and corruption as exogenously determined. In all three works, the authors report that when the economic growth rate is regressed on corruption while leaving out the channels of transmission (investment, human capital, political stability, and openness), corruption has a statistically significant negative effect on the growth rate. However, when the channels of transmission are added to the regression model, corruption ceases to be a significant explanatory variable. The conclusion from these studies is that corruption affects the rate of growth of an economy not directly but indirectly by lowering the investment rate, the rate of human capital accumulation, political stability, and the degree of openness.

Evidence of a direct effect of corruption on economic growth in a cross-sectional setting is sought by Méon and Sekkat (2005). Méon and Sekkat's methodology is different from the previously discussed works in that they add an interaction term between corruption and the quality of the government as an explanatory variable to the generic model discussed above. The underlying argument for this term is that corruption is an additional distortion separate from an existing distortion in the form of poor governance. They find that if governance is of very poor quality, an increase in corruption reduces the growth rate. As the quality of governance improves, the negative impact of corruption becomes weaker. One problem with this approach is that corruption and the quality of governance should not be treated as unrelated distortions because both are often parts of an integrated system of corruption (Bardhan 1997). Indeed, the measures of corruption used by the authors (the Corruption Perceptions Index provided by Transparency International (2009) and the Control of Corruption Index provided by the World Bank) apply to overall corruption—bureaucratic, political, and judicial corruption—not just bureaucratic corruption (which is what the corruption variable in Méon and Sekkat's model seeks to measure). Thus, corruption and the quality of governance are highly correlated with one another in which case the interaction term between corruption and governance considered by Méon and Sekkat works to magnify the effect of corruption when corruption is high (and governance is of poor quality).

Ehrlich and Lui (1999) and Mendez and Sepulveda (2006) use panel data to address the problem of the endogeneity of corruption through country time invariant fixed effects such as culture, colonial past, geographical location, and religion that the cross-sectional analyses mentioned above are unable to address. Ehrlich and Lui report that for a sample of 68 countries corruption affects the level of GDP, not the rate of economic growth. Mendez and Sepulveda find that in countries with more 'freedom', corruption and growth are negatively and non-linearly related. In the case of countries which are not 'free', the relationship between corruption and economic growth is not statistically significant.[4] Neither work addresses the problem posed by the endogeneity of corruption and investment.

Olson et al. (2000) contest the validity of the use of panel data techniques to study the relationship between corruption and growth. Their view is that corruption does not show enough within-country variation for a fixed-effect regression of the growth rate on corruption and other control variables to be useful. They treat corruption as a time invariant country fixed factor. The growth effect of all such country fixed factors is estimated as the residual of a fixed effects regression of the growth rate of output on the growth of capital stock and labor for a panel of countries in a first stage. In a second stage, the estimated residuals are regressed on corruption and other control variables. The authors find that corruption has a significant negative effect on the rate of growth of productivity. This econometric method is comparable to a cross-sectional regression of the rate of growth of productivity on corruption after controlling for variations in the growth of capital stock and labor across country and across time. The authors argue that the endogeneity of corruption is not a serious problem and that their cross-sectional estimates are free of bias.[5] We believe that this is a very strong assumption. The residuals from the first stage regressions are measures of the combined effect of time invariant country fixed factors like religion, culture, colonial history, and institutions on the growth of productivity. These time invariant country fixed factors are correlated with the incidence of corruption according to Treisman (2000) and, therefore, the coefficient estimates from the second stage regression are biased.

3 The empirical strategy

3.1 The proposed structural econometric model

Following the standard practice in the literature we start with a model of economic growth. The explanatory variables are ones used in the literature and we do not motivate these. To specify our structural econometric model, we first extend the traditional cross section model into a panel data model as follows:

$$g_{i,t} = \alpha_0 + \alpha_1 \mathrm{GDP}_{i,0} + \alpha_2 \mathrm{CORR} + \boldsymbol{\beta}^1 \mathbf{X}^{1'}_{i,t} + \boldsymbol{\beta}^2 \mathbf{X}^{2'}_{i,t} + \mu_i + v_{i,t}, \quad (1)$$

where g stands for growth rate of real per capita GDP, GDP for gross domestic product, and CORR for the incidence of corruption. $\mathbf{X}^1$ is a column vector of exogenous explanatory variables and includes PEDU (primary education enrollment rate), SEDU (secondary education enrollment rate), and POP (the growth rate of population). $\mathbf{X}^2$ is a column vector of explanatory variables that includes OPEN (the trade-GDP ratio), POLSTAB (political stability), GE (government expenditure as a share of GDP), and INV (investment-GDP ratio). CORR and $\mathbf{X}^2$ are endogenous in the sense that they are correlated with the error term $v_{i,t}$. $\boldsymbol{\beta}^1$ and $\boldsymbol{\beta}^2$ are vectors of coefficients. The unobserved country fixed effect (the omitted variable in an OLS

[4]The authors use the index of freedom from Freedom House International to classify countries as ‘free’ and ‘not free’.

