Economic Uncertainty and Corruption: Evidence from a Large Cross-Country Data Set

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ABSTRACT

Substantial research has considered numerous causes and correlates of corruption. Also, there have been many studies of the consequences of various forms of uncertainty. However, exploration of the nexus between economic uncertainty and corruption appears scarce. After providing a simple intuitive and heuristic linkage between general economic uncertainty and corruption, this paper uses a large cross-country data set to augment a fairly standard model with simple proxies for uncertainty and to investigate how economic uncertainty might affect prevalence of corruption. In addition, a quantile-regression framework is used to judge how the strength of various covariates may differ with the level of corruption. Seven main points emerge from the estimates. First, economic uncertainty is associated positively with corruption, and the relation seems robust across measures of uncertainty and corruption. Second, quantile regression estimates indicate considerable parametric heterogeneity across the distribution of corruption. Third, GDP per capita has the expected corruption-mitigating role. Fourth, "freedom" of political rights and civil liberties also appears to lower corruption. Fifth, increased government consumption is associated with lower corruption. Sixth, while the hyperinflation dummy lacks significance in most OLS regressions, its significance varies across the distribution of corruption. Seventh, neither police force nor government subsidies shows significance, but transition economies have more corruption.

For presentation at NÁRODNÁ BANKA SLOVENSKA
Applied Economics, forthcoming.

Keywords: Corruption; Uncertainty; Government; Quantile regression; Transition economies

JEL classification codes: H8; K4; P2

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1. Introduction

An enormous amount of scholarship has gone into the exploration of causes and correlates of corruption, as indicated, besides others, by Aidt (2003), Lambsdorff (2006), Serra (2006), Svensson (2005), and Treisman (2000). Similarly, an extensive literature exists on the consequences of various forms of uncertainty.[1] However, there has been very limited effort to link corruption with uncertainty. Among the very few studies on the topic, Braun and Di Tella (2004) related inflation variability with corruption in a cross-country panel, but their main focus was on inflation and its variability and not directly on uncertainty. Similarly, Kuncoro (2006) related corruption with uncertainty in Indonesia, but, besides being located in a narrow business context, it focused largely on uncertainty about the effectiveness of bribes from the perspective of bribe givers. We seek to augment the scant literature on the corruption-uncertainty nexus in at least five significant ways. First, we suggest a simple conceptual link between general economic uncertainty and bribes in terms of the "horizon", discount rate or "impatience" of the givers and takers of bribes. This differs from the audit-cost reasoning proposed by Braun and Di Tella (2004) in a principal-agent setting relative to different levels of inflation variance. Second, we augment fairly parsimonious "standard" models of corruption by including basic proxies for general economic uncertainty. Third, we work with a much larger and more recent cross-country sample than used in any existing study on the topic that we could find. Fourth, besides the usual OLS models, we estimate quantile regressions to get a sense of variability in the main parameters across different levels of corruption. Although we focus on uncertainty, this exercise is somewhat similar to that by Billger and Goel (2009). Fifth, besides accounting for episodes of hyperinflation, and allowing the possibility of transition economies being different, we consider some

additional variables, including size of the police force and magnitude of government subsidies that might affect the prevalence of corruption. We also experiment with two proxies for prevalence of corruption and for uncertainty.

The estimates indicate (a) a significant positive association between general economic uncertainty and corruption, (b) substantial parametric heterogeneity across high and low corruption regimes, (c) corruption-mitigating roles of income, "freedom", and government consumption spending, (d) higher prevalence of corruption in transition economies, and (e) lack of significant association of corruption with size of the police force and magnitude of public subsidies.

2. A Few Related Studies and Restatement of Motivation for the Project

As already noted, despite the vast literature on causes and correlates of corruption and considerable research on consequences of various types of uncertainty, there are very few studies that have explored the link between uncertainty and corruption. One such study is by Braun and Di Tella (2004). Their primary focus was on costs of higher inflation which is usually associated with higher inflation variance. Their core theoretical reasoning (2004, pp. 81-84) was based on a model in which the principal (investor) hires an agent to procure materials for the project, the agent inflates the cost and overinvoices, and the principal monitors (audits) the agent's accounts. The overinvoicing by the agent constitutes "corruption", and the extent of monitoring by the principal lowers it. Their postulated positive relation between corruption and inflation variance, which may be perceived as a measure of general economic uncertainty, is premised on the assumption (2004, p. 84) that the cost of audit is an increasing function of inflation variability. In a situation marked by greater inflation variance, audit costs are higher "which leads to an increase in corruption". Therefore, the suggested positive relation essentially reflects an assumption.

