Collective (In)Action and Corruption:

Access to Improved Water and Sanitation

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Abstract: A country's levels of collective action in the provision of socially desirable goods and services are primarily determined by its level of development, important natural attributes, and its unique institutional characteristics. In general, one can expect that, given a particular set of natural attributes and institutions, the greater a county's per capita GDP, the more extensive will be its commitment to the provision of goods and services that require collective action. The primary contention of this paper is that one of the most important aspects of institutions that affect socially desirable collective action is the extent of public sector corruption. More specifically, we first develop a theoretical model which explicitly shows the relations between per capita GDP, corruption, and collective action in the form of the provision of improved drinking water and appropriate sanitation facilities. We test our model by analyzing a sample of 77 countries, annually, between 1982 and 2001, for a total sample of 1,519 observations. Relying on a two-way fixed effects estimation strategy, we find that corruption does in fact lead to lower levels of both access to improved drinking water and appropriate sanitation than a given country's level of per capita GDP and other institutions alone would predict.

Keywords: Collective Action, Corruption, Institutional Variables.

JEL Classification(s): D31, H41, P16

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"Most Indians have extremely limited and unreliable access to what they need most. About three in every four people have no public sanitary facilities (such as toilets). Even more have no access to safe drinking water. They experience a daily crisis. Many even die from it: every year, more than 1m Indian children are killed by bad drinking water. It is no use pointing vaguely to the skies. In essence, the water crisis is about how India is governed. "If you look at data for the last 100 years, there has been absolutely no change in the pattern of India's monsoon," says Onkari Prasad, director of India's meteorological office. "Our problems are man-made. You cannot blame the weather."
Back in Delhi I arrange lunch with T.S.R. Subramanian, former cabinet Secretary of India—the most senior job in the civil service. Earlier this year, Mr. Subramanian published his memoirs. The book concludes with four iron laws of India's bureaucracy, of which the most scathing is: "The administration only takes decisions that benefit administrators."
"People complain about corruption as if it is a minor nuisance," Subramanian tells me over kebabs at the well-watered Delhi Golf Club. "What they haven't grasped—but will do so gradually—is the link between corruption and maladministration. This formula explains why India's administration can build large dams but is unable to maintain rural irrigation systems, why it can launch satellites but not build public toilets, why it can pave multilane highways but not all-weather roads to its villages. There is no money in providing drinking water or roads or education to people who have no money."[1]

I. Introduction

Data from the World Health Organization (WHO) show that 2.4 billion people live without access to basic sanitation, amounting to about 40 percent of the world's population. Similarly, 1.1 billion people lack access to adequate supplies of improved water. As dire as these statistics are, it must be kept in mind that potable water and appropriate sanitation are far from being luxuries. To the contrary, poor water quality and inadequate sanitation translate directly into a whole host of life-threatening illnesses including, but not limited to, diarrheal disesases such as cholera and dysentery as well as typhoid fever, viral Hepatitis A, and dengue and dengue hemorrhagic fever, each of which disproportionately target the young. WHO estimates that annually, 4 billion cases of diarrhea occur leading to more than 2 million deaths, another 600 thousand deaths result from typhoid fever and nearly 150 thousand succumb to dengue and dengue hemorrhagic fever. Worse yet, nearly all of these outcomes could be avoided if all peoples had access to improved water and adequate sanitation. Perhaps most striking, WHO estimates that as much as 4 percent of total deaths each year, worldwide, result from a lack of

[1] Excerpts taken from Edward Luce, "Supply and Demands," *Financial Times Weekend*, July 24/25, 2004, pp W1-2.

improved water and adequate sanitation.[2]

Equally important, research into the effects of waterborne illness is increasingly showing that even those who survive a bout with such an illness early in life carry its scars with them for the rest of their lives in a variety of ways. For example, Guerrant et al. (1999) have shown that children that experience significant bouts of diarrhea early in life evidence decreased physical fitness 4-7 years later while Moore et al. (2001) report that early diarrhea illness has lasting, significant negative effects on physical growth. And the ill-effects are not limited to physical development. Neihaus et al. (2002) find that diarrhea illness rates in the first two years of life are significantly related to lower scores on the Test of Nonverbal Intelligence when those children reach the ages of 6-10. Finally, Guerrant et al. (2002) report a significant correlation between early childhood diarrhea illnesses and late onset of starting school.

While inadequate access to clean water and proper sanitation are generally thought to be problems unique to developing countries, developed countries also have their shortcomings in these areas. For example, in the U.S. 10 percent of waste water is returned to the environment without treatment. That number rises to 34 percent in Europe. Further, Hunter (1997) reports that in the U.S. since 1940, both the number of outbreaks of waterborne illnesses and the number of those affected per given outbreak have risen sharply. So, while the ill-effects of inadequate access to improved water and appropriate sanitation are concentrated in the developing world to be sure, no part of the globe is free from the potentially devastating affects of waterborne illnesses.

