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CORRUPTION AND ECONOMIC DEVELOPMENT

Abstract:

This study investigates the impact of openness to trade and corruption on economic development for a cross-section of 143 countries for the year 2000 by analysing the effects of trade openness and corruption on income, productivity, innovation, and income inequality. Institutional, cultural and geographical factors, and country size are controlled for in the analysis. An instrumental variable approach has been adopted in order to address the endogeneity of corruption and openness to trade. The age of democracy and gravity-based predictors are chosen as the instruments for corruption and openness to trade, respectively. The estimates show that corruption negatively affects income per capita, productivity, and innovation, while it does not significantly impact income inequality (Gini). The control of corruption and the openness to trade affect output per worker through the total factor productivity. Both the control of corruption and openness to trade are statistically significant determinants of the 90/10 income gap. Landlockedness affects Gini Index directly, even after controlling for trade and corruption. These findings have important policy implications. For example, on the basis of the estimates, if Botswana improved its control of corruption to reach the level of Finland, its per capita income would rise by 2.7 times.

Keywords:

Coruption
Economic Development
Trade

I. Introduction

Efforts to fight corruption, at both the national and global levels, have been proven to be challenging. Understanding its determinants and its causes are essential in order to combat corruption. This study analyses the impact of corruption and openness to trade on economic development, such as on income per capita, productivity, innovation, and income inequality, for 143 countries for the year 2000 by taking into account the endogeneity of corruption and openness to trade, and by controlling for institutional, cultural, geographical, and historical factors that affect the economic performance of a country. To the best of our knowledge, no such overview has been conducted so far. The estimates particularly include openness to trade together with geographical and cultural controls. Empirical evidence has shown the importance of openness to trade for economic growth (Edwards, 1995; Rodrik, 1995; Frankel and Romer, 1999). However, Rodriguez and Rodrik (2000) argued that Frankel and Romer's measure of openness to trade is flawed and just reflects the importance of geographical factors instead. Ortega and Peri (2014) extended the work done by Frankel and Romer (1999) by producing a gravity-based predictor for trade based on the role of geographical and cultural distance between a pair of countries in order to avoid the measurement problem with openness to trade. Several scholars emphasize how geography might be the most important direct determinant of a country's development. For example, incidence of tropical diseases and poor soil quality may hamper productivity and economic growth (Sachs, 2003). Grier (1999) and Acemoglu et al. (2001) argued that the influence of European colonial settlers might explain today's prosperity. Therefore, in addition to corruption and openness to trade, geographical and cultural variables are included in order to control for their direct impact on economic development. A richer country can invest more resources in its institutions and in monitoring corruption, thus making them more effective in controlling corruption (Lipset, 1960 and Demsetz, 1967). Bai et al. (2013) also showed empirically that economic growth can directly reduce corruption. Since both corruption and openness to trade can be consequences, rather than causes of economic development, corruption is instrumented by the age of democracy index (Gupta et al., 2002; Aidt et al., 2008; Aidt, 2009), and the openness to trade is instrumented as in Ortega and Peri (2014) with gravity-based predictors.

This study contributes to the impact of corruption on development from several angles. Firstly, the impact of corruption on economic development is a controversial topic. On the one hand, the "grease the wheels" hypothesis states that corruption may actually be efficient if firms might be able to circumvent inefficient provision of public services, stark bureaucracy, and excessively rigid laws by paying bribes (Leff, 1964; Huntington, 1968; Bardhan, 1997; Treisman, 2000; Ramirez, 2014), especially if the institutions are weak and work poorly (Acemoglu and Verdier, 2000; Meon and Weill, 2010). This positive view is also called the Asian paradox, which explains the positive association between corruption and economic growth in a number of East Asian countries (Rock & Bonnett, 2004; Li and Wu, 2007). The contrasting view of the "sand the wheels" hypothesis, as in Mauro (1995), Murphy et al. (1991), Wolfenson (1996), Wei (1999), Coupet (2001), Attila (2008), and

Aghion et al. (2016), argued that the corruption supports inefficient firms and drives the allocation of talent, technology, and capital away from their most productive social uses to rent-seeking activities that slow economic growth. Therefore, corruption increases the cost and risk of doing business, is detrimental to human capital accumulation and new business set-ups, and encourages investment in the informal sector (Reinikka and Svensson, 2004, 2005; Svensson, 2005). Secondly, with respect to income distribution, few studies have investigated the distributional impact of corruption. Tanzi (1994) argued that corruption most benefits the better connected individuals and because they usually belong to the high-income group in society, corruption will affect income distribution and exacerbate inequality. According to Rose-Ackerman (1999), corruption creates incentives for higher investment in capital-intensive projects than in labour-intensive projects. These distortions in investment strategy worsen income inequality because poor individuals tend to benefit less from capital-intensive projects. Li et al. (2000) found that the impact of corruption on the Gini coefficient has an inverted U-shape.) Several studies found a positive relationship between corruption and income distribution (Gupta et al., 2002, Gyimah-Brempong, 2002, Apergis et al., 2010, Gyimah-Brempong and de Gyimah-Brempong, 2006, and Dincer and Gunalp, 2012). Thirdly, corruption has been found to lower total factor productivity in empirical studies. Tanzi and Davoodi (1998) found that corruption can actually decrease growth by increasing public investment and reducing its productivity at the same time. Isham and Kaufmann (1999), Olson et al. (2000), and Lambsdorff (2003) showed that different measures of institutional quality (including corruption) positively affect productivity growth. Finally, the link between corruption and innovation has been rather overlooked in the literature and therefore empirical evidence is scarce. Mahagaonkar (2009) conducted a firm-level analysis studying the impact of corruption on innovative activities of more than 3,000 African firms. The author estimated the effect of corruption on different types of innovation (product innovation, process innovation, marketing innovation, and organizational innovation) and finds that corruption negatively affects all types of innovation except for marketing innovation. Anokhin and Schulze (2009) studied how the control of corruption affected entrepreneurship and innovation with longitudinal data drawn from 64 countries. They found a positive relationship between better control of corruption and innovation, in which the latter was defined as the realized innovation and patenting rates.

The remainder of this work is organized as follows: Section II describes the identification strategy; Section III describes the data; Section IV illustrates the results of the estimations; and, finally, Section V ends with the concluding remarks and policy implications.

II. Identification Strategy

Income

The main equation, which estimates the effect of trade and corruption on income, is the following:

$$\ln y_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

The dependent variable is the logarithm of income per capita in the year 2000, measured in US dollars and adjusted for purchasing power parity. The estimations also include area and size (population) of a country to consider the impact of within-country trade. A country's income can be influenced by its international trade as well as by its within-country trade. We hypothesize that greater within-country trade raises income.

We are aware that longitudinal variation is better for identifying the effect of trade, as pointed out in Feyrer (2009); however, the cross-sectional approach is much more informative concerning the effect of corruption on income. In addition, the corruption variable for the same country does not vary much over the years.

Since corruption and openness to trade both enter as main determinants in the analysis, it is important to ascertain whether or not they are correlated. In order to rule out the possibility of a possible correlation between the main two variables, we checked the correlation coefficient, which is 0.2483. Therefore, such a correlation is not problematic for our analysis.

Productivity

The equations for productivity are:

$$\ln\left(\frac{Y}{L}\right)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

$$\frac{\alpha}{1-\alpha}\ln\left(\frac{Y}{K}\right)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

$$\ln\left(\frac{H}{L}\right)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

$$\ln TFP_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

The dependent variables are the logarithm of income per worker, the logarithm of the physical capital depth, the logarithm of the human capital intensity, and the logarithm of total factor productivity (TFP), respectively. Following Hall and Jones (1999) and Ortega and Peri (2014), the logarithm of income per worker can be decomposed as follows:

$$\ln y_c = \frac{\alpha}{1-\alpha}\ln\frac{K_C}{Y_C} + \ln h_C + \ln TFP_c$$

where $\alpha = 0.33$

Thus, the logarithm of output per worker is the sum of the contributions of capital depth, schooling, and productivity.

