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GROWTH MAXIMIZING CORRUPTION?

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Abstract

The paper tests the applicability of quadratic modelling in the estimation of the relationship between corruption and economic growth. The main finding is that non-linearity holds, implying that there is a growth maximizing level of corruption so that the initially positive marginal effect of corruption on growth turns detrimental after the threshold level. Furthermore, the nexus between corruption and growth is found to vary between country groups, and to be conditional on the quality of political institutions. Low institutional quality makes the impact of corruption on growth unambiguously positive, whereas the impact remains statistically insignificant in the regime of high institutional quality. Thus, the results contradict with those of e.g. Aidt *et al.*, 2008.

JEL classification: D73, H10, O57

Keywords: Grease / sand in the wheels, Institutional quality, Threshold

1 Introduction

The common wisdom is that corruption is to be univocally doomed. Still, corruption flourishes all over the world. Even more disturbingly, the economic literature on corruption entails an unresolved debate concerning the macroeconomic effects of corruption: some studies find corruption purely detrimental, while some argue that corruption helps to “grease the wheels” of the economy (Popov, 2015, provides an up-to-date summary).

In the literature, most of the studies approach the question from the viewpoint of linear relationship between corruption and macroeconomic variables, such as economic growth or investments. Yet, many existing studies juggle the idea that both the dependent and explanatory variables are sensitive to the quality of political institutions. A usual premise is that better governance enhances growth and welfare, and Leff (1964), Myrdal (1968), Kurer (1993), and Kaufmann *et al.* (2000) state that corruption endogenously leads to poor governance and exacerbates the distortions. This is to say that the effect of corruption on economic development is likely to be conditional on political institutions. As Treisman (2000) sums up, corruption is actually a very complex phenomenon.

It is quite plausible that the mapping of, say, the corruption-growth link is not linear. However, very few papers have attempted to explore the non-monotonic relationship between corruption and growth in spite of the fact that the intertwined relationship of corruption and growth should quite naturally call for non-linear econometric modelling. Recent examples include Méon & Sekkat, 2005; Méndez & Sepúlveda, 2006; Aidt *et al.*, 2008; and Kéïta & Laurila, 2016a; 2016b.

Méon & Sekkat (2005), and Kéïta & Laurila (2016a; 2016b) approach the non-linearity issue by using interaction terms between corruption and governance variables in testing the *Grease in the wheels* hypothesis against the *Sand in the wheels* hypothesis. Méon & Sekkat (2005) proves the latter claim by finding that corruption dampens growth and investments, and that the negative effects are particularly strong with certain deficiencies in the quality of governance. Thus, corruption is found to exacerbate the distortions caused by bad governance. In contrast, Kéïta & Laurila (2016a) manages to confirm the *Grease in the wheels* argument of Bardhan (1997) saying that, in a second-best world of many developing countries, corruption may significantly alleviate the deeply rooted distortions provoked by bad governance.

Méndez & Sepúlveda (2006) approach the issue by using a quadratic model to estimate the effect of corruption on growth according to different regimes of political freedom. The main finding is that there exists a growth-maximizing level of corruption so that corruption has a positive effect on long run growth in countries with low degree of political freedom, while the opposite holds in countries with high political freedom. Yet, the results are robust only in the latter sub-sample. Aidt *et al.* (2008) presents another non-linear model that allows for threshold effects, and manages to yield robust results. The results corroborate the argument that corruption hampers economic growth in countries with high quality institutions, but contradict the reversed claim: corruption is found to have no effects on growth in countries with low quality institutions.

This assesses the possibility of a non-linear relationship between corruption and economic growth. The first issue is to test the empirical applicability of a quadratic regression model. In this respect, the non-monotonic estimations of Méndez & Sepúlveda (2006), and Aidt *et al.* (2008) are particularly scrutinized. Based on data from 117 countries worldwide over 1970-2011, the analysis finds a statistically significant pattern of growth-maximizing corruption. Second, possible dependency of the pattern on country specific factors, and particularly on the role of institutional quality in determining this non-linear link is studied. The result is that, in countries with low degree of institutional quality, the effect of corruption on economic growth is positive and statistically significant, and the threshold of optimal corruption is relatively high. On the other hand, in countries with high quality of political institutions, optimal corruption rather minimizes than maximizes growth at a relatively low threshold level, but the result remains statistically insignificant. The findings somewhat match the results of Méndez & Sepúlveda (2006), but are quite opposite to those of Aidt *et al.* (2008).

The paper is organized as follows. Section 2 describes the methodology and data used in the estimations. Section 3 presents and discusses the results, including basic estimations and threshold tests over the whole sample, calculations of optimal corruption, assessment of optimality within different country groups, and a study on the role of institutional quality on the results. Section 4 concludes.

2 Modelling, data, and methods

To test the existence of GDP-maximizing corruption, the paper estimates a quadratic bivariate equation, which is commonly used for investigating a relationship that is supposed to be non-linear. In the estimations, all the statistics are expressed in natural logarithms to make the data conform more closely to normal distribution. It helps in correcting for skewed data, thus improving the quality of the estimations. The baseline model reads

$$(1)\quad \Delta logGDP_{i,t} = \gamma+\lambda logCorruption_{i,t}+\psi logCorruption_{i,t}^{2}+\zeta log\Omega_{i,t}+\mu_{i,t},$$

where the dependent variable on the left-hand side stands for the changes in GDP starting from the initial year 1970 (that is $\Delta logGDP_{i,t}= logGDP_{i,t} - logGDP_{i,1970}$). The GDP data come from *Penn World Tables 8.1* (Feenstra *et al.*, 2015), and describe the expenditure-side real GDP (at chained PPPs in millions 2005 US$) from 117 countries worldwide for 1970–2011 (including 42 time periods). Countries in the sample are listed in *Appendix 1*.

On the right-hand side of equation (1), the explanatory variable $Corruption_{i,t}$ is measured by two indicators. The first one is the Control of Corruption index from the World Bank's Worldwide Governance Indicators 2014 dataset. It is denoted *cc*, and it covers periods 1996-2013, excluding years 1997, 1999, and 2001. The original *cc* scores vary from -2.5 (utmost corruption) to 2.5 (perfect integrity). The second indicator is the Corruption Perception Index (denoted *cpi*), which has been published yearly by Transparency International since 1995.

The original *cpi* scores vary from 0 (utmost corruption) to 10 (perfect integrity). For ease of interpretation both variables are rescaled to make *cc* vary from 1 to 6, and *cpi* from 1 to 11 so that the lower end implies perfect integrity and the upper bound implies utmost corruption for both indices. The log-transformation of course modifies these numbers again (for example, the *cc* index becomes to vary from 0 to 1.79 as corruption increases).