Provision of improved water and adequate sanitation are clearly not collectively consumed goods, strictly defined. However, given the extreme positive spillovers of such systems as well as the negative spillovers when such systems are lacking, and given the enormous capital outlay required to develop high-level water and sanitation systems, collective action is

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[2] All data taken from WHO (1997), *The World Health Report*, WHO (2000), *Water for Health: Taking Charge*, and WHO (2002), *Global Water Supply and Sanitation Assessment*.

typically required to insure their provision. Of course, this does not imply that governments must themselves build or maintain these systems. What is necessary and typical, however, is for governments to contract with private parties to build and operate such systems. Systems to provide clean water and to treat wastes are expensive to construct and operate and, as such, a country's level of investment in them is necessarily limited by its per capita GDP.

Equally important, however, are a country's unique geo-physical characteristics and various aspects of a country's institutional environment. Some countries are blessed with abundant, clean aquifers located near the land's surface while others are not. Similarly, it is much more expensive to develop effective water and sanitation systems in arid, mountainous countries than in countries where the land tends to be relatively flat and dotted with bodies of freshwater. From an institutional standpoint, developing countries with histories of colonial ties to countries with well-developed water and sanitation systems may themselves have more extensive systems than other countries with similar income levels but differing geo-political histories. Likewise, the type of government existing in a country is no doubt important in the sense that one might expect to find a greater commitment to socially advantageous collective action in countries with relatively more democratic governance than in countries suffering comparatively despotic rule. And since the expense of such large capital projects have to be shared, one should expect to find populations more readily able to reach agreement on a division of the burden if ethnic tensions tend to be relatively minor in degree. No doubt other institutional characteristics unique to individual countries also play a role as well. One that we wish to focus on in this paper is public sector corruption.

Since the development of effective water and sanitation systems by their very nature require enormous capital outlays, often involve something approximating long term monopoly suppliers of an essential resource, and create the possibility of both significant profits and patronage employment, the potential for corruption is obvious. Examples of such corruption abound. In Grenoble, France in 1996, prison sentences were given to political decision-makers and a senior executive of a private water company for participating in bribery in the letting of contracts. Similarly, prosecutions of 12 multinational companies are underway in Lesotho for bribes involved with the engineering work for a large water supply system while in Angouleme, France a major company was convicted of bribery in its attempt to obtain water concessions.[3] When the corruption, as is most likely, takes the form of bribes being required by political decision-makers during construction or extension of water or sanitation systems, the outcome is invariably the same: for any given level of investment, a smaller portion of a country's population will have access to improved water and adequate sanitation than otherwise would be the case, exposing them to the dire risks of waterborne illness described above.

In this paper, we first present a theoretical model of the relations between collective action to provide improved water and proper sanitation and a country's level of per capita GDP and public sector corruption. We then test the predictions of this model by analyzing 77 countries during the 1982 through 1997 period. Using a two-way fixed effects estimation strategy we find that, holding constant per capita GDP and other institutional characteristics, public sector corruption significantly reduces the proportion of a country's population with access to improved water and adequate sanitation.

2. Theoretical Model

Consider a government which has a certain amount of resources to provide, among other services, water and sanitation systems as well as to investigate failures of these systems. Further, suppose that at least some elements of these systems were allowed to be built in a sub-standard fashion due to contractors bribing public officials overseeing the projects, as in the cases outlined above. What happens when there is a failure in some part of these systems? Inspectors are called in to investigate and determine the cause(s) of the failure. If the failure is determined to be naturally

[3] Information on these and other cases is available from UNCHS (Habitat) at www.unhabitat.org/HD/hdv6n3/contracts.

occurring, a contractor, perhaps the original contractor, is hired to correct the failure and the story ends. On the contrary, should the investigation determine that the failure was a result of faulty workmanship on the part of the original contractor, which the overseeing public official allowed in exchange for a bribe, both parties to the conspiracy face a penalty, $P>0$, which both serves as restitution and, hopefully, as a deterrent against similar misdeeds in future contracts.

Given that available resources are limited both in general and specifically with respect to the provision of water and sanitation systems, monies that must be devoted to investigating and repairing failures necessarily limit the government's ability to extend these systems to their citizens. Consequently, the greater is the degree of corruption in the original building process and, by extension, the greater is the need for investigation and correction of system failures beyond the minimum that result from natural failures, conspiracies between contractors and public officials necessarily result in water and sanitation systems which, per dollar spent, less fully provide coverage to a population.

