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Trung V. Vu
Department of Economics, University of Otago, Dunedin, New Zealand

Address for correspondence:

Trung Vu
Department of Economics
University of Otago
PO Box 56
Dunedin
NEW ZEALAND
Email: trung.vu@postgrad.otago.ac.nz or trungvu.ueb@gmail.com

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Climate, Diseases, and the Origins of Corruption

Trung V. Vu*

Department of Economics, University of Otago, Dunedin, New Zealand

Abstract

It has been commonly observed that tropical countries typically suffer from intense corruption and underdevelopment. I offer an explanation for this long-standing disparity across the world based on variation in the intensity of ultraviolet radiation (UV-R). The central idea of this paper holds that UV-R is positively associated with the (historical) prevalence of eye diseases, which significantly shortens work-life expectancy as a skilled worker. This arguably shapes the global pattern of corrupt practices. Interestingly, this finding appears to be strong and insensitive to accounting for different theories explaining differences in corruption levels across the globe. Further analyses using individual-level data taken from the World Values Survey and provincial level data for China lend strong credence to the cross-country evidence.

Key words: corruption, climate, diseases, ultraviolet radiation, comparative prosperity.

JEL Classification: O11, O43, O57, Q54.

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* Correspondence address: Department of Economics, University of Otago, PO Box 56, Dunedin 9054, New Zealand. Email: trung.vu@postgrad.otago.ac.nz or trungvu.ueb@gmail.com.

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1. Introduction

The pattern of comparative prosperity across the world is arguably one of the most debated topics in mainstream economics. As well as large and persistent disparities in wealth, there is also considerable variation in the perceived level of corruption across the globe (Figure 1). Countries located further away from the equator, in particular, enjoy a more transparent institutional environment. By contrast, corruption is more pervasive in societies located closer to the equator. While these patterns of inequality are well known for many decades or so, a systematic empirical analysis remains relatively scant.

A recent study by Andersen et al. (2016) attends to this line of inquiry, and finds that the intensity of ultraviolet radiation (UV-R), which is highly correlated with latitude, offers an explanation for the global income inequality. This novel idea rests upon the premise that UV-R shortens work-life expectancy as a skilled worker, thus shaping economic prosperity via affecting the timing of fertility transition. This piece of work, however, leaves it open to debate whether UV-R helps explain why some regions are much more corrupt than others.

It is commonly presumed that corrupt practices create unfavourable conditions for economic growth and development (e.g., Mauro, 1995; Aidt, 2003; Svensson, 2005; Glaeser & Saks, 2006; Ahlin & Bose, 2007; Aidt et al., 2008; Aidt, 2009; Dimant & Tosato, 2018). The annual cost associated with corrupt acts in the form of bribes and stolen money amounts to 2.6 trillion USD or five percent of the global GDP (OECD, 2013). Thus, corruption is highlighted as one of the most serious impediments to achieving the Sustainable Development Goals by 2030. To the extent that corruption is a global concern and its prevalence is distributed unequally across countries, we need to understand the underlying causes of corrupt activities.

A wealth of literature explores determinants of corruption, using cross-country data. This helps advance our understanding of the perennial question discussed above and contributes to forming corruption-related policies. The worldwide distribution of corruption, for instance, is attributable to the share of women in parliament (Swamy et al., 2001), democracy (Treisman, 2000), the size of government (Goel & Nelson, 1998), bureaucracy and regulations (Goel & Nelson, 2010), to name but a few.[1] A salient pitfall of these studies mainly stems from endogeneity concerns, making it difficult to draw valid statistical inference. Establishing causality, therefore, requires finding an instrumental variable that satisfies the exclusion restriction, which is challenging. Furthermore, these "proximate" factors are generally interrelated with and jointly determined by the level of corruption. For this reason, they offer an inadequate understanding of the deep roots of corrupt practices.[2] Aidt (2003) also emphasizes that corruption appears to be a persistent feature of human societies. This necessitates examining the deep roots of corrupt behaviour that help explain the long-lasting differences in corruption levels across the world more adequately.

Motivated by the above issues, several studies endeavour to examine the pattern of corruption from a (historical) fundamental determinant perspective. An influential viewpoint asserts that common-law countries have less corruption compared with civil-law counterparts (La Porta et al., 1999; Treisman, 2000; Swamy et al., 2001). Another hypothesis contends that communist legacy matters for today's corruption (La Porta et al., 1999; Paldam, 2002; Uberti, 2018). Specifically, corrupt practices are more prevalent in former socialist and transitional economies. Furthermore, Treisman (2000) and Dincer (2008) argue that ethnolinguistic diversity exerts a statistically significant influence on the incidence of corruption. Other studies attribute corrupt practices to culture and religion (La Porta et al., 1999; Treisman, 2000; Paldam, 2001, 2002). It is plausible that these variables may provide exogenous sources of

[1] Dimant and Tosato (2018) provide an excellent review of causes and effects of corruption.

[2] For example, if corrupt activities are attributable to cross-country differences in gender inequality, democratic institutions and inefficient bureaucracy, what further explain the global variation in these factors? This motivates understanding the origins of corrupt behaviour because curbing corruption requires treating the disease not just its symptoms.

variation in corruption levels because they were predetermined in history. For this reason, reverse causality is unlikely to exist, thus mitigating the potential endogeneity bias.

Importantly, the long-lasting observation that corruption appears to be more widespread when one moves more closely to the equator remains largely unexplored in the current literature. Even if we account for existing hypotheses, temperate countries (e.g., Denmark, New Zealand, and Finland) rank persistently high among the least corrupt economies in the world. By contrast, tropical regions (e.g., South Sudan, Somalia, and Yemen) suffer from much higher levels of corruption. Thus, it is still open to debate whether geographic endowments exert any causal effect on the prevalence of corruption across the world. Further, if geography matters for corrupt activities, what are the mechanisms behind this relationship? These questions are essential to advance our understanding of the origins of corruption, which is relevant for forming policies to eliminate corrupt behaviour.

This study proposes a novel hypothesis that the intensity of UV-R, which is perhaps the strongest correlate of latitude, matters for cross-country differences in corruption levels. I posit that there exists a positive reduced-form link between UV-R and the pervasiveness of corrupt practices. In particular, high UV-R countries face a permanent threat of contracting eye diseases that shortens the duration of work-life expectancy as a skilled worker (Andersen et al., 2016). I argue later that this channel of influence helps explain the uneven distribution of corruption across the globe. As far as I am aware, there is no study linking geographic endowments, particularly UV-R, and corruption levels.

To test the above proposition, I estimate cross-sectional models with data for up to 139 countries. Results provide strong empirical support for the reduced-form relationship between UV-R and corruption levels. To reduce the potential omitted variable bias, I allow for a number of confounding factors to enter the baseline regression, following the existing long-run comparative development literature. Furthermore, the baseline findings remain largely insensitive to performing a series of robustness tests. I also find evidence supporting the disease channel that helps explain the reduced-form link between UV-R and corruption behaviour in a cross-country analysis. Further evidence using individual-level and within-country data also lends strong credence to the cross-country evidence.

This paper relates to several lines of inquiry. Foremost, it contributes to a strand of literature documenting that geographic endowments lie at the roots of long-term comparative prosperity across countries (Gallup et al., 1999; Sachs, 2003; Andersen et al., 2016). While existing studies mostly focus on the effect of geography on income levels, little is known about the extent to which geographic conditions help shape the widespread presence of corruption. My findings advance our understanding of the persistent effect of geography on the global pattern of development. This study also intersects with macro-level research examining the influence of mortality and morbidity on growth and development (Gallup & Sachs, 2001; Acemoglu & Johnson, 2007; Ashraf et al., 2008; Aghion et al., 2011; Cervellati & Sunde, 2011; Nikolaev & Salahodjaev, 2017; Ang et al., 2018). I add further evidence to this literature by demonstrating that the disease environment matters for corrupt behaviour. Importantly, this research contributes to an emerging literature on the determinants of corruption as reviewed earlier. More specifically, this paper attempts to explain the uneven geographic distribution of corruption levels, which has been largely ignored when examining the causes of corruption.