On the right-hand side of equation (1), *Ω* is a vector of the other control variables including determinants of growth, and dummy variables. The most likely variables that explain growth (see Levine & Renelt, 1992) include initial income, physical capital, human capital, and demography. The inclusion of initial income y_{1970} (expenditure-side real GDP at chained PPPs in 1970, in millions 2005 US$) is supposed to catch the well-known *conditional* convergence hypothesis (Barro, 1991; Mankiw & Weil, 1992). This variable should be negatively correlated with GDP growth (that is ζ<0) suggesting that poorer countries will catch up the richer ones, as their economies grow more rapidly through the application of new technologies, by mimicking organizational patterns etc. In contrast, human and physical capital are commonly known for their positive influence on growth (i.e. ζ>0). Human capital is monitored by *Human capital index/person* based on schooling years (Barro & Lee, 2013) and returns to education (Psacharopoulos, 1994) Physical capital is measured by *Average capital stock*, and the demographic factor is measured by *Population growth*, both from the *Penn World Tables 8.1*. All indices are available over 1970–2011. The descriptive statistics of the main variables are in *Appendix 2*.

The dummy variables in vector *Ω* include *Post2000*, *Sub-Saharan Africa*, *Latin America - Caribbean*, *Middle East - North Africa*[1], *Euro area*, and *Emerging/Developing Asia*. The *Post2000* dummy gets the value 1 for years 2000–2011, and 0 for 1970–1999. This is reasoned by the strong anti-corruption actions taken by the international community in the 21st century with plausible influences on the link between corruption and economic growth. The country grouping reflected by the other five dummy variables is reasoned by the assumption that differences in governance patterns and socio-economics mentalities are likely to influence the corruption-growth link. The grouping follows the *World Economic Outlook Database, October 2015 (IMF)*. Belonging to a particular group means that the respective dummy gets the value 1 for the country in question.

A somewhat troublesome fact is that the corruption statistics start from 1996 for *cc* and from 1995 for *cpi*, while the other data range from 1970 to 2011. Following Méndez & Sepúlveda (2006), full use of the time series is made possible by writing out the missing corruption variable series. This is done by supplementing the averages of *cc* and *cpi* from their existing series (that 1995-2011 for *cpi*, and 996-2011 for *cc*) for the blanc years (between 1970-1994 for *cpi*, and between 1970-1995 for *cc*). Then, the regressions are carried out over 1970-2011 so that the corruption indices vary only between 1995/1996-2011.[2]

The estimations are based on the Two-Stage Least Squares (2SLS) method to avoid potential reverse causality from GDP fluctuation to corruption. The nexus between changes in GDP and corruption might occur, if economic downturns further encourage initially high corruption (Mauro, 1995). All regressors are also used as instruments. If the estimations of equation (1) would be conclusive regarding the significance of the quadratic form, the relationship between growth and corruption could be illustrated by a parabolic curve. Thus, the optimum, i.e. the growth maximizing

[1] In line with *World Economic Outlook Database*, the *Middle East - North Africa* group includes Pakistan.

[2] The procedure seems to suggest that the effect of changes in corruption are irrelevant, and to hide possible long run changes in corruption. However, the validity of the use of average indices was tested by regressing separately over the intervals 1970-1994/1995 (with constant *cpi* and *cc* values), and 1995/1996-2011 (with changing *cpi* and *cc* values), and the results turned out quite similar. Furthermore, the ADF test over the interval 1995/1996-2011 showed that there is no significant trend in corruption in that time span, and a plausible assumption is that there would have not been such trend during 1970-1994/1995, or 1970-2011 for that matter. Thus, the averaging technique should be reasonably reliable.

or minimizing value of the corruption variable, denoted *cc**, and *cpi**, can be calibrated (ref. Méndez & Sepúlveda, 2006). In the case of a maximum, marginal increases in corruption foster economic growth up to a certain point, after which further increases of corruption lead to a decline of growth. Thus, the illustrative curve is inverse U-shaped. Consequently, the curve is U-shaped in the case of a minimum.

The *cc**, and *cpi** values can be calculated from the estimates of equation (1). However, since equation (1) includes a set of other control variables besides the corruption variable, the calculation might not be accurate. By Levine & Renelt (1992), it is better to focus only on the variable of main interest. Hence, the vector of other explanatory variables, Ω, is excluded, and the calculations of *cc**, and *cpi**are based on the following equation:

(1') $\Delta logGDP_{i,t} = \gamma + \lambda logCorruption_{i,t} + \psi logCorruption_{i,t}^2 + \mu_{i,t}$.

The existence of *cc**, or *cpi**, is tested by the threshold approach developed by Hansen (1996; 2000). The threshold model can be specified by the following equations:

(2) $\Delta logGDP_{i,t} = \gamma + \beta X_{i,t} + \varrho Threshold1_{i,t} + \mu_{i,t}$,

(3) $\Delta logGDP_{i,t} = \gamma + \beta X_{i,t} + \tau Threshold2_{i,t} + \mu_{i,t}$.

In equations (2) and (3), $X_{i,t}$ is a vector of all explanatory variables used in equation (1). Considering the case of a possible maximum, *Threshold1* in equation (2) is a dummy variable that takes the value 1, if the corruption level is equal or smaller than the GDP-maximizing corruption threshold (i.e. $cc, cpi \leq cc^*, cpi^*$), and 0 otherwise. Recalling that the corruption indices are rescaled so that bigger values mean higher corruption, the dummy captures countries with relatively low levels of corruption. Thus, the estimated coefficient of *Threshold1* is expected to be positive (ϱ>0), because increases in corruption before the optimum stimulate growth. On the other hand, *Threshold2* gets the value 1, if the corruption level exceeds the GDP-maximizing corruption threshold (i.e. $cc, cpi > cc^*, cpi^*$), and 0 otherwise. Thus, the observations should be on the falling regime of the inverse U type curve, and the estimated coefficient of *Threshold2* should be negative ($\tau<0$), or insignificant. In the case of a possible minimum, all the above definitions are reversed.

3 Results

3.1 Basic estimations

The basic estimations include four types of regressions. On one hand, both corruption variables *cc* and *cpi* are used, and on the other hand, equation (1) is estimated in linear (i.e. ψ=0 by assumption) and quadratic (i.e. $\psi \neq 0$) forms in order to assess the non-linearity presumption. In *Table 1* below, regressions 1 and 2 are based on *cc*, while regressions 3 and 4 use *cpi*. Preliminary regressions 1 and 3 concern the linear form of equation (1), while regressions 2 and 4 concern the full quadratic form.

