

Vu, Trung V.

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## Climate, diseases, and the origins of corruption\*

Trung V. Vu<sup>†</sup>

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

### Abstract

It has been commonly observed that tropical countries tend to suffer from intense corruption and underdevelopment. This study provides an explanation for this long-standing disparity across the world based on variation in the intensity of ultraviolet radiation (UV-R). The central hypothesis is that UV-R is positively associated with the (historical) prevalence of eye diseases, which significantly shortens work-life expectancy as a skilled worker. This helps shape the worldwide distribution of corruption by affecting the incumbents' window of opportunity. Using data for up to 139 countries, I consistently find empirical support for the positive relationship between UV-R and corruption. The main findings withstand accounting for numerous alternative explanations for international differences in corruption levels. Employing individual-level data from the World Values Survey, I document suggestive evidence that exposure to UV-R is linked to surveyed respondents' tolerance towards corrupt activities. Furthermore, a subnational analysis for China lends 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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<sup>†</sup> *Correspondence:* Department of Economics, University of Otago, PO Box 56, Dunedin 9054, New Zealand. Email addresses: [trungvu.econs@gmail.com](mailto:trungvu.econs@gmail.com); [trung.vu@postgrad.otago.ac.nz](mailto:trung.vu@postgrad.otago.ac.nz).

## 1. Introduction

Identifying the driving forces of comparative prosperity across the world is 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 countries. As depicted in Figure 1, countries located further away from the equator typically enjoy a more transparent institutional environment. By contrast, corruption tends to proliferate 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 hard to find. A recent study by Andersen et al. (2016) documents that the intensity of ultraviolet radiation (UV-R) is a fundamental driver of global income differences. The basic idea is that UV-R shortens work-life expectancy as a skilled worker, thus shaping long-term comparative development *via* affecting the timing of fertility transition. This piece of work, however, leaves it open to debate whether UV-R helps explain why countries differ significantly in the perceived level of corruption. Against this background, this paper attempts to explore the relationship between exposure to UV-R and corruption across the globe.

It is widely acknowledged that corruption creates unfavourable conditions for economic growth and development (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 corruption in the form of bribes and stolen money amounts to 2.6 trillion USD or five percent of global GDP (OECD, 2013). Thus, corruption remains one of the most serious impediments to achieving the Sustainable Development Goals by 2030. To the extent that this widespread social concern is distributed unequally across countries, we need to understand the underlying causes of corrupt activities. As reviewed by Dimant and Tosato (2018), the existing literature provides suggestive evidence of numerous factors shaping the worldwide distribution of corruption, including, but not limited to, the share of women in parliament (Swamy et al., 2001; Jha & Sarangi, 2018), democracy (Treisman, 2000), the size of government (Goel & Nelson, 1998), bureaucracy and regulations (Goel & Nelson, 2010).

From a theoretical viewpoint, these conventional “proximate” causes of corruption offer an inadequate understanding of the deep origins of corruption because they are interrelated with and jointly determined by the degree of corruption.<sup>1</sup> As put forward by Aidt (2003),

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<sup>1</sup> There exists a two-way relationship between these “proximate” factors and corruption. For example, a larger share of seats held by women in national parliaments may reduce the prevalence of corruption, but corrupt

corruption appears to be an enduring feature of many societies across the globe. It is plausible that the persistence of corruption within an economy has its roots in country-level fixed (fundamental) geographic or historical attributes (Spolaore & Wacziarg, 2013). This argument is consistent with numerous influential studies in the long-term comparative development literature, highlighting the legacy of a country's geographic or historical characteristics for contemporary economic development (Spolaore & Wacziarg, 2013; Nunn, 2020; Maseland, 2021). To the extent that the intensity of UV-R is associated with existing disparity in the level of corruption, the efficacy of anti-corruption policies is arguably contingent on their compatibility with the prevailing geographical or historical environment (Nunn, 2009; Spolaore & Wacziarg, 2013; Nunn, 2020; Maseland, 2021; Vu, 2021b). Therefore, a better understanding of the fundamental determinants of corruption plays an important role in alleviating the persistence of corruption. From an econometric viewpoint, plausible concerns about reverse causation make it difficult to identify the causal effects of the aforementioned "proximate" factors on corruption. In this regard, exploiting exposure to UV-R to explain the worldwide distribution of corruption helps circumvent a major issue of reverse causality. The underlying intuition is that the level of corruption plausibly imparts no direct influence on the intensity of predetermined UV-R, which has remained largely constant over the last two billion years (Cockell & Horneck, 2001; Andersen et al., 2016). These arguments justify the desirability of an empirical examination of the relationship between UV-R and corruption.

This paper is closely related to several studies that attempt to examine the fundamental determinants of corruption (Dimant & Tosato, 2018). In particular, an influential viewpoint asserts that common-law countries have less corruption compared with their civil-law counterparts (La Porta et al., 1999; Treisman, 2000; Swamy et al., 2001). Another hypothesis contends that communist legacy matters for present-day 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 significant influence on the incidence of corruption. Other studies emphasize the important role of culture and religion in driving the cross-country variation in the level of corruption (La Porta et al., 1999; Treisman, 2000; Paldam, 2001, 2002). In line with the aforementioned arguments, these historically determined variables may provide plausibly exogenous sources of variation in corruption across countries.

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societies are less likely to promote female political representation (Jha & Sarangi, 2018). This provides a motivation for investigating the deep roots of corruption.

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. Against this background, the current 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. As put forward by Andersen et al. (2016), countries with greater exposure to UV-R face a permanent threat of contracting eye diseases, such as cataracts. This reduces the duration of work-life expectancy as a skilled worker, possibly leading to substantial variation in the incidence of corruption across the globe.

Additionally, this paper draws upon other 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 effects of geographic attributes on global income differences, little is known about the extent to which geographic conditions help shape the worldwide distribution of corruption. My findings advance our understanding of the contribution of geography to the persistence of underdevelopment. 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). The current research sheds light on this body of research by demonstrating that the disease environment caused by exposure to UV-R matters for corrupt activities, which remain a widespread social concern throughout the world.

Employing data for up to 139 countries, I consistently find suggestive evidence of a positive reduced-form relationship between UV-R and corruption. Controlling for numerous causes of corruption, I demonstrate that the main findings are not exclusively attributed to conventional explanations for cross-country differences in corruption. To find additional support for causal inference, I also perform individual-level and subnational analyses that permit accounting for time-invariant unobserved heterogeneity across countries. The results are consistent with the cross-country evidence that the intensity of UV-R is positively associated with the incidence of corruption.

The rest of this study is organized as follows. Section 2 discusses the theoretical framework, followed by a description of data and methods in Section 3. Sections 4 contains the baseline estimates and robustness analyses for cross-country regressions. Sections 5 and 6 present individual-level and subnational evidence, respectively. Section 7 concludes.

## **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 established in the epidemiological literature (see, for example, 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 (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. A possible explanation holds that visual acuity is of paramount importance for skill-intensive jobs because these occupations critically require literacy. Furthermore, countries characterized by greater exposure to UV-R tend to suffer from the pervasiveness of eye diseases (Andersen et al., 2016). Cataracts, for example, 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 attributed to exposure to UV-R amounts to up to 14 years, which is a sizeable influence.<sup>2</sup>

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 the worldwide distribution of corruption. 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 prevalence of corrupt activities by shortening the incumbents' horizons. In contrast, officials living in low UV-R societies typically face longer periods of work-life

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<sup>2</sup> According to Andersen et al. (2016), UV-R is a major driver of the length of work-life expectancy, leading to variation in the timing of fertility transition across countries. This at least partially accounts for persistent differences in income per capita throughout the world. Andersen et al. (2016) also find suggestive evidence that exposure to UV-R exerts a positive effect on the prevalence of eye diseases, measured by the log of cataracts, controlling for numerous confounding factors.

expectancy (Andersen et al., 2016). This reduces their likelihood of misappropriating public resources by increasing the horizon over which incumbents' employment gains are discounted. Employing cross-region data for Brazil, Ferraz and Finan (2011) find that areas where mayors face a binding one-term limit suffer from 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. These findings are in line with the premise that the reduced length of work-life expectancy caused by exposure to UV-R determines the motivation for abusing public resources for personal gain. On this basis, I argue that corrupt practices are more likely to proliferate in high UV-R regions.