Inequality

The equations that estimate the effects on inequality are:

$$\ln GINI_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

$$\left(\frac{90}{10} GAP\right)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

The dependent variables are the Gini index and the 90/10 income gap. The Gini coefficient is a measure of income inequality. It ranges from 0 to 1, where 0 corresponds to perfect equality and 1 corresponds to perfect income inequality. The 90/10 ratio of income percentiles is calculated as the ratio of the 10% of people with the highest income to the 10% of people with the lowest income.

Innovation

The equations estimating the effects on innovation are:

$$\ln(PATENTSpc)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$
$$\ln(TotPatents)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$
$$\ln(R\&D)_c = \beta_0 + \beta_T T\hat{S}H_c + \beta_c CO\hat{R}R_c + \beta_A \ln AREA_c + \beta_P \ln POP_c + \beta_D CONTROLS_c + u_c$$

The dependent variables are the logarithm of patents per capita, the logarithm of the total number of patents, and the research and development expenditure as a percentage of GDP.

The number of patents and patent applications has been used extensively as a measure of innovation. In addition, patenting rates are likely to be more affected by corruption because the patenting process involves various bureaucratic steps that create opportunities for bribery. Research and development expenditure as a percentage of GDP is also used as a dependent variable as an alternative measure in the analysis.

Set of controls

Each regression specification controls for the size of the country, in terms of both area and population, as well as for geographical and cultural factors.

The geographical controls are a dummy for being a landlocked country, the share of tropical land, the average distance to the coast or to a river, climate (average yearly humidity, and average yearly temperature), the incidence of tropical diseases (malaria and yellow fever), the presence of oil resources, the quality of the soil, and regional dummies

(Latin America, East Asia, Sub-Saharan Africa). These geographical controls are necessary in analysing the determinants of economic development. Sachs (2003) argues that geographical differences are the main drivers of development. For example, diseases such as malaria or yellow fever negatively impact labour productivity by making individuals weaker. Tropical soil is considered to have a low quality and is therefore not sufficiently productive for agricultural production.

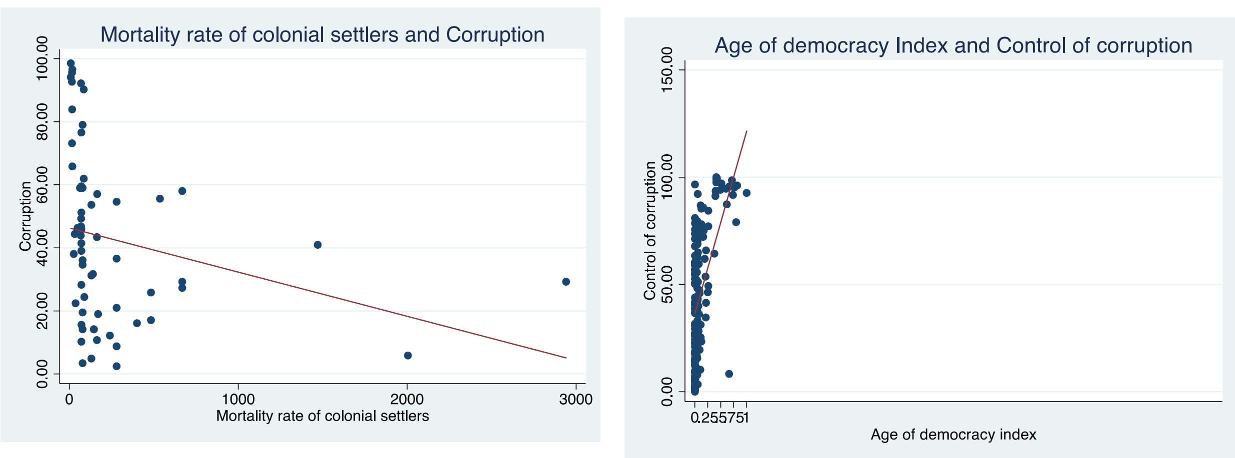
The cultural controls are added as dummies for colonial ties (British and French), which may affect a country's legal origin and current culture, and a set of dummies for Australia, New Zealand, the United States, and Canada (four rich young countries). Finally, distance to the equator is included as a proxy for the quality of the current institutional framework of a country. As explained in Hall and Jones (1999) and in Acemoglu et al. (2001), distance to the equator is strongly correlated with the incidence of tropical disease and mortality rates among early European settlers, and thus their incentive to build good institutions. Therefore, distance to the equator can be regarded as a source of exogenous variation in countries' institutional quality.

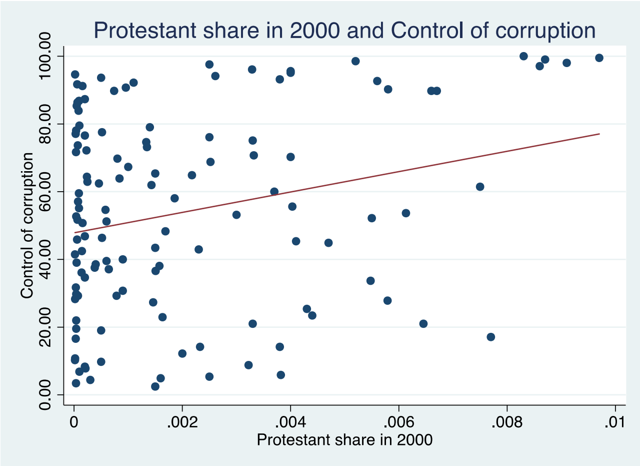
Corruption instruments

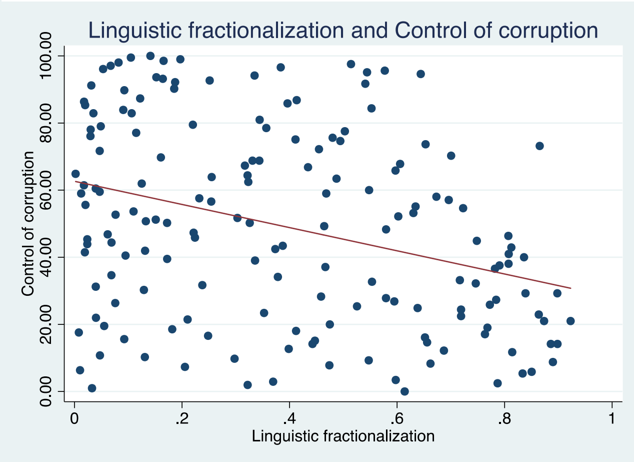
Variables from the literature such as age of democracy index, share of Protestants, linguistic and religious fractionalization, percentage of European descendants in 1900, and mortality rate of colonial settlers are tried as instruments.

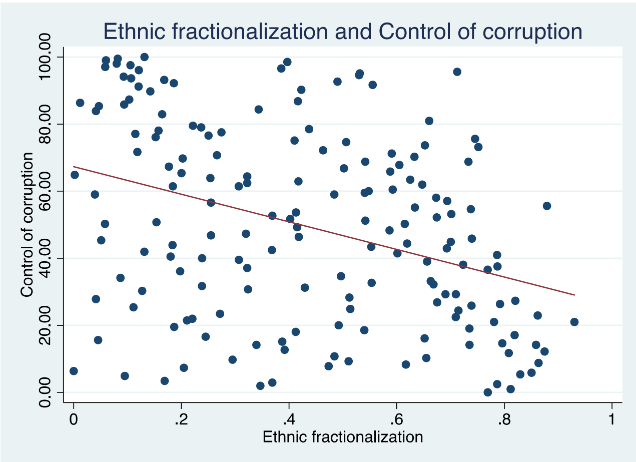
As it can be seen from the scatter plots in **Figure 1**, almost all instruments perform well with the expected signs in the first stage, apart from religious fractionalization, which does not seem to be significantly correlated with the control of corruption. The age of democracy index seems to perform particularly well in the first stage. The second step is to see whether these instruments satisfy the exclusion restriction clause.