Table 1: Basic estimations of the sources of GDP growth over 1970–2011

Corruption index	*cc*		*cpi*	
Regression	1	2	3	4
Corruption	0.245***	0.621***	0.209***	0.353***
	(0.025)	(0.083)	(0.019)	(0.087)
Corruption^2		-0.226***		-0.054·
		(0.047)		(0.032)
y_{1970}	-0.559***	-0.548***	-0.546***	-0.544***
	(0.013)	(0.013)	(0.013)	(0.013)
Average capital stock	0.511***	0.500***	0.498***	0.496***
	(0.013)	(0.013)	(0.013)	(0.013)
Human capital index/person	0.534***	0.484***	0.495***	0.474***
	(0.038)	(0.040)	(0.038)	(0.040)
Population growth	-1.332e-05	-0.3e-06	-3.726e-05	-3e-05
	(1.08e-04)	(1.0e-04)	(1.03e-04)	(1.0e-04)
Post 2000	0.746***	0.756***	0.813***	0.818***
	(0.016)	(0.016)	(0.016)	(0.016)
Sub-Saharan Africa	0.068*	0.063*	0.085**	0.084**
	(0.029)	(0.029)	(0.028)	(0.028)
Latin America - Caribbean	-0.042·	-0.044·	-0.062*	-0.061*
	(0.025)	(0.024)	(0.024)	(0.024)
Middle East - North Africa	0.262***	0.252***	0.275***	0.271***
	(0.028)	(0.028)	(0.028)	(0.028)
Euro area	-0.175***	-0.198***	-0.186***	-0.196***
	(0.023)	(0.024)	(0.022)	(0.023)
Emerging/Developing Asia	0.094***	0.098***	0.087***	0.091***
	(0.027)	(0.027)	(0.027)	(0.027)
Intercept	-0.435***	-0.479***	-0.510***	-0.558***
	(0.066)	(0.067)	(0.069)	(0.074)
Adjusted R-squared	0.5788	0.5809	0.6199	0.6200
Wald-statistic	555.5	513.6	604.5	554.6
Probability (Wald-statistic)	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16

Notes: Robust standard errors of the 2SLS estimator are reported in parentheses. The superscripts ***, **, *, and · mark the statistical significance at 0.1, 1, 5, and 10 per cent level, respectively.

Table 1 shows that the findings are quite similar whether the estimations are based on *cc* or *cpi*. The signs of the coefficients of the explanatory variables are almost identical in both cases, which reflects certain robustness of the results. With both *cc* and *cpi*, the results show that corruption is positively associated with the changes in real GDP. The estimated coefficients of corruption are also statistically significant. In the non-linear regressions (2 and 4), the estimated coefficients of corruption are 0.621 for *cc*, and 0.353 for *cpi*. The same positive relationship is reflected in the linear regressions (1 and 3). Thus, corruption seems to unambiguously foster real GDP growth. In particular, the negative coefficients of the quadratic term suggest (with 5 %, and 10 % error level for *cc* and *cpi*, respectively) that there exists a critical, growth maximizing level of corruption.

Overall, the growth control variables contained in Ω stay consistent with the literature by displaying their expected signs (Levine & Renelt, 1992). The estimated coefficients are statistically significant except that of *Population growth*. The negative sign of the estimated coefficient of initial income y_{1970} consistently validates the *conditional* convergence hypothesis (Mankiw & Weil, 1992). The estimated coefficients of *Average capital stock* and *Human capital index/person* are positive, confirming the contribution of human and physical capital to economic performance (Levine & Renelt, 1992).

Furthermore, the results in *Table 1* show that the dummy variables are meaningful. For example, the estimated coefficient *Post2000* is systematically positive suggesting that the recent anti-corruption mobilization has significantly enforced GDP growth. The same is true with the country-group dummy variables. For example in *Sub-Saharan Africa*, the estimated coefficients are always positive implying that, as such, belonging to this country group has a positive effect on growth.

3.2 Optimal corruption

Taking *cc* as the benchmark corruption index, the estimated coefficient in regression 2 in *Table 1* above indicates that a one percentage point increase in *Corruption* produces a 0.62 per cent increase in $\Delta logGDP$. Moreover, that the estimated coefficient of $Corruption^2$ is negative and significant implies that the results can be used to obtain the optimal corruption level. Estimation of equation (1') yields $\Delta logGDP = 0.3633+1.3364*cc-0.7578*cc^2$, where *cc* is used for *Corruption*. The optimal level of corruption cc^* is solved by maximizing the equation at $\Delta logGDP=0$. As a result, $cc^* = 0.88$, and $\Delta logGDP = 0.95$. *Figure 1* illustrates the result.

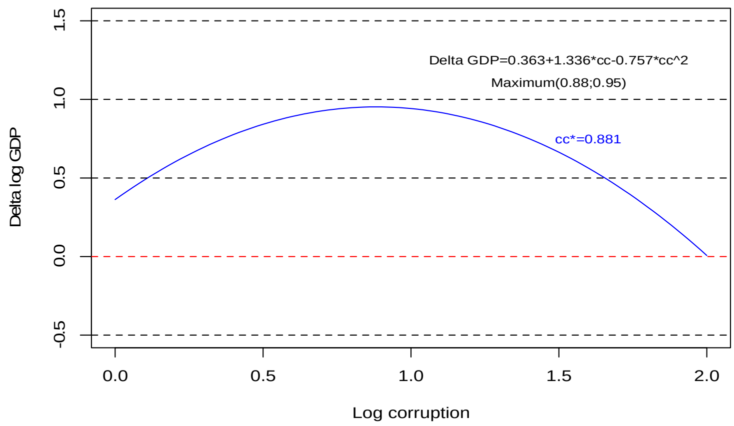

Figure 1: Estimating the optimal corruption threshold

Figure 1 plots an inverse U-type curve whose maximum is defined by the coordinates 0.88 and 0.95. From the full scale of *logcc* that is [0;1.79], corruption tends to stimulate growth within the range [0;0.88). Thus, corruption acts as *grease* in economic wheels. Once the maximum is reached, corruption becomes harmful, and further increases in corruption hinder economic growth. In other words, in the range beyond the optimal corruption level that is (0.88;1.79], corruption starts to *sand* the wheels of the economy. Appendix 3 checks the robustness of the results yielded by the quadratic functional form.