[5]The authors believe that simultaneity bias is only a theoretical, not a real, possibility in the relation between productivity growth and governance (corruption). In support of their view, the authors argue that in many countries a change in the quality of governance has occurred without a prior change in income or productivity, and that while oil price shocks have increased the income of oil exporting countries, they did not improve their institutions.

model) is represented by μ. INV and CORR—and possibly other explanatory variables—are correlated with μ. $\text{GDP}_{i,0}$ represents an initial value for real per capita GDP. Subscripts i ($i = 1, \ldots, N$) and t ($t = 1, \ldots, T$) index country and time, respectively.

The incidence of corruption and its effect on output and growth are influenced by how the market for corruption is organized and by the nature of services provided by public officials (Shleifer and Vishny 1993; Celentani and Ganuza 2002). In an economy where firms rely on public officials for several complementary inputs, if public officials act as decentralized independent monopolists in their respective spheres of influence, corruption is most harmful to growth. This is also the case when corruption is pervasive in terms of the number of times a bribe is sought as well as in terms of the aggregate sum of bribes sought. Such cases correspond to countries where corruption is perceived to be very high. Output is driven down by corruption to a very low level and the size of bribes collected is large relative to output. If, on the other hand, the public officials act jointly to maximize the collective bribe the adverse effect of corruption is smaller. In this case, the number of times a bribe is sought and the aggregate sum of bribes sought is lower and, therefore, the perception of corruption is lower. Bardhan (1997) appropriately labels such centralized corruption as a system of 'lump-sum' corruption which is less distortionary at the margin than decentralized corruption.

Note, however, that when public officials are engaged mostly in providing standalone services which are narrowly defined and not complementary (e.g., driver's license and hunting license services in the United States), they cannot act as independent monopolists. In such a case, decentralized bribe seeking leads to a lower incidence of corruption. Also, in countries where political power is completely centralized (e.g., Zaire under Mobuto and Indonesia under Suharto) public policy is up for sale at the highest level.[6] Corruption is highly centralized in such countries and public officials' malfeasance is an addition to the corruption by the dictator so that the perception of corruption will be high and corruption will be more distortionary even though it is highly centralized.

For our panel, as the incidence of corruption increases, we expect its marginal effect on growth to change. To test for this non-linearity, we add squared corruption (CORR^2) as an explanatory variable. A negative sign will support the hypothesis that at a high level of incidence corruption is decentralized and more growth reducing. A positive sign will suggest that the relationship between the organization of corruption and its effect on growth is tenuous.

Applying the definition of a country's growth rate ($g_{i,t} = \log \text{GDP}_{i,t} - \log \text{GDP}_{i,t-1}$), rearranging terms and adding squared corruption (CORR^2) as an explanatory variable, we have a dynamic panel data model with the logged level of real per capita income as the dependent variable.[7]

$$\log \text{GDP}_{i,t} = \gamma_0 + \gamma_1 \text{GDP}_i^0 + \gamma_2 \text{GDP}_{i,t-1} + \gamma_3 \text{CORR}_{i,t} + \gamma_4 \text{CORR}_{i,t}^2 + \boldsymbol{\beta}^1 \mathbf{X}_{i,t}^{1'} + \boldsymbol{\beta}^2 \mathbf{X}_{i,t}^{2'} + \mu_i + \varepsilon_{i,t}. \tag{2}$$

The coefficient for corruption in (2) measures the change in the logarithm of current year's GDP (i.e., the change in growth of per capita income in percentage point terms) owing to a change in corruption holding constant last period's GDP and other control variables.[8]

[6] See Fisman (2001) for a discussion of the value of Suharto's power to those who obtained access to the dictator.

[7] Neeman et al. (2008) presents an excellent discussion of the merit of choosing the level of GDP rather than growth rate as the dependent variable.

[8] We can now elaborate the estimation challenge resulting from the persistence of a dependent variable. $E(\log \text{GDP}_{i,t-1}\mu_i) \neq 0$ by assumption which renders the OLS estimator biased. In the case of a fixed ef-