Within a country in which government must at least minimally be cognizant of public opinion, a natural upper limit exists concerning the share of water and sanitation system funds that can be credibly devoted to inspection and correction of failures as these funds necessarily limit the government's ability to extend these systems. That is, should failures be so extreme that correcting them results in actual falls in the percentage of the population with access to clean water and adequate sanitation during some time period, that government would be at the mercy, rightly so, of their population. This upper limit on the amount of funds that can be credibly devoted to inspection and correction of failures is likely determined, primarily, by two factors, per capita GDP and the country's degree of democratic institutions. The former simply provides access to greater funding for both construction of water and sanitation systems, and thus a higher upper limit on the amount of money available for inspection and repairs while the latter can be expected to provide for more effective detection, deterrence, and enforcement/punishment of corruption through more openness in the bidding and inspection process as well as a more well-developed legal system. And, as will be shown, this upper limit on the resources that can be devoted to inspection and correction of failures is crucial to preventing corruption.

Assume that there is a network of corrupt public officials who are charged with overseeing the construction and maintenance of water and sanitation systems and that these officials are known within the contractors' network. Thus, any contractor can link with a corrupt public official assigned to a specific project and, in return for a bribe, build a sub-standard system. If the conspiracy takes place, the contractor earns a normalized surplus of one, net of the bribe paid to the corrupt official. Given the sub-standard workmanship, the system will fail, in time, with probability one. If an effective investigation is conducted, the poor workmanship and the underlying bribe leading to it will be discovered with probability one and the contractor will consequently face a penalty of $0 > (-P) > -\infty$. On the contrary, if a contractor, practicing appropriate building techniques, links with a non-corrupt public official in producing the same project, the normalized payoff is zero. Of course, even in this case where there is no corruption, there is some probability that the system will fail due to natural causes. Two points are important here, however. First, the probability of a naturally occurring failure is much less than in the case in which sub-standard workmanship exists due to bribery and, second, since the contractor practiced due diligence in the construction process, he or she will not face a penalty for the failure. Finally, throughout the model, we assume all agents to be risk-neutral.

Assuming that there are *n* contractors, we will consider an *n*-person simultaneous-move game in which each contractor decides whether or not to build a sub-standard or "faulty" system. We assume there is an optimal maximum penalty for conspiring to build sub-standard systems, $P^* > 1$.[4] Let the cost of investigating a failure in a system be $c > 0$. In that case, the maximum

[4] Glaeser (1999) states that "many police forces in developing countries are either corrupt or committed to their own, occasionally brutal, policies. Anecdotes (and survey evidence) documenting extremely high levels of police extortion abound. Judges are often unreliable in developing countries." Thus, in countries where corruption is rampant, neither the police nor the judicial system can be trusted to apprehend offenders and assign optimal penalties. High penalties often serve to do little more than increase the bribes that must be paid by offenders to avoid the legal system. As a result, Friedman (1999) argues that less severe punishments are often optimal when the behavior of corrupt public officials is taken into account.

total cost of the investigation process to the government will be nc, that is, the number of contractors (and, thus, the number of projects) multiplied times the cost of investigating a failure when all projects fail. Given the necessary resources and well-functioning democratic institutions designed to identify and punish corruption in the contracting process, any such conspiracy to bribe public officials in exchange for the right to build a sub-standard system will be both detected and appropriately punished. In such an environment, rational contractors will never offer bribes and consequently sub-standard production due to corruption in the contracting process will never be the equilibrium outcome of the game. To summarize:

Proposition 1: *If government can commit nc resources and has effective democratic institutions in place, the unique Nash equilibrium is such that no contractor will offer to bribe a public official for the right to build sub-standard water or sanitation systems.*

The more interesting case, of course, exists when either government cannot afford the resources, nc, or (and) lacks the democratic institutions necessary to ensure that all conspiracies are detected and appropriately punished. Even in this case, however, it turns out that one of the two possible equilibria results in the same outcome as above, that is, no sub-standard production taking place due to corruption in the contracting process. To see this, consider the optimal response of a typical contractor, J, when no other contractor is corrupt. Suppose that the probability of an adequately built system malfunctioning is negligible and the cost of investigating such malfunctions is also negligible. Suppose the government can commit only a $0 < q < 1$ fraction of nc to investigate system failures such that $qnc > c + \gamma$ where $\gamma > 0$ is the overall negligible cost of the remaining (n–1) adequately constructed systems malfunctioning.