The existence of cc^* is tested using the Hansen approach (Hansen, 1996, 2000). *Table 2* reports the estimation results of equations (2) and (3). Since the estimates are overall consistent with those in *Table 1*, attention is here paid only on those relevant to the Hansen test.

Table 2: Testing the presence of the growth maximizing corruption threshold over 1970–2011

Corruption index	*cc*					
Regression	5	6	7	8	9	10
cc	0.594***	0.594***	0.795***	0.552***	0.862***	0.604***
	(0.095)	(0.095)	(0.126)	(0.087)	(0.140)	(0.088)
cc^2	-0.213***	-0.213***	-0.292***	-0.232***	-0.321***	-0.253***
	(0.049)	(0.049)	(0.059)	(0.051)	(0.064)	(0.055)
y_{1970}	-0.539***	-0.539***	-0.538***	-0.535***	-0.535***	-0.537***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Average capital stock	0.492***	0.492***	0.491***	0.488***	0.489***	0.491***
	(0.014)	(0.014)	(0.013)	(0.014)	(0.013)	(0.013)
Human capital index/person	0.455***	0.455***	0.453***	0.448***	0.462***	0.457***
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
Population growth	-1.17e-05	-1.17e-05	-1.23e-05	-1.25e-05	-1.13e-05	-1.17e-05
	(1.10e-04)	(1.10e-04)	(1.09e-04)	(1.10e-04)	(1.09e-04)	(1.09e-04)
Post 2000	0.762***	0.762***	0.763***	0.764***	0.761***	0.762***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Sub-Saharan Africa	0.069*	0.069*	0.070*	0.065*	0.072*	0.067*
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Latin America – Caribbean	-0.022	-0.022	-0.016	-0.022	-0.018	-0.028
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Middle East-North Africa	0.274***	0.274***	0.277***	0.270***	0.277***	0.271***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Euro area	-0.187***	-0.187***	-0.179***	-0.176***	-0.176***	-0.179***
	(0.025)	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)
Emerging/Developing Asia	0.124***	0.124***	0.127***	0.121***	0.126***	0.120***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Threshold 1	0.021					
	(0.038)					
Threshold 2		-0.021				
		(0.038)				
Threshold 1.1			0.105*			
			(0.044)			
Threshold 2.1				0.058		
				(0.035)		
Threshold 1.2					0.126**	
					(0.048)	
Threshold 2.2						0.050
						(0.030)
Intercept	-0.463***	-0.441***	-0.584***	-0.417***	-0.630***	-0.447***
	(0.083)	(0.068)	(0.091)	(0.069)	(0.100)	(0.068)
Adjusted R-squared	0.5819	0.5819	0.5823	0.5821	0.5824	0.5821
Wald-statistic	452.5	452.5	453.5	453	453.7	453
Probability (Wald statistic)	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16

Notes: Robust standard errors of the 2SLS estimator are in parentheses. The superscripts ***, **, *, and · represent statistical significance at 0.1, 1, 5, and 10 percent level, respectively.

The Hansen test aims to verify if there exists a GDP growth pattern, when observed corruption is below cc^*=0.88 (regression 5 in *Table 2*), and if there are any signs of economic downturn when observed corruption is above cc^*=0.88 (regression 6 in *Table 2*). The result of this test depends on the signs of the estimated coefficients of the *Threshold* variables. In regression 5, the estimated coefficient of *Threshold1* is positive (ϱ>0), while that of *Threshold2* is negative (τ<0) in regression 6.

The signs are consistent with the existence of a maximum at *cc**=0.88, but neither of the estimates is statistically significant. Therefore, two additional experiments are carried out by exploring the close neighbourhood of *cc=0.88* with the presumption that the odds of *cc** residing within the neighbourhood would be improved. The first experiment reported in *Table 2* considers a 0.4 *logcc* wide neighbourhood around *cc*=0.88, i.e. $cc^* \in [0.68;1.08]$. The dummy variable *Threshold1.1* gets the value 1 if *cc* is equal to or below 0.68 (and 0 otherwise), while *Threshold2.1* gets 1 if *cc* is equal to or above 1.08 (and 0 otherwise). Regression 7 in *Table 2* yields a positive and statistically significant (at 5 % level) coefficient estimate for *Threshold1.1*, and regression 8 yields now a positive but insignificant estimate for *Threshold2.1*. The second experiment expands the neighbourhood further to 0.6, i.e. $cc^* \in [0.58;1.18]$ with respective dummies *Threshold1.2* and *Threshold2.2*. The coefficient estimate for *Threshold1.2* from regression 9 is consistent with that of *Threshold1.1* (the positive marginal effect is even stronger, and the degree of statistical significance is better). However, the coefficient estimate for *Threshold2.2* from regression 10 remains positive and insignificant. In any case, the experiments are statistically robust, and suffice to confirm the existence of an optimal corruption level in the close neighbourhood of *cc*=0.88.

3.3 Optimal corruption according to country groups

The results presented in *Table 1* and *Table 2* hint that there may be differences in the non-linear correlation between corruption and GDP growth between the specified country groups. As presumed, there should exist considerable variation in socioeconomic, political, moral or other such characteristics that may affect the realization of the threshold of optimal corruption. Therefore, the applicability of the quadratic formulation is worthy of testing also from this point of view. In particular, the test focuses on if the relationship between corruption and economic growth plots a U-shaped curve, and whether that curve is inversed or not. In other words, the test is about finding a growth maximizing or growth minimizing level of corruption.

In the test, equation (1') is estimated using the country groupings specified above. The estimation method remains otherwise unaltered so that the results should be consistent with those presented in *Table 1* and *Table 2*. The results yielded by the testing procedure are reported in *Table 3*.

Table 3: Testing for the presence of an optimal *cc** according to country groups

Country groups	*cc* coefficient	cc^2 coefficient	*cc**
Sub-Saharan Africa	-12.087*** (1.816)	3.895*** (0.703)	1.551
Latin America - Caribbean	1.952 (1.283)	-0.638 (0.592)	1.529
Middle East-North Africa	0.698 (1.678)	-0.484 (0.664)	0.721
Euro area	0.417 (0.257)	-0.194 (0.192)	1.074
Emerging/Developing Asia	13.482** (4.140)	-5.421*** (1.562)	1.243

Notes: Robust standard errors of 2SLS estimator are in parentheses. The superscripts ***, and ** represent statistical significance at 0.1, and 1 % level, respectively.