The remainder of this paper proceeds as follows. Section 2 discusses the theoretical framework behind the reduced-form link between UV-R and the prevalence of corruption. Section 3 presents the model specification and data. In Section 4, I discuss cross-country evidence, followed by an individual-level analysis in Section 5. Next, Section 6 offers further evidence using provincial level data for China. The paper concludes by summarizing the main findings in Section 7.

2. The economic argument

A plausible argument for the reduced-form relationship between UV-R and corruption rests upon the disease channel that shapes the cross-country variation in work-life expectancy as a skilled worker. In particular, the prevalence of various kinds of eye disease is attributable to the intensity of UV-R as pointed out by many studies in the epidemiological literature (e.g., Dong et al., 2003; Gallagher & Lee, 2006; West, 2007; Lucas et al., 2008; Löfgren, 2017). The permanent threat of contracting eye diseases, including cataracts, is significantly associated with impaired vision and blindness across the world (Gallagher & Lee, 2006; Löfgren, 2017). Andersen et al. (2016) argue that the risk of eye diseases matters for the global pattern of expected work life as a skilled worker. The explanation for this holds that visual acuity is of paramount importance for skill-intensive jobs because these occupations critically require literacy. Furthermore, there appears a global pattern of the prevalence of eye diseases, caused by the level of UV-R (Andersen et al., 2016). Cataracts, for instance, are common among the elderly population in Western Europe, but they tend to appear significantly earlier in life in countries located near the equator. Using survey data, Andersen et al. (2016) demonstrate that the estimated loss of work-life expectancy, caused by UV-R, amounts to up to 14 years, a sizeable influence.

It follows from the above line of reasoning that the intensity of UV-R is a major cause of eye diseases, which shortens work-life expectancy as a skilled worker. This mechanism offers several implications for cross-country differences in corruption levels. The incentives for engaging in corrupt practices critically depend on the duration of work-life expectancy. Specifically, officials are more likely to misappropriate public resources for private gain when their window of opportunity is short (Olson, 1991; Campante et al., 2009). The threat of diseases, therefore, positively affects the frequency of corrupt behaviour via shortening the incumbents' horizon. In contrast, officials face a significantly longer work-life expectancy in low UV-R regions (Andersen et al., 2016). This reduces their likelihood of exploiting public funds by increasing the horizon over which incumbents' employment gains are discounted. Examining regional-level corruption in Brazil, Ferraz and Finan (2011) find that areas where mayors face a binding one-term limit suffer from significantly higher corruption than ones where mayors are eligible for serving a second term. Accordingly, corrupt practices are 27% lower among mayors with re-election incentives. This result is consistent with the argument that the cross-country variation in the length of work-life expectancy, caused by UV-R related diseases, determines the motivation for abusing public resources for personal gain. I argue that this channel of influence helps explain the uneven distribution of corruption across the world.

The reduced-form link between UV-R and corruption is consistent with the view that the disease environment helps shape long-term comparative institutional quality. An influential study by Acemoglu et al. (2001) contends that the prevalence of diseases determined the nature of European colonization, starting around the seventeenth century. For instance, inclusive institutions were established in areas where Europeans could easily settle because of a favourable disease environment. By contrast, extractive institutions were set up in places where a hostile disease environment made it difficult for European colonizers to settle permanently. The early institutions persist until today, thus shaping the path of development across the globe. Additionally, Ang et al. (2018) argue that the prevalence of eye diseases in some societies is detrimental to investment in cooperation by building institutions, leaving those countries with poorer institutional quality. Nikolaev and Salahodjaev (2017) find that the historical prevalence of infectious diseases helps shape the quality of economic institutions. Specifically, the pervasiveness of infectious diseases exerts a long-lasting effect on personality traits, cultural traits and regional-level morality, which ultimately determine the disparity in institutional quality. More recently, Vu (2019) documents a strong positive relationship between UV-R and the quality of institutions, measured by the Economic Freedom of the World index. Thus, the disease environment matters for the frequency of corrupt practices because countries with bad institutions may lack efficient and transparent regulations to combat corruption (Dimant & Tosato, 2018).

Andersen et al. (2016) demonstrate that the (historical) prevalence of eye diseases affects the perceived return to obtaining skills and knowledge across countries. This (early) persistent disparity negatively affects the availability of well-trained and competent bureaucrats who can design better rule of law to combat corruption. Importantly, the lack of incentives for skill accumulation also triggers inequality in power and wealth. It is plausible that powerful elites with superior skills and knowledge tend to emerge to manage a cadre of unskilled workers. Meanwhile, countries with a powerful elite group are usually more corrupt because they tend to exploit public resources for their own profits. A final reason works through the accumulation of food surpluses (Ang, 2013). Countries facing a permanent risk of developing eye diseases had lower (historical) motivation for investing in skills and technologies, which deterred the accumulation of food surplus (Andersen et al., 2016; Ang et al., 2018). Early food surpluses induced the emergence of a group of specialists who focused on designing rule of law, property rights and created the initial political structure of society (Diamond, 1997; Ang, 2013). As argued by Acemoglu et al. (2001), these factors are persistent, shaping the pattern of comparative prosperity across the world. For this reason, I argue that they formed the fundamentals for tackling corruption in modern societies.

In summary, this section proposes that there exists a positive reduced-form link between the intensity of UV-R and the level of corruption across countries. The central hypothesis of this study posits that high UV-R countries face a long-lasting threat of contracting eye diseases, thus having a shorter work-life expectancy than low UV-R regions. This pattern ultimately helps determine the geographic distribution of corrupt practices across the globe. The following sections empirically investigate this reduced-form relationship.

3. Models and data

To explore a reduced-form relationship between the intensity of UV-R and corruption across countries, I employ the following basic econometric specification:

$$Corruption_i = \alpha + \beta \log(UV)_i + \gamma X_i + \varepsilon_i$$

where i denotes country i. $Corruption$ is the outcome variable, capturing the perceived level of corruption. UV is the main variable of interest, measuring the intensity of UV-R. X stands for a vector of baseline control variables, including geographic endowments, legal origins, a communist dummy, ethnolinguistic fractionalization, and religions. ε is the error term that includes unobserved country-specific factors. β reflects the estimated effect of UV-R on corruption, and is expected to be positive.[3]

Estimating the above equation requires some attention to omitted variable bias. This is because the nature of cross-sectional data does not allow us to control for unobserved country-specific factors properly using fixed effects. To avoid such bias, this paper follows the long-term comparative development literature to include an extensive set of confounding factors (Acemoglu, 2009, Ch. 4). It is also important to note that reverse causality is not a major concern in this context. Specifically, the level of UV-R can be affected by the ozone layer's thickness, which may be partly influenced by economic development. Andersen et al. (2016), however, highlight that there appears no systematic evidence on the causal effect of economic activities in a specific region and its ozone layer.[4] Thus, any reverse causation running from corruption to UV-R is even more tenuous.

This study employs the World Bank's reversed index of control of corruption in 2010 as the baseline dependent variable. For ease of interpretation, I multiply the original index by minus one so that higher values correspond to more intense corruption. Corrupt practices are

[3] I follow the logarithmic transformation of UV-R of Andersen et al. (2016).