3.2 The Arellano–Bond GMM first difference estimator

Arellano and Bond (1991) present a method (AB first difference GMM method) that is suited for estimating this dynamic model for a panel of countries with data available for a short time span (N is large and T is small). The estimating equation in the AB first difference GMM method is the structural equation (2) in first difference:

$$\begin{aligned}\log\mathrm{GDP}_{i,t}-\log\mathrm{GDP}_{i,t-1}&=\gamma_2(\log\mathrm{GDP}_{i,t-1}-\log\mathrm{GDP}_{i,t-2})+\gamma_3\big(\mathrm{CORR}_{i,t}-\mathrm{CORR}_{i,t-1}\big)\\&\quad+\gamma_4\big(\mathrm{CORR}^2_{i,t}-\mathrm{CORR}^2_{i,t-1}\big)+\boldsymbol{\beta}^1\big(\mathbf{X}^{1'}_{i,t}-\mathbf{X}^{1'}_{i,t-1}\big)\\&\quad+\boldsymbol{\beta}^2\big(\mathbf{X}^{2'}_{i,t}-\mathbf{X}^{2'}_{i,t-1}\big)+(\varepsilon_{i,t}-\varepsilon_{i,t-1}).\end{aligned}\tag{3}$$

With μ_i eliminated, the AB method uses internal instruments for each of the first differenced explanatory variables. For strictly exogenous variables, the first differenced term $(\mathbf{X}^{1'}_{i,t}-\mathbf{X}^{1'}_{i,t-1})$ is instrumented by itself. In the case of endogenous variables, $(\mathbf{X}^{2'}_{i,t}-\mathbf{X}^{2'}_{i,t-1})$ can be instrumented by $\mathbf{X}^{2'}_{i,t-2}$ under the assumption that $E[\mathbf{X}^2_{i,t-s},(\varepsilon_{i,t}-\varepsilon_{i,t-1})]=0$ for $s\geq 2$; $t=3,\ldots,$ i.e., that current shocks are uncorrelated with the level of corruption (and other endogenous variables) two periods ago. A similar assumption, i.e., $E[\log\mathrm{GDP}_{i,t-s},(\varepsilon_{i,t}-\varepsilon_{i,t-s})]=0$, for $s\geq 2$; $t=3,\ldots,T$, allows the term $(\log\mathrm{GDP}_{i,t-1}-\log\mathrm{GDP}_{i,t-2})$ to be instrumented by $\log\mathrm{GDP}_{i,t-2}$.

3.3 The Blundell–Bond GMM system estimator

Blundell and Bond (1998) show that in situations when the lagged dependent and explanatory variables are persistent, as they are in our case, the lagged-level instruments are weak, which compromises the asymptotic precision of the AB (1991) estimator.[9] Additionally, the first differencing used in the AB method worsens the bias due to measurement errors in variables (Griliches and Hausman 1986).

Blundell and Bond (1998) propose a generalized method of moments system estimator (GMM system estimator) to address these problems. The system estimator jointly estimates the dynamic regression equation (2) in first differences and levels, using different sets of instruments for each part. The instruments for the equation in first difference are lagged level values of the endogenous variables and first differences of the exogenous variables. The instruments for the equation in levels are lagged differences of the endogenous variables under the weak assumption that the country effect is time invariant. Thus, in the system GMM estimator of the dynamic model in (2), the internal instruments are lagged levels and lagged differences of all endogenous variables and differences of all exogenous variables. Additional instruments (in level or difference) can be added for the level or difference equations or both.[10] Relative to the first difference GMM estimator, the extra moment conditions in a system GMM estimator improve the precision and lower the finite sample bias—particularly with panel data having a short time span and persistent series (Blundell and Bond 2000; Blundell et al. 2000, as reported in Baltagi 2005).

fects (FE) estimator, the within transformation eliminates μ, but the transformed variable $(\log\mathrm{GDP}_{i,t-1}-\overline{\log\mathrm{GDP}}_{i,-1})$ is now correlated with $(\varepsilon_{i,t}-\overline{\varepsilon}_{i,.})$ because $\overline{\log\mathrm{GDP}}_{i,t-1}=\sum_{t=2}^{T}\log\mathrm{GDP}_{i,t-1}/(T-1)$ is correlated with $\overline{\varepsilon}_{i,.}$, as $\overline{\varepsilon}_{i,.}$ includes $\varepsilon_{i,t-1}$ (Baltagi 2005).

[9] See Baltagi (2005) for an excellent discussion on the poor precision of the first difference AB (1991) GMM estimator.

[10] We add the lagged gross national saving (GNS) rate as an instrument for the differenced equation.

3.4 Addressing bias in the variance-covariance matrix

The unknown weighting matrix for system GMM estimation is obtained in two steps. In the first step, the model is estimated under an assumption of homoscedasticity over time and across countries. The first step residuals are used to construct a consistent variance—covariance matrix of the moment conditions. This is then used to re-estimate the coefficients in a second step. The estimated standard error of the two-step GMM estimator is known to be biased downwards. Windmeijer (2005) presents a bias-corrected robust estimator for the variance—covariance matrix that can be substituted for the standard variance—covariance matrix used in the two-step system GMM estimator to obtain robust standard errors for the two-step estimator.