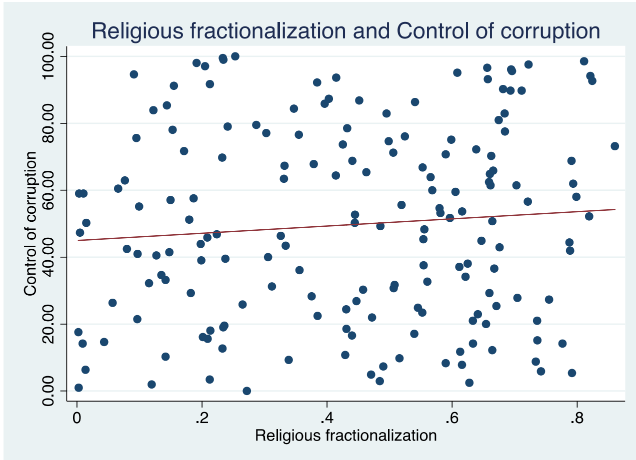
Figure 1: Instruments

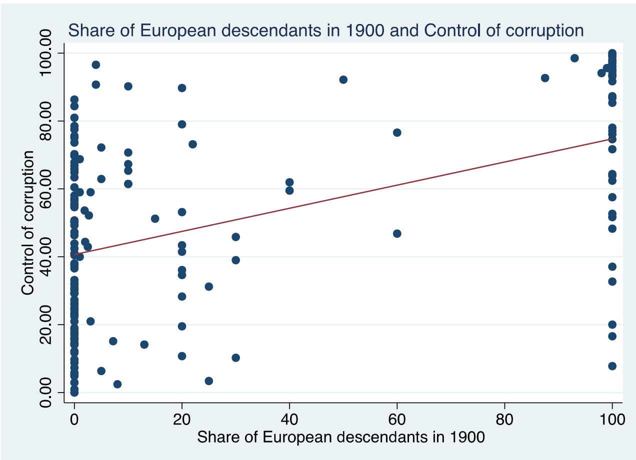












An argument that can be made is that the age of democracy index may affect development today because poor countries that have recently made strides toward democracy might receive international aid more easily and this may favour their economic development today. However, the instrument is not the age of democracy of a country in absolute values, but rather an index (ranging from 0 to 1) which measures the cumulative effect on corruption of having a democratic system, from 1800 to 2000. What matters for corruption is not the actual level of democracy but whether a country maintained a democracy over a longer period of time (La Porta et al., 1999; Treisman, 2000; Serra, 2006; Keefer, 2007; Pellegata, 2013; Schleiter & Vozyana, 2014). Thus, countries with a long democratic tradition establish checks and balances and the rule of law, which are effective in controlling corruption. In addition, Linz and Stephan (1996) and Diamond (1999) argue that the consolidation of democracy demonstrated by changes in norms, values, beliefs, attitudes, and behaviours among elites, organizations, and institutions in civil society and mass publics requires time. As Schnedier and Schmitter (2004) argue, this process orientation definition of democracy should include some time dimension, such as the duration of democracy expressed as the number of years a democratic government has been in power. Persson and Tabellini (2003), Persson (2004), and Eicher and Leukert (2009) explain that the type of constitutional arrangement is an important determinant of corruption and that this arrangement impacts economic outcomes only through corruption. This “hierarchy of institutions” hypothesis suggests that measures of political institutions can be used as instruments for corruption. In particular, countries with a longer democratic tradition could develop better and more effective ways of dealing with corruption. Older democracies are therefore likely to have different policies than newer ones, while at the same time age of democracy is not in itself a determinant of economic outcomes.

Therefore, since the age of democracy index performs well in the first stage and is likely to satisfy the exclusion restriction clause, it is chosen as an instrument for corruption. A more detailed explanation of the data and methodology used to construct this variable can be found in Appendix 2 and also in Treisman (2000).

Trade and the gravity-based model

Trade has been considered to be an important determinant of income since Adam Smith’s idea of specialization and extent of the market, with more emphasis in recent work on increasing returns and endogenous technological progress. Indeed, trade can increase income through exchange of ideas, spread of technology, and exposure to new goods. However, cross-country regressions of income on trade find a moderate positive relationship (Rodrik, 1995). Frankel and Romer (1999) explain this result with trade being an endogenous variable and suggest to instrument trade with gravity-based predictors. However, they still could not estimate the effect of trade on income with great precision. They could only marginally reject the hypotheses that the impacts of trade and size are zero at standard significance levels. Ortega and Peri (2014) showed that trade could still be robust in the income equation depending on the inclusion of other determinants such as geographical and cultural controls in the gravity model for trade and in the income equation.

As in Ortega and Peri (2014), openness to trade is instrumented with the gravity-based predicted trade share. The gravity model of trade is based on the idea that the value of trade between two countries is proportional, other things being equal, to the product of their GDPs, and it decreases in the geographical and cultural distances between the same two countries. The basic gravity-based equation for the volume of trade between country *i* and country *j* can be written as follows:

$$T_{i,j} = \frac{(AxGDP_i xGDP_j)}{D_{i,j}}$$

where *A* is a constant term and $D_{i,j}$ is the distance between the two countries. However, if formulated this way, the gravity-based equation may miss important factors apart from GDP and distance that can influence trade volumes, and therefore lead to wrong estimation of the predicted trade share. For example, cultural and linguistic proximity might affect trade patterns; countries that share a language or a colonial history might trade more, regardless of distance.

Ortega and Peri (2014), following the model proposed in Frankel and Romer (1999), examined trade differences arising from geography-based costs instead of looking at the GDP. These costs are proxied by bilateral geographic and cultural characteristics. They first build a bilateral trade predictor as follows:

$$\begin{aligned} \ln TSH_{c,j} = {} & \gamma_1 \ln(\text{Distance})_{\text{c,j}} + \ln\gamma_2 (Population)_j + \ln\gamma_3 (Population)_c + \gamma_4 \ln(Area)_j + \gamma_5 \ln(Area)_c \\ & + \gamma_6 \ln(Landlocked)_{\text{c}} + \gamma_7 \ln(Landlocked)_{\text{j}} + \gamma_8 \ln(Border)_{\text{c,j}} + \gamma_9 \ln(CommonLanguage)_{\text{c,j}} \\ & + \gamma_{10} \ln(Colony)_{\text{c,j}} + \gamma_{11} \ln(\text{Distance})_{\text{c,j}} (Border)_{c,j} + \gamma_{12} \ln(\text{Population})_{\text{j}} (Border)_{c,j} \\ & + \gamma_{13} \ln(Area)_{\text{c}} (Border)_{c,j} + \gamma_{14} \ln(\text{Landlocked})_{\text{c}} (Border)_{c,j} + u_{c,j} \end{aligned}$$

As a next step, they aggregate bilateral trade estimates across countries to find countries' overall trade shares.

$$T\hat{S}H = \sum_{c \neq j} \exp(\hat{\gamma}_T Z_{c,j})$$

where $\hat{\gamma}_T$ is the vector of coefficients in the bilateral trade regressions and $Z_{c,j}$ is the vector of the explanatory variables included in the gravity-based regression. The regression results for the gravity model in **Table 1** confirm that geographical and cultural distances are the major determinants of bilateral trade. The linear gravity-based trade share is used in the regression analysis, as this performs better.