The authors stated that their principal-agent framework was applicable also to the public-sector corruption which is the focus of almost all research on the subject.

Using panel data for 75 countries covering the period 1982-1995, they found a generally positive association between inflation variance (which we treat as an indicator of general economic uncertainty) and several measures of corruption. Besides inflation variance, the only other variable that showed significance in most regressions was hyperinflation dummy with a significant negative sign. GDP per capita had a negative sign in some regressions but positive in some others. Although significant and positive in most cases, magnitude of the coefficient of inflation variance varied greatly across different models.

Another study that we could find on the subject is that by Kuncoro (2006) who investigated the relation between corruption and "business uncertainty" in Indonesia. The main thesis of the research was that bribes are less likely to be offered when the outcome of the bribe is uncertain due to the possibility of additional bribes being demanded by other officials in the decision chain. Based on data for the period 2001-2003, it was noted that the bribe-rate variable, while indicating a positive association with bribe-uncertainty in 2001, shows a significant negative association in 2003. The author's interpretation of the estimates is (2006, p. 22) that the "coefficient in 2003 agrees with the model hypothesis that an increase in uncertainty would reduce a firm's desire to bribe". The rationale for the positive sign in observations for 2001 is not clear, but seems to have something to do with greater fragmentation in the bribe-chain in 2003 and a greater overall uncertainty level.

While the few existing studies on the uncertainty-corruption nexus are useful, our primary motivation is to investigate the relation more directly by (a) suggesting a conceptual link between corruption and general economic uncertainty through a simple intuitive reasoning, (b) using a very large (and

recent) cross-country data set, (c) exploring variability in the major parameters across different levels of corruption through quantile regressions, (d) augmenting fairly standard models by including simple proxies for general economic uncertainty, (e) permitting the possibility of greater (or smaller) prevalence of corruption in transition economies, and (f) exploring the possible roles of police-force size and magnitude of public subsidies.

3. A Simple Conceptual Link between General Economic Uncertainty and Corruption

The main point we suggest is that general economic uncertainty lowers the predictability of outcomes of future economic activities. Therefore, such uncertainty lowers the value of future activities and shifts the focus from the uncertain future to the present. This is similar to an increase in the discount rate, and implies greater "impatience" or shorter horizon. Therefore, potential bribe givers are likely to be more willing to offer, and potential bribe takers are more likely to accept or demand, bribes at a given time (see Chan (2001) for support of this argument in the context of Hong Kong). We may thus expect an increased prevalence of corruption in an environment of greater economic uncertainty. Such a prediction does not relate to the magnitude of the bribes, but to the prevalence of corruption, and to the perception of such prevalence, which is what most data on the variable capture. The uncertain future and the implied impatience induce the economic agents to get things done quickly within a short "horizon", even if greater uncertainty lowers the value of the project.[2] The foregoing reasoning is somewhat similar to that of Mahajna et al. (2008) who suggest that the "trust hypothesis" implies lower trust being associated with higher subjective discount rates. In some ways, greater economic uncertainty is similar to lower trust in the future and a shift of the focus to the present.

Although not rigorous, our reasoning suggests a simple possible link between general economic uncertainty and corruption, and might be slightly more appealing

than an assumption that greater inflation variance, which is one measure of general economic uncertainty, increases the principal's cost of monitoring overinvoicing by the agent and thus increases corruption in the form of overinvoicing. Also, corresponding to the aggregative character of the corruption variables, our reasoning relates corruption with the degree of uncertainty in the general economic environment. Moreover, not equating corruption with overinvoicing by the agent, it can apply directly to public-sector corruption in the usual sense of bribes being given and taken, as stated by Svensson (2005).

