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Sunlight, culture and state capacity

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Abstract

This paper examines the impact of ultraviolet radiation (UV-R) on state capacity. The results indicate that the intensity of UV-R is a strong predictor of cross-country differences in state capacity. Countries with a higher degree of UV-R exposure tend on average to have weaker states. This finding remains unaffected after controlling for different variables that may be correlated with both UV-R and state capacity, including an extensive set of geographical, historical and contemporary factors. The observed link between sunlight and state capacity is not driven by potential outliers and is robust to the employment of alternative measures of state capacity, estimation methods and other sensitivity checks. Furthermore, the analysis also reveals that the individualistic–collectivist dimension of culture acts as a transmission channel connecting UV-R and state capacity. The estimates show that a lower degree of UV-R exposure leads to the adoption of individualistic values, which in turn contribute to the development of state capacity.

1 | INTRODUCTION

During the last years, the concept of state capacity has received a growing attention in development economics and political economy. The interest in this topic is related to the idea that state capacity, broadly defined as the ability of a state to attain its intended policy goals (Dincecco & Wang, 2022; O'Reilly & Murphy, 2022), is an important determinant of economic development. This argument, which goes back at least to Tilly (1990), is consistent with the evidence that many less-developed countries in sub-Saharan Africa and Asia are characterized by a limited state capacity (Acemoglu, 2005; Herbst, 2000), while richer countries appear to have significantly stronger states

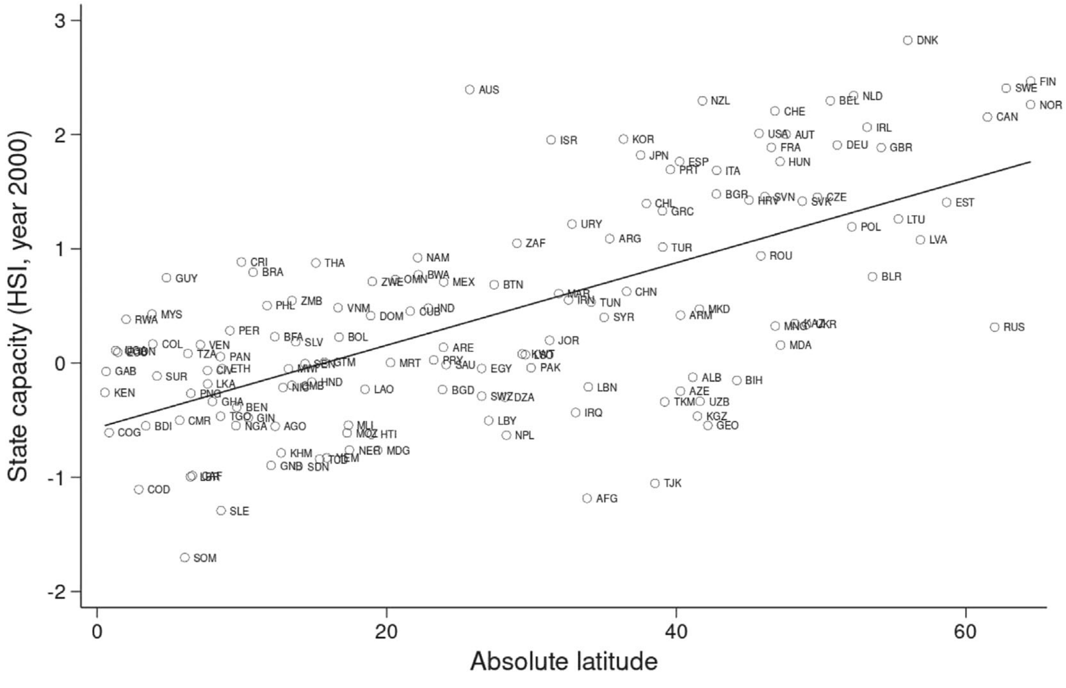

FIGURE 1 Latitude and state capacity.