Table 3 shows that the test result is statistically significant only for *Emerging/Developing Asia* and *Sub-Saharan Africa*. In *Emerging/Developing Asia* countries, the corruption-to-growth relationship plots an inverse U-shaped curve just like in the case of the whole sample of countries illustrated in *Figure 1* above. The growth maximizing level of corruption is *cc**=1.243 saying that *grease* in the economic wheels turns to *sand* at that point. In *Sub-Saharan Africa*, however, the plotting is U-shaped with *cc**=1.551 as the growth minimizing level of corruption. This is to say that when the observed level of corruption is lower than 1.551, further increases in corruption *sands* the economic wheels, but when corruption is beyond this threshold, corruption starts to *grease* the wheels. The result sounds surprising, but it merely reflects the fact that corruption is particularly severe in that country group. For *Latin America - Caribbean*, *Middle East - North Africa*, *or Euro area*, the test suggests growth maximizing optima, but the estimates are not statistically significant. Figure 2 illustrates the results.

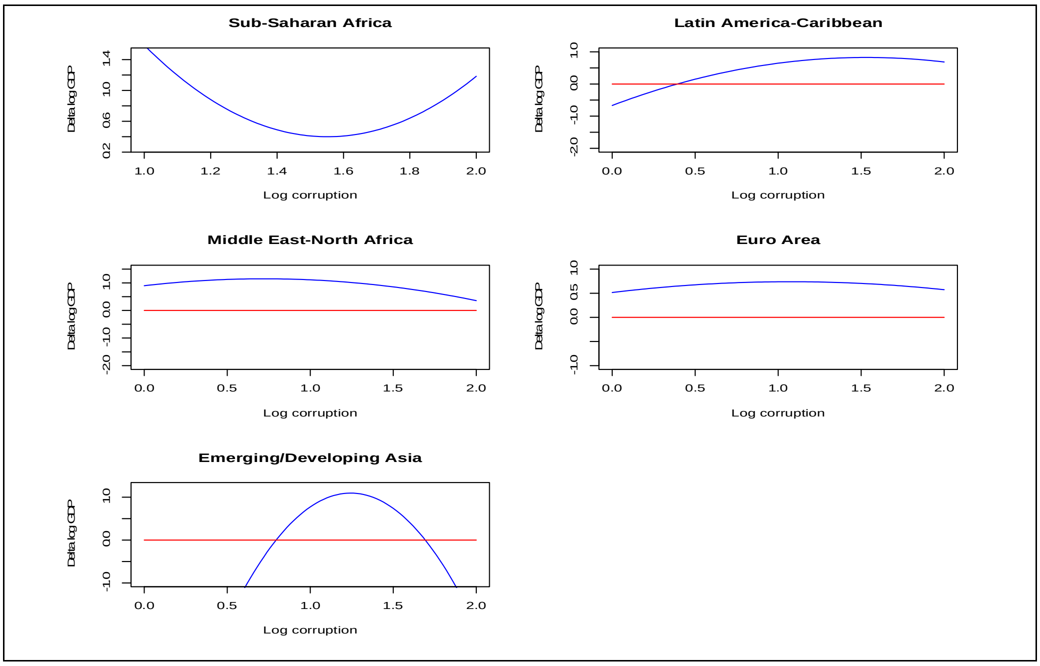

Figure 2: Estimating the optimal GDP-maximizing corruption threshold by country groups

In *Figure 2*, the shapes of the curves give reasons to believe that GDP-maximizing corruption thresholds should exist in all country groups besides *Sub-Saharan Africa*. The insignificant findings for *Latin America - Caribbean*, *Middle East - North Africa*, *or Euro area*, in *Table 3* are reflected by the generally very flat curvatures of the respective inverse U-shaped plotter outputs, which indicates low elasticity of GDP growth to increases in corruption.

3.4 The influence of institutional regimes

Earlier investigations on the macroeconomic effects of corruption suggest that the interplay between corruption and governance determines the effects in large extent. Corruption is found to have positive economic impacts in countries with deficient political institutions or poor governance, and negative or less positive elsewhere (Méon & Sekkat, 2005; Méndez & Sepúlveda, 2006; Méon & Weill, 2008; Kéïta & Laurila, 2016b).

Based on the above findings on the non-linear relationship between corruption and economic growth, the next step is to examine whether institutional quality can affect the long-run link, and the calibrated thresholds of optimal corruption. To capture the institutional factor, the indicators *Safety and Rule of law*, and *Government effectiveness* from the world Bank's WGI dataset are used (see Kéïta & Laurila, 2016a). *Safety and Rule of law* assesses the "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." On the other hand, *Government effectiveness* "reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality if policy formulation and implementation, and the credibility of the government's commitment to such policies" (see Kaufmann *et al.*, 2010). The indicators are available from 1996.

Countries are sorted according to institutional quality (from low to high quality) measured by the observed values of the two indicators, and divided into three groups, each consisting of 39 countries. The quality measurement is again supplemented by calculating the average values of *Safety and Rule of law* and *Government effectiveness* indicators over 1996–2011, and using the averages for the missing observations over 1970-2011. The grouping is supposed to represent three types of regimes of institutional quality. In order to make analytical difference, the middle regime 2 is dropped out. The list of countries in the remaining regimes 1 and 3 is presented in *Appendix 4*). Then, equation (1') is estimated with respect to regime 1 (poorest institutional quality), and regime 3 (best institutional quality) over the whole time span 1970-2011. The robustness of the results is checked by doing the same over 1996–2011 that is by using only the observed indicator values. The results are reported in *Table 4*.

Table 4: Growth maximizing corruption levels with respect to institutional quality

	Time span	1970–2011			1996–2011		
	Regime	*cc*	*cc*^{2}	*cc**	*cc*	*cc*^{2}	*cc**
Safety and Rule of law	1	20.955*** (4.751)	-7.763*** (1.649)	1.349	23.589*** (5.896)	-8.868*** (2.051)	1.330
	3	-0.380 (0.242)	0.689*** (0.187)	0.276	-0.054 (0.380)	0.585* (0.292)	0.046
Government effectiveness	1	8.353· (4.915)	-3.426* (1.701)	1.219	18.419** (6.173)	-7.078*** (2.143)	1.301
	3	-0.338 (0.208)	0.502** (0.158)	0.336	-0.096 (0.311)	0.418· (0.236)	0.114

Notes: Robust standard errors of 2SLS estimator are in parentheses. The superscripts ***, **, *, and · represent statistical significance at 0.1, 1, 5, and 10 % error level, respectively.