It is well documented in the long-term development literature that the disease environment helps explain the persistence of poor-quality institutions across countries. An influential study by Acemoglu et al. (2001) puts forward that the prevalence of diseases imparts long-lasting impacts on contemporary institutions by shaping the nature of European colonization. For instance, inclusive institutions were established in areas where Europeans could easily settle down due to 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. Early colonial institutions persist until today, leading to substantial variation in the quality of institutions throughout the world. Ang et al. (2018) argue that the prevalence of eye diseases is detrimental to investment in cooperation by building institutions, thus shaping the persistence of poor governance. Nikolaev and Salahodjaev (2017) find that the historical prevalence of infectious diseases lies at the deep roots of contemporary economic institutions through driving the formation of cultural values. Specifically, the pervasiveness of infectious diseases exerts persistent effects on personality traits, cultural traits and regional-level morality, which ultimately determine international differences in institutions. In a similar vein, Vu (2019) provides suggestive evidence that inclusive economic institutions tend to proliferate in low UV-R societies. In line with previous studies, the current study documents that the intensity of UV-R is a key driving force of corruption, which is in turn an important sub-dimension of (economic) institutions (Dimant & Tosato, 2018). As such, this research advances our understanding of the extent to which the disease environment transmits to the persistence of poor governance and underdevelopment.

Andersen et al. (2016) demonstrate that the (historical) prevalence of eye diseases affects the perceived return to obtaining skills and knowledge, thus reducing human capital accumulation. For this reason, exposure to UV-R is associated with lack of well-trained and

competent bureaucrats who could specialize in designing the rule of law and early socio-political structures (Diamond, 1997; Ang, 2013), leading to a reduced capacity to tackle corrupt practices. Additionally, high UV-R countries may suffer from persistent inequality in power and wealth. This is partially explained by reduced human capital accumulation attributed to a greater disease burden. It is plausible that powerful elites with superior skills and knowledge tend to emerge to manage a cadre of unskilled workers (Lee & Vu, 2020). Meanwhile, the presence of powerful and wealthy elites within an economy may induce higher degrees of corruption because these entrenched groups tend to maintain their privileges by rent-seeking activities (Vu, 2021b). Overall, this research 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 helps explain the global distribution of corrupt practices.

### 3. Data and methods

#### 3.1. Model specification and main variables of interest

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

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

where  $i$  denotes country  $i$ . *Corruption* is the outcome variable, capturing the perceived level of corruption. The main variable of interest is the intensity of UV-R.  $X$  stands for a vector of baseline control variables, including geographic endowments, legal origins, communist legacy, ethnolinguistic fractionalization, and religions.  $\varepsilon$  is the error term.  $\beta$  reflects the estimated effects of UV-R on corruption, and is expected to be positive. The benchmark model is estimated using data for up to 139 countries, which is mainly dictated by the availability of data on exposure to UV-R and the perceived degree of corruption (see Appendix A1 for the list of countries).

This study employs the World Bank's reversed index of control of corruption in 2010 as the main dependent variable. Corrupt practices are generally hidden from official statistics, making it hard to obtain an internationally comparable measure of corruption.<sup>3</sup> Therefore, I

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<sup>3</sup> Lan and Li (2018) attempt to capture the incidence of corruption in China by using the import value of luxury watches, which constitutes a popular form of corrupt practices of Chinese officials. In a similar vein, Blavatsky (2021b) exploits trade flows in luxury watches between Switzerland and Ukraine to detect corrupt behaviours of



employ an index of control of corruption obtained from the Worldwide Governance Indicators dataset, which has gained popularity among empirical studies on the causes and consequences of corruption. This measure of corruption is based on standardized surveys on public perceptions of the degree of corruption, covering a large number of world economies. In particular, the indicator reflects surveyed respondents' perceptions of the extent to which public power is misused for personal gain, with higher values corresponding to an enhanced capacity to control both petty and grand forms of corruption. For ease of interpretation, I multiply the original index by minus one so that higher values represent more intense corruption. Figure 1 depicts cross-country differences in the perceived level of corruption for the years 1996 and 2010. Accordingly, I obtain a broadly similar pattern of the global distribution of corruption over time. Figure 2 reveals that the index of corruption exhibits high degrees of persistence over time within selected countries and regions. This motivates using the corruption index in 2010 to estimate the cross-sectional models. Later, I also document evidence of the persistence of the contribution of UV-R to corruption over the years.

The main variable of interest is the UV-R index, obtained from Andersen et al. (2016). 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. The use of averaged data is motivated by the observation that cross-country differences in UV-R remain relatively constant over the last two billion years (Cockell & Horneck, 2001). Appendix A2 contains a detailed description of key variables and data sources.

### **3.2. Key control variables**

Estimating the benchmark model requires some attention to omitted variables bias. Indeed, 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, the main analysis is augmented with an extensive set of possibly confounding factors. It is argued that the intensity of UV-R can be affected by the ozone layer's thickness, which may be partly influenced by economic

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Ukrainian officials. Moreover, Blavatsky (2021a) employs the median estimated body-mass index of cabinet ministers to capture the prevalence of corruption across 15 post-Soviet economies. Hlatshwayo et al. (2018) exploit news media coverage of corruption to measure the degree of political corruption. More recently, Cheung et al. (2020) provide a novel measure of corruption for 60 world economies using detected cases of corruption of governmental officials between 1975 and 2015.

development. However, Andersen et al. (2016) highlight that there exists no systematic evidence on the causal effects of economic activities in a specific region and its ozone layer.<sup>4</sup> Thus, reverse causation running from corruption to UV-R is even more tenuous.

First, country-level geographic characteristics, including mean elevation, temperature and precipitation, are incorporated in the regression. It is well established in the long-term comparative development literature that geographic attributes impart a persistent influence on income levels and institutional quality. Additional geographic characteristics are also used to rule out the possibility that the 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 their civil-law counterparts (Treisman, 2000). I account for this effect by including binary variables for legal traditions in the regression, following Klerman et al. (2011).<sup>5</sup> Third, a dummy variable for former socialist and transitional economies (*Communist*) is included to account for the impacts of a communist legacy on the incidence of corruption (La Porta et al., 1999; Uberti, 2018). Fourth, ethnolinguistic diversity may shape social hierarchy via influencing cultural attitudes, thus affecting the prevalence of corruption (Dimant & Tosato, 2018). I control for this effect by including an index of ethnic fractionalization.

Finally, I include region dummies to account for unobserved region-specific factors. While sub-Saharan African countries are among the most corrupt economies in the world, European countries enjoy significantly lower levels of corruption. Furthermore, corruption may spread across countries located in the same region due to common cultures, histories and geographic characteristics (Correa et al., 2016). Therefore, the hypothesized relationship between exposure to UV-R and corruption may be attributed to time-invariant unobserved heterogeneity across world regions. As demonstrated in the notes to Table 1, region dummies include binary variables for Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia, Sub-Saharan Africa (the base group is East Asia and Pacific). The classification of regions is obtained from the World Bank's World Development Indicators.

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<sup>4</sup> Andersen et al. (2016) find that regional economic development exerts no direct influence on UV-R.

<sup>5</sup> Klerman et al. (2011) define three legal traditions, including common, civil and mixed laws. This is broadly consistent with the classification of legal origins of La Porta et al. (1999). Nevertheless, Klerman et al. (2011) introduce a group of mixed-law countries that partially replaced their originally adopted French civil law by British common law. Hence, the main analysis is augmented with dummy variables for common and mixed laws (civil law is omitted as the base category).