(Acemoglu & Robinson, 2019; Besley & Persson, 2011). This is in line with the positive association between various measures of state capacity and economic performance reported by Acemoglu (2005), Dincecco and Prado (2012) and Besley et al. (2013). In turn, the evidence provided by Dincecco and Katz (2016) reveals a direct relationship between fiscal centralization and economic growth in eleven European countries over four centuries from the Old Regime to the First World War. Taken together, these findings point to the key role of state capacity in explaining why some countries have succeeded in achieving economic development whereas others have not. Furthermore, the literature also shows that countries with weaker states tend to invest relatively little in public goods (Gennaioli & Rainer, 2007) and to have lower levels of income redistribution (Rothstein & Uslaner, 2005). In addition to its effects on economic outcomes, state capacity also affects human rights protection (Englehart, 2009), regime stability (Andersen et al., 2014), environmental quality (Schwartz, 2003) and the effectiveness of government interventions in response to pandemics (Serikbayeva et al., 2021).

In view of the importance of state capacity, it is crucial to find out why some countries have stronger states than others. In fact, there exists an increasing body of empirical research on the determinants of state capacity, which has highlighted the relevance in this context of factors such as external wars (Dincecco & Prado, 2012), internal conflicts (Besley & Persson, 2008), democracy (Wang & Xu, 2018), ethnic diversity (Singh & Vom Hau, 2014) or colonial legacies (Kohli, 2004). So far, however, this literature has barely paid attention to the potential influence of geography on state capacity. Indeed, to the best of my knowledge, the only exception is the work of Jimenez-Ayora and Ulubaşoğlu (2015), who examine the impact of terrain ruggedness on state capacity. The scant attention received by geography in this literature is particularly striking taking into account the important role of geographical factors in shaping institutional development and culture (Diamond, 1997; Fernández-Villaverde et al., 2023; Galor & Özak, 2016; Jones, 2010). Interestingly, Figure 1 shows the existence of a positive link between the location of a country vis-à-vis the equator and its level of state capacity.[1] As can be seen, as one moves from the equator in either direction, state capacity tends

[1]State capacity is measured in Figure 1 using the aggregate index constructed by Hanson and Sigman (2021). See Section 3 for further details.

to increase. Indeed, Figure A1 in the Supporting Information reveals that this relationship still holds even after controlling for the GDP per capita level of the countries. Nevertheless, it is difficult to establish a priori the underlying causes of the observed association between latitude and state capacity. In order to improve our understanding of this issue, the present paper aims to investigate for the first time in the literature the role played in this context by the intensity of ultraviolet radiation (UV-R), which is perhaps the strongest among the correlates of absolute latitude (Andersen et al., 2016).[2] At first glance, the existence of a relationship between UV-R and the ability of a state to attain its intended policy goals might seem striking. Nevertheless, a recent body of research has highlighted the relevance of UV-R for contemporary economic and institutional development (Andersen et al., 2016; Ang et al., 2018; Vu, 2021), which suggests that the degree of UV-R exposure may also affect state capacity.

There are various reasons to justify the relevance of an empirical analysis of the link between UV-R and state capacity. The study of this issue could provide insights on the deep origins of state-building processes, complementing the findings of the existing literature on the proximate determinants of state capacity. Furthermore, the potential association between UV-R and state capacity may have policy implications when devising public initiatives intended to enhance state capacity. Moreover, because UV-R intensity has remained largely constant over the last two billion years (Andersen et al., 2016; Cockell & Horneck, 2001), exploiting the cross-country variation in UV-R exposure can help overcome possible problems of reverse causality that often complicate the identification of the causal impact of the proximate determinants of state capacity (Vu, 2021).

The paper also examines a potential transmission channel linking UV-R and state capacity. Specifically, I advance and empirically test the hypothesis that UV-R may affect state capacity through its impact on the individualistic–collectivist dimension of culture. In particular, following Fredriksson and Mohanty (2021), I argue that societies with higher UV-R exposure are more likely to face a greater risk of eye disease, specifically cataracts. This, in turn, leads to an increased importance of close family networks as an insurance mechanism against the negative consequences associated with visual impairment and fosters the emergence of collectivist values (Fafchamps & Gubert, 2007). Moreover, although cataracts are not contagious, they may be perceived (consciously or unconsciously) as a signal of a potential threat to human life (Fredriksson & Mohanty, 2021; Nussinson et al., 2018), leading to the adoption of collectivist values with an in-group conservative bias against foreigners and outside influence as a defence mechanism, in line with the predictions of the parasite-stress theory (Fincher et al., 2008). Building on these arguments, Fredriksson and Mohanty (2021) empirically show a negative association between UV-R exposure and individualistic values using cross-country data, individual-level data and evidence from preindustrial societies.