4. Model, Data, and the Main Results

Following the empirical literature on determinants of corruption, we augment a fairly standard parsimonious model, which may be written as

$$CORR_i = b_0 + b_1\ UNCER_i + b_2\ RY_i + b_3\ FRDM_i + b_4\ GY_i + b_5\ HINF_i + b_6\ TRANS_i + b_7\ POLICE_i + b_8\ SUBS_i + u_i \quad (1)$$

where CORR is a measure of (perceived) corruption; UNCER is a proxy for general economic uncertainty; RY denotes real GDP per capita; FRDM reflects the status of political rights and civil liberties; GY denotes government consumption share; HINF indicates episodes of hyperinflation; TRANS indicates a transition economy; POLICE is an indicator of the size of police force; SUBS denotes the extent of public subsidies; i denotes the observation (country); and u is a standard stochastic term.

The rationale behind the explanatory variables is straightforward in most cases. GDP per capita indicates the degree of economic development of a country and is usually believed to lower corruption and its perception. Political rights and civil liberties are dimensions of freedom and the country's institutional context, which are likely to affect the prevalence of corruption. Government consumption share indicates government "size" and may affect prevalence of corruption. Episodes of hyperinflation are also believed to affect corruption and

would constitute a reasonable control variable. Similarly, transition economies are believed or observed to be marked by higher overall corruption levels. Size of the police force and government subsidies are exploratory variables since these may constitute significant loci of corruption and its perception. In particular, administration of subsidies may offer greater opportunity for bribes due to the process being subject to fewer official restrictions. Most of these variables have been included in almost all empirical research on corruption.

While possible endogeneity of some regressors may seem worrisome, several considerations suggest that endogeneity is not likely to be significant. First, in regard to income, Gundlach and Paldam (2009) have shown that long-run causality runs from economic prosperity to corruption. Second, Brunetti and Weder (2003) and Freille et al. (2007) show that the direction of causality is from press freedom to corruption. Third, it seems unlikely that the prevalence of corruption would have a significant influence on general economic uncertainty proxied by inflation variability. Also, use of lagged values of the regressors should mitigate any feedback from the dependent variable.

The proxies for the variables are largely standard. The well-known Corruption Perception Index of Transparency International (TI) is used as the primary proxy for prevalence and perception of corruption. Following some other studies, 3-year and 5-year standard deviation of inflation are taken as proxies for general economic uncertainty. This reflects the common view that greater inflation variability is a good indicator of general economic uncertainty. Similar proxies have been used in other contexts by Goel and Ram (1999, 2001) and others. Also, use of these proxies makes our study more comparable to that by Braun and Di Tella (2004). GDP per capita is measured in real international dollars. Index of political rights and civil liberties compiled by Freedom House is the proxy for "freedom" and institutional quality. As usual, government consumption as a percent of GDP is taken as a proxy for government size.

Hyperinflation episode is defined as a situation that is marked by an inflation rate of over 100% during the period 2002-2006. It is entered as a 0-1 intercept dummy. There is a similar 0-1 intercept dummy for transition economies. Police force as percent of population serves as the proxy for size of the police force, and government subsidies and other transfers as percent of government expenditure is the proxy for magnitude of subsidies. Most data points lie in the period between 2005 and 2007. The data sources are fairly standard. Table 1 provides variable definitions, descriptive statistics, and the data sources.

Table 2 contains the basic OLS estimates with several combinations of regressors from equation (1). It suggests seven points. First, relative to the variable of primary interest, both measures of general uncertainty have a positive association with corruption, and the estimates are significant at the conventional levels. Although a direct interpretation of the coefficients is difficult due to rescaling, the magnitudes appear substantial. For example, an increase of one standard deviation in the 3-year uncertainty index raises corruption by about one-sixth of its standard deviation in terms of three of the four estimates. Magnitude of the coefficient for 5-year inflation-uncertainty is also fairly sizable. There is thus an indication of greater economic uncertainty increasing "impatience", moving the economic agents' focus to the present, and increasing the bribe-giving and bribe-taking propensities. The empirical estimates are broadly consistent with the scenario indicated by Braun and Di Tella (2004) from a smaller cross-country sample and different theoretical construct. It may perhaps be noted that our estimates for the 3-year inflation variability measure are very similar across the models. The estimate in model 2.2 is not comparable with others due to the much smaller sample size.

Second, higher level of economic development reflected in greater GDP per capita lowers corruption. This broadly conforms to the general indication in the literature, including Svensson's (2005, pp. 27-30) graph and tables and Gundlach

and Paldam (2009), although Braun and Di Tella's (2004, p. 92) fixed-effects estimates suggested a positive association, which seems somewhat unusual.[3]

Third, increased political rights and civil liberties lower corruption significantly. This is consistent with the theme that better institutions lower corruption. The theme has been articulated in the literature in several forms, and has been noted by Svensson (2005), Lambsdorff (2006) and others.