## 4. Cross-country evidence

### 4.1. Main results

Table 1 presents empirical estimates of the contribution of UV-R to corruption. The estimated coefficient of UV-R is positive and statistically significant at the 1% level when excluding key control variables from the regression (column 1). The positive effects of UV-R on corruption remain precisely estimated at conventional thresholds of statistical significance when the main control variables are added to the regression, as demonstrated in columns (2) to (4) of Table 1. Figure 3 illustrates the partial effects of UV-R on the incidence of corruption across countries, based on the baseline estimates reported in column (4) of Table 1. Accordingly, the intensity of UV-R is positively associated with the perceived level of corruption, holding everything else constant. These findings lend credence to the main hypothesis that places with greater exposure to UV-R are likely to suffer from the prevalence of corrupt practices. The stability of the sign and statistical precision of the coefficients on UV-R suggests that the results are not exclusively attributed to other deep causes of corruption.<sup>6</sup>

The standardized beta coefficients are shown in the last column of Table 1. They indicate that UV-R exerts quantitatively larger effects on corruption compared with those attributed to the main control variables. The results are suggestive of the economic importance of UV-R in explaining the worldwide distribution of corrupt practices. Moreover, 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 approximately 56 and 134, respectively. The difference between these two countries is 78, which equates to roughly one standard deviation of UV-R. If Denmark instead experienced the level of UV-R of Greece, its perceived level of corruption would increase by approximately 2.23 units, *ceteris paribus*. This provides suggestive evidence that exposure to UV-R imparts a sizeable influence on the persistence of corruption.<sup>7</sup> In short, the main findings lend support to the economic and statistical significance of the effects of exposure to UV-R on corruption across countries.

As suggested by an anonymous reviewer, the main results could be purely driven by using a measure of corruption in 2010. To the extent that the intensity of UV-R is linked to the

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<sup>6</sup> The magnitude and statistical precision of the benchmark estimates remain insensitive to incorporating additional geographic controls in the regression, including absolute latitude, mean levels of land suitability for agriculture, the proportion of the population at risk of contracting malaria and a dummy variable for being landlocked. These findings are not reported to conserve space, but are available on request.

<sup>7</sup> See Appendix A3 for summary statistics of key variables included in the benchmark regression.

persistence of corruption, the results should remain intact if the dependent variable is measured in different years. Following a recent study by Maseland (2021), I perform a year-by-year replication of the main analysis to explore the time-series evolution of the long-term effects of UV-R on corruption. More specifically, I re-estimate the benchmark model with the dependent variable measured for each year from 1996 to 2019.<sup>8</sup> The point estimates and 95% confidence intervals are depicted in Figure 4. It permits an investigation of the evolution of the contribution of UV-R to corruption across the period 1996 – 2019. Accordingly, I consistently find precise estimates of the positive effects of UV-R on corruption at the 1% level of statistical significance (Figure 4). Moreover, there exist trivial changes to the magnitude of the estimated coefficients of UV-R, thus providing evidence of the persistence of the main findings. The results illustrated in Figure 4 are also in line with the aforementioned argument that corruption exhibits little variation within an economy over time (Figure 2). For this reason, the cross-country variation in corruption appears to be highly persistent (Figure 1). Overall, the benchmark results reveal that the intensity of UV-R lies at the deep roots of cross-country differences in the perceived degree of corruption.

#### **4.2. Sensitivity analyses**

To provide a valid basis for statistical inference, this sub-section discusses numerous robustness analyses, which are conducted using the baseline estimates in column (4) of Table 1. All regressions are augmented with the set of main control variables and region dummies.

#### **Robustness to controlling for historical confounders**

An influential viewpoint in the long-run comparative development literature holds that early state development exerts a persistent influence on global income differences (Bockstette et al., 2002; Borcan et al., 2018). A recent study by Owen and Vu (2020) finds that the relationship between statehood experience and corruption follows a U-shaped pattern. Accordingly, countries with medium statehood are among the least corrupt economies. By contrast, corruption tends to proliferate in both newly established and older states. In a similar vein, Vu (2021b) finds evidence of a U-shaped relationship between state history and the level of income inequality within a country. Other scholars highlight the role of a transition to

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<sup>8</sup> The choice of this period is mainly driven by the availability of data on the World Bank's reversed index of corruption. Admittedly, exploring the persistence of the effects of UV-R on corruption requires using data covering a prolonged period of years. However, obtaining an internationally comparable measure of corruption spanning a large number of years is challenging primarily due to the scarcity of data. However, this empirical exercise is consistent with the empirical approach of Maseland (2021) who attempts to examine the persistence of the effects of historical and geographic factors on income per capita.

sedentary agriculture (Ang, 2013), the duration of human settlements (Ahlerup & Olsson, 2012) and prehistorically determined genetic diversity (Ashraf & Galor, 2013; Vu, 2021a) in driving economic prosperity across the world. Hence, the core results could be purely driven by failure to account for the impacts of early development. To address this concern, I allow different measures of early development to enter the main regression in a quadratic form, following Vu (2021b). As shown in Table 2, the estimated effects of UV-R on corruption withstand controlling for different measures of early development.

An additional concern relates to the possibility that the baseline results reflect the persistent effects of historical migration flows (Acemoglu et al., 2001). As discussed above, the expansion of European colonizers throughout the world starting around the sixteenth century led to substantial and persistent variation in economic institutions and income levels across the globe (Acemoglu et al., 2001). It is plausible that people could choose to migrate to low UV-R regions due to a more favourable disease environment. Moreover, people brought with them cultures and economic institutions developed in their home countries when migrating. Therefore, cross-country differences in the perceived level of corruption could be attributed to historical migration flows. In order to circumvent this issue, I replicate the main analysis using various sub-samples of countries, including ones for which the indigenous population (as at 1500CE) accounts for more than 70%, 80%, 90% and 95% of the current population. Data are taken from the World Migration Matrix (Putterman & Weil, 2010). The results reported in Table 3 indicate that the reduced-form relationship between UV-R and corruption retains its sign and statistical precision when excluding countries characterized by substantial migration flows. This at least partially rules out the possibility that the main findings are confounded by the long-term effects of European migration/colonialization.

### **Robustness to controlling for “proximate” determinants of corruption**

A key distinguishing feature of this study lies in the exploitation of exposure of UV-R as a plausibly exogenous source of variation in corrupt practices across countries. One may well argue that the main analysis fails to account for numerous “proximate” causes of corruption, leading to omitted variables bias. Previous studies document evidence of various determinants of corruption, 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). It is important to note that these variables are

also affected by the prevalence of corrupt practices. The results would suffer from reverse causation if these variables were to enter the model specification. Furthermore, Andersen et al. (2016) reveal that exposure to UV-R matters for global income differences. Given the two-way relationship between income levels and corruption, the inclusion of income per capita in the regression may mask much of the reduced-form association between UV-R and corruption (see, for example, Vu, 2021b, 2021a). This partially provides a motivation for the benchmark model specification. Nevertheless, incorporating numerous “proximate” causes of corruption in the regression fails to attenuate the coefficients on UV-R towards zero (Table 4).

### **Robustness to controlling for possible spatial dependence and outliers**

Several studies suggest that corrupt practices may transcend national borders through socio-economic interactions between world economies (Correa et al., 2016). The presence of spatial autocorrelation in the error terms may lead to biased estimates of the standard errors in the main analysis. Following Conley (1999), I estimate the standard errors corrected for potential cross-sectional spatial dependence, and report the results in Table 5. Accordingly, the magnitude of the corrected standard errors is considerably smaller than that of the heteroscedasticity-robust ones. For this reason, the reduced-form effects of exposure to UV-R on the incidence of corruption withstand accounting for possible spatial dependence in the disturbance terms. To check whether the results are confounded by the presence of possible outliers, I replicate the main analysis by estimating different sub-samples of countries excluding outliers. As demonstrated in Appendix A4, the core results remain largely robust to excluding potential outliers from the regression.

### **Robustness to using alternative dependent variables and additional controls**

One may argue that the positive reduced-form relationship between UV-R and corruption is merely driven by using the World Bank’s reversed index of corruption in the main analysis. For this reason, I employ an alternative dependent variable by using Transparency International’s Perception of Corruption Index (CPI). The CPI is a perception-based measure of the pervasiveness of corrupt practices in the public sector for a large number of countries, provided by business people and country experts. For this reason, the CPI offers an internationally comparable measure of corruption. This indicator takes values ranging between 0 and 100, in which higher values correspond to a more transparent environment. For ease of interpretation, I rescale the CPI by multiplying it by minus one. Hence, higher values of the reversed CPI reflect a greater prevalence of corrupt activities. I re-estimate the benchmark

model using the reversed CPI as an alternative outcome variable. Consistent with the main analysis, the dependent variables are measured for each year between 2012 and 2019 to explore the persistence of the results.<sup>9</sup> Figure 5 depicts the point estimates and 95% confidence intervals of the coefficients on UV-R. Accordingly, the intensity of UV-R enters all regressions with positive and statistically significant coefficients when using the reversed CPI as an alternative outcome variable. The persistence of the estimates is also in line with the main findings discussed in Section 4.1. Overall, the results illustrated in Figure 5 demonstrate that the reduced-form impacts of UV-R on corruption are unlikely to be purely attributed to adopting the World Bank’s reversed index of corruption.