In collectivist societies, effective cooperation usually takes place within cohesive in-groups, while people outside the group are often distrusted (Alesina & Giuliano, 2014; Moscona et al., 2017). In contrast, individualistic societies must set up large-scale, impersonal institutions to enforce cooperative behaviour in social dilemmas such as public good provision or bilateral trade (Enke, 2019), which ultimately fosters the development of state capacity (Besley & Persson, 2009; Enke, 2019). Furthermore, Ezcurra (2021) shows that, unlike collectivist norms, individualistic values contribute to making the political environment more stable. This relationship is important in this context, because internal political stability is a critical factor in investing in state capacity (Besley & Persson, 2008, 2009). At the same time, the political science literature has emphasized the importance of individualistic values such as personal freedom and self-expression in the development of democratic institutions (Ang et al., 2021; Inglehart & Welzel, 2005). In contrast, authoritarian regimes are more likely in societies with collectivist values, which tend to exhibit greater respect for authority and hierarchy, and a stronger aversion for radical institutional innovations (Gorodnichenko & Roland, 2021). In turn, democratic institutions reduce corruption and the risk of property expropriation and improve bureaucratic quality and the rule of law, which ultimately contributes to increasing state capacity (Grassi & Memoli, 2016; Wang & Xu, 2018).

The results of the paper indicate that the intensity of UV-R is a strong predictor of cross-country differences in state capacity. Namely, countries with a higher degree of UV-R exposure tend to have weaker states. This finding remains unaffected after controlling for different variables that may be correlated with both UV-R and state capacity,

[2]The correlation coefficient between both variables is above −0.95.

including an extensive set of geographical, historical and contemporary factors. The observed link between sunlight and state capacity is not driven by potential outliers and is robust to the employment of alternative measures of state capacity, estimation methods and other sensitivity checks. Consistent with the arguments laid down above, the analysis also reveals that the individualistic–collectivist dimension of culture acts as a transmission channel that connects UV-R and state capacity. The estimates show that a lower degree of UV-R exposure leads to the adoption of individualistic values, which in turn promote the development of state capacity.

The present paper is related to several strands of literature. First, this research contributes to the empirical literature on the determinants of state capacity (Dincecco & Prado, 2012; Grassi & Memoli, 2016; Jimenez-Ayora & Ulubaşoğlu, 2015; Wang & Xu, 2018). As mentioned above, this literature has identified various factors that affect state capacity, but none of these prior studies have investigated the potential influence of UV-R exposure and the individualism–collectivism divide on state capacity. Second, this work also complements a recent body of research that examines the effect of UV-R exposure on various aspects such as economic performance or institutional quality (Andersen et al., 2016; Ang et al., 2018; Fredriksson & Mohanty, 2021; Vu, 2021). Third, this paper is also related to the literature that emphasizes the endogeneity of culture (Alesina et al., 2013; Bisin & Verdier, 2001; Galor & Özak, 2016; Michalopoulos & Xue, 2021) and its effects on comparative development (Ang et al., 2021; Gorodnichenko & Roland, 2017, 2021; Mokyr, 2016).

The remainder of the paper is structured as follows. After this introduction, Section 2 puts forward the reasons why the intensity of UV-R should affect state capacity. Section 3 describes the main measures used in the paper to quantify the level of UV-R exposure and the degree of state capacity in the various countries. Section 4 provides evidence of a reduced-form relationship between UV-R and state capacity, as well as an extensive set of robustness tests that confirm the observed association. In order to complement these findings, Section 5 examines the role of the individualistic-collectivist dimension of culture as a potential transmission channel linking UV-R and state capacity. The last section summarizes the main conclusions of the paper.

2 | WHY MIGHT UV-R EXPOSURE INFLUENCE STATE CAPACITY?