What happens when contractor J is the only contractor offering a bribe and thus producing a sub-standard system? By assumption, contractor J's system will, in time, fail. While some other systems will also fail, simply due to natural causes, this number will be extremely small meaning government will clearly have the resources to fully investigate contractor *J*, uncover his conspiracy, and force *J* to face the penalty (-P*). Thus, his net payoff will be negative. Given this certainty of detection and surety of facing the optimal penalty, one equilibrium outcome in the case in which government lacks the resources or democratic institutions necessary to investigate every construction project that fails involves no corruption and thus no sub-standard construction. In this "socially desirable" equilibrium, given $q < 1$, each contractor will have a zero payoff allowing a large majority of the government's water and sanitation resources to be devoted to actually building and maintaining the systems, leading to the maximum extension of these services within the population possible, given the country's income constraints.

With $q < 1$ there is, however, another equilibrium in which while every contractor offers a bribe, only some are detected and prosecuted. Consider the case where all contractors, except contractor *J*, bribe the officials designated to oversee their projects and thus build sub-standard systems. In other words, while all contractors other than *J* definitely enter into a bribe with the public official, *J* may or may not do so. Consider the payoffs $\pi_f = (1\text{-}q)\text{-}q\text{P*}$ and $\pi_a = 0$, to *J* when he does and does not conspire with the public official. Since the government commits only *qnc* funds to investigate failures, it can investigate only *q* fraction of the total failures when all *n* contractors are corrupt, and thus only *q* fraction of these contractors will be caught and punished. Suppose $q/(1\text{-}q) \geq 1/\text{P*}$ (i.e., $\text{P*} \geq (1\text{-}q)/q$). Then observe that $\pi_f = (1\text{-}q)\text{-}q\text{P*} \leq 0$. Given this, once again we have an equilibrium in which no conspiracies to bribe public officials occur.

Suppose, however, that $q/(1\text{-}q) < 1/\text{P*}$ (i.e., $\text{P*} < (1\text{-}q)/q$). Then observe that $\pi_f = (1\text{-}q)\text{-}q\text{P*} > 0$. In this case, no contractors will choose to, on their own, not offer a bribe. Thus, "all-contractors bribing" is another Nash equilibrium when $q < 1$. Note that, given $\text{P*} < (1\text{-}q)/q$, this "all-contractors bribing" equilibrium will payoff-dominate the other "no bribing" equilibrium for the contractors since $\pi_f = (1\text{-}q)\text{-}q\text{P*} > \pi_a = 0$. Thus, it is the prominent Nash equilibrium in this coordination game among *n* contractors. This feature resolves the strategic uncertainty inherent above by causing all rational contractors to choose the "all-contractors bribing" equilibrium instead of the alternative "no bribing" equilibrium. The other aspect of the latter equilibrium is that q fraction of the contractors will be investigated and will be found guilty, and each such contractor will thus suffer the negative payoff of (-P*). To summarize:

Proposition 2: *(1) If government can commit only qnc with $q < 1$, there are two pure-strategy Nash equilibria: (i) In the "no bribing equilibrium" no contractor offers to bribe and as a consequence all systems are appropriately built. (ii) In the "all-contractors bribing equilibrium" all contractors offer bribes and build sub-standard systems but only q fraction of them are detected, prosecuted, and forced to face the penalty of P*.*

(2) Given $P^* < (1-q)/q$, the strategic uncertainty regarding the multiple pure-strategy Nash equilibria is resolved in favor of the "all-contractors bribing equilibrium" if the contractors use a payoff-dominance criterion.

Thus, in the above simple model of corruption and a government's monitoring ability, corruption can be prevented if the government can commit a sufficiently large amount of resources to monitoring. What determines the monitoring ability of government, to a large extent, is a country's level of per capita GDP and its institutional environment.

This section started by considering "a government which has a certain amount of resources to provide, among other services, water and sanitation systems as well as to investigate failures of these systems." Thus, apart from their effect on collective action via reduced corruption, a higher level of per capita income and a better institutional environment can affect collective action directly too—by enabling a country to build a more effective infrastructure of water and sanitation systems (clearly more so when corruption is prevented, which is one of the equilibrium outcomes in our theoretical analysis). Given this, our primary empirical prediction is that, given a country's level of per capita GDP and its institutional environment, the degree of corruption that exists in the process of bid-letting for water and sanitation system projects necessarily serves to limit the extent to which these systems can be extended to the country's population.

3. Data and Univariate Results

Based on the theoretical model, our primary focus is both on how per capita GDP and corruption influence the degree of collective action that is taken within an economy with respect to the provision of improved water and sanitation facilities. The unit of analysis is an individual country during the period 1982 to 2001, giving us a panel of 1,519 country-year observations arising from 77 countries. These come from the Americas, Africa, Asia and Europe and were chosen based strictly on having access to complete data (with the notable exception of the variable for sanitation which was only available for 1,066 of the 1,519 observations and 54 of the 77 countries in the primary sample). Here, we briefly describe each of the variables used in our models and, in Table 1, offer descriptive statistics. For more precise definitions and sources, refer to Appendix 1.