## **5. Individual-level evidence**

The reduced-form effects of UV-R on corruption withstand accounting for numerous confounding factors in cross-country regressions. However, plausible concerns about omitted variables bias remain unaddressed if the benchmark model specification fails to account for unobserved country-specific factors. I attempt to circumvent this concern by using individual-level data obtained from wave 6 of the World Values Survey. In particular, individual-level analyses permit controlling for time-invariant unobserved confounders at the national level.

Individual-level data, available for more than 60 countries across the world, were collected through face-to-face interviews from 2010 to 2014. To capture the cross-country variation in the prevalence of corrupt practices, I exploit self-reported individual attitudes towards corrupt activities as the outcome variable.<sup>10</sup> More specifically, survey respondents are asked about the extent to which they think corrupt practices are justifiable. Answers to this survey question are recorded on a categorical scale from 1 (“never justifiable”) to ten (“always justifiable”). Hence, higher values of the dependent variables correspond to greater tolerance towards corruption. It is argued that countries characterized by greater social tolerance toward corruption would suffer from a greater prevalence of corrupt activities. Subnational data on the

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<sup>9</sup> A recent study by Gründler and Potrafke (2019) highlights that the CPI was not measured in a consistent manner across countries and over time before 2012, leading to possible measurement errors in a cross-country framework. For this reason, I use data on the CPI from 2012 to 2019.

<sup>10</sup> The World Values Survey also provides other self-reported measures of corruption within the private and public sectors. More specifically, surveyed respondents are asked about the perceived pervasiveness of corruption, changes in corruption levels and the government’s efforts to tackle corrupt practices. Unfortunately, using these measures of perceived corruption constrains the feasible sample size significantly due to the scarcity of the data, making it difficult to obtain a generalized understanding of the relationship between UV-R and corruption across the world. Nevertheless, the results, available upon request, remain unchanged when using these alternative measures of corruption within individual-level analyses.

intensity of UV-R, provided by Andersen et al. (2016), are merged with survey data based on surveyed respondents' answers about regions in which they are living. Geographic controls, measured at the regional level, include absolute latitude, mean elevation, precipitation, and temperature. The model specification also incorporates individual characteristics, such as age, age squared, gender, income, education and the degree of trust in others. The inclusion of country dummies accounts for time-invariant unobserved heterogeneity across countries. Language dummies are included to account for unobserved culture-specific factors because people speaking a common language may share similar cultures.

Table 6 reports the individual-level evidence on the relationship between exposure of UV-R and corruption. The results reveal that surveyed respondents in high UV-R regions are more likely to self-report that corrupt practices are justifiable. The empirical estimates are robust to incorporating an exhaustive set of observable controls and fixed effects in the regression. This provides suggestive evidence of a positive association between UV-R and social tolerance towards corrupt activities. The findings lend support to the cross-country estimates that exposure to UV-R is positively associated with the incidence of corruption.

## **6. Subnational evidence**

This section contains a subnational analysis of the relationship between UV-R and corruption across provinces in China. This empirical exercise further helps address a key concern about omitted variables bias within a cross-country framework. There exists substantial variation in the degree of corruption and exposure to UV-R across provinces in China. This permits a replication of the main findings at the province level for China, holding many unobserved confounders at the country level constant.<sup>11</sup>

A major challenge with estimating subnational regressions at the province level for China lies in obtaining a regionally comparable measure of corruption. To my knowledge, there exists no comprehensive dataset of corruption across regions in China. For this reason, I employ an index of local government efficiency of Tang et al. (2014) to capture the variation in corruption

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<sup>11</sup> It is important to re-emphasize that performing subnational analyses of the reduced-form effects of UV-R on corruption depends on variation in the data at the subnational level. This is suggestive of the desirability of employing data at the province level for China. Future studies may further explore this possibility by using macro- and/or micro-level data for other countries should they be readily available. An anonymous reviewer puts forward that the main findings may not be replicated by using subnational data for other countries. However, this paper undertakes cross-country analyses of the relationship between UV-R and corruption. To the extent that empirical estimates at the local level of a particular economy stand in contrast to those of the current paper, such findings could provide new insights into the role of UV-R in shaping the incidence of corruption.



at the province level. This indicator reflects the transparency of public affairs and the efficiency of public services of the provincial government. It is argued that provinces characterized by higher levels of government efficiency and transparency are less likely to experience the incidence of corruption. Additionally, the ability to combat corruption critically depends on how efficient, transparent and accountable the local government is. Hence, this index provides a measure of cross-province differences in corruption for China.

I use three controls including trade openness, ethnic fractionalization, and a binary variable for coastal provinces. It is important to highlight that data limitations do not permit the inclusion of a wide range of control variables. Furthermore, including many controls imposes further constraints on the feasible degree of freedom given the limited number of observations. The empirical estimates of the reduced-form relationship between UV-R and corruption in China are reported in Appendix A4. Accordingly, I find evidence of a negative association between exposure to UV-R and the local government efficiency index. This reveals that provinces characterized by higher degrees of UV-R tend to establish a less transparent and efficient government, which may translate into the prevalence of corrupt practices. Overall, the results lend credence to the cross-country evidence.

## **7. Concluding remarks**

A growing body of research in economics attempts to investigate the role of deeply rooted geographic or historical factors in shaping comparative development across the world. This research contributes to this line of inquiry by establishing that the intensity of ultraviolet radiation (UV-R) matters for international variation in corrupt practices. The central hypothesis of this paper rests upon the premise that high UV-R societies tend to experience a permanent threat of contracting eye diseases, such as cataracts, leading to substantially reduced work-life expectancy as a skilled labour. This possibly translates into the persistence of corruption *via* shortening the incumbents' horizons.

Exploiting data for up to 139 countries, I consistently find evidence supporting the positive reduced-form effects of UV-R on the incidence of corruption. The main findings withstand accounting for conventional explanations for cross-country differences in corruption. In order to control for time-invariant unobserved heterogeneity across countries, I perform individual-level analyses using data from the World Values Survey. Consistent with the cross-country evidence, the paper documents that surveyed respondents in high UV-R regions are more likely to self-report tolerance towards corrupt activities. The individual-level evidence

remains intact when incorporating an exhaustive set of control variables and fixed effects in the regression. Moreover, the main analysis is replicated using data at the province level for China. Accordingly, provinces characterized by greater exposure to UV-R tend to suffer from a less transparent and efficient local government, which is a possible proxy for the prevalence of corrupt practices. Overall, the current study establishes a positive reduced-form association between the intensity of UV-R and corruption using cross-country data, individual-level data from the World Values Survey, and data at the province level for China.

The findings of this paper help improve our understanding of the impacts of geographic endowments on the persistence of underdevelopment. As discussed previously, corrupt practices and underdevelopment tend to proliferate in societies lying further away from the equator. This paper provides an explanation for this long-standing stylized fact based on the disease environment caused by the intensity of UV-R, which is a strong correlate of absolute latitude. Importantly, policy-makers should consider the long-term legacy of geographic characteristics for the prevalence of corruption when formulating relevant policies. It follows from the main findings that countries endowed with higher degrees of UV-R exposure may find it difficult to tackle corruption, which appears to be a persistent nature of these societies. In other words, my findings suggest that there may exist little room for contemporary policies to break from the disadvantages of geography in high UV-R societies. Therefore, addressing corruption critically requires some attention to the adverse long-term impacts of geography.

A potential avenue for future research is to examine whether the reduced-form relationship between UV-R and corruption can be replicated using subnational data across the world. Using macro- and/or micro-level data at the subnational level is particularly relevant for understanding the underlying mechanisms through which the intensity of UV-R transmits to the incidence of corruption.