According to Lucas et al. (2008), there exist two main health risks associated with excessive UV-R exposure. The first is the increased risk of several types of skin cancers, including malignant melanoma, basal cell carcinoma and squamous cell carcinoma. However, in order to protect the skin from damage by UV-R, natural selection has modified human skin pigmentation in the aftermath of the prehistoric exodus of Homo sapiens out of Africa, leading to a balance between harmful and beneficial effects (i.e., boosting vitamin D levels) of sunlight. As a result, in regions with higher exposure to UV-R skin colour turned darker, while it became lighter in regions with lower UV-R levels (Diamond, 2005). Therefore, while excessive UV-R exposure is undoubtedly a major cause of skin cancers, there is unlikely to be a direct association between the incidence of this variety of cancers and cross-country differences in state capacity.

The second type of health risk identified by Lucas et al. (2008) is eye disease. Among the various forms of eye disease, cataracts are particularly important given that they are the leading cause of preventable blindness worldwide (Bastawrous et al., 2019; Pascolini & Mariotti, 2012). According to estimates from the Global Burden of Disease Study, in 2020, between 12.7 and 18 million people aged 50 and older were blind in the world due to cataracts, and between 67.2 and 91.4 million suffered from moderate or severe visual impairment as a result of the disease (Steinmetz et al., 2021). Cataracts are caused by the clouding or opacity of the lens of the eye, which can lead to impaired vision and ultimately blindness. The risk of developing this condition is known to increase with advancing age and is often considered a normal part of the aging process (Athanasiov et al., 2008; Cedrone et al., 1999). This reflects the cumulative effect over a lifetime of certain risk factors, such as UV-R exposure (Delcourt et al., 2000; Yu et al., 2016). In fact, there is well-documented evidence in the medical literature that supports a positive association between UV-R exposure and the development of cataracts. Numerous epidemiological studies have demonstrated the impact of excessive UV-R exposure on the formation of cataracts (West et al., 1998; Zhu et al., 2015), confirming the findings of animal models (Ayala et al., 2000; Meyer et al., 2005; Zhang et al., 2012). However, there is not yet a similar consensus on the effect of UV-R on other eye diseases such as pterygium or macular degeneration (Andersen et al., 2016; Lucas et al., 2008).

Visual impairment caused by cataracts has been shown to have a negative impact on the quality of life of those affected by this condition, and this effect may have been even greater in the past, when effective cataract surgery was unavailable (Ademola-Popoola et al., 2010; Boagey et al., 2022). This raises the possibility that the intensity of UV-R exposure, which is closely linked to the incidence of cataracts as mentioned above, may have contributed to the development of certain cultural values over time. Namely, Fredriksson and Mohanty (2021) argue that populations located in areas with higher levels of UV-R exposure tend to exhibit a greater degree of collectivism due to the impact of visual impairment caused by cataracts. According to these authors, there are two main reasons why cataracts may influence the individualistic–collectivist dimension of culture. The first one has to do with the idea that a higher risk of eye disease generates uncertainty and a preference for risk aversion, increasing the relevance of kinship networks as an insurance mechanism against the negative consequences of visual impairment and leading ultimately to the emergence of collectivist values. Throughout human history, informal solidarity networks have played a key role in situations in which formal institutions are weak or absent, and individual survival is threatened by a debilitating chronic illness, such as cataracts in preindustrial societies (Fafchamps, 1992). For instance, Spikins et al. (2018) point out that Neanderthals already provided medical treatment and healthcare as part of a social context of strong pro-social bonds. In the same vein, Fafchamps and Gubert (2007) show how gifts between network partners respond to differences in health status in rural Philippines.

Furthermore, Fredriksson and Mohanty (2021) identify an additional pathway linking cataracts and the individualism–collectivism cleavage. As pointed out by these authors, although cataracts are not contagious, they may be perceived by others as a sign of potential health threat, either consciously or unconsciously (Nussinson et al., 2018; Wu & Chang, 2012). According to the parasite-stress theory developed by Fincher et al. (2008) and Thornhill et al. (2009), this suggests that communities located in regions with higher cataract prevalence may tend to adopt collectivist values as a defence mechanism with an in-group conservative bias against foreigners and outside influence, putting stronger limits on individual behaviour. In line with this, Navarrete and Fessler (2006) find through survey data that ethnocentric attitudes increase as a function of perceived disease vulnerability. Consistent with these arguments, Fredriksson and Mohanty (2021) provide evidence showing that countries with higher levels of UV-R exposure, where the prevalence of cataracts is also greater, tend to have a more collectivist culture, with less importance placed on individualistic values. These authors also check that this relationship between UV-R exposure and culture holds using individual-level data and evidence from preindustrial societies.