3.5 Statistical tests of the GMM system estimator

Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) suggest two tests for the GMM system estimator, a Sargan test of over-identifying restrictions to test the validity of the instruments[11] and a test of the absence of second-order serial correlation in the differenced error term. A failure to reject the null hypothesis in both cases supports the model.

3.6 Rigging the model for the long-run

Finally, our structural model is derived from a model of economic growth that focuses on the long-run relationship between the level of real per capita GDP and its determinants. When switching from cross section to panel analysis, we can select each year as a data (time) point or the average of a number of years as a data point. Islam (1995) favors the latter, arguing that with yearly data points short-term disturbances may loom large. He chose 5-year spans. We do the same in our paper. Thus, the time subscript in our model stands for 5-yearly averages of the observations.

4 The data

4.1 The unreliability of objective measures of corruption

Corruption occurs in secret and is not directly observable. Reliability of the measurement of corruption is, therefore, a key issue in any empirical study. A reliable measure must be able to quantify the frequency and the depth of corruption and be comparable over time and across countries.

Possible objective measures of corruption, such as the number of corruption related convictions or the number of corruption cases reported in the press, do not reflect the incidence of corruption alone. They also measure the performance of the judiciary and freedom of the press. Both vary from country to country. Also, measures based on such objective definitions are difficult to compare because countries differ in their legal definitions of bribery and corruption. Separating fraud and embezzlement from corruption is also difficult.

[11] There is a concern that the Sargan test is undersized in cases when the number of time periods (T) is large relative to the number of cross-sectional units (N) as there are too many moment conditions leading to zero rejection rate under the null and the alternative (Baltagi 2005). This is not a concern in the present study because our panel consists of 117 countries and five time periods.

4.2 Subjective measures of corruption used in the literature

The current literature on corruption commonly uses subjective measures created by Transparency International (TI), the World Bank (WB) and Political Risk Services (PRS). Some early empirical works use measures prepared by Business International (BI).[12] The TI and WB measures are composite indices based on individual surveys of corruption. The PRS and BI measures are expert rankings by specialized institutions. It is generally accepted that these measures equally reflect the frequency of corruption as well as its depth. The measures are also highly correlated with one another.

4.3 The ICRG index

The corruption in government index from the International Country Risk Guide prepared by Political Risk Services (referred to as the ICRG index hereafter) is available from 1984. The ICRG index allows for cross country comparison and has wide usage starting with Knack and Keefer (1995). Braun and Di Tella (2004), Dreher and Siemens (2003), and Dal Bó and Rossi (2007) all employ the ICRG index.

The ICRG index is a measure of corruption within the political system that threatens foreign investment by distorting the economic and financial environment, reducing the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability. Critics point to four weaknesses of the ICRG index as a measure of corruption (Williams and Siddique 2008). First, the ICRG index strictly measures the risk to political stability owing to corruption—not corruption itself. Second, the index is compiled for foreign investors by non-resident country experts and seeks to measure only corruption that threatens foreign investment rather than corruption faced by all firms, foreign and domestic. Third, the focus on foreign investment may mean that more expert resources are allocated to assess corruption in relatively larger economies (that are preferred destinations of foreign investment) and less to smaller economies leading to greater measurement error in case of the latter group. Fourth, the ICRG rating scores may lag the major events they seek to measure, and thus may be an inaccurate reflection of current conditions.

We believe that although the ICRG index is not a direct measure of corruption, it is still a good proxy of corruption under the reasonable assumptions that (i) the perceived threat of political instability to foreign investors owing to corruption (which is what the ICRG index measures) increases linearly with the incidence of corruption in the country, (ii) corrupt public officials make no distinction at the margin between foreign and domestic firms when it comes to extracting bribes, and (iii) the experts use the same range of information for all countries when assessing country risks. The problem that the ICRG index may be an inaccurate measure of current corruption is addressed if long-run averages are used (an average of the ICRG index for 5 years in place of the annual ICRG index) as we do in this paper.

The ICRG index ranges from zero to six with a higher number signifying lower corruption. For ease of interpretation, we rescaled the index as $\mathrm{CORR} = 6 - \mathrm{ICRG}$ so that a higher number means a higher incidence of corruption.

[12] BI was later taken over by the Economist Intelligence Unit (EIU). EIU rankings are used in the composite indices prepared by TI and the WB.

4.4 The CPI index

We use the TI's CPI index to check for the robustness of our estimates using the ICRG index. The CPI is a composite index based on individual surveys of corruption and it ranges from zero to ten with a score of ten signifying the least corruption. We rescaled the index ($\text{CORR} = 10 - \text{CPI}$) so that a high score means that corruption is perceived to be high. The CPI index is available from 1995. The usefulness of the CPI in year-to-year comparisons is questioned by many (Williams and Siddique 2008) due to the fact that the set of countries covered by the index has changed over time as new countries have been added. Additions of new data sources improve the precision of estimates of the incidence of corruption, which can disturb the continuity of an index. Lambsdorff (1999) argues that this is similar to the problem of designing the price index for a basket of goods when the composition of the basket actually is changing. According to Lambsdorff (2004), the effect of a changing sample and methodology on the continuity of the CPI appears to be small, particularly when looking at the long-term trend. A number of previous works use the CPI panel, e.g., Gyimah-Brempong and de Comacho (2006), Gyimah-Brempong (2002), and Ganuza and Hauk (2000).