[4] Andersen et al. (2016) find that regional economic development exerts no direct influence on UV-R. This finding is presented in their online appendix Table A1.

generally hidden from official statistics, making it hard to measure corruption levels accurately. This raises a concern that the results may be spurious due to measurement error. Thus, alternative measures of corruption will be used in sensitivity analysis. The main variable of interest is the UV-R index, obtained from Andersen et al. (2016).[5] This indicator is constructed using daily satellite-based data for ambient UV-R from NASA, measuring the intensity of radiation in a particular region on the earth. Thus, it reflects the extent to which people living in a specific area are exposed to sunburn caused by the intensity of UV-R. Andersen et al. (2016) employ highly disaggregated data at the pixel level to calculate the averaged index for each country for the years 1990 and 2000.[6]

As argued above, I control for a number of potential confounders to isolate the causal effect of the UV-R on corruption. *First*, geographic endowments, including mean elevation, temperature and precipitation, are included as baseline controls because they may affect the intensity of UV-R. These factors may arguably influence corrupt behaviour via shaping motivation to work. Additional geographic characteristics will be used to rule out the possibility that a reduced-form link between UV-R and corruption is just a proxy for other geographic variables. *Second*, common-law countries have been shown to be less corrupt than civil-law counterparts (Treisman, 2000). Hence, legal origins are included, following the classification of Klerman et al. (2011).[7]

Third, a dummy for being former socialist and transitional economies (*communist*) is included to account for the possibility that a socialist legacy is positively correlated with the incidence of corruption (La Porta et al., 1999; Uberti, 2018). *Fourth*, ethnolinguistic diversity

[5] See also Andersen et al. (2016) for more details.

[6] Cross-country differences in UV-R remains relatively constant over the last two billion years (Cockell & Horneck, 2001). This justifies the use of averaged data.

[7] Klerman et al. (2011) define three legal codes including common, civil and mixed law. This is broadly similar to La Porta et al. (1999), except for a few countries that partly replaced their originally adopted French civil law by British common law. Civil-law countries are omitted as the base category.

may shape the social hierarchy via influencing cultural attitudes, thereby affecting the prevalence of corruption (Dimant & Tosato, 2018). I control for this effect by including the index of ethnic fractionalization of La Porta et al. (1999). *Finally*, I include regional dummies, following the World Bank's geographic classification, to control for unobserved region-specific factors. This is motivated by the observation that sub-Saharan African countries are among the most corrupt economies in the world while European countries enjoy significantly low levels of corruption. Furthermore, corruption may spread across countries located in the same region through sharing some common-culture values and economic interactions (Correa et al., 2016).[8] The core results may reflect the effect of region-specific characteristics on corruption levels if we fail to include regional dummies.

4. Cross-country evidence

4.1. Main results

Figure 2 illustrates the partial effect of UV-R on the incidence of corruption across 136 countries after I control for all potential confounders discussed above. Accordingly, the intensity of UV-R is positively associated with corruption levels. This positive reduced-form relationship is consistent with the proposition discussed in Section 2 that high UV-R regions suffer from more intense corruption.

Table 1 presents the OLS estimates of the effect of UV-R on corruption. The estimated coefficient of UV-R is positive and statistically significant at the 1% level when no control variables are included in the regression (column 1). The positive effect of UV-R on corruption levels remains precisely estimated when additional control variables are added to the regression. This suggests that the estimates in column (1) do not reflect a spurious relationship. The standardized beta coefficients are shown column (5) of Table 1. They indicate that UV-R

[8] This argument also suggests that the error term is spatially correlated. Hence, I will check whether the results are sensitive to this in Section 4.2.

exerts a larger effect on the level of corruption compared with any of the other baseline controls. This lends credence to the economic importance of UV-R in explaining cross-country differences in corrupt practices.

The estimated coefficients in column (4) of Table 1 suggest that a one percent increase in the UV-R index is associated with approximately a 0.016-unit increase in corruption, ceteris paribus. For instance, the values of UV-R of Denmark and Greece are about 56 and 134, respectively. The difference between these two countries is 78, roughly one standard deviation of UV-R. If Denmark instead experienced the level of UV-R of Greece, its corruption level would increase by approximately 2.23 units, ceteris paribus. This is a substantial effect. Taken together, I find strong evidence supporting the positive reduced-form link between the UV-R and the prevalence of corruption.

4.2. Sensitivity analysis

To rule out the possibility that the benchmark findings reflect a spurious relationship between UV-R and corruption, I perform a series of robustness tests. The set of baseline control variables and regional dummies remains unchanged throughout these sensitivity analyses.

Controlling for the effect of historical confounders

An influential view in the long-run comparative development literature holds that the early development of historical states and societies matters for today's economic development. In particular, several studies demonstrate that the historical depth of experience with state institutions, measured by an index of state history, lies at the root of comparative prosperity across countries (Bockstette et al., 2002; Ang, 2013; Borcan et al., 2018). A recent study by Owen and Vu (2019) finds that there exists a non-linear relationship between measures of state history and corruption levels across the world. Accordingly, countries with medium statehood are among the least corrupt economies. In contrast, corrupt activities are more pervasive in nations either lacking or having excessive statehood experience. The core results in Table 1 may be biased if I fail to account for this hypothesis. For this reason, I control for the non-linear effect of different measures of early development in Table 2. Accordingly, the estimated effect of UV-R on corruption remains largely similar to the baseline estimates in column (4) of Table 1.

Another concern relates to the effect of (historical) migration flows. One may argue that the baseline results just reflect the persistent effect of the pattern of European settlement across countries (Acemoglu et al., 2001). This historical event led to the emergence of the global income differences by affecting the early institutional quality established during the colonization period. An additional basic argument holds that people brought with them institutions and regulations developed in their home countries when migrating. It is also plausible that people could choose to migrate to areas with low UV-R where the disease environment is less hostile. The core results, therefore, may merely reflect the long-lasting impact of migration flows throughout history on today's corruption levels. To address this concern, I restrict the sample size to countries where the proportion of indigenous population (as of 1500) in the current population is greater than 70%, 80%, 90% and 95% (Table 3). Data are taken from the World Migration Matrix (Putterman & Weil, 2010). Results indicate that the reduced-form relationship between UV-R and corruption is statistically significant at the 1% level when countries facing substantial inflows of immigrants since 1500 are excluded from the regression.

Controlling for the effect of contemporary confounders

Do the findings just reflect the impact of other contemporary determinants of corruption? Our understanding of cross-country differences in corrupt practices has mainly relied on some "proximate" factors, including income levels (Serra, 2006; Aidt et al., 2008), natural resource endowments (Bhattacharyya & Hodler, 2010), trade openness (Sandholtz & Koetzle, 2000; Neeman et al., 2008), the size of government (Goel & Nelson, 1998, 2010), democracy

(Bhattacharyya & Hodler, 2010), education (Glaeser & Saks, 2006), urbanization (Goel & Nelson, 2010), and gender (Swamy et al., 2001).[9] As argued above, it is hard to draw valid statistical inference on the causal effect of these factors on corruption mainly because of the issue of reverse causation. Furthermore, these proximate factors are jointly determined and interrelated with corruption, which necessitates understanding deeper or more fundamental roots of corrupt behaviour.[10] Hence, they are not included as baseline controls. To address a concern that this may bias the benchmark results, I use them as additional controls in Table 4.[11] All variables are averaged across the preceding decade (2000-2009) to mitigate any reverse causality bias. Including these variables, however, does not alter the results. This suggests that the baseline findings are insensitive to controlling for a number of proximate determinants of corruption. Importantly, even if the estimated coefficients of UV-R were to become statistically insignificant when I control for these factors, this would provide insights into channels explaining the reduced-form link between UV-R and corruption.

Controlling for spatial dependence

A third concern is that corruption may transcend across borders. Countries located in high corruption areas tend to experience a greater frequency of corrupt practices (Correa et al., 2016). The explanation for this rests on the premise that corrupt behaviour may be transmitted through economic interactions, cultural, institutional and other geographic factors. If this assumption is true, the OLS estimates could yield a spurious relationship between UV-R and corruption. To address this concern, I replicate the baseline estimates, using Conley's (1999) spatial corrected standard errors (Table 5). This method has been widely applied in the comparative development literature (e.g., Ashraf & Galor, 2013; Borcan et al., 2018). Results

[9] Dimant and Tosato (2018) provide an excellent review of causes and effects of corruption across countries.