Table 1. Gravity models for bilateral trade share (TSH)

	(1)	(2)	(3)
	OLS	FE	Poisson
VARIABLES	Ln bil. TSH	Ln bil. TSH	Ln bil. TSH
Ln distance	-1.82***	-1.71***	-0.87***
	[0.04]	[0.03]	[0.08]
Sum landlocked	-0.82***	0.05	-0.64***
	[0.03]	[0.45]	[0.07]
Border	-4.71***	-7.64***	-1.95
	[1.00]	[0.95]	[1.25]
Border*(ln dist.)	0.69***	-0.04	0.23
	[0.21]	[0.20]	[0.39]
Border*(lnpop origin)	-0.32***	-0.49***	0.01
	[0.08]	[0.07]	[0.09]
Border*(ln pop dest.)	-0.34***	-0.54***	-0.28***
	[0.08]	[0.07]	[0.10]
Border *(ln area origin)	0.05	0.41***	-0.11
	[0.09]	[0.08]	[0.13]
Border *(ln area dest.)	0.11	0.45***	0.21
	[0.09]	[0.08]	[0.22]
Border*landlocked	0.81***	0.80***	0.83***
	[0.11]	[0.11]	[0.14]
Common language	0.60***	0.21***	1.00***
	[0.08]	[0.07]	[0.26]
Common official language	0.01	0.69***	-0.38
	[0.08]	[0.07]	[0.27]
Time zone difference	0.13***	0.01	0.02
	[0.01]	[0.01]	[0.03]
Colonial ties	3.09***	0.94***	1.43***
	[0.13]	[0.09]	[0.13]
Ln pop. Dest	0.02		-0.21***
	[0.01]		[0.03]
Ln pop. Origin	1.08***		0.83***
	[0.01]		[0.04]
Ln area origin	-0.07***		0.04
	[0.01]		[0.03]
Ln area dest.	-0.25***		-0.21***
	[0.01]		[0.05]
Origin hegemon	-2.23***		-1.78***
	[0.18]		[0.23]
Observations	24,627	24,627	33,108
R-squared	0.40	0.71	0.22

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

III. Data

We mostly utilize the data in Ortega and Peri (2014), which cover 188 countries. These authors' dataset is extended with additional data such as corruption data from the World Bank and democracy rating from the Polity IV Project for the age of democracy index. **Table 2** shows the summary statistics and the sources of the main variables used in the analysis.

Corruption variable

The Kaufmann-Kraay Governance Index (also called the Worldwide Governance Index) measures six dimensions of governance: Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (Kaufmann et al., 2011). In our analysis, the control of corruption part of the Kaufmann-Kraay Governance Index is selected as a corruption variable for the year 2000, since the Transparency International Index of the same year had too few observations. In addition, the correlation between the World Governance Index of 2000 and 2005 and the Transparency International Index of the same years are very high.

Table 2 : Summary statistics and the sources of the main variables

Variable	Obs.	Mean	Std. Dev.	Min	Max	Source
Dummy Frankel & Romer sample	188	0.78	0.42	0	1.00	Frankel & Romer (1999)
Real GDP per capita in 2000	184	10682.50	12881.16	117.23	74162.95	Penn World Table
TSH (trade flows/GDP)	184	0.90	0.50	0.02	3.78	Penn World Table
Predicted TSH	188	0.85	0.42	0	2.17	Ortega & Peri (2014) calculations
Real Trade Share	184	0.50	0.42	0.01	2.72	Alcalà & Ciccone (2004), Penn World Table 7.2.
Transparency International Index 2000	88	4.78	2.40	1.2	10	Transparency International
Worldwide Governance Indicator 2000	190	48.94	29.24	0	100.00	World Bank
Protestant share in 1980	152	0.11	.21	0	.978	La Porta et al. (1999)

Protestant share 2000	128	0.00	0.00	0	0.01	Own calculations
Age of democracy index	156	0.18	0.82	0	10.00	Own calculations
Religious fractionalization index	183	0.44	0.23	0	0.86	Alesina & La Ferrara (2005)
Ethnic fractionalization index	175	0.43	0.25	0	0.93	Alesina & La Ferrara (2005)
Linguistic fractionalization index	172	0.39	0.28	0	0.92	Alesina & La Ferrara (2005)
Dummy for British legal origin	160	0.31	0.46	0	1.00	La Porta et al. (1999)
Logarithm of population	183	1.71	2.01	-3.12	7.14	Penn World Table, 7.2
Logarithm of area	186	11.34	2.68	3.22	16.65	BACI dataset
Distance to equator	187	25.07	17.00	0	67.47	BACI dataset
Share of tropical land	153	0.49	0.48	0	1.00	BACI dataset
Percentage of European descendants in 1900	153	28.37	40.97	0	100	Acemoglu et al. (2001)
Percentage of people speaking English in 1975	149	31.01	43.02	0	100	Acemoglu et al. (2001)
Mortality of colonial settlers	90	212.53	404.25	2.55	2940	Acemoglu et al. (2001)
Logarithm of income per worker	109	-2.03	1.39	-5.51	0.00	Ortega & Peri (2014) calculations
Logarithm of physical capital intensity	109	0.11	0.21	-0.74	0.69	Ortega & Peri (2014) calculations
Logarithm of human capital intensity	109	-0.47	0.31	-1.11	0.03	Ortega & Peri (2014) calculations
Logarithm of total factor productivity	109	-1.66	1.14	-5.39	0.07	Ortega & Peri (2014) calculations
Gini coefficient	130	41.53	11.04	21.80	76.60	World Income Inequality database
90/10 income ratio	71	11.57	11.21	3.16	67.58	World Income Inequality database
R&D expenditures as a % of GDP	68	.94	.88	0.04	3.96	World Bank
Patent grants by country/patent office (Avg. 1995-2010)	171	3487.05	19425.90	1.00	201504.90	World Intellectual Property Organization
Number of resident patent filings per million population (Avg. 1995-2010)	123	103.04	314.38	0.05	2734.49	World Intellectual Property Organization

IV. Empirical results

In this section, the impacts of corruption on income, productivity, inequality, and innovation are analysed by instrumenting corruption with the age of democracy index and trade with the gravity-based predictors, as well as including geographical and cultural distances as controls.

The Kleibergen–Paap F-statistic (K-P F-test) and the Angrist–Pischke F-statistic (A-P F-test) are reported in each table with the related Stock and Yogo critical values. The K–P F-statistic allows for testing the null hypothesis of jointly weak instruments. The A–P F-statistic instead tests whether each single endogenous regressor is weakly identified. All the tables can be found in **Appendix 1**. A list of all countries employed in the analysis can be found in **Appendix 3**.

Income per capita

The age of democracy index is found to be a strong instrument for corruption in the impact of corruption on income per capita since the control of corruption is well identified through all specifications, (**Table 3**, in Appendix 1). The null hypothesis of a weakly identified endogenous regressor can be rejected at the 10% level of Stock and Yogo's critical value, which is the most stringent critical value. Control of corruption has a statistically significant positive impact on income per capita through all specifications, which is consistent with the "sand the wheels" hypothesis. The magnitude of the effect remains constant at 0.04 through all specifications, when both the Frankel and Romer (1999) sample and the full sample of 147 countries are employed.

In columns (4) and (5), where the regression specifications include geographical and colonial controls, it can be seen that East Asia and Sub-Saharan Africa and the incidence of malaria have detrimental impacts on income. The presence of oil resources in a country is also a significant predictor of income per capita, but the magnitude of this effect is negligible, as it approaches zero. The last two columns, (6) and (7), of **Table 3** report the OLS estimates, both with and without colonial ties, which are less than the instrumental variable coefficients, suggesting measurement error in corruption variable. Thus, there is no evidence that the positive association between (low) corruption and income happens because countries whose incomes are high for other reasons are less corrupt or because of omitted factors. Otherwise, this would make OLS estimates upward biased. On the contrary, the IV estimate of the effect of corruption in every specification is larger than the OLS estimate.