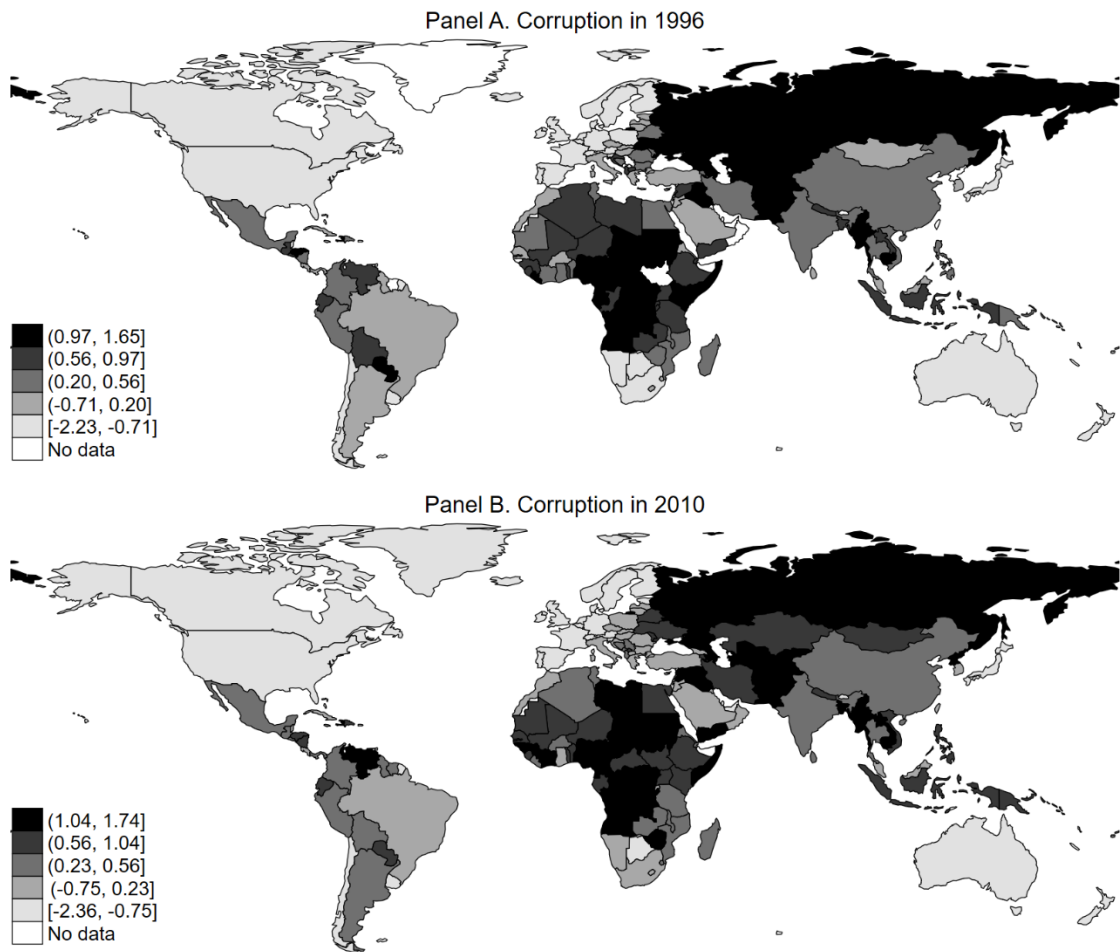
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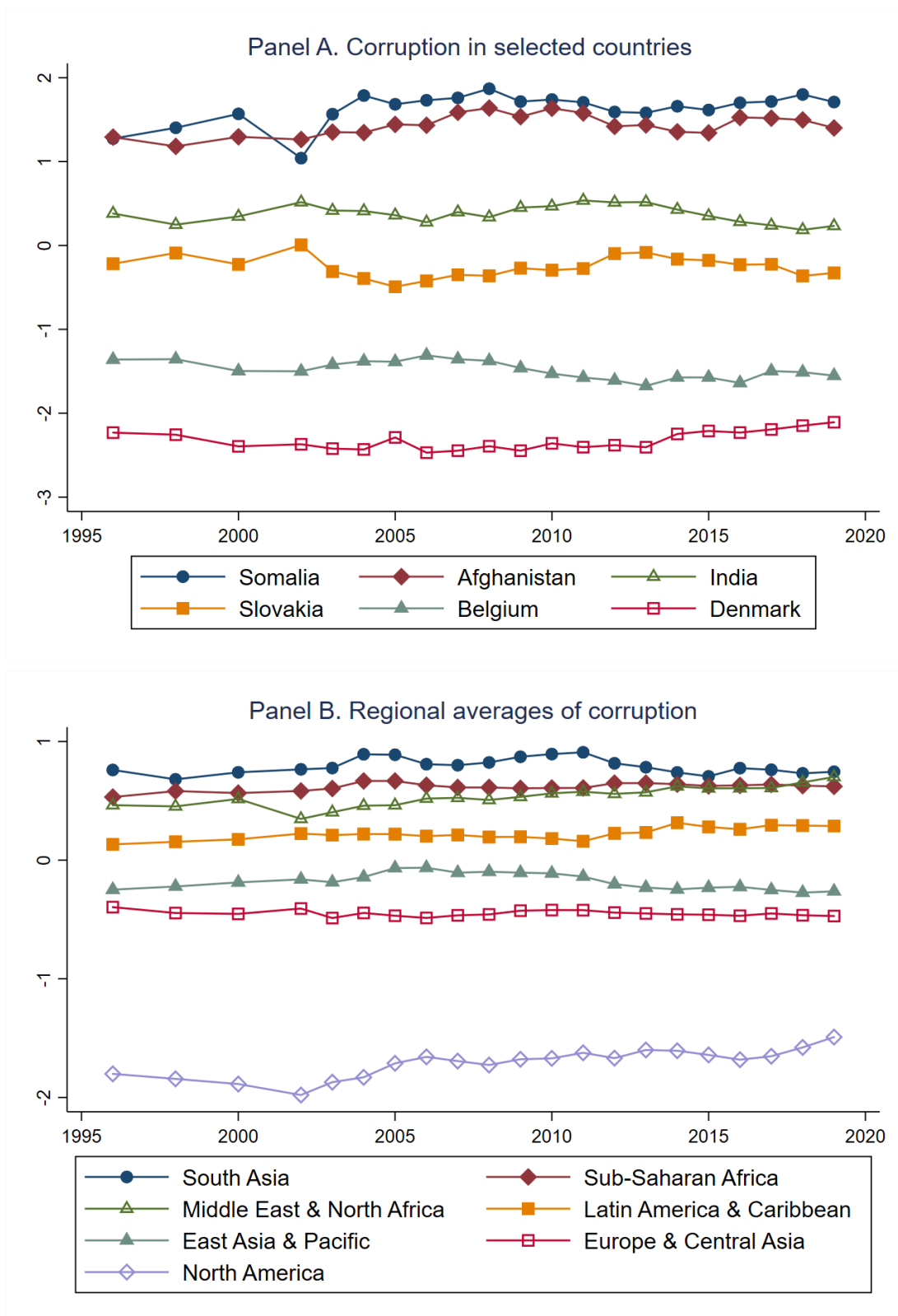
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**Figure 1. Cross-country differences in corruption levels**