Table 4 confirms the common view that the impact of corruption on growth is highly regime specific. In regime1 that is with poor institutional quality, corruption has a positive impact on growth over 1970-2011. The estimated coefficients of *cc* stay statistically significant (at 0.1 % error level with *Safety and Rule of law*, and at 10 % error level with *Government effectiveness*). Over 1996-2011, the same conclusion prevails and the statistical significance is even higher (0.1 % level for *Safety and Rule of law* and and 1 % level *Government effectiveness*). This result is consistent with Méndez & Sepúlveda (2006), which says that corruption tends to be beneficial to economic growth in countries with low *political freedom*. Yet, Aidt *et al.* (2008) does not find such connection with respect to low *political accountability*.

Second, in regime 3 with high institutional quality, the signs turn the other way round over the interval 1970-2011. In particular, the estimated coefficient of *cc* is negative but statistically insignificant whether *Safety and Rule of law* or *Government effectiveness* is concerned. This means that corruption has no obvious impact on economic performance in this regime. The result stays robust even when the shorter time span 1996-2011 is considered, and contradicts Aidt *et al.* (2008), which finds corruption substantially detrimental to growth in the high quality context.[3]

Third, beyond the conclusion that the effects of corruption on growth are conditional on institutional quality, the results in *Table 4* suggest that *cc** is also correlated with the quality regimes. The *cc** values are relatively high in regime 1, while they are relatively low in regime 3. Thus, the growth maximizing threshold seems to vary in reverse order with institutional quality. The finding is also robust, because the estimations over both time spans 1970-2011, and 1996-2011 yield similar results. *Figure 3* illustrates the results with respect to the quality regimes constructed according to *Safety and Rule of law* and *Government effectiveness*. The regimes under consideration are indicated by numbers 1 and 3 after the respective indicator titles.

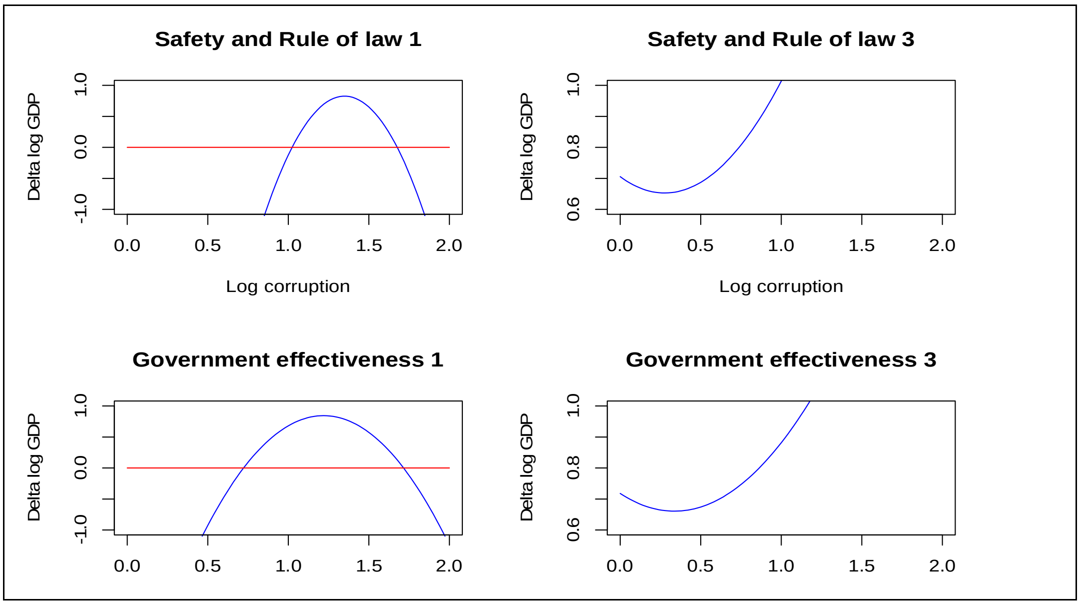

Figure 3: Optimal corruption with respect to institutional quality (1970-2011)

In *Figure 3*, regime 1 shows inverse U-shaped curves with growth maximizing *cc** values. On the other end, the curves in regime 3 are U-shaped, which would say that the *cc** values minimize GDP growth. However, since the estimates are statistically insignificant, the test remains inconclusive.

3 Yet, note that Aidt *et al.* (2008) uses other quality measures and a more restricted sub-sample.

Nevertheless, there is some support to the idea that corruption hampers economic growth in the high quality regime, as claimed by Méndez & Sepúlveda (2006) and Aidt *et al.* (2008).

4 Conclusions

This study is an empirical analysis that tests the non-linear relationship between corruption and real GDP changes. The test, including the Hansen threshold technique (Hansen, 1996; 2000), is performed through the estimation of a long run bivariate quadratic function over 117 countries worldwide within the time span from 1970 to 2011. The econometric technique is 2SLS, which helps to correct potential reverse causality from growth to corruption.

The main results indicate that the corruption-growth nexus is indeed non-linear. Thus, there also exists a GDP growth maximizing corruption threshold over the whole sample of countries. Within a logarithmic variation interval (from 0 to 1.79, where the upper bound means utmost corruption), the growth maximizing corruption threshold is found to be 0.88 within the sample. This implies that the marginal effect of corruption on growth is positive, if perceived corruption is below the threshold level, and turns negative beyond that threshold. The relationship plots an inverse U-shaped curve, which reaches its top at the threshold level.

The same is experimented with respect to presumed differences between the country groups sorted out already in the basic estimations. The results are unambiguous in two groups, *Emerging/Developing Asia*, and *Sub-Saharan Africa*, but remain statistically insignificant in *Latin America - Caribbean*, *Middle East - North Africa*, and *Euro area*. In *Emerging/Developing Asia*, a reasonably high (cc*=1.243) growth maximizing corruption threshold is found, but in *Sub-Saharan Africa*, the threshold is growth minimizing, and very high (cc*=1.551). The results in the remaining three groups speak in favour of growth maximization, but plot very flat inverse U-shaped curves. Overall, the results manage to confirm non-linearity in the corruption-growth nexus.