Our measures of collective action reflect the percentage of a country's population that has reasonable access to an adequate amount of improved, clean water (*WATER*) and the percentage that has access to proper sanitation facilities (*SANITATION*), each taken from the World Bank's *World Development Indicators.* It should be noted that these variables are not available for each year in the sample period, a shortcoming that we address by linearly interpolating annual values from the years for which data are available. That is, we assume that the improvement that all countries in the sample experienced in terms of the provision of clean water and sanitation over the time period being considered was linear. This is likely not the case, as water projects are not completed in a linear fashion, however, there is neither an alternative source for data on water/sanitation access nor any way to take into account any non-linear changes that occur.

Fortunately, however, we are at least certain of the positive direction that annual changes are taking, limiting the error that linear interpolation creates. These variable's means indicate that the average country in the sample provides clean water to about 81 percent and proper sanitation to about 74 percent of its population. More importantly, we do see rather dramatic differences for each measure of collective action between countries, as reflected in their rather broad ranges.

Our measure of the level of corruption within an economy is taken from the International Country Risk Guide, published by Political Risk Services Group, as assembled by the IRIS Center at the University of Maryland (*CORRUPT)*. This source reports complete data on more than 100 countries beginning with 1982. The specific variable taken from this source evaluates the overall level of corruption in government. *CORRUPT* ranges from zero to six with higher numbers indicating less corruption in the forms of whether high-level government officials are likely to require special payments to conduct business and whether such bribes are expected throughout all levels of government (see Knack and Keefer (1995) for a thorough treatment of this measure). Given the examples of corruption identified in actual water projects as noted above, this measure of corruption seems particularly well-suited for our analysis. For this sample, the mean value is about 3.5 but varies widely from 0, the least corrupt possible, to 6, the most corrupt. Given the preceding discussion, we expect that *CORRUPT* will be positively correlated with both access to improved water and adequate sanitation (keeping in mind that higher *CORRUPT* scores indicate a reduced likelihood of bribing of government officials being necessary to transact business within a country).

Other measures of public sector corruption are also available and regularly used in empirical analysis, though none is as comprehensive as that of the International Country Risk Guide. We chose this measure because it allows for the broadest treatment of corruption both in terms of years and countries covered and because the variable refers directly to the type of corruption that is commonly found in the water and sanitation areas, as the examples noted above indicate. It should be noted however that as has been shown by Alesina and Weder (2002) and

Treisman (2000), among others, each of the commonly used measures of corruption tend to be very highly correlated so it is rather unlikely that the results presented below would be materially different were another measure of corruption employed. For example, Treisman (2000) reports simple correlations between the index of corruption we use in this paper and those put out by Transparency International and Business International to be both above 0.85. Perhaps more importantly, Alesina and Weder (2002) who use seven alternate indexes of corruption in their analysis, conclude that their results are unchanged regardless of the specific corruption index employed.

We measure income as a country's GDP per capita (*GDPPC*), based on purchasing power parity, as reported in the World Bank's *World Development Indicators. GDPPC* for the entire sample has a mean of $7,021 per year with a rather broad range of just over $107 to $35,433. We expect that *GDPPC* will be positively correlated with both measures of collective action. We take into account the size of a country by controlling for its population (*POP*). Given the capital-intensive nature of water and sanitation systems, countries with larger populations, holding GDP per capita constant, should be found to have more developed systems. This variable's mean suggests that the typical country in the sample has a population of about 58 million inhabitants.

Finally, we include two additional measures of a country's institutional environment, its degree of ethnic tensions (*ETHNIC*) and its extent of democratic institutions (*DEM*). The first of these is taken from the same source as the corruption variable, the International Country Risk Guide, and is scaled from zero to six with lower values indicating countries that have relatively high levels of tensions attributable to racial, nationality, or language divisions. As such, we expect to find this variable positively correlated with both measures of collective action, that is, it seems reasonable to assume that countries which are rather homogenous in terms of ethnicity will be both more likely to be able to arrive at a distribution of the tax burden necessary to fund the proposed collective action and more likely to avoid the partisan distrust and animosity that can prevent differing groups from agreeing to projects that would benefit all. The mean for *ETHNIC* is about 4, with a wide range from zero, most ethnic tensions to six, least ethnic tensions.

The latter variable, *DEM*, is taken from Polity IV and estimates a country's general openness of its public institutions. *DEM* ranges from zero, least democratic to ten, most democratic and has a mean of about 5. *DEM* can be thought of as influencing the extent of a country's water and sanitation systems in at least three ways. First, since *DEM* is based on the openness of a country's public institutions, relatively high values for this variable should indicate an environment in which bribing of public officials is comparatively easy to detect, increasing the likelihood that proper construction and maintenance procedures will be followed. Second, to the extent that the variable indicates a general sense of egalitarianism, it can be expected to be positively correlated with both measures of collective action. Finally, *DEM* may be viewed as a proxy for relatively more democratic governments' tendency, especially in lesser developed countries, to spend on public goods as a means of securing popular support. In each case, *DEM* can be expected to be positively related to both measures of collective action.