Fourth, government-consumption variable has a negative association with corruption that is significant at the 10% level. This also broadly reflects the pattern reported in several cross-country studies, as noted by Lambsdorff (2006, pp. 4-5), and is consistent with "enhanced checks and balances" view of a larger government size. Rose-Ackerman (1999) provided an elaborate discussion of this aspect.

Fifth, transition economies are marked by higher corruption as the sizable and significant positive coefficient suggests. This is basically consistent with Svensson's (2005, p. 24) observation that countries with the highest levels of corruption are developing or transition economies.

Sixth, hyperinflation dummy lacks significance in each of the five models and the coefficients have mixed signs.

Seventh, neither size of the police force nor the magnitude of government subsidies shows significance. Although the sample size gets curtailed, particularly for police size, the very tiny t-statistics indicate these variables to have little significance.

The general conclusion from table 2 is that there is a significant positive association between economic uncertainty and corruption, and other estimates are plausible and generally consistent with the patterns reported in the literature. The new police-size and public-subsidy variables have extremely tiny t-statistics and lack significance at almost any level.

To provide a feel for the parametric variations at different corruption

levels, table 3 reports estimates of quantile regressions.[4] These are based on 3-year inflation uncertainty since that has a stronger association with corruption than the 5-year measure. The police-size and public-subsidy variables are not included due to the very tiny t-statistics in table 2. Transition dummy is also excluded since most transition economies are concentrated in one part of the distribution of corruption. The estimates are shown for five segments of (predicted) corruption levels at 0.10, 0.25, 0.50, 0.75, and 0.90 quantiles. While generally showing substantial parametric variations for most variables, the estimates suggest five points. First, for the uncertainty variable, the positive association is the strongest at the bottom decile, indicating that uncertainty affects corruption most at the lowest levels of corruption. The coefficient is the smallest and the weakest in the middle of the distribution, and is smaller and weaker at the top decile than at the bottom decile. Second, the negative coefficient for GDP per capita is also strongest at the bottom decile; there is a steady decline in its size at higher corruption levels, and the value for the top a decile is one-half of that at the bottom. There is a similar substantial difference for the top and the bottom quartiles. Third, the corruption-mitigating role of political rights and civil liberties appears fairly similar at different corruption levels. Fourth, the effect of government consumption is the weakest in the least corrupt segment at the bottom decile relative to other parts of the distribution, which is the opposite of the pattern for uncertainty and GDP per capita. Fifth, the parametric variation is most striking for hyperinflation. While hyperinflation episodes raise corruption substantially at the lowest decile, the phenomenon has a sizable and significant negative association at the top decile. There is a similar contrast for the bottom and top quartiles, but there is little association in the middle of the distribution. It is somewhat instructive to note that while the OLS regressions show no significant association of hyperinflation with corruption, quantile regressions indicate a

sharp contrast between highly significant coefficients around the two tails at the decile and quartile levels.

By way of a simple robustness check, table 4 shows the pattern for an alternative measure of corruption based on World Bank data corresponding to models 2.1, 2.2 and 2.5 of table 2. It may be seen that, except for hyperinflation, the estimates are almost identical across the three columns and remarkably similar to the corresponding estimates in table 2.

5. Concluding Observations

Noting the paucity of work relating uncertainty with corruption in the vast literature on corruption (and uncertainty), this study supplements the existing research in five ways. First, after suggesting a simple conceptual link between uncertainty and corruption, we augment a fairly standard set of regressors by including measures of general economic uncertainty. Second, we make an effort to study variations in the association of corruption with the regressors at different levels of corruption. Third, we use a cross-country sample that is probably larger than any used in earlier studies, and covers a more recent period. Fourth, we allow a slightly different structure for transition economies by including an intercept dummy. Fifth, we explore the possible role of the size of police force and public subsidies in the prevalence of corruption.