Next, the paper proceeds to examine the role of institutional quality (measured by *Safety and Rule of law*, and *Government effectiveness*) in the context of the model. The results are unambiguous, when countries with low institutional quality are considered: the statistically significant finding is that the effect of corruption on economic growth is clearly positive. Furthermore, the growth maximizing corruption threshold is found to be high (relatively close to the upper bound 1.79). The results are less clear among countries with high institutional quality. The effect of corruption on economic growth turns out negative suggesting that, in this group of countries, the optimal corruption threshold should be low (relatively close to the lower bound 0), and minimize rather that maximize growth. However, the result remains statistically insignificant. The findings are broadly consistent with the conclusions of Méndez & Sepúlveda (2006), but are in strict contrast with those of Aidt *et al.* (2008).

In any case, the findings of this paper comport with the idea that the possible virtues of corruption arise from pre-existing distortions caused by bad governance. To some extent, corruption can alleviate malfunctions that are rooted deeply in governmental practices. What makes this particularly disturbing is that, in many developing countries, corruption might be reasoned by macroeconomic grounds. As Méndez & Sepúlveda (2006, p. 96) puts it, “public policies designed to eliminate corruption alone might not be optimal for growth”.

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Appendix 1: List of countries/territories in the sample (117 in total)

Albania	Ecuador	Lesotho	Rwanda
Argentina	Egypt	Liberia	Saudi Arabia
Australia	El Salvador	Luxembourg	Senegal
Austria	Fiji	Macao	Sierra Leone
Bahrain	Finland	Malawi	Singapore
Bangladesh	France	Malaysia	South Africa
Barbados	Gabon	Maldives	Spain
Belgium	Gambia	Mali	Sri Lanka
Belize	Germany	Malta	Sudan
Benin	Ghana	Mauritania	Swaziland
Bolivia	Greece	Mauritius	Sweden
Botswana	Guatemala	Mongolia	Switzerland
Brazil	Honduras	Morocco	Syrian Arab Rep.
Brunei Darussalam	Hong Kong	Mozambique	Taiwan
Bulgaria	Hungary	Mexico	Tanzania
Burundi	Iceland	Nepal	Thailand
Cambodia	India	Niger	Togo
Cameroon	Indonesia	Namibia	Trinidad and
Canada	Iran	Netherlands	Tobago
Central African Rep.	Iraq	Norway	Tunisia
Chile	Ireland	New Zealand	Turkey
China	Israel	Pakistan	Uganda
Colombia	Italy	Panama	United Kingdom
Congo, Republic of	Jamaica	Paraguay	United States
Democratic Rep. of Congo	Japan	Peru	Uruguay
Costa Rica	Jordan	Philippines	Venezuela
Cote d'Ivoire	Kenya	Poland	Viet Nam
Cyprus	Korea, Republic of	Portugal	Zambia
Denmark	Kuwait	Qatar	
Dominican Republic	Lao	Romania	

Notes: The total sample of countries (117 countries) is used in the estimations based on *cc*. Central African Republic does not appear in the estimations based on *cpi*, because there are no such statistics for this country.

Appendix 2:

Table 2.1: Descriptive statistics

	Minimum	Median	Mean	Standard deviation	Maximum
Real GDP	5.066	10.476	10.665	2.019	16.416
cc	-0.089	1.317	1.143	0.397	1.715
cpi	0.000	2.002	1.770	0.489	2.361
Aggregate capital stock	4.997	11.159	11.386	2.247	17.628
Human capital index/person	0.039	0.760	0.733	0.289	1.286
Population growth	-2.222	2.151	2.097	1.746	7.189

Note: The descriptive statistics are based on the natural logarithm values of the variables.

Furthermore, unit-root tests are undertaken in order to explore the time series properties of the data. Based on the Augmented Dickey Fuller (ADF) test, the findings presented in *Table 2.2* shows that series are all stationary. The test results are reported over the whole period 1970-2011, but the results are practically the same, when the true corruption data is examined over 1995/1996-2011. This is to say that the distribution of the variables neither follows any trend nor changes over time.

Table 2.2: Results of the Augmented Dickey-Fuller tests

Variable	Statistic	P-value
Delta log GDP	-9.3067	< 0.01
cc	-9.3856	< 0.01
cpi	-9.4731	< 0.01
Average capital stock	-10.645	< 0.01
Human capital index/person	-9.073	< 0.01
Population growth	-8.8751	< 0.01

Notes: The ADF tests the null hypothesis that the series contain a unit-root, i.e. are *nonstationary*. The conclusion is that the series are stationary, because all probabilities (P-values) associated with the Dickey-Fuller statistics are smaller than the critical value 0.05.

The same conclusion prevails when the KPSS technique is applied:

Table 2.3: Results of the KPSS test for stationarity

Variable	KPSS Level	KPSS Trend	P-value
Delta log GDP	0.1814	0.0799	> 0.1
cc	0.2906	0.0510	> 0.1
cpi	0.0491	0.0291	> 0.1
Average capital stock	0.1667	0.0298	> 0.1
Human capital index/person	0.1129	0.1046	> 0.1
Population growth	0.0613	0.0605	> 0.1

Notes: The tests conclude that the series are stationary; all probabilities (P-values) associated with the KPSS statistics are greater than the critical value 0.05.

Appendix 3: Robustness checks

The investigations on the non-linear relationship between corruption and real GDP changes are based on a quadratic function, and suggest that the optimal GDP-maximizing corruption threshold is cc*= 0.881. Based on equation (1'), the robustness of the finding is checked by using alternative power functions to see how sensitive the threshold is. The results are reported in *Table 3.1*.

Table 3.1: Optimal GDP-maximizing corruption levels with alternative power functions

Power	cc coeff.	cc^{power} coeff.	cc*
1.2	5.155***	-4.471***	0.819
	(0.514)	(0.443)	
1.4	2.767***	-2.121***	0.838
	(0.270)	(0.204)	
1.6	1.966***	-1.349***	0.855
	(0.188)	(0.126)	
1.8	1.563***	-0.968***	0.872
	(0.148)	(0.088)	
2	1.336***	-0.757***	0.881
	(0.120)	(0.065)	
2.2	1.153***	-0.592***	0.903
	(0.107)	(0.052)	
2.4	1.033***	-0.486***	0.916
	(0.095)	(0.042)	
2.6	0.941***	-0.407***	0.929
	(0.086)	(0.034)	
2.8	0.869***	-0.345***	0.942
	(0.079)	(0.029)	
3	0.785***	-0.290***	0.949
	(0.073)	(0.024)	

Notes: Robust standard errors of 2SLS estimators are in parentheses. The superscript *** represents statistical significance at 0.1 % level.