The individualism–collectivism cleavage is traditionally considered as the most important source of cross-cultural variation (Heine, 2007; Kashima & Kashima, 2003; Kyriacou, 2016; Oyserman et al., 2002), and numerous studies have demonstrated its importance for different economic and political outcomes (Ang et al., 2021; Gorodnichenko & Roland, 2017, 2021; Nikolaev et al., 2017). However, as far as I am aware, the possible effect of the individualistic–collectivist dimension of culture on state capacity has received no attention in the literature. Nevertheless, there are various reasons to believe that this cultural trait could affect the state's ability to achieve its objectives and implement policies. For instance, using information from the Ethnographic Atlas, Enke (2019) shows that societies with strong kinship ties are more likely to have hierarchical structures at the village level but less-developed institutions at the supra-tribal level. This is consistent with the idea that in collectivist societies, effective cooperation takes place within cohesive in-groups, whereas people outside the group are distrusted (Alesina & Giuliano, 2014; Moscona et al., 2017). In contrast, individualistic societies must set up large-scale, impersonal institutions to enforce cooperative behaviour in social dilemmas such as public good provision or bilateral trade (Enke, 2019), which ultimately fosters the development of state capacity (Besley & Persson, 2009; Enke, 2019). At the same time, disagreements are more likely to be solved through negotiation in countries with individualistic values, in which the risk of intergroup conflict is lower (Hofstede, 2011; Thornhill & Fincher, 2014).[3] Indeed, the evidence provided by Ezcurra (2021) indicates that individualistic values contribute to a more stable political environment. This is potentially important, because internal political stability plays a critical role in building state capacity (Besley & Persson, 2008, 2009, 2010).

Democracy is another potential mechanism that may connect the individualistic–collectivist dimension of culture with state capacity. Beginning with the contribution of Almond and Verba (1963), the political science literature has highlighted the significance of self-expression, a fundamental individualistic value, as an important determinant of democratic institutions. In contrast, authoritarian regimes are more likely in societies in which prevail collectivist values such as the respect for authority and hierarchy. As pointed out by Inglehart and Welzel (2005, p. 271), 'effective democracy is not simply a matter of institutional arrangements; it reflects deep-rooted normative commitments', including a civic commitment that prioritizes individual freedom over collective discipline and civic autonomy over state authority (Ang et al., 2021). The positive impact of individualistic values on democracy is empirically confirmed by Ang et al. (2021) and Gorodnichenko and Roland (2021). In turn, democracy may also affect state capacity. The traditional argument in the political science literature is that state capacity is considered a precondition for the development of democratic institutions (Fukuyama, 2014; Kaplan, 1997). Nevertheless, some authors argue that the greater political accountability in a democratic system can reduce corruption, mitigate the risk of property expropriation and strengthen bureaucratic quality and the rule of law, ultimately leading to an increase in overall state capacity (Adserà et al., 2003; Grassi & Memoli, 2016). In fact, Wang and Xu (2018) find a positive causal effect of democracy on state capacity in a global panel of countries over 50 years.

Taken together, the various arguments laid down in this section point to the existence of a negative relationship between UV-R and state capacity. Specifically, according to the previous discussion, we can formulate the following hypotheses:

Hypothesis 1. The degree of UV-R exposure has a negative effect on state capacity. In other words, countries with lower levels of UV-R exposure tend to have stronger and more effective states.

Hypothesis 2. The individualistic–collectivist dimension of culture acts as a transmission channel that connects UV-R exposure with state capacity. Namely, a lower degree of UV-R exposure leads to the adoption of individualistic values, which in turn contribute to the development of state capacity.

In the rest of the paper, I aim to empirically test the validity of these hypotheses.

3 | MEASURING STATE CAPACITY AND UV-R EXPOSURE

This section briefly describes the key variables used in the paper to capture the level of state capacity and the intensity of UV-R exposure across different countries. The Supporting Information provides detailed definitions and data sources for all the additional variables employed in the empirical analysis, as well as several summary statistics (Table A1).