[10] Using these variables to explain corruption levels induces the additional question about what further explains the cross-country variation in these proximate determinants. For this reason, it is necessary to understand what determined corruption in the first place.

[11] See the online appendix for variables' description.

indicate that the effect of UV-R on corruption levels remains precisely estimated even if I rule out the potential bias of spatial dependence. Specifically, the standard errors that correct for the residual interdependence are much smaller than conventional robust standard errors. This suggests that inference on the reduced-form relationship between UV-R and corruption is not affected by spatial autocorrelation.

Other robustness tests

The results of additional sensitivity checks are provided in the online appendix. *First*, I test whether the baseline results are driven by using the World Bank's reversed index of corruption in 2010 as the main dependent variable. To this end, I use the World Bank's index measured at different periods and the Transparency International's corruption perception index (Table A2).[12] The results are broadly similar to those in column (4) of Table 1. *Second*, I control for additional geographic endowments, including absolute latitude, land suitability, the fraction of today's population at risk of contracting malaria and a dummy for being landlocked (Table A3). The effect of UV-R on corruption remains precisely estimated if these variables are added. *Finally*, Figure 1 shows a strong effect of UV-R on corruption, but some outliers may arguably confound the baseline inference. Motivated by this concern, I perform a final sensitivity test by excluding some outliers in Table A4. I remove countries of which the Cook's distance is larger than the rule-of-thumb value (four divided by the number of observations). Next, I identify a country as an outlier if the absolute value of its standardized residual is bigger than 1.96, thus being excluded in the regression. I further estimate robust regression weights, following Li (1985). These weights are employed to re-estimate the baseline model. Accordingly, the core findings remain largely unchanged when I control for the effect of outliers.

[12] The ICRG's index of corruption reflects investment risks associated with corrupt practices but not the prevalence of corruption per se. For this reason, I do not use this index as a dependent variable.

4.3. A mechanism analysis

In Section 2, I propose a reduced-form relationship between UV-R and corruption working through the disease channel. Accordingly, the permanent risk of contracting eye diseases, particularly cataracts, shortens the expected work life in high UV-R regions. This increases the prevalence of corrupt behaviour by reducing incumbents' horizons. This sub-section estimates an IV regression to test this channel of influence. The log of UV-R is employed as an instrument for eye disease (*cataracts*).[13] To be a valid instrument for eye disease, the hypothesized channel of influence, UV-R needs to satisfy the exclusion restriction. This requires that UV-R affect corruption only indirectly through the prevalence of eye disease. This is consistent with the proposed reduced-form argument discussed earlier. Indeed, it is difficult to envisage another channel of influence. Furthermore, the intensity of UV-R should be highly correlated with the incidence of eyes disease across countries, which justifies the assumption of a strong instrument (Andersen et al., 2016).

Table 6 presents the IV-2SLS estimates. Accordingly, the estimated effect of UV-R on eye diseases in the first-stage regression is statistically significant at the 1% level (Panel A). This suggests that the UV-R is not a weak instrument for eye diseases, which is consistent with the findings of Andersen et al. (2016).[14] Additionally, I present the value of F-statistics of excluded instruments and the weak identification test, following Anderson and Rubin (1949), Cragg and Donald (1993), and Sanderson and Windmeijer (2016). The results are larger than the conventionally accepted value of 10, which implies that UV-R is not a weak instrument. Turning to the second-stage regression, the estimated coefficients of cataracts are positive and statistically significant at the 1% level. This indicates that areas facing a higher risk of

[13] I use cataracts which are the most common eye disease, following Andersen et al. (2016). See also the online appendix.

[14] Andersen et al. (2016) find a strong and robust effect of the log of UV-R on the prevalence of cataracts across countries. This suggests that UV-R is a strong instrument for cataracts.

contracting cataracts suffer from more intense corruption. The results lend strong empirical support to the proposed channel of influence presented in Section 2.

5. Individual-level evidence

Although I attempt to control for a number of confounding factors to minimize the potential omitted variable bias, there may exist some unobserved country-specific factors that this paper may fail to account for properly. To address this concern, I employ individual-level data, obtained from the World Values Survey wave 6. This survey is conducted in more than sixty countries through face-to-face interviews. Yet this survey does not include a separate theme for corruption. Fortunately, there is one relevant question about individuals' attitudes towards corrupt acts in wave 6. In particular, respondents are asked about the extent to which they think corrupt practices are justifiable. The answers take ordinal values ranging from one to ten where higher values correspond to high corruption. It is plausible that countries where most people think giving a bribe is justifiable should experience a high level of corruption. Hence, I use this ordinal variable as the dependent variable measuring the prevalence of corruption.[15]

The intensity of UV-R, measured at the regional level, is merged with survey data based on respondents' answers about regions in which they are living. The set of geographic controls includes absolute latitude, mean elevation, precipitation, and temperature. These regional-level variables are obtained from Andersen et al. (2016). I control for a number of individual characteristics such as age, gender, income, educational attainment and social trust. Unobserved country-specific characteristics are removed using country fixed effects. Language dummies are included to account for unobserved individual-specific factors because people speaking a common language may share similar attitudes toward corrupt behaviour. Results in Table 7 suggest that respondents living in high UV-R regions are more likely to self-report that

[15] I drop observations with responses coded as "don't know" or "no answer". Variables' descriptions are explained in the online appendix.

corrupt practices are justifiable. This is in line with cross-country evidence that the intensity of UV-R exerts a positive influence on the incidence of corruption. The finding is also robust to the choice of estimators and controlling for a number of confounding factors.[16]

The World Values Survey wave 6 also provides some additional questions that are directly related to the perceived level of corruption. For instance, respondents are asked about the extent to which they think corruption is pervasive within businesses and the government, the perceived changes in corruption levels compared with five years ago, and the government's efforts to reduce corrupt activities. Unfortunately, these questions contain many missing values. Using them as the dependent variable, therefore, imposes a major constraint on the country coverage.[17] Importantly, the individual-level evidence remains largely unchanged when using these alternative dependent variables.[18] This provide additional evidence supporting a positive link between UV-R and corruption levels.

6. Within-country evidence

This section further examines the effect of UV-R on corruption across 31 provinces in China. The main limitation of a cross-country analysis is that we may not fully control for country-specific factors. For this reason, we can explore the effect of UV-R on the prevalence of corrupt activities across regions in China, holding institutional characteristics and other potential confounders constant. There exists an uneven distribution of the prevalence of corruption across regions in China, making it an interesting case to examine the reduced-form relationship between UV-R and corruption.

To my knowledge, there are no surveys or province-level data on corruption in China. Thus, I employ the government efficiency index of Tang et al. (2014) as an indirect measure

[16] According to ordered logit estimates in Table 7, the estimated coefficients of UV-R are positive and statistically significant at the 1% level. Results remain largely unchanged when I estimate OLS regressions (Table 7).
[17] Because of a limited country coverage, the findings may not be generalized to obtain a broad understanding of the link between UV-R and corruption.
[18] Results are presented in the online appendix Table A5.

of control of corruption. This index captures the extent to which the provincial government can efficiently provide public services, and reflects the transparency of public affairs. It is plausible that an efficient government is less likely to misuse public resources for private gain. Additionally, the ability to combat corruption critically depends on how efficient, transparent and accountable the government is. Hence, this index provides a measure of the institutional environment and a proxy for regional-level corruption in China. I assume that regions in which the government is less efficient are more corrupt.

I use three controls including trade openness, ethnic fractionalization, and a coastal dummy.[19] It is important to highlight that data limitations do not allow for replicating all the control variables in the cross-country models. Furthermore, including many controls imposes further constraints on the feasible degree of freedom given the limited number of observations. Estimation results in the online appendix Table A6 show that UV-R is negatively correlated with the government efficiency. This suggests that high UV-R regions have a more inefficient government, ceteris paribus. These findings are consistent with the cross-country evidence.