Table 4 in Appendix 1 considers the joint effect of openness to trade and control of corruption on income per capita. The K–P F-statistic turned out not to be too high in all specifications, and thus it has not been possible to reject the null hypothesis of the control of corruption and openness to trade being jointly weakly identified. However, by looking at the A–P F-statistic, it can be seen that this is probably due to the weakness of the predicted trade share as an instrument. The age of democracy index remains a robust instrument, as the A-P F-statistic for the control of corruption remains high through all specifications. Even when a different specification of the predicted trade share – the value added trade share – is adopted, the relative A–P F-statistic continues to be too low to reject the null hypothesis. The rationale behind introducing a value-added measure of the openness to trade is that gross trade flows may overestimate the real value-added content of trade because countries do not trade only final goods but also intermediate goods (Johnson & Noguera, 2012).

The coefficient on the control of corruption variable is still robust to the inclusion of trade shares, and it does have a statistically significant effect on income per capita. Also, the magnitude of such effect is unchanged (0.04).

Productivity

The strategy in Hall and Jones (1999) and in Ortega and Peri (2014) is adopted to study the effect of corruption on productivity. Specifically, the effect of corruption on the logarithm of output per worker ($\ln y_c$), the logarithm of the capital–output ratio ($\frac{\alpha}{1-\alpha}\ln y\frac{K_c}{Y_c}$), the logarithm of human capital per person ($\ln h_c$), and the logarithm of TFP ($\ln TFP_c$) are analysed.

The logarithm of output per worker is decomposed as follows (Hall and Jones, 1999) :

$$\ln y_c = \frac{\alpha}{1-\alpha}\ln\frac{K_C}{Y_C} + \ln h_C + \ln TFP_c$$

Where α is the labour share in income (set at $\alpha = 0.03$), $\frac{K_c}{Y_c}$ is the capital–output ratio (capital depth), and h_c is the average human capital per person or schooling, calculated as the exponential of average years of schooling times its Mincerian return. Finally, TFP_c is the total factor productivity, calculated as a Solow residual (Ortega and Peri, 2014). For both the endogenous regressors control of corruption and openness to trade, the null hypothesis of weak identification can be rejected at the 15% level (**Table 5,** Appendix 1). The A–P F-statistic for the control of corruption is consistently higher than the one of the openness to trade regressor. Both control of corruption and openness to trade have a statistically significant and positive effect on output per worker. The control of corruption and the openness to trade seem to affect output per worker through the TFP. In fact, openness to trade impacts significantly neither physical capital depth nor schooling. Similarly, the control of corruption does not seem to impact significantly the physical capital depth. However, it has a positive effect on human capital intensity, even if the effect is statistically significant at the 10% confidence level. Thus, the impact of corruption on schooling is rather moderate. The impact on the total factor productivity is positive and statistically significant for both regressors. Therefore, both corruption and openness to trade have an impact on productivity through the total factor productivity, by either facilitating technological progress or increasing efficiency levels.

Apart from openness to trade and corruption, it is interesting to note that the soil quality variable has a negative and statistically significant effect on output per worker, human capital intensity, and total factor productivity. Such effect may substantiate the geography hypothesis, according to which poor quality soil negatively affects productivity.

Income inequality

Table 6 reports the estimates on the effect of control of corruption on income inequality, measured by the Gini index and the 90/10 income gap. The results show that there does not seem to be a significant impact of corruption or openness to trade on the income distribution. Both the control of corruption and openness to trade are statistically significant determinants of inequality only when the most basic regression specifications are considered in the 90/10 income gap estimates (column 4), and they are significant only at the 10% level. However, the significance of such effects fade away when the geographical controls and colonial ties are added to the regressions. The Heckscher-Ohlin model, one of the best known theoretical frameworks of trade, argues that even if there are gains from trade, not all groups benefit from them equally. Trade may even aggravate income inequality by benefiting one group more than another, especially if the group that benefits is already well off. However, our study could not confirm this result.

As far as the geographical controls and colonial ties are concerned, some of the controls are statistically significant, but not across different regression specifications. The dummy for a country to be landlocked is the only control that remains statistically significant regardless of whether the Gini index or the 90/10 income gap is used. Apparently, not having direct access to the sea increases income inequality. This interesting result can be explained with the insights from Carmignani (2015), who empirically investigates whether landlockedness impacts income indirectly via institutions and trade, or directly. As highlighted in the literature (Rose, 2004; Santos Silva and Tenreyno, 2006; Yu, 2010; Chang and Lee, 2011), landlockedness has a negative and significant impact on bilateral trade flows. However, in addition to having indirect impact on income through trade and institutions, landlockedness can have a direct impact on income for various reasons. Landlockedness not only hinders flows of goods and services but also the movement of people; therefore, it hampers the diffusion of ideas, technological advances, and institutional innovations. Landlocked countries are also characterized by a lower degree of cultural and genetic diversity than coastal countries. It has been shown by several studies that genetic isolation and lack of cultural diversity can restrict long-term economic development and economic growth, (Alesina and La Ferrara, 2005; Ottoviano and Peri, 2005; Spolaore and Wacziarg, 2009; Ager and Bruckner, 2013). Carmignani (2015) shows that landlockedness explains a large part of the cross-country variation in GDP after controlling for the effect of trade and institutional quality through which landlockedness has an impact indirectly on income. Our results in **Table 6,** in columns (3) and (6), indicate that if landlockedness reduces the movement of people and cultural and genetic diversity, which in turn reduce productivity and economic performance in landlocked countries, then landlockedness affects Gini Index directly, even after controlling for the transmission through trade and corruption. This finding has important policy implications for landlocked countries, suggesting that reducing trade-related costs is a restrictive policy measure and other determinants of income dynamics beyond trade need to be addressed.

Innovation

Two measures of innovation, patent intensity and research and development expenditures as a percentage of GDP, are employed to estimate the impact of corruption on innovation. **Table 7** reports the results for three dependent variables: the logarithm of the number of patent per capita, the logarithm of the total number of patents, and the R&D expenditures as a percentage of GDP. Unfortunately, data on the R&D expenditures as a percentage of GDP were available only for 39 countries. It is not possible to reject the null hypothesis of the endogenous variables being weakly identified. However, the A–P F-statistic for the control of corruption was high, and the null hypothesis of weak identification for the corruption variable can be rejected at the strictest level of confidence for almost all regression specifications, except for that with the R&D expenditures as a dependent variable. Thus, even if openness to trade is weakly identified, the control of corruption is not, and it is possible to make inferences on its coefficient. The results in **Table 7** show that the control of corruption has a positive and statistically significant effect on innovation, measured by both the absolute numbers of patents and the numbers of patents per capita. The magnitude of this effect is rather sizable (0.09). Unfortunately, none of the coefficient estimates of the R&D expenditures are significant. This may be due to the small sample size.

The finding that corruption is a significant determinant of innovation measured by patenting rates has important implications for the previous findings on productivity. Thus, productivity increases through innovation, which in turn occurs through reduction of corruption. This finding is an important policy ingredient, suggesting that an increase in innovation and technological progress through reduction of corruption promotes total factor productivity, economic development, and growth.