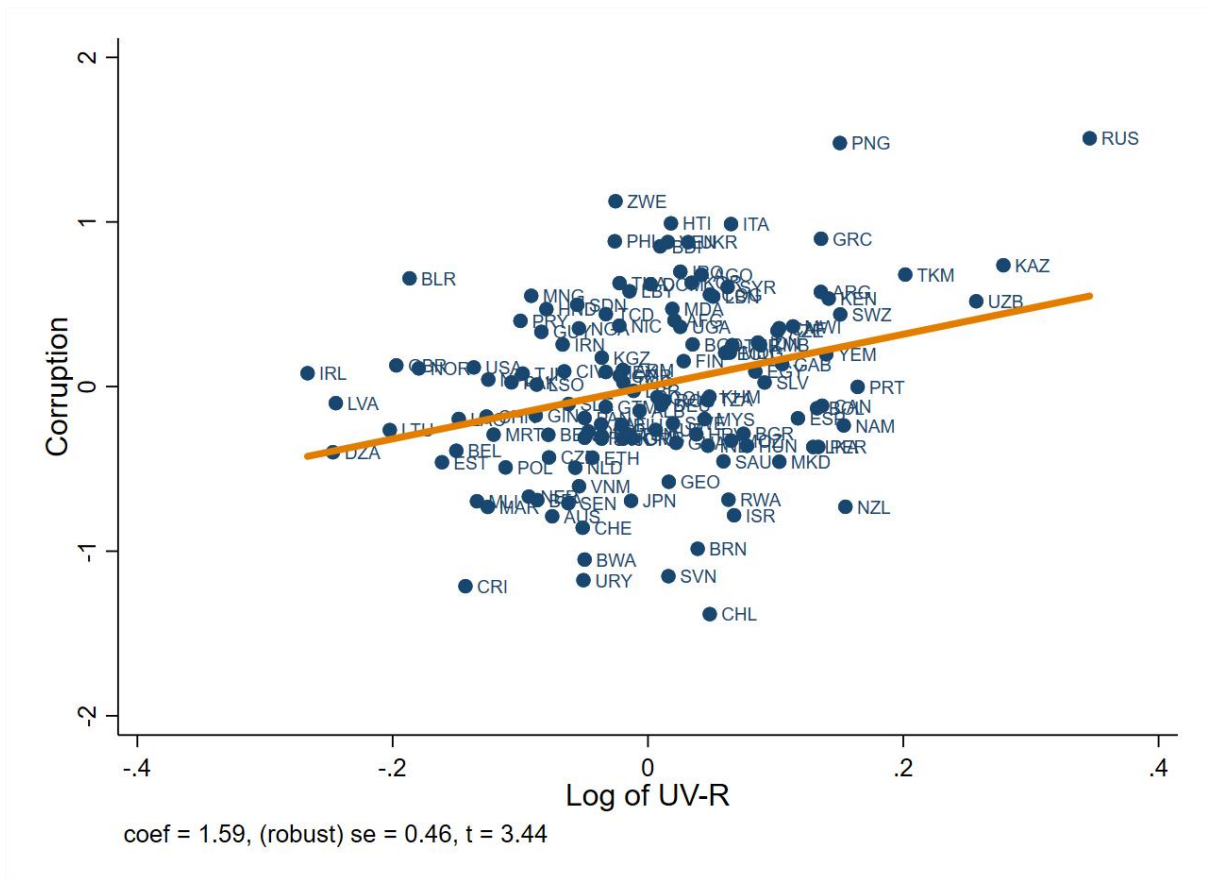
*Notes:* This figure depicts international variation in corruption for the years 1996 and 2010, captured by the World Bank's reversed index of corruption. Darker regions represent societies with a greater prevalence of corrupt practices.



**Figure 2. The evolution of corruption over time**

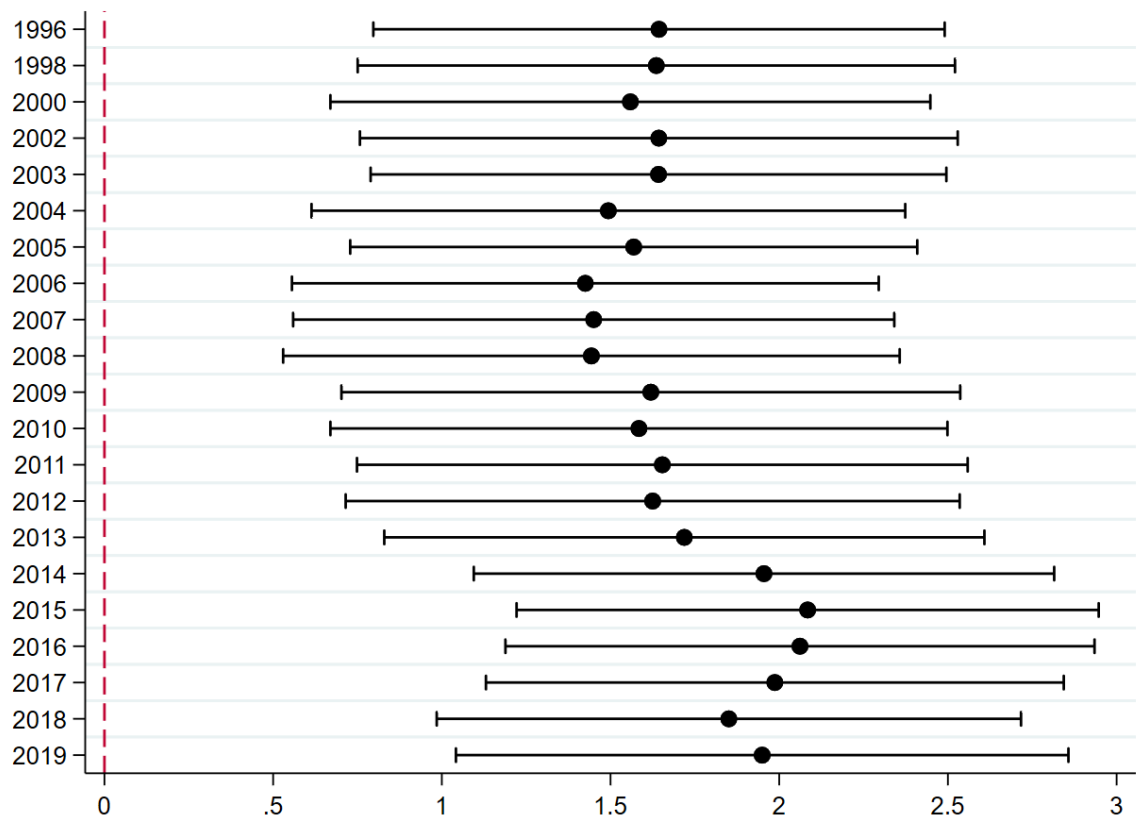
*Notes:* This figure depicts the variation in the World Bank's reversed index of corruption within selected countries and regions between 1996 and 2019. Panel A illustrates the evolution of corruption for different countries characterized by high, medium and low levels of corruption. Panel B presents regional averages of corruption for different world regions. See also the notes to Figure 1.





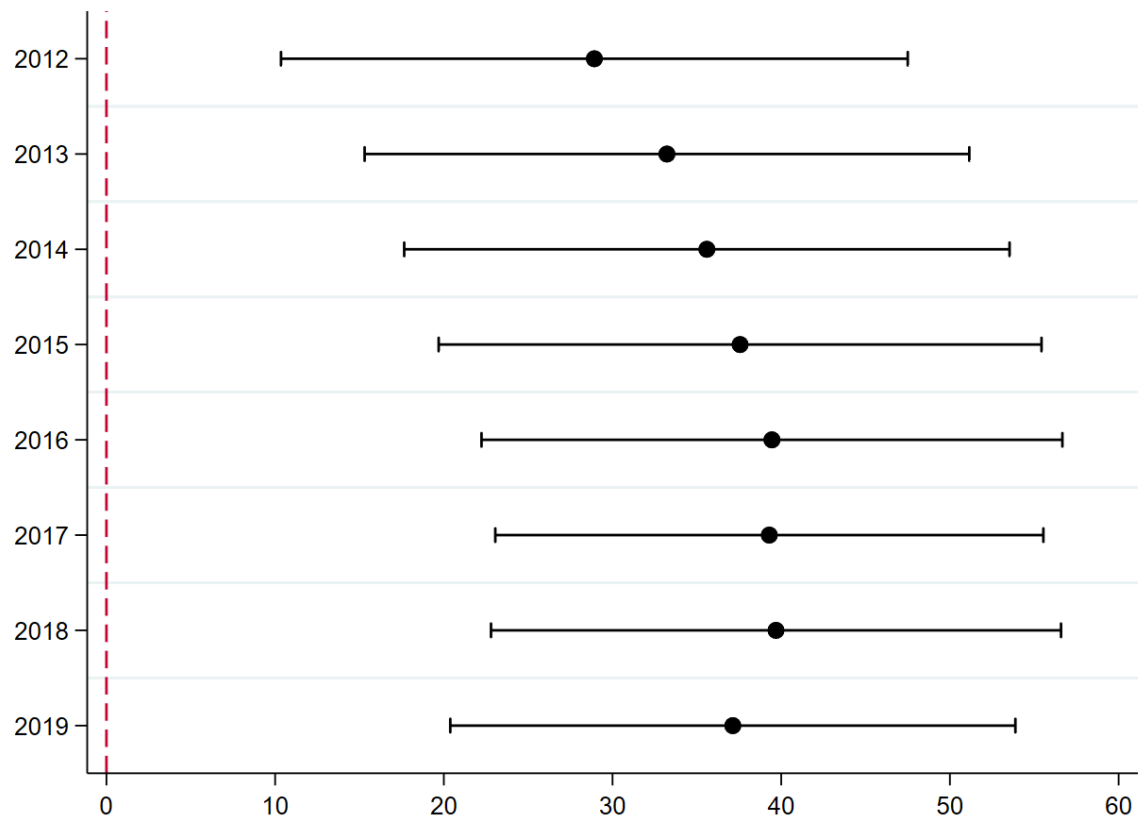
**Figure 3. The partial effects of UV-R on corruption**