4.5 Between and within variation in corruption

Summary data on corruption measured by the ICRG index and the CPI (Table 1) reveal sufficient between and within variation in corruption for a meaningful panel-data analysis. The average of the ICRG index for 143 countries varies between 0.51 and 6 and the variation within a country from respective country averages ranges from 0.52 to 5.23. The annual average of CPI for a country varies between 1.57 and 9.60 and the variation within a country from the respective country averages ranges from 3.11 and 5.33. In the case of Bangladesh, e.g., a country with persistent and high corruption, the annual average for the ICRG index is 1.16. The deviation from this average in a particular period varied from zero to two leading to a within standard deviation of 0.76 in the ICRG index for Bangladesh.

4.6 Definition and source for data on other variables

Political stability is proxied by how 'durable' a 'polity' is. A *polity* is an organized body (government) with five clusters of dimensions of authority. *Durable* measures the number of years since the most recent regime change. If a regime is stable, then the durability score will be higher by one point in each successive year. We expect that higher durability across time and countries has a positive effect on the growth of per capita income. The regime durability measure is obtained from the Polity IV data base.[13]

Data on all other variables have been obtained from the World Bank's World Development Indicators database (2007). The summary statistics are presented in Table 1. The variable definitions can be seen in the Appendix.

[13] Readers are referred to Marshall and Jaggers (2002) for a discussion of the Polity IV (2007) data base and the variable definitions.

Table 1 Summary statistics

Variable	Symbol	Standard deviation			Number of
		Mean	Within	Overall	countries
Real GDP per capita[a] (2000 US $)		5725	1592	8694	166
Primary enrollment rate (%)	Pedu	98.32	9.33	19.32	168
Secondary enrollment rate (%)	Sedu	67.16	8.96	32.75	167
Population growth rate (%)	Pop	1.59	1.40	0.81	172
Political stability (years)	Polstab	23.78	29.87	8.10	150
Openness (%)	Open	66.17	19.57	46.30	168
Gov. exp/GDP (%)	GE	16.42	2.91	7.02	169
Investment/GDP (%)	Inv	22.51	4.43	7.90	170
Corruption:	CORR				
ICRG index		3.05	0.65	1.32	143
CPI index		4.30	0.30	2.24	169

[a]Note: Rounded to the nearest dollar

5 Empirical results

5.1 Cross-section model

The results from a single cross-section regression are reported in Table 2. The dependent variable is the average annual growth rate of real per capita GDP during 1984–2007. The explanatory variables are the initial real GDP per capita (real GDP per capita in 1985), the average values of the determinants of growth commonly considered by previous authors (Mauro 1995; Mo 2001; Pelligrini and Gerlagh 2004; Méon and Sekkat 2005), and the average of the incidence of corruption.

The coefficient for corruption is statistically significant and negative in sign indicating that corruption is growth reducing. The coefficient for squared corruption ($CORR^2$, in columns 4 and 5) is statistically significant and positive in sign. When squared corruption is added as an explanatory variable, the coefficient for corruption is decidedly larger (compare column 4 with column 2; and column 5 with column 3). Taken together these estimates suggest that in countries where the incidence of corruption is low, corruption is more growth reducing than in countries where its incidence is high. This finding is robust to the measure of corruption. The cross-section estimates are, however, all biased and inconsistent as the underlying model ignores unobserved time invariant country specific factors and the endogeneity of various explanatory variables—notably, corruption, and investment.

5.2 Fixed effects model

In Table 3, we present models estimated after controlling for unobserved time invariant country specific factors that the cross-sectional models in Table 2 ignores. As these factors are known to be correlated with some of the explanatory variables (Islam 1995), we used fixed effects (FE) estimation instead of random effects (RE) estimation.[14] Our model ignores

[14]A Hausman test was performed and the result supports the use of FE estimation.