V. Concluding remarks and policy implications

The literature on corruption mainly concentrates on the impact of corruption on economic growth, and rarely examines the effect of corruption on income inequality, productivity, and innovation. This study analyses the impact of corruption on income per capita, productivity, income inequality, and innovation for 143 countries for the year 2000. In the analysis, openness to trade, institutional quality (as proxied by distance to the equator), geographical and cultural factors, and colonial ties have been taken into account. In addition, an instrumental variable approach has been adopted in order to avoid any endogeneity bias. The main finding is that control of corruption indeed has a positive effect on income per capita, productivity, and innovation. Corruption does not seem to be a significant determinant of income inequality. In particular, corruption has been found to negatively affect productivity by reducing the total factor productivity rather than by impacting physical or human capital intensity. This means that corruption might affect productivity by impacting technological progress or efficiency levels, or both. The positive impact of corruption on innovation also confirms this result, suggesting that low corruption benefits technological progress. However, we have not been able to uncover the role played by openness to trade with respect to income. Nevertheless, openness to trade seems to have a significant and positive effect on productivity. Still, even when openness to trade is included in the regressions, the control of corruption is still robust and has a positive and more statistically significant effect on productivity, suggesting that institutional settings rather than trade are more important for economic development.

All in all, these findings highlight the fact that corruption is not an issue to overlook, as it has important consequences for economic development. For example, on the basis of the estimates in this study, if Botswana improved its control of corruption to reach the level of Finland, its per capita income would rise by 2.7 times – almost a threefold increase. There is no doubt that tackling corruption is not an easy task. In societies entrenched by corruption, good governance practices struggle to survive. Corruption is flexible and corrupt officials can easily find loopholes around anti-corruption legislations, initiatives, and policies. Moreover, corruption erodes social trust, and this may further complicate the establishment of initiatives and policies against corruption. If corruption takes place at many levels in society, individuals may become more tolerant to it and accept it as a necessary evil to live with. People may also become less willing to report or condemn such practices. However, this does not mean that the fight against corruption is a losing battle. Advances in technology are likely to become important tools in fighting against corruption. The availability of a large amount of information and the possibility of sharing it at no cost are likely to increase transparency and accountability. The Internet and social networks represent a free space where individuals can express their views but also keep their leaders and public officials accountable. The leaking and distribution of the Panama Papers is an example of the effectiveness of these technologies.

Appendix 1. Tables

Table 3. Income per capita

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		FULL SAMPLE		GEOGRAPHICAL CONTROLS	GEOGRAPHICAL AND COLONIAL CONTROLS	OLS GEOGRAPHICAL CONTROLS	OLS GEOGRAPHICAL AND COLONIAL CONTROLS
VARIABLES	Income per capita	Income per capita	Income per Capita	Income per Capita	Income per capita	Income per capita	Income per capita
Control of corruption	0.04***	0.04***	0.04***	0.04***	0.04***	0.02***	0.02***
	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]

Ln population	0.07	0.01	0.06	-0.01	-0.02	-0.10	-0.11*
	[0.06]	[0.06]	[0.06]	[0.07]	[0.08]	[0.06]	[0.06]
Ln area	-0.01	0.03	-0.02	0.04	0.03	0.07	0.06
	[0.05]	[0.06]	[0.05]	[0.07]	[0.06]	[0.06]	[0.06]
Distance to equator			0.01	-0.01	-0.02	0.00	0.00
			[0.01]	[0.02]	[0.02]	[0.01]	[0.01]
Sub. Africa				-0.97***	-0.96***	-1.01***	-0.98***
				[0.32]	[0.32]	[0.27]	[0.28]
Eastasia				-0.67***	-0.65***	-0.70***	-0.68**
				[0.25]	[0.24]	[0.26]	[0.26]
Latin America				-0.13	-0.20	-0.35	-0.46*
				[0.30]	[0.32]	[0.26]	[0.26]
% of tropic land				0.10	0.03		
				[0.40]	[0.39]		
Landlock				-0.24	-0.27	-0.29	-0.30
				[0.20]	[0.20]	[0.18]	[0.18]
Dist. to coast/river				0.00	0.00	0.00	0.00
				[0.00]	[0.00]	[0.00]	[0.00]
Avg. temperature				-0.00	-0.00	0.00	0.01
				[0.01]	[0.02]	[0.01]	[0.02]
Avg. humidity				0.01	0.01	0.01*	0.01*
				[0.00]	[0.01]	[0.00]	[0.00]
Soil quality				-0.21	-0.16	-0.16	-0.08
				[0.19]	[0.20]	[0.18]	[0.18]
Malaria index				-0.30	-0.38	-0.74**	-0.83**
				[0.43]	[0.44]	[0.32]	[0.35]
Yellow fever				-0.16	-0.12	-0.23	-0.17
				[0.22]	[0.22]	[0.19]	[0.19]
4rich young countries				-0.25	-0.12	0.10	0.28
				[0.42]	[0.43]	[0.32]	[0.34]
Oil resources				0.00***	0.00***		
				[0.00]	[0.00]		
British					-0.22		-0.29

colon. ties							
					[0.22]		[0.19]
French colon. ties					-0.03		-0.24
					[0.33]		[0.26]
Constant	6.18***	5.93***	6.33***	6.40***	6.87***	6.89***	7.15***
	[0.55]	[0.64]	[0.55]	[0.91]	[0.90]	[0.87]	[0.87]
Observations	123	147	123	110	110	123	122
R-squared	0.57	0.49	0.60	0.79	0.79	0.83	0.83

Instruments	ADI	ADI	ADI	ADI	ADI
K-P Wald F test	107.917	68.791	49.76	33.178	27.697
S&Y					
10%	16.38	16.38	16.38	16.38	16.38
15%	8.96	8.96	8.96	8.96	8.96
20%	6.66	6.66	6.66	6.66	6.66
25%	5.53	5.53	5.53	5.53	5.53

ADI = Age of Democracy Index

Table 4. Income per capita and trade

	(1)	(2)	(3) FULL SAMPLE	(4) GEOGRAPHICAL AND COLONIAL CONTROLS	(5) VATSH	(6) OLS
VARIABLES	Income per capita	Income per capita	Income per capita	Income per capita	Income per capita	Income per capita
Pred. TSH	1.20	0.83	0.99	1.22*		0.40**
	[0.78]	[0.70]	[1.47]	[0.64]		[0.16]
Control of corruption	0.04***	0.04***	0.04***	0.04***	0.04***	0.02***
	[0.00]	[0.00]	[0.00]	[0.01]	[0.01]	[0.00]
Ln population	0.12	0.09	0.06	0.11	0.24	-0.03
	[0.07]	[0.07]	[0.11]	[0.12]	[0.18]	[0.06]
Ln area	0.11	0.07	0.10	0.08	0.31	0.05
	[0.11]	[0.10]	[0.14]	[0.07]	[0.23]	[0.06]
Distance to equator		0.01	0.01	-0.03	-0.03	0.00
		[0.01]	[0.01]	[0.02]	[0.02]	[0.01]

Sub. Africa				-0.90***	-0.81	-0.88***
				[0.34]	[0.53]	[0.29]
Eastasia				-1.29***	-2.28*	-0.74***
				[0.47]	[1.29]	[0.25]
Latin America				0.05	-0.42	-0.21
				[0.35]	[0.46]	[0.25]
% of tropic land				-0.31	-0.80	-0.02
				[0.41]	[0.51]	[0.39]
Landlock				-0.30	0.32	-0.20
				[0.19]	[0.28]	[0.18]
Dist. to coast/river				0.00	-0.00	-0.00
				[0.00]	[0.00]	[0.00]
Avg. temperature				-0.01	0.01	0.00
				[0.02]	[0.02]	[0.01]
Avg. humidity				-0.00	0.00	0.01
				[0.01]	[0.01]	[0.00]
Soil quality				-0.23	-0.53*	-0.10
				[0.20]	[0.32]	[0.19]
Malaria index				-0.05	-0.72	-0.58
				[0.54]	[0.74]	[0.40]
Yellow fever				-0.18	-0.02	-0.15
				[0.20]	[0.31]	[0.20]
Oil resources				0.00**	0.00***	0.00**
				[0.00]	[0.00]	[0.00]
4rich young countries				0.33	0.92	0.53
				[0.43]	[0.64]	[0.37]
British colon. ties				-0.34	-0.88	-0.25
				[0.21]	[0.61]	[0.17]
French colon. ties				-0.06	-1.43***	-0.15
				[0.28]	[0.51]	[0.24]
VATSH					4.86*	
					[2.92]	
Constant	3.82**	4.68***	4.21	6.04***	1.41	6.62***
	[1.88]	[1.68]	[2.87]	[1.05]	[3.98]	[0.86]
Observations	123	123	147	110	64	119
R-squared	0.55	0.61	0.54	0.80	0.82	0.85