Table 3.1 shows that all the estimated coefficients of the cc and cc^{power} terms stay statistically highly meaningful. Moreover, the GDP-maximizing corruption level goes up as the power of the non-linear term increases. Thus, the use of alternative functional forms does not significantly affect the results. The relationship between corruption and GDP growth remains non-linear and systematically translates to an inverse U-shaped curve, which is consistent with the quadratic form around power 2. *Figure 3.1* illustrates the results.

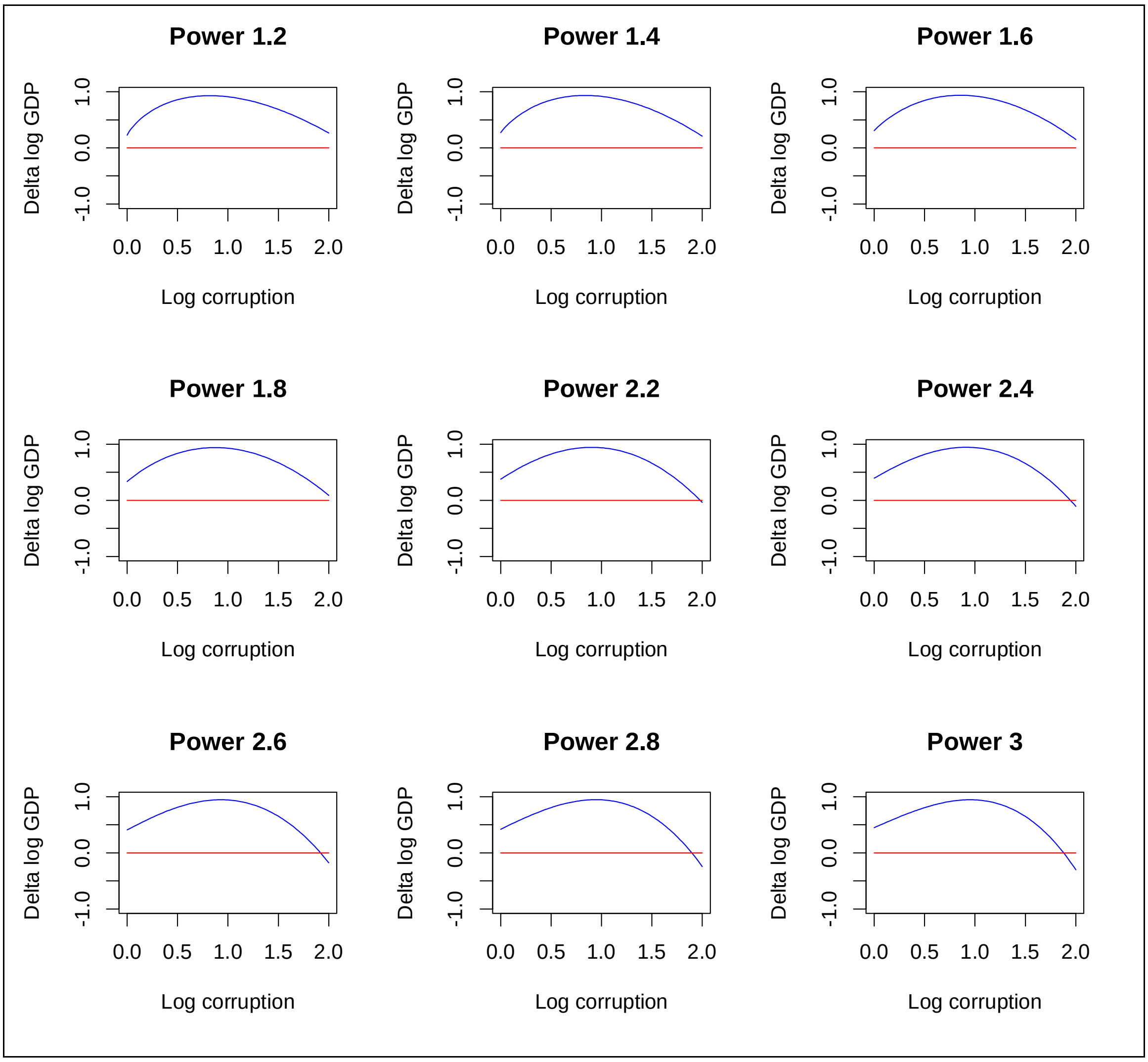

Figure 3.1: Optimal GDP-maximizing corruption levels using alternative functional forms

Appendix 4: Institutional quality regimes

Safety and Rule of law 1:
Iraq, Democratic Republic of Congo, Venezuela, Central African Republic, Cote d'Ivoire, Ecuador, Sudan, Congo, Burundi, Bolivia, Cameroon, Cambodia, Liberia, Guatemala, Kenya, Lao, Paraguay, Iran, Honduras, Sierra Leone, Nepal, Togo, Pakistan, El Salvador, Mauritania, Bangladesh, Dominican Republic, Fiji, Argentina, Benin, Peru, Swaziland, Mexico, Philippines, Indonesia, Mozambique, Gabon, Albania, Niger.

Safety and Rule of law 3:
Kuwait, Greece, Botswana, Uruguay, Macao, Hungary, Brunei Darussalam, Israel, Taiwan, Mauritius, Barbados, Republic of Korea, Qatar, Portugal, Spain, Cyprus, Chile, Japan, Belgium, France, Malta, Hong Kong, United States, Singapore, Germany, Iceland, United Kingdom, Australia, Ireland, Switzerland, Austria, Netherlands, Canada, Luxembourg, Norway, Denmark, New Zealand, Sweden, Finland.

Government effectiveness 1:
Democratic Republic of Congo, Central African Republic, Togo, Sudan, Liberia, Congo, Sierra Leone, Iraq, Cote d'Ivoire, Burundi, Venezuela, Lao, Nepal, Paraguay, Cambodia, Fiji, Mauritania, Cameroon, Zambia, Mali, Bangladesh, Pakistan, Ecuador, Gabon, Swaziland, Guatemala, Honduras, Niger, Mongolia, Gambia, Uganda, Dominican Republic, Kenya, Tanzania, Bolivia, Syrian Arab Republic, Iran, Benin, Mozambique.

Government effectiveness 3:
Poland, Uruguay, Greece, Hungary, Mauritius, Spain, Brunei Darussalam, Malaysia, Qatar, Republic of Korea, Portugal, Malta, Taiwan, Chile, Israel, Macao, Ireland, Cyprus, Japan, France, United Kingdom, United States, Barbados, Germany, Belgium, Iceland, Austria, Australia, Hong Kong, Netherlands, Luxembourg, Canada, Norway, New Zealand, Switzerland, Sweden, Denmark, Finland, Singapore.