Table 2 Cross-sectional models: dependent variable—average annual growth rate 1984–2007

Explanatory[a] variables	(1)	(2)[b]	(3)[c]	(4)[b]	(5)[c]
Per capita GDP in ’85	–	−0.001	−0.002	−0.001	−0.001
	(0.18)	(0.02)	(0.00)	(0.10)	(0.00)
Primary enrollment	0.083	0.028	0.103	0.010	0.099
Rate (Pedu)	(0.48)	(0.81)	(0.36)	(0.92)	(0.37)
Secondary enrollment	0.072	0.032	−0.083	0.021	−0.122
Rate (Sedu)	(0.48)	(0.76)	(0.43)	(0.83)	(0.25)
Pop. growth rate (Pop)	−1.952	−2.434	−1.395	−3.025	−1.819
	(0.35)	(0.14)	(0.43)	(0.070	(0.28)
Pol. Stability (Polstab)	0.143	0.077	0.054	0.096	0.078
	(0.03)	(0.20)	(0.39)	(0.11)	(0.18)
Openness (Open)	−0.086	−0.083	−0.125	−0.076	−0.121
	(0.25)	(0.18)	(0.02)	(0.20)	(0.02)
Gov. exp. as ratio	−0.107	−0.300	0.296	−0.341	−0.358
of GDP (GE)	(0.75)	(0.35)	(0.35)	(0.28)	(0.30))
Investment—GDP	1.647	1.840	1.675	1.716	1.594
Ratio (Inv)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Corruption (CORR)		−4.755	−7.081	−16.812	−14.882
		(0.03)	(0.00)	(0.01)	(0.00)
Corruption squared ($CORR^2$)				1.871	0.733
				(0.04)	(0.03)
Wald statistics	0.000	0.000	0.000	0.000	0.000
(*p*-value)					
R squared	0.366	0.472	0.494	0.493	0.515
No. of obs	120	109	118	109	118

Notes: Robust estimates. Coefficients reported after multiplication by 1,000. Figures in parentheses are *p*-values

[a]Average of 1984–2007 values

[b]Corruption measured by ICRG

[c]Corruption measured by CPI

initial GDP (GDP *per capita in 1985*) as an explanatory variable because within regressions treat this variable as a ‘fixed effect’ and drop it from calculation. The dependent variable is the annual growth rate and explanatory variables are the same as before.

The estimated coefficients for population growth rate (Pop), openness of the economy (Open), government expenditure as a ratio of GDP (GE), and investment-GDP ratio (Inv) are all statistically significant and have the expected sign. The coefficient for corruption (measured by the ICRG index) is significant and has a positive sign. However, when corruption is measured by the CPI index (column 2) the coefficient is not significant. Adding squared corruption ($CORR^2$) as an explanatory variable (columns 3 and 4) does not change this. Overall, fixed effects estimation shows that the partial effect of corruption on the rate of growth of real GDP per capita is not statistically significant.

Table 3 Fixed effects estimates: dependent variable—annual growth rate of GDP, 1984–2007

Explanatory variables	(1)[a]	(2)[b]	(3)[a]	(4)[b]
Primary enrollment	0.328	–	0.317	−0.020
rate (Pedu)	(0.26)	(0.98)	(0.27)	(0.96)
Secondary enrollment	−0.433	−0.165	−0.437	−0.174
rate (Sedu)	(0.09)	(0.60)	(0.09)	(0.58)
Pop. growth rate (*Pop*)	−5.924	−12.470	−5.948	−12.528
	(0.10)	(0.00)	(0.10)	(0.00)
Political stability (Polstab)	–	0.247	−0.019	0.239
	(0.98)	(0.73)	(0.95)	(0.74)
Openness (Open)	1.002	0.929	1.000	0.920
	(0.00)	(0.00)	(0.00)	(0.00)
Govt. exp as a	−4.650	−1.549	−4.640	−1.572
ratio of GDP (GE)	(0.00)	(0.25)	(0.00)	(0.25)
Investment—GDP	1.885	1.750	1.895	1.768
ratio (Inv)	(0.01)	(0.01)	(0.01)	(0.01)
Corruption (CORR)	5.335	4.261	1.108	9.169
	(90.05)	(0.31)	(0.99)	(0.40)
Corruption squared ($CORR^2$)			0.858	−0.558
			(0.47)	(0.56)
Wald statistics	0.000	0.000	0.000	0.000
(p-value)				
Within R squared	0.244	0.139	0.244	0.140
No. of observations	748	558	748	558
No. of countries	122	116	122	116

Notes: Robust estimates. Coefficients reported after multiplication by 1,000. Figures in parentheses are p-values

[a]Corruption measured by ICRG

[b]Corruption measured by CPI

5.3 GMM first difference estimator

The estimates of partial effects in Table 3, however, are still biased as the underlying models ignore the endogeneity of investment and corruption. We now proceed to estimate the dynamic model specified in (2) which has the logarithm of real per capita GDP as the dependent variable. Recall that (2) presents a model that can address the problems of endogeneity originating in time invariant country fixed effects, a contemporary correlation between the explanatory variable(s) and the stochastic error term, and the persistence in the dependent and the explanatory variables. Also, when estimating this dynamic panel data model, we use averages of observations over four distinct 5-year spans: 1984–1988, 1989–1993, 1994–1998, 1999–2003, and a 4-year span 2004–2007, for each country and each variable. This ensures that the observed variations in the growth rate of real GDP per capita are to a large extent due to long term growth, as opposed to business cycles.