*Notes:* This figure depicts the partial reduced-form effects of UV-R on the perceived degree of corruption across countries, derived from the baseline estimates reported in column (4) of Table 1. Countries' abbreviations are obtained from the World Bank's World Development Indicators.



**Figure 4. The partial effects of UV-R on corruption over time**

*Notes:* This figure replicates the main analysis using the World Bank’s reversed index of corruption measured for each year between 1996 and 2019. All regressions are augmented with a set of main control variables and region dummies. Here, I plot the point estimates and 95% confidence intervals of the coefficient of the main variable of interest (UV-R). The results are directly comparable to the baseline estimates reported in column (4) of Table 1. The full estimates, available on request, are not reported for brevity.



**Figure 5. The partial effects of UV-R on the corruption perception index over time**

*Notes:* This figure depicts the evolution of the partial effects of UV-R on Transparency International’s corruption perception index. The outcome variables are measured for each year between 2012 and 2019. All regressions are augmented with the set of main control variables and region dummies. In order to conserve space, I plot the point estimates and 95% confidence intervals of the coefficient on UV-R.

**Table 1. The effects of UV-R on corruption, main results**

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

*Notes:* This table presents empirical estimates of the reduced-form effects of UV-R on corruption across countries. Region dummies denote binary variables for world regions, including Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa. An intercept, not reported for brevity, is incorporated in all regressions. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Table 2. Robustness to controlling for historical confounders**

Dep_var: <i>corruption</i>	(1)	(2)	(3)	(4)
<b><i>Log (UV-R)</i></b>	<b>1.448***</b>	<b>1.534***</b>	<b>1.795***</b>	<b>1.630***</b>
	[0.458]	[0.487]	[0.531]	[0.470]
<i>State history</i>	-3.284**			
	[1.292]			
<i>State history squared</i>	4.226**			
	[1.697]			
<i>Neolithic revolution</i>		0.055		
		[0.138]		
<i>Neolithic revolution squared</i>		-0.002		
		[0.011]		
<i>Human settlement</i>			-0.846	
			[0.942]	
<i>Human settlement squared</i>			0.408	
			[0.645]	
<i>Predicted genetic diversity</i>				40.376
				[51.246]
<i>Predicted genetic diversity squared</i>				-20.057
				[36.885]
Baseline controls	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Observations	136	136	136	136
<i>R-squared</i>	0.753	0.740	0.742	0.761

*Notes:* This table replicates the main analysis by accounting for the effects of historical confounders, including statehood experience, the timing of Neolithic transition, the duration of human settlements, and a measure of prehistorically determined genetic diversity. The inclusion of all variables in one single regression fails to alter the main results despite higher degrees of multicollinearity. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. See also the main text and Appendix A2 for more details.

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

Dep_var: <i>corruption</i>	Indigenous people (as of 1500) as a percentage of the current population			
	>70%	>80%	>90%	>95%
	(1)	(2)	(3)	(4)
<b><i>Log (UV-R)</i></b>	<b>1.946***</b>	<b>2.004***</b>	<b>2.332***</b>	<b>2.517***</b>
	[0.500]	[0.514]	[0.565]	[0.682]
Baseline controls	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Observations	98	91	73	57
<i>R-squared</i>	0.797	0.805	0.830	0.819

*Notes:* This table replicates the main analysis by using different sub-samples of countries. In columns (1) to (4), I restrict the analysis to countries of which the indigenous population accounts for more than 70%, 80%, 90% and 95% of the current population, respectively. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Table 4. Robustness to controlling for contemporary confounders**

Dep_var: <i>corruption</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>Log (UV-R)</i>	<b>1.404***</b> [0.437]	<b>1.259***</b> [0.430]	<b>1.642***</b> [0.469]	<b>1.473***</b> [0.460]	<b>1.381***</b> [0.420]	<b>1.621***</b> [0.484]	<b>1.523***</b> [0.422]	<b>1.502***</b> [0.420]	<b>0.810**</b> [0.357]
<i>Log (GDP per capita)</i>	-0.302*** [0.068]								-0.391*** [0.096]
<i>Fuel exports</i>		0.007*** [0.002]							0.012*** [0.002]
<i>Trade openness</i>			0.001 [0.001]						-0.000 [0.001]
<i>Government size</i>				-0.038*** [0.014]					-0.013 [0.014]
<i>Democracy (polity2)</i>					-0.035*** [0.011]				-0.013 [0.011]
<i>Education</i>						-0.107*** [0.036]			0.006 [0.039]
<i>Urbanization</i>							-1.144*** [0.385]		-0.325 [0.405]
<i>Gender</i>								-0.017*** [0.006]	-0.016*** [0.006]
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	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:* This table replicates the main analysis by accounting for the effects of numerous “proximate” determinants of corruption. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. See also the main text and Appendix A2 for more details.

**Table 5. Robustness to controlling for spatial dependence**

Dep_var: <i>corruption</i>	(1)	(3)	(4)
<b><i>Log (UV-R)</i></b>	<b>1.162***</b>	<b>1.251***</b>	<b>1.589***</b>
Heteroscedasticity-robust standard errors	[0.142]	[0.357]	[0.462]
Conley's (1999) standard errors	(0.039)	(0.073)	(0.074)
Baseline controls	No	Yes	Yes
Region dummies	No	No	Yes
Observations	139	136	136
<i>R</i> -squared	0.360	0.689	0.738

*Notes:* This table replicates the main analysis by estimating the standard errors corrected for possible spatial autocorrelation in the disturbance terms, following Conley (1999). The calculation of the corrected standard errors are based on weighted covariance matrices, and the weights are the inverse distance between countries. The weights take a value of zero after a certain threshold. Heteroscedasticity-robust standard errors are also reported for ease of comparison. \*\*\*  $p < 0.01$ .



**Table 6. The relationship between UV-R and tolerance towards corrupt practices**

Dep_var: <i>tolerance towards corrupt practices</i>	OLS estimates				Ordered logit estimates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b><i>Log (UV-R)</i></b>	<b>0.374***</b>	<b>0.213***</b>	<b>0.212***</b>	<b>0.344***</b>	<b>0.424***</b>	<b>0.293***</b>	<b>0.262**</b>	<b>0.481***</b>
	[0.013]	[0.078]	[0.080]	[0.082]	[0.016]	[0.100]	[0.103]	[0.108]
<i>Latitude</i>		-0.017	-0.018	-0.012		0.078***	0.079***	0.085***
		[0.018]	[0.018]	[0.018]		[0.022]	[0.023]	[0.023]
<i>Mean elevation</i>		-0.000	-0.000*	0.000***		-0.000	-0.000	-0.000***
		[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]
<i>Precipitation</i>		0.026	0.017	0.011		0.020	0.000	-0.048
		[0.024]	[0.025]	[0.026]		[0.026]	[0.027]	[0.031]
<i>Temperature</i>		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 dummies	No	No	No	Yes	No	No	No	Yes
Individual controls	No	No	Yes	Yes	No	No	Yes	Yes
Country dummies	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:* This table contains empirical estimates of the reduced-form relationship between UV-R and surveyed respondents' attitudes towards corrupt practices, using data from the World Values Survey. Higher values of the dependent variable correspond to greater tolerance toward corruption. Individual controls represent socio-economic characteristics of survey participants, including age, age squared, income, education and the degree of trust in others. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. See also the main text and Appendix A2 for more details.