Instruments	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.VATSH
K-P Wald F-test	2.528	2.195	0.946	2.493	1.685
S&Y					
10%	7.03	7.03	7.03	7.03	7.03
15%	4.58	4.58	4.58	4.58	4.58
20%	3.95	3.95	3.95	3.95	3.95
25%	3.63	3.63	3.63	3.63	3.63
A-P F-test for ADI	18.35	42.14	13.3	26.7	4.72
A-P F-test for pred.TSH	5.94	4.75	2.15	5.24	3.42
S&Y					
10%	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25

Table 5: Output per worker, physical capital intensity, human capital intensity and TFP

VARIABLES	(1) Output per worker (in log)	(2) Physical capital intensity (in log)	(3) Human capital intensity (in log)	(4) TFP (in log)
Pred. TSH	1.63*	-0.15	0.19	1.58**
	[0.88]	[0.20]	[0.28]	[0.75]
Control of corruption	0.03***	-0.00	0.01*	0.03***
	[0.01]	[0.00]	[0.00]	[0.01]
Ln population	0.23	-0.10***	0.02	0.30**
	[0.15]	[0.03]	[0.04]	[0.14]
Ln area	0.07	0.02	0.03**	0.02
	[0.07]	[0.02]	[0.01]	[0.07]
Distance to equator	-0.03	-0.01	-0.00	-0.02
	[0.02]	[0.00]	[0.00]	[0.02]
Sub. Africa	-0.88**	-0.05	-0.17**	-0.66
	[0.43]	[0.10]	[0.08]	[0.43]
Eastasia	-1.64**	0.16	-0.20	-1.60**
	[0.71]	[0.18]	[0.20]	[0.67]
Latin America	0.36	-0.14	0.05	0.45
	[0.40]	[0.09]	[0.09]	[0.36]
% of tropic land	-0.45	-0.16	-0.08	-0.20
	[0.51]	[0.13]	[0.11]	[0.49]

Landlock	-0.17	-0.08	-0.02	-0.07
	[0.20]	[0.07]	[0.04]	[0.21]
Dist. to coast/river	0.00	0.00	-0.00	0.00
	[0.00]	[0.00]	[0.00]	[0.00]
Avg. temperature	-0.00	0.00	-0.01	-0.00
	[0.02]	[0.00]	[0.00]	[0.02]
Avg. humidity	-0.01	0.00	0.00	-0.01
	[0.01]	[0.00]	[0.00]	[0.01]
Soil quality	-0.53**	0.11*	-0.12**	-0.52**
	[0.24]	[0.06]	[0.05]	[0.23]
Malaria index	0.02	-0.28**	-0.03	0.33
	[0.60]	[0.13]	[0.14]	[0.57]
Yellow fever	-0.26	-0.01	-0.08	-0.17
	[0.22]	[0.06]	[0.06]	[0.20]
4rich young countries	0.52	-0.17	0.16	0.53
	[0.47]	[0.12]	[0.13]	[0.45]
British colon. ties	-0.47*	-0.02	0.02	-0.47*
	[0.26]	[0.09]	[0.06]	[0.27]
French colon. ties	-0.03	0.03	-0.10*	0.04
	[0.25]	[0.07]	[0.05]	[0.24]
Oil resources	-0.00	0.00	0.00	-0.00
	[0.00]	[0.00]	[0.00]	[0.00]
Constant	-4.42***	0.39	-1.03***	-3.78***
	[1.07]	[0.39]	[0.28]	[1.21]
Observations	93	93	93	93
R-squared	0.78	0.27	0.82	0.63
Instruments	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.TSH	Age of democracy index, pred.TSH
K-P Wald F test	4.604	4.604	4.604	4.604
S&Y				
10%	7.03	7.03	7.03	7.03
15%	4.58	4.58	4.58	4.58
20%	3.95	3.95	3.95	3.95
25%	3.63	3.63	3.63	3.63
A-P F test for ADI	21.36	21.36	21.36	21.36
A-P F test for pred.TSH	10.37	10.37	10.37	10.37
S&Y				
10%	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25

Table 6. Gini index and the 90-10 income gap

	(1)	(2)	(3) GEOGRAPHICAL AND COLONIAL CONTROLS	(4)	(5)	(6) GEOGRAPHICAL AND COLONIAL CONTROLS
VARIABLES	Gini	Gini	Gini	90/10 income gap	90/10 income gap	90/10 income gap
Control of corruption	-0.00	-0.00	-0.00	-0.10*	0.02	-0.11
	[0.00]	[0.00]	[0.00]	[0.05]	[0.14]	[0.13]
Pred. TSH	-0.32*	-0.20	-0.11	-12.94*	-6.41	-0.67
	[0.19]	[0.15]	[0.08]	[7.35]	[5.86]	[6.48]
Ln population	-0.03	-0.02*	-0.01	-3.55**	-3.33**	-1.83
	[0.02]	[0.01]	[0.01]	[1.72]	[1.62]	[1.43]
Ln area	-0.03	-0.01	-0.00	0.43	1.67	2.83
	[0.03]	[0.02]	[0.01]	[1.52]	[1.92]	[2.16]
Distance to equator		-0.00**	-0.00		-0.25	-0.12
		[0.00]	[0.00]		[0.19]	[0.17]
Sub. Africa			0.14***			-6.13
			[0.04]			[6.39]
East Asia			0.13**			6.06
			[0.06]			[5.24]
Latin America			0.13***			-5.43
			[0.04]			[5.96]
% of tropic land			0.03			9.40
			[0.06]			[8.35]
Landlock			0.07**			18.36**
			[0.03]			[8.23]
Dist. to coast/river			-0.00			-0.01
			[0.00]			[0.01]
Avg. Temperature			-0.00			-0.65**
			[0.00]			[0.29]
Avg. Humidity			-0.00			-0.12
			[0.00]			[0.11]
Soil quality			0.04*			9.28
			[0.02]			[6.91]
Malaria index			-0.14**			-14.25

			[0.06]			[10.39]
Yellow fever			-0.01			8.51***
			[0.03]			[2.92]
Oil resources			-0.00	-0.00**	-0.00***	-0.00***
			[0.00]	[0.00]	[0.00]	[0.00]
4 rich young countries			0.03	0.74	-0.82	16.77
			[0.06]	[5.23]	[5.63]	[14.22]
British col. ties			0.06**			-1.92
			[0.03]			[4.90]
French col.ties			0.03			3.98
			[0.02]			[4.77]
Constant	1.19**	0.85**	0.54***	33.22	12.24	8.51
	[0.53]	[0.40]	[0.10]	[20.48]	[25.99]	[28.33]
Observations	102	102	95	58	58	57
R-squared	-1.27	-0.18	0.59	0.25	0.32	0.58
Instruments	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.TSH	ADI, pred.TSH	Age of democracy index, pred.TSH	Age of democracy index, pred.TSH
K-P Wald F test	1.667	1.497	2.182	5.184	3.562	4.611
S&Y						
10%	7.03	7.03	7.03	7.03	7.03	7.03
15%	4.58	4.58	4.58	4.58	4.58	4.58
20%	3.95	3.95	3.95	3.95	3.95	3.95
25%	3.63	3.63	3.63	3.63	3.63	3.63
A-P F test for ADI	12.41	37.31	25.1	16	10.5	12.09
A-P F test for pred.TSH	3.83	3.07	4.78	10.43	8.88	8.12
S&Y						
10%	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25