The present research requires a cross-country measure of state capacity. With this aim, I rely on the most recent version of the State Capacity Index (HSI) developed by Hanson and Sigman (2021), which is one of the most popular indicators of state capacity in comparative cross-country studies (Vaccaro, 2023).[4] The HSI has two key

[3]Using data from a quasi-experimental study, LeFebvre and Franke (2013) find that subjects with higher levels of individualism usually are more rational in their decision-making processes in a context of interactive conflict resolution, while those with higher levels of collectivism tend to be more dependent and prioritize in the negotiation the interests of their group.
[4]In Section 4.3.2, I examine how the use of alternative measures of state capacity affects the main results of the paper.

advantages for empirical analyses in comparison with other alternative indices. First, the measure developed by Hanson and Sigman (2021) is characterized by its broad geographical coverage, which is particularly important given the aim of the present study. Second, and most importantly, the HSI explicitly accounts for the multi-dimensional nature of the concept of 'state capacity', and it is therefore more comprehensive than measures that focus solely on a single dimension. Namely, in line with the unifying approach proposed by Berwick and Christia (2018), the HSI is based on the three dimensions of state capacity that are 'minimally necessary to carry out the functions of contemporary states, and [...] most plausibly distinct from one another' (Hanson & Sigman, 2021, p. 1498): extractive capacity, coercive capacity and administrative capacity. These three dimensions of state capacity are captured by 21 variables drawn from different sources (see Table A2 in the Supporting Information for further information) and synthesized into a single aggregate indicator through Bayesian latent variable analysis.[5] Figure 2 displays the spatial distribution of the HSI in 2000. According to the map, there exists a striking variation in the degree of state capacity across the world. While sub-Saharan Africa, South Asia and Central Asia host most of the countries with the lowest values of the index, the strongest states are typically found in Europe, North America and Oceania (Besley & Persson, 2011).

The UV-R measure used in the paper is taken from Andersen et al. (2016) and is based on data provided by NASA. Using satellite data, NASA has developed a measure which captures the intensity of UV-R at a specific location, taking into account various inputs such as the total ozone column, solar zenith angle, distance between the earth and sun, surface irradiance under clear skies, cloud optical thickness and cloud attenuation factor. This measure reflects the level of sunburn exposure in a specific location caused by the intensity of UV-R and is available in the form of geographical grids and daily rasters with pixel size of 1° latitude by 1° longitude. Relying on data for daily local-noon irradiances for 1990 and 2000, Andersen et al. (2016) calculate the average yearly UV-R levels for each country.[6] Following Andersen et al. (2016), the analysis below uses the average UV-R index for each country for the years 1990 and 2000. The employment of average data is motivated by the fact that the intensity of UV-R on the earth's surface has remained relatively constant over the past two billion years (Cockell & Horneck, 2001). Indeed, the correlation coefficient between the UV-R measure in 1990 and 2000 is above .99. Figure 3 depicts a world map showing the distribution of UV-R levels. The countries with the highest levels of UV-R exposure are Peru, Bolivia and Yemen, while the lowest values are experienced by Norway, Finland and Estonia.

As pointed out in the introduction, in the present paper, I am interested in examining the link between UV-R and state capacity. At a first insight into this relationship, countries are divided into three equally sized groups according to the values of the measure of UV-R described above. Figure 4 shows the distribution of the index of state capacity in the three groups. As can be seen, countries that are more exposed to sunlight generally have weaker states. In contrast, countries with lower intensities of UV-R are characterized as a whole by stronger states. The visual impression derived from Figure 4 is corroborated by the information provided by Figure A2 in the Supporting Information. In fact, the differences in the mean value of the measure of state capacity across the various groups of countries are statistically significant at the 1% level, as indicated by the corresponding *F* test.

When considering these findings, however, it is important to note that this analysis is merely descriptive, and the results discussed above may ultimately be sensitive to the specific number of groups used to perform the country classification. Furthermore, the information presented in Figures 4 and A2 should be interpreted with caution, because omitted variables may also affect the apparent link between UV-R and state capacity. Bearing this in mind, in the next sections, I will conduct a more appropriate statistical analysis to investigate the extent to which the degree of UV-R exposure affects the state's ability to implement its goals and policies.