We assume that the rate of growth of population and the primary and secondary enrollment rates are exogenous; that political stability, the degree of openness and government expenditure as a share of GDP are predetermined; and that investment-GDP ratio and corruption are endogenous. As mentioned earlier, the AB first difference GMM estimator uses lagged level values to instrument the endogenous variables in first difference under an assumption of weak endogeneity.[15]

Table 4, column 1 presents GMM first difference estimates with corruption measured by the ICRG index. The coefficients have the expected sign. The coefficients for corruption and squared corruption are both significant. The model is identified and the differenced error term does not exhibit an AR(2) process. The same general results are obtained when the CPI index is used as a measure of corruption (column 2), except that the estimated coefficients cease to be significant in case of some of the control variables and there are not enough time periods left to test the absence of AR(2) in the differenced residuals.

5.4 GMM system model

The system model estimates the dynamic regression equation (2) in first differences and levels jointly. The model is robust to (i) the presence of lagged dependent and explanatory variables that are persistent and, (ii) to bias due to measurement errors in variables (see Sect. 3.3). Table 4 columns 3, 4, and 5 present GMM system estimates. We treat the population growth rate and primary and secondary enrollment rates as exogenous and all other variables as endogenous. In all cases, the model passes the Sargan test. The model passes the test of absence of AR(2) in the error term when the ICRG index is used.[16] The estimated standard error of the GMM system estimator is known to be biased downward. We recalculated the model in column 3 using Windmeijer (2005) WC robust estimator that corrects for this bias. The robust estimates are presented in column 6. With robust estimation secondary enrollment ceases to be statistically significant. The coefficients for corruption and the square of corruption continue to be statistically significant.

The dependent variable in the models in Table 4 is Log *real* GDP *per capita* and the interpretation of the reported estimates are different from the coefficients reported in Tables 2 and 3. In Table 4, the reported coefficients for *Lagged* log *real* GDP *per capita* and Log CORR measures the elasticity of *Real* GDP *per capita* with respect to its lagged value and corruption respectively. All other coefficient estimates measure the partial effect of the corresponding explanatory variable on the Log *real* GDP *per capita*—i.e., the change in growth of real per capita income in percentage point terms.

The estimated elasticity of current real per capita GDP with respect to its lagged value reveals a large degree of persistence in the level of *Real* GDP *per capita*. The coefficients for all control variables have the expected sign except for the coefficient for openness. The coefficient for corruption is significant regardless of how corruption is measured. The coefficient for squared corruption is significant only when corruption is measured by the ICRG index.

6 Conclusion

That corruption has an adverse effect on the rate of growth of per capita income is now widely accepted. The underlying empirical literature, however, suffers from some major de-

[15] We add the lagged gross national saving (GNS) rate to the matrix of instruments. Attanasio et al. (2000) provide evidence that lagged saving rates are positively correlated with investment and this result is robust across data sets and estimation methods for a panel of 123 countries over the period 1961–1994. The lagged saving rate is uncorrelated with the error term in (2).

[16] When the CPI index is used, there are not enough data points to test for the absence of AR(2).

Table 4 Dynamic model estimates: dependent variable—logarithm of real GDP per capita

Explanatory variables	GMM first difference estimator		GMM system estimator			Robust estimator
	(1)[a]	(2)[b]	(3)[a]	(4)[a]	(5)[b]	(6)[a]
Lagged real GDP	61.571	47.881	97.184	98.456	86.464	97.184
per capita	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Primary enrollment	0.269	0.195	0.180	0.196	0.201	0.180
rate (Pedu)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Secondary enrollment	0.057	0.023	0.076	0.034	0.137	0.076
rate (Sedu)	(0.00)	(0.72)	(0.01)	(0.22)	(0.00)	(0.18)
Population growth rate	−1.256	−1.426	−3.912	−3.800	−3.716	−3.912
(Pop)	(0.22)	(0.38)	(0.00)	(0.00)	(0.00)	(0.00)
Political stability	0.406	0.171	0.037	−0.013	0.147	0.037
(Polstab)	(0.00)	(0.62)	(0.32)	(0.74)	(0.01)	(0.64)
Openness	0.217	0.220	−0.017	−0.019	0.013	−0.017
(Open)	(0.00)	(0.01)	(0.38)	(0.37)	(0.69)	(0.70)
Government expenditure	−1.061	−1.549	−0.624	−0.557	−0.535	−0.623
as ratio of GDP (GE)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.12)
Investment	0.909	0.883	1.038	1.031	0.993	1.038
as ratio of GDP (Inv)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Corruption (CORR)	−9.330	−7.943	−8.875		−8.279	−8.875
	(0.00)	(0.01)	(0.00)		(0.01)	(0.05)
Corruption squared	1.823	8.280	1.167		0.310	1.167
($CORR^2$)	(0.00)	(0.14)	(0.00)		(0.35)	(0.10)
Log corruption (log CORR)				−3.911		
				(0.00)		
Wald test (p-value)	0.00	0.00	0.00	0.00	0.00	0.00
Sargan test (p-value)	0.75	0.06	0.52	0.39	0.21	na
H_0: AR(1) is absent (p-value)	0.41	0.48	0.13	0.09	0.86	0.14
H_0: AR(2) is absent (p-value)	0.34	–	0.44	0.59	–	0.44
No. of observations	174	136	334	322	259	334
No. of countries	105	105	117	116	123	117