## Appendices

### Appendix A1. List of countries by the World Bank's classification of regions

East Asia & Pacific: Australia, Brunei, China, Indonesia, Japan, Cambodia, Korea, Lao PDR, Mongolia, Malaysia, New Zealand, Philippines, Papua New Guinea, Thailand, and Vietnam.

Europe & Central Asia: Albania, Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Bosnia and Herzegovina, Belarus, Switzerland, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Georgia, Greece, Croatia, Hungary, Ireland, Italy, Kazakhstan, Kyrgyz Republic, Lithuania, Latvia, Moldova, North Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Sweden, Tajikistan, Turkmenistan, Turkey, Ukraine, and Uzbekistan.

Latin America & Caribbean: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Guyana, Honduras, Haiti, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Uruguay, and Venezuela.

Middle East & North Africa: Algeria, Egypt, Iran, Iraq, Israel, Jordan, Lebanon, Libya, Morocco, Saudi Arabia, Syrian Arab Republic, Tunisia, and Yemen.

North America: Canada and United States.

South Asia: Afghanistan, Bangladesh, India, Sri Lanka, Nepal, and Pakistan.

Sub-Saharan Africa: Angola, Burundi, Benin, Burkina Faso, Botswana, Central African Republic, Côte d'Ivoire, Cameroon, Congo, Ethiopia, Gabon, Ghana, Guinea, The Gambia, Kenya, Liberia, Lesotho, Madagascar, Mali, Mozambique, Mauritania, Malawi, Namibia, Niger, Nigeria, Rwanda, Sudan, Senegal, Sierra Leone, Eswatini, Chad, Togo, Tanzania, Uganda, South Africa, Zambia, and Zimbabwe.

### Appendix A2. Variables' description and data sources

#### Variables used in cross-country regressions

*Corruption*: the World Bank's reversed index of corruption, with higher values denoting a greater prevalence of corrupt practices. *Source*: the World Bank's World Governance Indicators.

*CPI*: Transparency International's Corruption Perception Index. This index is rescaled by multiplying by minus one, with higher values denoting a greater prevalence of corrupt practices. *Source*: Transparency International.

*Log (UV-R)*: a measure of the intensity of ultraviolet radiation across countries, calculated using daily satellite-based data for ambient UV-R obtained from NASA. *Source*: Andersen et al. (2016).

*Mean elevation*: a country-level measure of mean degrees of elevation above the sea level (in kilometres). *Source*: Portland Physical Geography dataset.

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

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

*Common law*: this variable takes a value of one for common-law countries, and zero otherwise. *Source*: Klerman et al. (2011).

*Mixed law*: this variable takes a value of one for countries that partially replace their originally adopted French civil law by British common law, and zero otherwise. *Source*: Klerman et al. (2011).

*Communist*: this variable takes a value of one for countries with socialist legal systems. *Source*: La Porta et al. (1999).

*Fractionalization*: an index of ethnic fractionalization. This variable captures the probability that two individuals, randomly selected from a relevant population, belong to different ethnic groups. *Source*: Alesina et al. (2003)

*Catholic, Muslim and Protestant*: the proportions of the population practicing major religions. *Source*: La Porta et al. (1999).

*State history*: an index of statehood experience obtained from 3500BCE to 2000CE. *Source*: Borcan et al. (2018).

*Neolithic revolution*: the length of time elapsed since the adoption of sedentary agriculture. *Source*: Putterman (2006).

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

*Predicted genetic diversity*: an index of predicted genetic diversity predetermined over the prehistoric course of the exodus of Homo sapiens from East Africa tens of thousands of years

ago. Genetic diversity reflects the likelihood that two individuals, randomly selected from a country's population, are genetically dissimilar to each other. *Source*: Ashraf and Galor (2013).

*Log (GDP per capita)*: the log of GDP per capita, measured in 2010USD constant prices. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

*Fuel exports*: the value of fuel exports as a proportion of total exports. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

*Trade openness*: the sum of exports and imports as a proportion of total GDP. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

*Government size*: the government's final consumption expenditure as a proportion of total GDP. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

*Democracy*: the polity2 index of democracy. *Source*: Marshall et al. (2014).

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

*Urbanization*: the proportion of urban population in a country's total population. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

*Gender*: the proportion of seats held by women in national parliaments. Data are averaged between 2000 and 2009. *Source*: the World Bank's World Development Indicators.

#### Variables used in individual-level regressions

*Attitudes towards corrupt practices*: an index of surveyed respondents' attitudes towards corrupt practices. Higher values correspond to greater tolerance towards corruption. *Source*: the World Values Survey.

*Individual controls*: age, age squared, gender, income, education, and the degree of trust in others. *Source*: the World Values Survey.

*Language dummies*: binary variables for surveyed participants' native language. *Source*: the World Values Survey.

*Country dummies*: binary variables for countries in which the survey was conducted. *Source*: the World Values Survey.

### Appendix A3. Descriptive statistics of key variables used in cross-country regressions

**Table A1. Summary statistics of key variables**

Variables	Observations	Mean	Standard deviation	Min	Max
<i>Corruption</i>	158	0.13	1.03	-2.36	1.74
<i>Log (UV-R)</i>	139	5.14	0.52	3.75	5.79
<i>Mean elevation</i>	149	0.64	0.55	0.01	3.19
<i>Temperature</i>	158	18.23	8.35	-7.93	28.64
<i>Precipitation</i>	158	9.29	6.17	0.29	25.99
<i>Common law</i>	156	0.21	0.41	0	1
<i>Mixed law</i>	156	0.09	0.29	0	1
<i>Communist</i>	158	0.22	0.41	0	1
<i>Fractionalization</i>	158	0.29	0.31	0	1
<i>Catholic</i>	158	30.28	35.52	0	96.90
<i>Muslim</i>	158	23.46	35.23	0	99.80
<i>Protestant</i>	158	11.47	20.31	0	97.80

## Appendix A4. Additional results

**Table A2. Robustness to excluding possible outliers**

Dep_var: <i>corruption</i>	(1)	(2)	(3)
<b><i>Log (UV-R)</i></b>	<b>1.590***</b>	<b>1.310***</b>	<b>1.505***</b>
	[0.372]	[0.385]	[0.361]
Baseline controls	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Observations	121	128	136
R-squared	0.796	0.816	0.796

*Notes:* This table replicates the main analysis by excluding potential outliers from the regression. In column (1), I construct the Cook's distance, and remove countries with values larger than the conventional threshold (four divided by the number of observations). As reported in column (2), the baseline model is re-estimated for a sub-sample of countries of which the absolute values of the standardized residuals are smaller than 1.96. In column (3), I estimate robust regression weights to replicate the main analysis. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Table A3. UV-R and corruption, subnational evidence from China**

Dep_var: <i>the local government efficiency index</i>	(1)	(2)	(3)	(4)
<b><i>Log (UV-R)</i></b>	<b>-0.369***</b>	<b>-0.328***</b>	<b>-0.364***</b>	<b>-0.354**</b>
	[0.118]	[0.107]	[0.130]	[0.170]
<i>Trade openness</i>		0.462***	0.349***	0.346***
		[0.083]	[0.064]	[0.064]
<i>Coastal dummy</i>			0.184**	0.183**
			[0.080]	[0.083]
<i>Ethnic fractionalization</i>				-0.020
				[0.287]
Observations	31	31	31	31
R-squared	0.105	0.467	0.533	0.533

*Notes:* This table contains empirical estimates of the reduced-form relationship between UV-R and an index of government efficiency across provinces in China. Accordingly, high UV-R provinces tend to establish a less transparent and efficient local government, which is a possible proxy for a greater prevalence of corrupt practices. Trade openness is captured by the sum of exports and imports as a proportion of gross regional products in 2010, obtained from National Bureau Statistics of China. Coast dummy is a binary variable for coastal provinces. An index of ethnic fractionalization captures the effects of ethnic diversity. Robust standard errors in square brackets. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.