Initial insight into the hypothesized relationships between corruption and access to clean water and proper sanitation can be had by considering the simple correlations between the collective action measures and corruption. Specifically, as expected, both *WATER* and *SANITATION* are strongly and positively correlated with *CORRUPT*, 0.47 and 0.58, respectively (recall that higher values of *CORRUPT* reflect relatively less corruption). More enlightening are the univariate relations offered in Table 2 which divides the sample into two parts, those observations resulting from *relatively* corrupt country/year observations and those from the remaining relatively uncorrupt observations, based on whether the observation is above or below a *CORRUPT* value of 3.01 (the sub-groups differ in size only because a large number of observations have the value of 3). As each panel of Table 2 shows, the relatively corrupt observations have statistically significant and lower values for both of the measures of collective action, *WATER* and *SANITATION*. That is, while the typical corrupt country/year observations offer their populations access to clean water and adequate sanitation of about 72 and 64 percent, respectively, those percentages rise to about 91 and 88, respectively, for the relatively uncorrupt observations (while the numbers categorized as corrupt and uncorrupt obviously change, the outcome is qualitatively unaffected if the dividing point between corrupt and uncorrupt is adjusted anywhere between 2.5 and 3.5).

4. *Multivariate Results*

Clearly, taken together with the simple correlations, the univariate results are indicative of our primary contention, but to more formally test the proposition, we estimate the following two-way fixed effects model:[5]

$$\begin{aligned} COLLECTIVE\ ACTION_{it} = \alpha_0 + \alpha_1 CORRUPT_{it} + \alpha_2 GDPPC_{it} + \alpha_3 POP_{it} + \\ \alpha_4 ETHNIC_{it} + \alpha_5 DEM_{it} + \gamma_t + \gamma_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where *COLLECTIVE ACTION* is, alternatively, *WATER* or *SANITATION* for country i in year t, *CORRUPT* is the degree of corruption existing in terms of the necessity to pay bribes to government officials as an ordinary part of doing business, *GDPPC* represents per capita income (PPP in 2000 constant dollars), *POP* is population (entered in thousands), *ETHNIC* is a measure of the degree of the ethnic tensions, and *DEM* reflects the degree of democracy.

We use year fixed effects, γ_t, to control for any time-specific effects that shift the level of collective action for all countries. In our context, the most obvious of such effects are the significant technological changes that have taken place in both erecting and extending water lines and in filtering dirty water prior to its reuse or release into the environment. Giving us the second dimension of potential fixed effects, the γ_i represent individual countries, allowing us to capture

[5] The choice of the fixed effects estimator was based on he results of Hausman (1978) tests.

any unobserved country heterogeneity that is relatively fixed over time, such as colonial heritage, topography, proximity to clean aquifers, and cultural norms that are fixed, at least within the period of time in which we are observing the countries (20 years). Furthermore, since our interest is on the partial effects of time-varying covariates, fixed-effects estimation is attractive because it allows any unobserved heterogeneity to be freely correlated with the time-varying covariates.

Table 3 presents the results of the two-way fixed effects models for each of the two measures of collective action, *WATER* and *SANITATION*. Before addressing the individual coefficient estimates, however, note the goodness of fit statistics of the models as given by the extremely significant likelihood ratio chi-squares for each of the models, both significant beyond the .0001 level, pointing to the relatively strong explanatory power of the models. That is, the likelihood of the included independent variables, other than the constant, being jointly equal to zero is effectively nil. Further, it should be noted that the estimations employ standard errors that are fully robust with respect to arbitrary heteroskedasticity (Wooldridge, 2002).

Turning to the individual explanatory variables, for each model all variables are both statistically significant, beyond the 0.01 level, and of the hypothesized sign. Most importantly, in each regression, our measure of public sector corruption, *CORRUPT*, is significant and positive indicating that, holding all else constant, as corruption within a country/year declines (*CORRUPT* increases) there is a corresponding increase in both access to improved water, *WATER*, and adequate sanitation, *SANITATION*. Clearly, as intimated by the simple correlations and univariate analysis, the multivariate analysis reported in Table 3 indicates that public sector corruption creates a significant obstacle to the provision of the vitally needed collective actions; appropriate water and sanitation systems.