7. Conclusion

An important viewpoint in the long-term comparative development literature attributes disparity in the global wealth to geographic endowments (Gallup et al., 1999; Sachs, 2003). It is commonly observed that countries located near the equator suffer from underdevelopment while prosperity generally proliferates in societies lying further away from the equator. Andersen et al. (2016) recently provide an explanation for this long-standing fact. They find that UV-R helps explain income differences across the world. This paper adds to this strand of literature by proposing a novel hypothesis that UV-R also matters the prevalence of corrupt activities. By doing so, this study aims to improve our understanding of the deep roots of cross-country differences in corruption levels.

[19] See the online appendix.

The central idea of this paper rests on the premise that the permanent threat of contracting eye diseases, caused by high UV-R, significantly shortens work-life expectancy as a skilled worker. I argue that this detrimental effect of sunlight exerts an influence on incumbents' horizons. This helps explain the persistent divergence corrupt practices across the world. The prevalence of diseases also affects (historical) motivation for accumulating knowledge, skills and technologies, resulting in fewer competent and well-trained bureaucrats. I contend that these individuals are of great importance in designing good rule of law and regulations, which is arguably essential for combating modern-day corruption. The results, based on estimating cross-sectional data for up to 139 countries, lend strong credence to these arguments. Additionally, the baseline estimates are largely robust to performing a number of sensitivity tests. This suggests that the positive reduced-form relationship between UV-R and corruption is not spurious. Further analyses, drawn from estimating individual-level and within-country data, lend empirical support to the cross-country evidence.

Overall, this study suggests that the intensity of UV-R has a strong and robust reduced-form effect on the incidence of corruption. This link can be explained by the disease channel for various reasons discussed earlier. It is important to note that this paper by no means implies that the prevalence of corruption can be fully attributable to UV-R. Instead, the major objective this work is to advance our understanding of the deep roots of corrupt activities. Eliminating corrupt practices appears to be elusive. Understanding the origins of corruption, therefore, is the first step toward curbing corruption.

To conclude, corruption is a global concern that poses a great challenge toward fulfilling the 2030 Sustainable Development Goals. The global disparities in corruption levels are large and persistent. This paper argue that corruption is deeply rooted in geographic conditions, particularly the intensity of UV-R. My findings, therefore, demonstrate the importance of geography on the persistent nature of corrupt acts. It is hoped that these findings will induce further discussion on the link between geography, diseases, and corrupt behaviour at both the macro- and micro-level.

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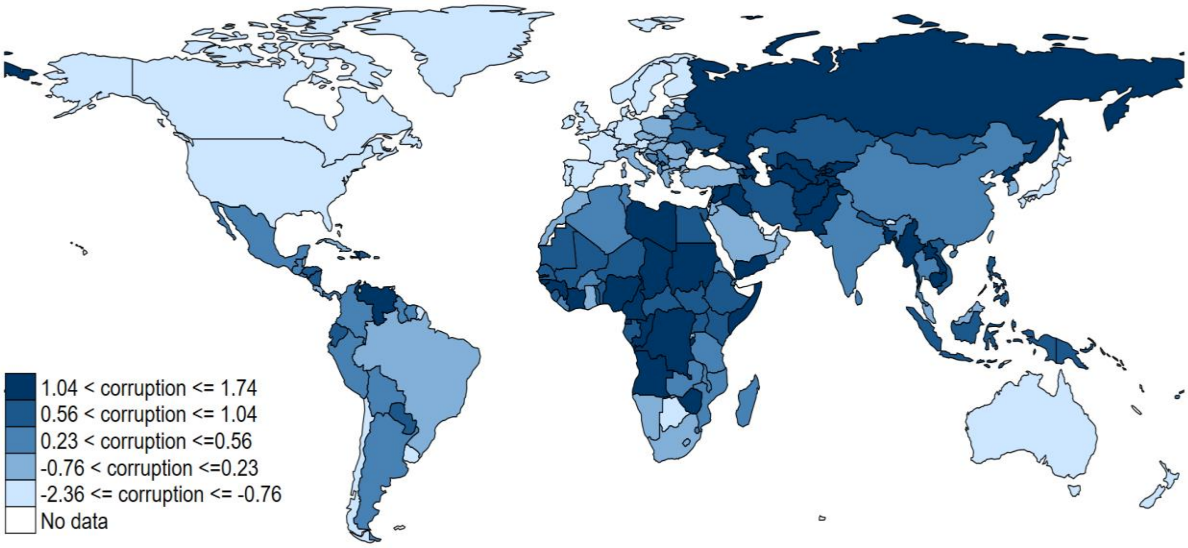

Figure 1. Geographic distribution of corruption levels

Notes: This figure illustrates cross-country differnces in the perceived level of corruption, using the World Bank's reversed index of control of corruption. Accordingly, darker regions with higher values of the reversed index face a higher frequency of corrupt acts.