Table 7. Patent intensity, logarithm of number of patents, and R&D as a % of GDP

	(1)	(2)	(3)
VARIABLES	Ln patents per capita	Ln of number of patents	R&D expenditures as % of GDP
Pred.TSH	4.48*	4.50*	-6.03*
	[2.68]	[2.70]	[3.44]
Control of corruption	0.09***	0.09***	0.06
	[0.03]	[0.03]	[0.04]
Ln of population	0.67*	1.68***	-0.51
	[0.39]	[0.39]	[0.51]
Ln of area	0.14	0.14	-0.51*
	[0.25]	[0.25]	[0.27]
Distance to equator	-0.05	-0.06	-0.05
	[0.06]	[0.06]	[0.08]
Sub.Africa	-0.25	-0.26	0.91
	[0.97]	[0.97]	[1.83]
East Asia	-2.67*	-2.64*	5.35
	[1.54]	[1.54]	[3.26]
Latin America	0.74	0.77	0.57
	[1.23]	[1.23]	[1.17]
% of tropic land	-1.08	-1.15	-3.57
	[1.36]	[1.36]	[3.15]
Landlock	-0.80	-0.79	0.24
	[0.64]	[0.64]	[1.51]
Dist. to coast/river	0.00	0.00	-0.00
	[0.00]	[0.00]	[0.00]
Avg. Temperature	-0.08	-0.08	0.00
	[0.05]	[0.05]	[0.08]
Avg. Humidity	-0.04	-0.04	0.02
	[0.02]	[0.02]	[0.02]
Soil quality	-1.16**	-1.18**	0.62
	[0.59]	[0.59]	[0.88]
Malaria index	0.54	0.58	0.94
	[1.63]	[1.63]	[3.14]
Yellow fever	-0.38	-0.36	0.57
	[0.51]	[0.51]	[0.89]
4 rich young countries	1.26	1.26	-4.54*
	[1.33]	[1.34]	[2.41]
Oil resources	-0.00	-0.00	0.00*
	[0.00]	[0.00]	[0.00]
British col.ties	-0.98	-0.97	3.09
	[0.70]	[0.71]	[1.98]

French col.ties	0.02	0.01	-0.28
	[0.72]	[0.73]	[1.16]
Constant	-3.69	3.23	9.67*
	[3.51]	[3.55]	[5.62]
Observations	98	98	39
R-squared	0.69	0.73	-1.13

Instruments	ADI, pred.TSH	ADI, pred.TSH	Age of democracy index, pred.TSH
K-P Wald F test	2.762	2.762	0.738
S&Y			
10%	7.03	7.03	7.03
15%	4.58	4.58	4.58
20%	3.95	3.95	3.95
25%	3.63	3.63	3.63
A-P F test for ADI	22.46	22.46	1.68
A-P F test for pred.TSH	5.67	5.67	1.50
S&Y			
10%	19.93	19.93	19.93
15%	11.69	11.69	11.69
20%	8.75	8.75	8.75
25%	7.25	7.25	7.25

Appendix 2. Additional variables

Worldwide Governance Indicator – Control of Corruption dimension

It ranks countries from 0 (highly corrupt) to 100 (highly clean).

http://data.worldbank.org/data-catalog/worldwide-governance-indicators

Age of democracy index (ADI)

The ADI index is calculated by following Persson & Tabellini (2004) methodology and using Polity IV.

http://www.systemicpeace.org/inscrdata.html

It's an index ranging from 0 to 1, which measures countries' democratic tradition:

$$\frac{(2000 - \text{Year of birth of democracy})}{200}$$

The year of birth of democracy is the first year of an uninterrupted string of positive yearly POLITY ratings until the end of the sample. The number of years under democratic rule is then divided by 200, which is the difference between the year 2000 and the year 1800 (beginning of the sample).

R&D as a percentage of GDP

http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS.

Appendix 3. Countries

ARUBA, AFGHANISTAN, ANGOLA, ALBANIA, UNITED ARAB EMIRATES, ARGENTINA, ARMENIA, ANTIGUA AND BARBUDA, AUSTRALIA, AUSTRIA, AZERBAIJAN, BURUNDI, BELGIUM, BENIN, BURKINA FASO, BANGLADESH, BULGARIA, BAHRAIN, BAHAMAS, BELIZE, BERMUDA, BOLIVIA, BRAZIL, BARBADOS, BRUNEI DARUSSALAM, BHUTAN, BOTSWANA, CENTRAL AFRICAN REPUBLIC, CANADA, SWITZERLAND, CHILE, CHINA, CÔTE D'IVOIRE, CAMEROON, CONGO REPUBLIC., COLOMBIA, COMOROS, CAPE VERDE, COSTA RICA, CUBA, CYPRUS, CZECH REPUBLIC, GERMANY, DJIBOUTI, DOMINICA, DENMARK, DOMINICAN REPUBLI, ALGERIA, ECUADOR, EGYPT, ARAB REPUBLIC, ERITREA, SPAIN, ESTONIA, ETHIOPIA, FINLAND, FIJI, FRANCE, MICRONESIA, FED. STS., GABON, UNITED KINGDOM, GEORGIA, GHANA, GUINEA, GAMBIA, GUINEA-BISSAU, EQUATORIAL GUINEA, GREECE, GRENADA, GUATEMALA, GUYANA, HONG KONG, CHINA, HONDURAS, CROATIA, HAITI, HUNGARY, INDONESIA, INDIA, IRELAND, IRAN, IRAQ, ICELAND, ISRAEL, ITALY, JAMAICA, JORDAN, JAPAN, KAZAKHSTAN, KENYA, KYRGYZISTAN, CAMBODIA, KIRIBATI, ST. KITTS AND NEVIS, KOREA, KUWAIT, LAO PDR, LEBANON, LIBYA, ST. LUCIA, SRI LANKA, LESOTHO, LITHUANIA, LUXEMBOURG, LATVIA, MACAO SAR, CHINA, MOROCCO, MOLDOVA, MADAGASCAR, MALDIVES, MEXICO, MALI, MALTA, MYANMAR, MONTENEGRO, MONGOLIA, MOZAMBIQUE, MAURITANIA, MAURITIUS, MALAWI, MALAYSIA, NAMIBIA, NEW CALEDONIA, NIGER, NIGERIA, NICARAGUA, NETHERLANDS, NORWAY, NEPAL, NEW ZEALAND, OMAN, PAKISTAN, PANAMA, PERU, PHILIPPINES, PALAU, PAPUA NEW GUINEA, POLAND, PUERTO RICO, PORTUGAL, PARAGUAY, FRENCH POLYNESIA, QATAR, ROMANIA, RUSSIAN FEDERATION, RWANDA, SAUDI ARABIA, SUDAN, SENEGAL, SINGAPORE, SOLOMON ISLANDS, SIERRA LEONE, EL SALVADOR, SAN MARINO, SOMALIA, SÃO TOMÉ AND PRINCIPE, SURINAME, SLOVAK REPUBLIC, SLOVENIA, SWEDEN, SWAZILAND, SEYCHELLES, SYRIA, CHAD, TOGO, THAILAND, TAJIKISTAN, TURKMENISTAN, TIMOR-LESTE, TONGA, TRINIDAD AND TOBAGO, TUNISIA, TURKEY, TAIWAN, TANZANIA, UGANDA, UKRAINE, URUGUAY, UNITED STATES, UZBEKISTAN, ST. VINCENT AND THE GRENADINES, VENEZUELA, VIETNAM, VANUATU, SAMOA, YEMEN, REP. SOUTH AFRICA, ZAIRE, ZAMBIA, ZIMBABWE

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