As noted, each of the other remaining explanatory variables is equally well behaved in each model. We find that collective action in the form of both access to clean water and adequate sanitation is enhanced with higher levels of *GDPPC* and *POP*. Perhaps of greater interest, we also find that each measure of collective action is positively and significantly correlated with reduced ethnic tensions (*ETHNIC*) and increasing degrees of democracy (*DEM*).

Implicit in the results of Table 3 is the assumption that corruption in a given year limits the provision of clean water and appropriate sanitation in that year. While certainly possible, it seems equally plausible that, given the fairly long-term nature of many water and sanitation projects as well as the fact that even poorly constructed projects typically don't fail immediately, any corruption occurring in a given year may not affect water and sanitation for several years. For this reason, we re-estimate the models presented in Table 3 replacing the current year value of corruption with its four-year lagged value, (*CORLAG*).[6] Thus, for the results presented in Table 4, the corruption index is a pre-determined variable taken from 1982-1997 while the remaining variables encompass the period 1986-2001.[7]

Given the near-identical nature of the results of Table 3 using the current year's corruption value with those of Table 4 which rely on the four-year lagged value of corruption, our remarks on Table 4 are brief.[8] Specifically, two elements of Table 4 warrant particular notice. First, as was the case when the current year's corruption variable was used, the model's employing the four-year lagged value of corruption exhibit very strong measures of goodness of fit with likelihood ratio chi-squares significant beyond the .0001 level. And second, all independent variables, including most notably the lagged value of corruption, are of the same sign

[6] We chose a four-year lag so as to allow for time for sub-standard facilities to start decaying without unnecessarily losing data (the corruption variable is unavailable prior to 1982 thus each year's lag longer than four years would require the loss of an additional year's data).

[7] Institutions, such as corruption, may well be endogenously determined. As a practical matter, this issue is addressed at least to some extent in the models of Table 4 in that the corruption variable there is pre-determined. To more formally address this issue, prior to the estimation of the models in Table 3, a set of Hausman (1978) tests were conducted. Implementation of these tests requires one or more variables which tend to be relatively highly correlated with the suspected endogenous variable (*CORRUPT*, in our case) but rather less correlated with the dependent variables *WATER* and *SANITATION*. Given his excellent treatment of the determinants of corruption across countries, we primarily relied on Treisman (2000) for these instruments choosing the percent of the population self-reporting to be of a protestant faith and a measure of ethnolinguistic fractionalization. As desired, the instruments exhibited much stronger simple correlations with corruption than with the water and sanitation variables. In each test, the assumption of the coefficients not being systematically different could not be rejected, even at very modest levels of significance (.1), providing no support for the notion that corruption is, in this case at least, endogenous. These tests are available upon request. Consequently, in all the models presented, corruption is assumed to be exogeneous.

[8] As with the prior regressions, those reported in Table 4 employ standard errors that are fully robust with respect to arbitrary heteroskedasticity (Wooldridge, 2002).

and level of significance in Table 4 as in Table 3. Consequently, while it is clearly plausible to assume that corruption may negatively affect the provision of clean water and proper sanitation after a period of time has past, this lagged affect is likely to simply reinforce any estimated current-year corruption/collective action relationship, not mitigate or reverse it.[9]

5. Conclusions

Access to improved water and adequate sanitation are essential to healthy human development. Unfortunately today, about 40 percent of the world's population faces life without adequate sanitation and almost 20 percent lack adequate supplies of clean water, exposing them to a wide range of potentially deadly and debilitating waterborne illnesses. Modern systems to provide clean water and proper sanitation are, of course, quite expensive to construct and maintain, typically requiring collective action. For any given country, the extent of its water and sanitation systems is primarily determined by the country's level of per capita income. And unfortunately for the people of many countries, there simply is not enough income domestically to construct modern water and sanitation systems, requiring inflows of international aid to insure widespread access.

Making matters worse, however, we have shown that public sector corruption such as bribery in the process of building and operating water and sanitation systems serves to significantly reduce a population's access to clean water and adequate sanitation, at any given level of income. That is, even when a country has the financial resources necessary, whether domestically generated or not, to develop and operate proper water and sanitation systems, public sector corruption can and does keep the systems from being as effective as is possible. And the results of this corruption are clear: each year countless individuals suffer and in many cases die from waterborne illnesses that could have been rather easily prevented had the ill-effects of

[9] Shorter lags yield results that are qualitatively the same, as do slightly longer lags, though the latter result in substantial reductions in sample sizes.

corruption not limited the effectiveness of the water and sanitation systems in their countries. The costs to these communities in terms of lives lost, bodies and minds suffering permanent damage, and the resulting loss in human capital formation and its requisite negative impact on economic growth is both obvious and potentially self-reinforcing to the initial problem.