The estimates suggest several points. First, there is a sizable and significant positive association between economic uncertainty and corruption, indicating that higher uncertainty may shift the economic agents' focus to the present, induce "impatience" and strengthen the propensity to offer and demand bribes. Second, GDP per capita and "freedom" lower corruption, which is consistent with most research. Similarly, government consumption appears to have a modest corruption-reducing role, while transition economies are marked by greater prevalence of corruption. Most OLS estimates for hyperinflation have

mixed signs and lack significance. Size of the police force and public transfers have tiny t-statistics and show little traction. Third, while generally supporting the OLS patterns, quantile regression estimates indicate sizable heterogeneities across the distribution of corruption. The corruption-mitigating role of GDP per capita is strongest at the lowest decile and smallest at the top decile, and a somewhat similar pattern holds for the role of uncertainty. However, the role of government consumption is weaker in the lowest part and stronger at higher quantiles, but the coefficients for freedom are fairly similar at various quantiles. For hyperinflation, the parametric contrast is remarkable, with large and significantly positive coefficients in the lower parts and sizable and significant negative coefficients in the upper parts. Last, a comparison of the estimates based on TI's corruption perceptions index with those indicated by World Bank's index shows a consistent pattern.

While a direct consideration of the possible role of uncertainty in prevalence of corruption is our main theme, indication of sizable variations for most coefficients at different corruption levels also appears useful. However, we recognize that the conceptual linkage between uncertainty and corruption suggested by us is not rigorous and is properly perceived as heuristic and somewhat intuitive. Similarly, our uncertainty measures may not fully capture economic agents' perception of general uncertainty. Also, our OLS and quantile regressions represent somewhat basic procedures. It is hoped that future research will refine our work on these dimensions and also provide other theoretical and methodological improvements. Nevertheless, to the extent our estimates reflect the real world, one policy implication might be mentioned. In the context of their proposition about uncertainty raising the threshold for irreversible investments, Dixit and Pindyck (1994, p. 14) noted that reduction or elimination of uncertainty may be the best kind of public policy to stimulate investment. Somewhat similarly, the positive association between uncertainty and corruption

implies that reduction of uncertainty might lower corruption, which may indirectly also increase investment. Such a possibility may be particularly significant due to the increased economic uncertainty in recent years.

Table 1

Variable Definitions, Summary Statistics, and Data Sources

Variable	Definition	Mean (SD)	Source
CORR	TI's Corruption Perception Index (CPI), 2007, rescaled as log[(10-CPI)/CPI], larger values indicate more corruption	0.42 (1.02)	www.transparency.org
CORRWB	World Bank's Corruption Perception Index (WB), 2007, rescaled as log{[(5-(WB+2.5)]/(WB+2.5)}, larger value more corrupt	0.01 (1.03)	www.worldbank.org
UNCER3	3-year standard deviation of inflation, 2004-2006	3.65 (8.21)	2007 World Development Indicators CD-ROM
UNCER5	5-year standard deviation of inflation, 2002-2006	5.03 (10.38)	2007 World Development Indicators CD-ROM
RY	GDP per capita, 2005, (thousands of PPP international dollars, at 2000 prices)	9.65 (10.50)	2007 World Development Indicators CD-ROM
FRDM	Sum of a country's political rights and civil liberties scores, 2007, higher score, more freedom	-6.71 (3.83)	www.freedomhouse.org
GY	General government final consumption expenditure, percent of GDP, 2006	15.28 (5.65)	2007 World Development Indicators CD-ROM
HINF	Dummy variable: equals one if inflation rate > 100% during 2002-2006; zero otherwise	0.01 (0.10)	World Development Indicators
TRANS	Dummy variable: equals one if a transition economy; zero otherwise	0.15 (0.36)	World Bank
POLICE	Police force as percent of population, 2005	0.31 (0.66)	2007 World Development Indicators CD-ROM
SUBS	Government subsidies and other transfers as percent of government expenditure, 2006	41.16 (20.30)	2007 World Development Indicators CD-ROM

Note. Sample size is 143, except for CORRWB (N=141), POLICE (N=57) and SUBS (N=92). Rescaling of corruption variables is done to convert these into more continuous numbers and to make larger variable values reflect higher corruption levels.