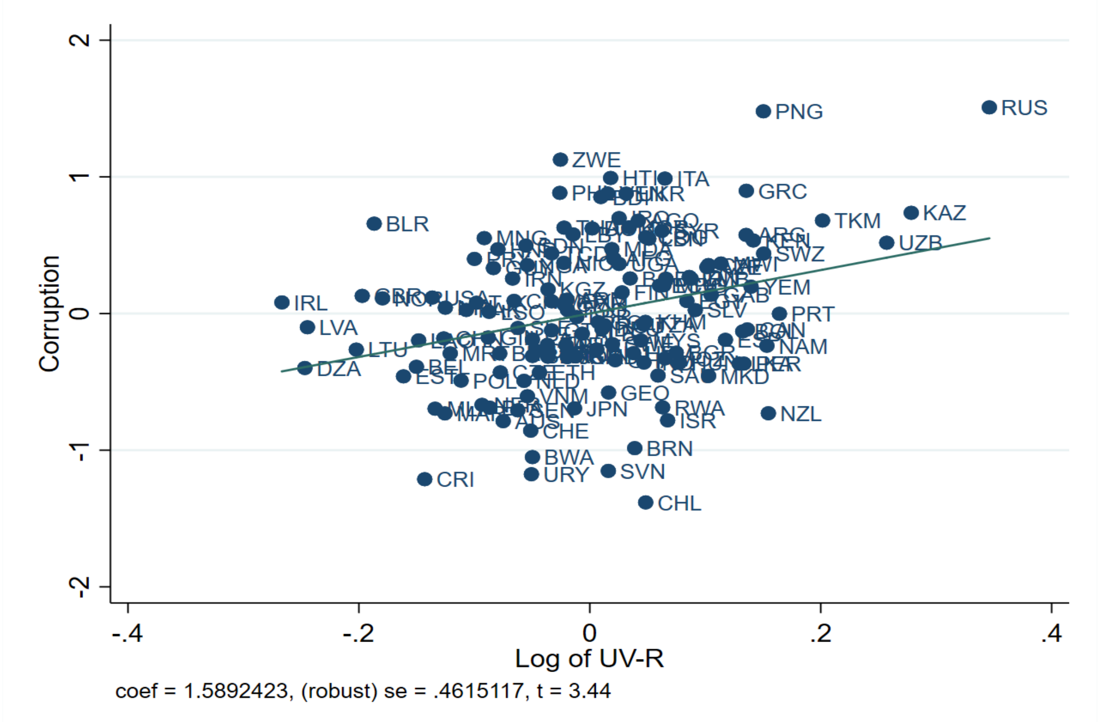

Figure 2. The partial effect of UV-R on corruption levels across countries

Table 1. Main results

	(1)	(2)	(3)	(4)	(5)
	Baseline specification (Unconditional estimates)	Include geographic controls	Include additional controls	Full specification (Include region dummies)	Standardized beta coefficients
Dependent variable: the World Bank's reversed index of control of corruption					
Log (UV)	**1.162*****	**1.317****	**1.251*****	**1.589*****	**0.827*****
	[0.142]	[0.657]	[0.357]	[0.462]	[0.462]
Mean elevation		0.020	-0.005	-0.203	-0.114
		[0.289]	[0.168]	[0.172]	[0.172]
Temperature		-0.002	0.007	-0.026	-0.221
		[0.044]	[0.027]	[0.030]	[0.030]
Precipitation		-0.033***	-0.005	0.014	0.082
		[0.012]	[0.014]	[0.013]	[0.013]
Common law			-0.407**	-0.427***	-0.165***
			[0.170]	[0.143]	[0.143]
Mixed law			-0.347*	-0.415*	-0.113*
			[0.194]	[0.238]	[0.238]
Communist			1.143***	1.355***	0.567***
			[0.163]	[0.186]	[0.186]
Fractionalization			0.578**	0.624**	0.189**
			[0.248]	[0.276]	[0.276]
Catholic			-0.001	-0.001	-0.040
			[0.002]	[0.003]	[0.003]
Muslim			0.006**	0.004*	0.144*
			[0.002]	[0.002]	[0.002]
Protestant			-0.006*	-0.004	-0.082
			[0.003]	[0.004]	[0.004]
Region FE	No	No	No	Yes	Yes
Observations	139	139	136	136	136
R-squared	0.360	0.395	0.689	0.738	0.738

Notes: Region FE denotes regional dummies, including Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa. East Asian and Pacific countries are excluded as the base group. All regressions include an intercept, which is omitted for brevity. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2. Robustness to controlling for historical confounders

	(1)	(2)	(3)	(4)
Dependent variable: the World Bank's reversed index of control of corruption				
Log (UV)	**1.448***** [0.458]	**1.534***** [0.487]	**1.795***** [0.531]	**1.630***** [0.470]
State history	-3.284** [1.292]			
State history squared	4.226** [1.697]			
Neolithic revolution		0.055 [0.138]		
Neolithic revolution squared		-0.002 [0.011]		
Human settlement			-0.846 [0.942]	
Human settlement squared			0.408 [0.645]	
Predicted genetic diversity				40.376 [51.246]
Predicted genetic diversity squared				-20.057 [36.885]
Baseline Controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	136	136	136	136
R-squared	0.753	0.740	0.742	0.761

Notes: State history reflects the experience with state institutions, calculated across six millennia from 3500BCE to 2000 by Borcan et al. (2018). Neolithic revolution reflects the length of time elapsed since a country experienced a transition to sedentary agriculture, obtained from Putterman (2006). Human settlement is the duration since the first human settlement, constructed by Ahlerup and Olsson (2012). The last control variable is the measure of genetic diversity of Ashraf and Galor (2013). Baseline controls are those included in column (4) of Table 1. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Robustness to controlling for the effect of migration flows

	Baseline estimates	Indigenous people (as of 1500) as a percentage of current population			
		70%	80%	90%	95%
	(1)	(2)	(3)	(4)	(5)
Dependent variable: the World Bank's reversed index of control of corruption					
Log (UV)	**1.589***** [0.462]	**1.946***** [0.500]	**2.004***** [0.514]	**2.332***** [0.565]	**2.517***** [0.682]
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	136	98	91	73	57
R-squared	0.738	0.797	0.805	0.830	0.819

Notes: I replicate the baseline estimates in column (1) for the purpose of comparison. From columns (2) to (5), I gradually restrict the sample size to only countries whose current population includes 70%, 80%, 90% and 95% of indigenous population as of 1500. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Robustness to controlling for contemporary confounders

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: the World Bank's reversed index of control of corruption								
Log (UV)	**1.404*****	**1.259*****	**1.642*****	**1.473*****	**1.381*****	**1.621*****	**1.523*****	**1.502*****	**0.810****
	[0.437]	[0.430]	[0.469]	[0.460]	[0.420]	[0.484]	[0.422]	[0.420]	[0.357]
Log (GDP per capita)	-0.302***								-0.391***
	[0.068]								[0.096]
Fuel exports		0.007***							0.012***
		[0.002]							[0.002]
Trade openness			0.001						-0.000
			[0.001]						[0.001]
Government size				-0.038***					-0.013
				[0.014]					[0.014]
Democracy [polity2]					-0.035***				-0.013
					[0.011]				[0.011]
Education						-0.107***			0.006
						[0.036]			[0.039]
Urbanization							-1.144***		-0.325
							[0.385]		[0.405]
Gender								-0.017***	-0.016***
								[0.006]	[0.006]
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	135	129	134	132	129	120	136	135	108
R-squared	0.783	0.760	0.738	0.760	0.768	0.765	0.759	0.761	0.877

Notes: All variables are averaged across the period from 2000-2009 to minimize reverse causality. Variables' descriptions are explained in the online appendix. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Robustness to controlling for spatial dependence

	(1)	(3)	(4)
Dependent variable: The World Bank's reversed index of control of corruption			
Log (UV-R)	**1.162*** **	**1.251*** **	**1.589*** **
	[0.142]	[0.357]	[0.462]
Conley standard errors	(0.039)	(0.073)	(0.074)
Baseline Controls	No	Yes	Yes
Region FE	No	No	Yes
Observations	139	136	136
R-squared	0.360	0.689	0.738

Notes: Robust standard errors are in squared brackets. Conley's (1999) standard errors that correct for spatial autocorrelation across countries are reported in parentheses. This is performed by calculating the weighted covariance matrices, where the weights correspond to the inverse of the distance between countries and equals zero after a specified threshold. Following Borcan et al. (2018), a threshold of twenty coordinate degrees is specified. Importantly, results are insensitive to the choice of different thresholds. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. A mechanism analysis

	(1)	(2)
Panel A. First-stage regression. Dependent variable: log of cataracts		
Log (UV-R)	2.361***	1.189***
	[0.143]	[0.332]
Panel B. Second-stage regression. Dependent variable: the World Bank's reversed index of control of corruption		
Log (Cataracts)	0.492***	1.296***
	[0.053]	[0.329]
Baseline Controls	No	Yes
Region FE	No	Yes
Observations	139	136
R-squared	0.445	0.328
Diagnostic tests		
F-test of excluded instruments	273.08	12.84
Cragg-Donald weak identification test	224.39	11.86
Anderson-Rubin Wald test	67.28	30.12

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Individual-level analysis

	OLS estimates				Ordered logit estimates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: respondents' attitude toward corrupt practices							
Log of UV-R	**0.374*** **	**0.213*** **	**0.212*** **	**0.344*** **	**0.424*** **	**0.293*** **	**0.262** **	**0.481*** **
	[0.013]	[0.078]	[0.080]	[0.082]	[0.016]	[0.100]	[0.103]	[0.108]
Latitude		-0.017	-0.018	-0.012		0.078***	0.079***	0.085***
		[0.018]	[0.018]	[0.018]		[0.022]	[0.023]	[0.023]
Mean elevation		-0.000	-0.000*	0.000***		-0.000	-0.000	-0.000***
		[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]
Precipitation		0.026	0.017	0.011		0.020	0.000	-0.048
		[0.024]	[0.025]	[0.026]		[0.026]	[0.027]	[0.031]
Temperature		0.005	0.004	-0.010*		0.005	0.004	0.011*
		[0.005]	[0.005]	[0.005]		[0.006]	[0.006]	[0.007]
Language FE	No	No	No	Yes	No	No	No	Yes
Individual Controls	No	No	Yes	Yes	No	No	Yes	Yes
Country FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
(Pseudo) R-squared	0.010	0.118	0.129	0.179	0.004	0.046	0.053	0.072
Observations	83,103	83,103	78,320	75,906	83,103	83,103	78,320	75,906
Number of countries	56	56	56	56	56	56	56	56