Notes: Coefficients reported after multiplication by 100. Figures in parentheses are p-values

[a]Corruption measured by the ICRG index

[b]Corruption measured by the CPI index

ficiencies. First, the previous studies are based mostly on cross-sectional OLS models which ignore the role of country-specific time invariant factors that affect corruption. Second, the codetermination of the rate of growth of per capita income, the incidence of corruption, and the rate of investment is ignored. Third, the persistence of corruption is not taken into consideration. Fourth, the importance of how corruption is organized is overlooked. This paper extends the literature by using a well-known dynamic panel data model to handle all of these problems in a data set.

We present evidence that, *ceteris paribus*, corruption has a direct effect on growth that is in addition to its indirect effects via investment and other channels, and that this direct effect is negative. To judge the relative importance of the effect of corruption, one can compare the partial effects of a one standard deviation change in the explanatory variables on the growth rate of real GDP per capita using the results in column 3 of Table 4. For the representative country with the incidence of corruption at the average for the full sample (3.05 by the ICRG index), a one standard deviation change in CORR (1.32) changes the rate of growth of real per capita GDP by 0.12 percentage points. This effect is larger than the effect of a one standard deviation change in the investment-GDP ratio. We re-estimated the GMM system model in Table 4 column 3 by substituting log CORR for CORR and CORR^2 to check for the sign of the coefficient for log CORR. The results are reported in column 4. The model passes the test for the absence of AR-2 process in the differenced error term and the Sargan test. The estimated elasticity of real per capita GDP with respect to corruption is −0.04 and is statistically significant. This supports our finding that the effect of corruption on the rate of growth is negative and, furthermore, that the marginal effect of a change in the level of corruption on the rate of growth declines with an increase in level.

With regard to how the effect of corruption changes with its level (measured by squared corruption), we find support for the hypothesis that it changes with the incidence of corruption. The coefficient for squared corruption is significant when measured by the ICRG index. However, the sign for squared corruption is positive in all specifications, rejecting our hypothesis based on Shleifer and Vishny (1993) that corruption is more growth reducing at higher levels because of how corruption is organized.

For our sample of countries, the partial effect of a change in the incidence of corruption is

$$\frac{\partial \log y}{\partial \text{CORR}} = -0.08875 + 0.02334 \times \text{CORR}. \tag{4}$$

Equation (4) shows that when the level of corruption is allowed to vary in our sample, corruption is not growth reducing at all levels. In the case of Finland, a country in the sample with the least possible corruption with an average ICRG index at six (CORR = 0) during 1984–2006, corruption is growth reducing. When CORR reaches 3.80 (the average for Egypt during 1984–2006), corruption has no effect on growth at the margin. Beyond this level, corruption is actually growth augmenting. At its highest incidence in our sample, i.e., in the case of Congo which has the lowest average ICRG index for 1984–2006 (0.467, i.e., CORR = 5.53), corruption is actually growth augmenting. This pattern is consistent with the 'grease-in-the-wheel' argument that in high-corruption countries corruption spurs growth by helping firms sidestep burdensome public policies.

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Appendix: Variable definitions

Primary enrollment ratio. Primary Enrollment Ratio is the ratio of the number of children of official school age (as defined by the national education system) who are enrolled in school to the population of the corresponding official school age.

Secondary enrollment ratio. Secondary Enrollment Ratio is the ratio of the number of children of official school age (as defined by the national education system) who are enrolled in school to the population of the corresponding official school age.

Population growth rate. Based on the annual growth in total population which counts all residents regardless of legal status or citizenship–except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin.

Openness. The sum of import-GDP ratio and export-GDP ratio. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments.

GDP per capita. GDP Per Capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 US dollars.

Gross domestic investment (as a ratio of GDP). Gross Domestic Investment (as a ratio of GDP) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.

Gross domestic savings. Gross Domestic Savings are calculated as GDP less final consumption expenditure (total consumption).

General government final consumption expenditure. General Government Final Consumption Expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditure on national defense and security, but excludes government military expenditures that are part of government capital formation.

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