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Table 1. Descriptive Statistics

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
WATER	80.627	19.301	35.599	100.000
SANITATION	73.630	23.227	12.870	100.000
CORUPT	3.476	1.448	0.000	6.000
GDPPC	7,021.053	7,587.249	107.409	35,433.280
POP	57,900,000	165,000,000	625,000	1,270,000,000
ETHNIC	4.056	1.497	0.000	6.000
DEM	5.064	4.139	0.000	10.000

Table 2. Relations Between CORRUPT, WATER, and SANITATION

Panel 2a. CORRUPT and WATER

Variable	*CORRUPT<3.01 Mean (n=693)*	*CORRUPT<3.01 Std. Dev.*	*CORRUPT>3.01 Mean (n=826)*	*CORRUPT>3.01 Std. Dev.*	*Difference t-test*
WATER	72.337	16.913	90.508	17.216	18.17* (20.69)

Panel 2b. CORRUPT and SANITATION

Variable	*CORRUPT<3.01 Mean (n=442)*	*CORRUPT<3.01 Std. Dev.*	*CORRUPT>3.01 Mean (n=624)*	*CORRUPT>3.01 Std. Dev.*	*Difference t-test*
SANITATION	63.772	19.552	87.547	20.661	23.77* (19.06)

Note: t-statistics for differences in means are in parentheses; * denotes significance beyond the .01 level.

Table 3. Correlates of WATER and SANITATION (Current Year Corruption Value)

Variable	*WATER* *Two-Way Fixed Effects Estimates*	*SANITATION* *Two-Way Fixed Effects Estimates*
CORRUPT	0.10847* (0.047043)	0.00268* (0.000950)
GDPPC	0.00002* (0.000004)	0.00005* (0.000007)
POP	0.00002* (0.000003)	0.00002* (0.000003)
ETHNIC	0.19613* (0.038338)	0.00289* (0.000591)
DEM	0.07215* (0.013992)	0.000885* (0.000199)
Intercept	39.63360* (0.226606)	0.05734* (0.028341)
Number of Observations	1,519	1,066
Number of Countries	77	54
Log-Likelihood	-2306.444	-3129.56
LR Chi-Square	8,689.85**	6,170.92**

Notes: Robust standard errors in parentheses.
* denotes significance beyond the .01 level.
** denotes significance beyond the .0001 level.

Table 4. Correlates of WATER and SANITATION (Four-Year Lagged Corruption Value)

Variable	*WATER* Two-Way Fixed Effects Estimates	*SANITATION* Two-Way Fixed Effects Estimates
CORLAG	0.14128* (0.049632)	0.00373* (0.000835)
GDPPC	0.00002* (0.000009)	0.00005* (0.000008)
POP	0.00002* (0.000001)	0.00002* (0.000003)
ETHNIC	0.16492* (0.034691)	0.00294* (0.000563)
DEM	0.07657* (0.004964)	0.00056* (0.000221)
Intercept	39.85693* (0.245955)	0.94092* (0.007099)
Number of Observations	1,202	845
Number of Countries	77	54
Log-Likelihood	-1,605.941	-2,718.657
LR Chi-Square	7,289.51**	5,353.35**

Notes: Robust standard errors in parentheses.
* denotes significance beyond the .01 level.
** denotes significance beyond the .0001 level.

Appendix 1: Variable Definitions and Sources Appendix

VARIABLE	*DEFINITION*	*SOURCE*
WATER	The percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring or rainwater collection. Reasonable access is defined as the availability of at least 20 liters per person, per day from a source within one kilometer of the dwelling.	World Bank *World Development Indicators 2002*
SANITATION	The percentage of the population with reasonable access to improved sanitation facilities defined as adequate excreta disposal facilities (private or shared, but not public) that can effectively prevent human, animal, or insect contact with excreta.	World Bank *World Development Indicators, 2002*
CORRUPT	Corruption index from ICRG, annual surveys from 1982-2001 6 (lowest corruption), 0 (highest corruption).	Knack and Keefer (1995)
GDPPC	GDP per capita based on purchasing power parity (PPP).	World Bank *World Development Indicators 2002*
POP	The de facto total of population, which counts all residents regardless of legal status or citizenship.	World Bank *World Development Indicators 2002*
ETHNIC	Ethnic tensions index from ICRG, annual surveys from 1982-2001: 6 (lowest tension), 0 (highest tension).	Knack and Keefer (1995)
DEM	Democracy index from Polity IV, annual surveys from 1982-2001, with scores based on three dimensions: Competitiveness of Political, Competitiveness of Executive Recruitment; and Constraints on Chief Executive: 10 (most democratic), 0 (least democratic).	Polity IV database, downloaded from the Center for International Development and Conflict Management. The data is available on line at: www.cidcm.umd.edu/inscr/polity.