Notes: Individual-level controls include age, gender, income levels, educational attainment, and social trust. The estimated coefficients of these individual-level control variables are statistically significant at the 1% level in all regressions, but they are omitted for brevity. Country dummies (country FE) and the intercept estimates are also omitted to conserve space. Language FE represents 227 binary variables for common language. The values of R-squared and Pseudo R-squared are reported for OLS estimates and ordered logit estimates, respectively. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

ONLINE APPENDIX FOR

"Climate, Diseases, and the Origins of Corruption"

1. List of countries

Afghanistan, Angola, Albania, Argentina, Armenia, Australia, Austria, Azerbaijan, Burundi, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bosnia and Herzegovina, Belarus, Bolivia, Brazil, Brunei, Botswana, Central African Republic, Canada, Switzerland, Chile, China, Cote d'Ivoire, Cameroon, Democratic Republic of Congo, Republic of Congo, Colombia, Costa Rica, Cuba, Czech Republic, Germany, Denmark, Dominican Republic, Algeria, Ecuador, Egypt Arab Republic, Spain, Estonia, Ethiopia, Finland, France, Gabon, United Kingdom, Georgia, Ghana, Guinea, The Gambia, Greece, Guatemala, Guyana, Honduras, Croatia, Haiti, Hungary, Indonesia, India, Ireland, Islamic Republic of Iran, Iraq, Israel, Italy, Jordan, Japan, Kazakhstan, Kenya, Kyrgyzstan, Cambodia, Republic of Korea, Laos, Lebanon, Liberia, Libya, Sri Lanka, Lesotho, Lithuania, Latvia, Morocco, Moldova, Madagascar, Mexico, Macedonia, Mali, Mongolia, Mozambique, Mauritania, Malawi, Malaysia, Namibia, Niger, Nigeria, Nicaragua, Netherlands, Norway, Nepal, New Zealand, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Poland, Portugal, Paraguay, Romania, Russia, Rwanda, Saudi Arabia, Sudan, Senegal, Sierra Leone, El Salvador, Somalia, Slovakia, Slovenia, Sweden, Swaziland, Syrian Arab Republic, Chad, Togo, Thailand, Tajikistan, Turkmenistan, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Uruguay, United States, Uzbekistan, Venezuela, Vietnam, Yemen, South Africa, Zambia, and Zimbabwe.

2. Variables and data

Cross-country data

Control of corruption (CC): This indicator reflects perception about the extent to which public resources are misappropriated for private gains. The reversed index is calculated by multiplying by minus one and is used throughout the paper. Higher values correspond to more intense corruption. Source: the World Bank's World Governance Indicators (Kaufmann et al., 2010).

Corruption perception index (CPI): This index measures the perceived level of corruption, with higher values denoting less corruption. Source: Transparency International (https://www.transparency.org/research/cpi).

Log of ultraviolet radiation (log UV): This index reflects the strength of ultraviolet radiation across regions in the world. It is calculated using daily satellite-based data for ambient UV-R, obtained from NASA. Source: Andersen et al. (2016).

Mean Elevation: This index measures a country's mean elevation above the sea level (in kilometres). Source: Portland Physical Geography dataset.

Temperature: The average monthly temperature from 1961 to 1990 (in degrees Celsius). Source: Ashraf and Galor (2013).

Precipitation: The average monthly precipitation from 1961 to 1990 (in degrees centimetres). Source: Ashraf and Galor (2013).

Legal origins: This is dummy variables for legal origins of Klerman et al. (2011). These include common law, civil law and mixed law. Civil law is removed as the base category.

Communist: equals one if a country has a communist legacy and zero otherwise. This is identical to the socialist origin variable of La Porta et al. (1999). Source: La Porta et al. (1999).

Fractionalization: this is a measure of ethnolinguistic diversity. Source: La Porta et al. (1999).

Catholic: the proportion of Catholics in the population. Source: La Porta et al. (1999).

Muslim: the proportion of Muslims in the population. Source: La Porta et al. (1999).

Protestant: the proportion of Protestants in the population. Source: La Porta et al. (1999).

State history: This index reflects the experience with state institutions, measured from 3500BCE to 2000. Source: Borcan et al. (2018).

Neolithic revolution: This index measures the length of time elapsed since the transition to sedentary agriculture 10000 years ago. Source: Putterman (2006).

Human settlement: This index captures the length of time elapsed since the first human settlement. Source: Ahlerup and Olsson (2012).

Predicted genetic diversity: This indicator reflects a country's genetic diversity. Source: Ashraf and Galor (2013).

GDP per capita: GDP per capita in 2010 USD constant prices, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Fuel exports: the value of fuel exports as a proportion of the total merchandise exports value, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Trade openness: the value of exports and imports as a percentage of GDP, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Government size: the value of government final consumption expenditure as a percentage of GDP, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Democracy: the polity2 index of political institutions. Source: Marshall et al. (2014).

Education: the index of years of schooling. Source: Barro and Lee (2013).

Urbanization: urban population as a proportion of total population, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Gender: the proportion of women in parliament, averaged from 2000 to 2009. Source: the World Bank's World Development Indicators.

Cataracts: This index reflects the number years of healthy life lost due to the incidence of cataracts. Source: Andersen et al. (2016).

Absolute latitude: This index capture a country's absolute latitude (in 100s). Source: Portland Physical Geography dataset.

Land suitability: This index measures land suitability for agriculture. Source: Michalopoulos (2012).

Malaria: the proportion of the population at risk of contracting malaria. Source: Gallup and Sachs (2001).

Landlocked: equals one if being surrounded by land and zero otherwise. Source: CIA World Fact Book.

Individual-level data

Dependent variable: question V202, the World Values Survey wave 6. This variable captures the extent to which respondents think giving a bribe is justifiable. Answers contain ordinal values, ranging from one to ten. Higher values correspond to more corruption.

Individual controls include age, age squared (question V242), gender (question V240), income levels (question V239), educational attainment (question V248), and social trust (question V24), obtained from the World Values Survey wave 6. Detailed information can be found in WVS wave 6's codebook (http://www.worldvaluessurvey.org/WVSDocumentationWV6.jsp).

Geographic controls include absolute latitude, mean elevation, precipitation, and temperature, which are similar to geographic variables in cross-country models. These variables are measured at the regional level. Source: Andersen et al. (2016).

Within-country data

Log UV: the intensity of ultraviolet radiation across 31 provinces in China. Source: Andersen et al. (2016).

Government efficiency index: this index reflects the efficiency of the provincial government's provision of public services and infrastructure, and the transparency of public affairs, measured in 2010. Source: Tang et al. (2014).

Trade openness: the value of exports and imports as a proportion of gross regional products in 2010 for 31 provinces. The values of exports and imports are measured in USD. Gross regional product is measured in the Chinese yuan, and is converted into USD using the OCED's exchange rate in 2010. Source: National Bureau Statistics of China (http://www.stats.gov.cn/english/).

Coastal dummy: equals zero if a province is surrounded by land and one otherwise. Source: author's calculation.

Ethnic fractionalization: this index reflects ethnic diversity across 31 provinces in China in 2000. Source: Yeoh (2012).