Table 2

Estimates of Several Variants of Corruption Model of Equation (1):
Dep. variable: TI's CPI

	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5
UNCER3	0.02**		0.003*	0.02**	0.02**
	(2.9)		(1.9)	(2.8)	(3.1)
UNCER5		0.01*			
		(1.7)			
RY	-0.07**	-0.07**	-0.09**	-0.07**	-0.07**
	(-9.0)	(-9.0)	(-5.5)	(-5.9)	(-9.0)
FRDM	-0.05**	-0.05**	-0.01	-0.06**	-0.05**
	(-3.5)	(-3.6)	(-0.7)	(-2.8)	(-3.7)
GY	-0.01*	-0.01*			-0.01*
	(-1.8)	(-1.7)			(-1.9)
HINF	0.08	0.09	-0.06	0.11	-0.11
	(1.1)	(1.4)	(-0.7)	(0.8)	(-1.4)
TRANS					0.23**
					(3.4)
POLICE			-0.04		
			(-0.3)		
SUBS				0.001	
				(0.2)	
R^2	0.80	0.80	0.75	0.77	0.81
N	143	143	57	92	143

Note. See table 1 for variable definitions. A constant term is included in all models, but its estimates are not reported. The numbers in parentheses are robust t-statistics.

* Denotes statistical significance at the 10% level.
** Denotes statistical significance at the 5% level or better.

Table 3

Parametric Variability Across Various Corruption Levels:
Quantile Regression Estimates
Dep. variable: TI's CPI

	q(0.10)	q(0.25)	q(0.50)	q(0.75)	q(0.90)
UNCER3	0.03**	0.02**	0.01	0.03*	0.02*
	(2.1)	(2.4)	(0.9)	(1.7)	(1.7)
RY	-0.10**	-0.08**	-0.07**	-0.06**	-0.05**
	(-7.4)	(-10.4)	(-9.8)	(-6.5)	(-11.2)
FRDM	-0.06**	-0.05**	-0.04**	-0.04**	-0.05**
	(-2.9)	(-3.5)	(-3.5)	(-2.5)	(-4.0)
GY	-0.01	-0.02**	-0.01**	-0.02**	-0.02*
	(-1.2)	(-2.3)	(-2.0)	(-2.4)	(-1.8)
HINF	0.59**	0.31**	0.05	-0.24**	-0.36**
	(2.0)	(2.0)	(1.1)	(-2.1)	(-2.0)
Pseudo-R^2	0.69	0.66	0.58	0.50	0.44
N	143	143	143	143	143

Note. See table 1 for variable definitions. The numbers in parentheses are t-statistics based on standard errors from 200 bootstrap replications. A constant term is included, but its estimates are omitted. Lower quantiles cover countries with lower levels of (predicted) corruption. Since quantile regressions are now a well-known procedure, related technical details are omitted.

* Denotes statistical significance at the 10% level.
** Denotes statistical significance at the 5% level or better.

Table 4

A Simple Robustness Check with an Alternative Corruption Index:
Basic Models of table 2 with World Bank Corruption Index

	Model 3.1	Model 3.2	Model 3.5
UNCER3	0.02**		0.02**
	(3.4)		(3.6)
UNCER5		0.01*	
		(1.7)	
RY	-0.08**	-0.08**	-0.08**
	(-11.3)	(-11.3)	(-11.3)
FRDM	-0.04**	-0.04**	-0.04**
	(-3.4)	(-3.5)	(-3.7)
GY	-0.01*	-0.01*	-0.01*
	(-1.6)	(-1.6)	(-1.8)
HINF	0.29**	0.31**	0.06
	(4.1)	(4.4)	(0.9)
TRANS			0.29**
			(4.0)
R^2	0.78	0.78	0.79
N	141	141	141

Note. See table 1 for variable definitions. A constant term is included in all models, but its estimates are not reported. The numbers in parentheses are robust t-statistics.

* Denotes statistical significance at the 10% level.
** Denotes statistical significance at the 5% level or better.

NOTES

[1] An arbitrary and solitary example is the recent research by Bachmann, Elstner and Sims (2010).

[2] It might be possible for the value of the project to go down due to greater uncertainty, but the propensity to offer and demand bribes to increase.

[3] Gundlach and Paldman (2009) show not merely a negative association between income and corruption, but also that long-run causality appears to be entirely from income to corruption.

[4] The quantile-regression methodology is now well known, and its details are omitted. The procedure enables one to estimate the parameters for each regressor at different levels of the predicted distribution of the dependent variable, which is the prevalence of corruption in this project. The methodology has been described by Chamberlain (1994, p. 181), Deaton (1997, pp. 83-84) and other scholars. Koenker (2005) has provided an elaborate explanation of the methodology and some applications.

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