Table A1. Summary statistics of cross-country data

	N	Mean	Std	Min	Max
The reversed index of control of corruption	158	0.13	1.03	-2.36	1.74
Corruption perception index	157	41.99	19.84	0	90
UV	139	191.09	78.59	42.66	328.53
Log (UV)	139	5.14	0.52	3.75	5.79
Mean elevation	149	0.64	0.55	0.01	3.19
Temperature	158	18.23	8.35	-7.93	28.64
Precipitation	158	9.29	6.17	0.29	25.99
Common law	156	0.21	0.41	0	1
Mixed law	156	0.09	0.29	0	1
Communist	158	0.22	0.41	0	1
Fractionalization	158	0.29	0.31	0	1
Catholic	158	30.28	35.52	0	96.90
Muslim	158	23.46	35.23	0	99.80
Protestant	158	11.47	20.31	0	97.80
State history	159	0.23	0.17	0.02	0.74
Neolithic revolution	151	4.72	2.44	0.36	10.50
Human settlement	158	0.59	0.49	0.002	1.6
Predicted genetic diversity	158	0.71	0.05	0.57	0.77
GDP per capita (log)	154	8.27	1.53	5.42	11.37
Fuel exports	146	17.78	28.25	0	97.36
Trade openness	151	84.28	47.53	0.44	391.67
Government size	147	15.63	5.79	4.84	37.98
Democracy	145	3.96	6.03	-10	10
Education	132	8.25	2.88	1.87	13.18
Urbanization	157	0.54	0.22	0.09	1
Gender	154	15.82	9.26	0	45.40
Cataracts (log)	139	5.06	1.56	2.12	6.85
Absolute latitude	159	0.26	0.17	0.004	0.67
Land suitability	145	0.37	0.24	0	0.96
Malaria	151	0.31	0.42	0	1
Landlocked	134	0.22	0.42	0	1

3. Additional sensitivity tests

Table A2. Robustness to using other measures of corruption

Dependent variable	The World Bank's reversed index of control of corruption				The Transparency International's reversed index of corruption
	(1)	(2)	(3)	(4)	(5)
	Baseline estimates	Corruption in 2000	Averaged corruption, 2000-2010	Corruption in 2015	Corruption perception index
Log (UV)	**1.589*****	**1.589*****	**1.568*****	**2.080*****	**0.688*****
	[0.462]	[0.448]	[0.432]	[0.436]	[0.241]
Observations	136	135	135	136	136
R-squared	0.738	0.754	0.757	0.715	0.604
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes

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

Table A3. Robustness to controlling for additional geographic endowments

	(1)	(2)	(3)	(4)	(5)
Dependent variable: the World Bank's reversed index of control of corruption					
Log (UV)	**1.221****	**1.574*****	**1.567*****	**1.731*****	**1.097***
	[0.554]	[0.477]	[0.437]	[0.451]	[0.568]
Absolute latitude	-1.914				-3.404**
	[1.496]				[1.477]
Land suitability		0.183			0.290
		[0.293]			[0.309]
Malaria			0.591**		0.338
			[0.246]		[0.247]
Landlocked				0.010	0.039
				[0.130]	[0.128]
Observations	136	136	136	125	125
R-squared	0.742	0.739	0.750	0.770	0.783
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes

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

Table A4. Robustness to excluding outliers

	(1)	(2)	(3)
Dependent variable: the World Bank's reversed index of control of corruption			
Log (UV)	**1.590*****	**1.310*****	**1.505*****
	[0.372]	[0.385]	[0.361]
Mean elevation	-0.227	-0.142	-0.190
	[0.151]	[0.140]	[0.132]
Temperature	-0.029	-0.025	-0.038
	[0.026]	[0.024]	[0.023]
Precipitation	0.003	0.011	0.014
	[0.011]	[0.011]	[0.010]
Common law	-0.283**	-0.402***	-0.412***
	[0.134]	[0.134]	[0.126]
Mixed law	-0.373**	-0.659***	-0.497**
	[0.182]	[0.214]	[0.203]
Communist	1.164***	1.247***	1.272***
	[0.157]	[0.157]	[0.152]
Fractionalization	0.407*	0.349	0.442*
	[0.240]	[0.254]	[0.232]
Catholic	-0.004	-0.003	-0.003
	[0.002]	[0.002]	[0.002]
Muslim	0.003	0.004*	0.004**
	[0.002]	[0.002]	[0.002]
Protestant	-0.007**	-0.009***	-0.007**
	[0.003]	[0.003]	[0.003]
Observations	121	128	136
R-squared	0.796	0.816	0.796
Region FE	Yes	Yes	Yes

Notes: This table replicate the baseline regressions by excluding some influential observations. In column (1), outliers are identified by calculating the Cook's distance. Accordingly, counties of which the value is bigger than four divided by the number of observations are removed from the regression. Next, I calculate the standardized residual and exclude countries whose absolute value is greater than 1.96 (column 2). Finally, I estimate robust regression weights, which are used to re-estimate the baseline model. In all cases, the core results appear to be highly robust. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A5. Individual-level analysis

	OLS estimates				Ordered logit estimates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	bus_pci	gov_pci	delta_pci	eff_pci	bus_pci	gov_pci	delta_pci	eff_pci
Log (UV)	**4.890*** **	**0.984**	**2.112***	**1.245*** **	**4.153*** **	**1.738** **	**2.246*** **	**3.594*** **
	[1.030]	[0.977]	[1.080]	[0.295]	[0.831]	[0.820]	[0.800]	[0.874]
Absolute latitude	1.946**	-1.453**	-1.019	0.343	1.127*	-0.940*	-0.749	1.058
	[0.762]	[0.601]	[0.762]	[0.219]	[0.592]	[0.530]	[0.581]	[0.671]
Elevation	-0.001***	-0.001***	-0.000	-0.000***	-0.001***	-0.001***	-0.000**	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Precipitation	-0.735***	-0.509***	0.045	-0.120**	-0.517***	-0.365**	0.033	-0.392**
	[0.193]	[0.189]	[0.202]	[0.057]	[0.156]	[0.150]	[0.146]	[0.168]
Temperature	-0.054*	-0.011	0.007	-0.006	-0.051**	-0.029	-0.010	-0.016
	[0.029]	[0.030]	[0.031]	[0.009]	[0.023]	[0.023]	[0.023]	[0.025]
Age	-0.001	0.001	-0.002	0.000	-0.001	0.001	-0.001	0.002
	[0.002]	[0.002]	[0.002]	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]
Male	0.033	0.061	-0.034	0.059***	0.027	0.051	-0.021	0.164***
	[0.051]	[0.051]	[0.055]	[0.015]	[0.040]	[0.040]	[0.039]	[0.043]
Income	-0.024*	-0.007	0.021	-0.016***	-0.028**	-0.019*	0.004	-0.050***
	[0.014]	[0.014]	[0.015]	[0.004]	[0.011]	[0.011]	[0.011]	[0.011]
Education	0.041***	0.042***	0.004	0.014***	0.033***	0.036***	0.005	0.041***
	[0.011]	[0.011]	[0.012]	[0.003]	[0.008]	[0.008]	[0.008]	[0.009]
Trust	-0.203***	-0.294***	-0.251***	-0.135***	-0.176***	-0.213***	-0.183***	-0.381***
	[0.060]	[0.061]	[0.065]	[0.019]	[0.045]	[0.046]	[0.047]	[0.053]
Observations	8,094	8,101	8,089	8,079	8,094	8,101	8,089	8,079
R-squared	0.088	0.095	0.083	0.091	0.023	0.025	0.021	0.048
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variables are different measures of respondents' perceived level of corruption, obtained from the World Values Survey: (1) *buss_pci* (the extent to which corruption is widespread within businesses); (2) *gov_pci* (the extent to which corruption is widespread within the government); (3) *delta_pci* (the perceived changes in the level of corruption compared with 5 years ago); (4) eff_pci (the government's efforts to combat corruption). Higher values mean more corruption. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6. Within-country analysis

	(1)	(2)	(3)	(4)
	Dependent variable: government efficiency index			
Log (UV)	**-0.369*** **	**-0.328*** **	**-0.364*** **	**-0.354** **
	[0.118]	[0.107]	[0.130]	[0.170]
Integration (trade)		0.462***	0.349***	0.346***
		[0.083]	[0.064]	[0.064]
Coastal dummy			0.184**	0.183**
			[0.080]	[0.083]
Ethnic fractionalization				-0.020
				[0.287]
Observations	31	31	31	31
R-squared	0.105	0.467	0.533	0.533

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

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