[5]See Hanson and Sigman (2021) for a detailed description of the methodology.
[6]See Andersen et al. (2016, SI pp. 2–3) for further details.

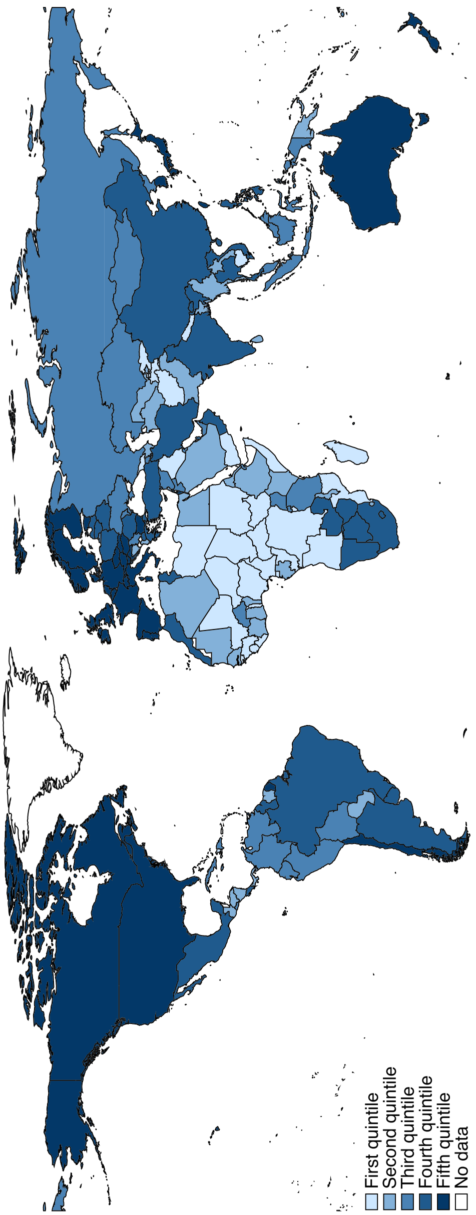

FIGURE 2 Spatial distribution of state capacity (HSI). [Colour figure can be viewed at wileyonlinelibrary.com]

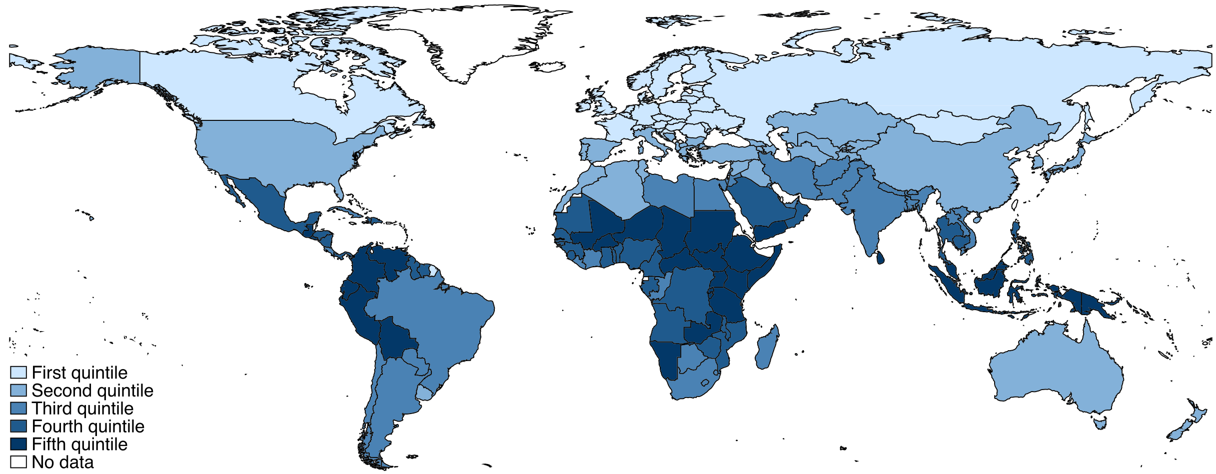

FIGURE 3 Spatial distribution of UV-R. [Colour figure can be viewed at wileyonlinelibrary.com]

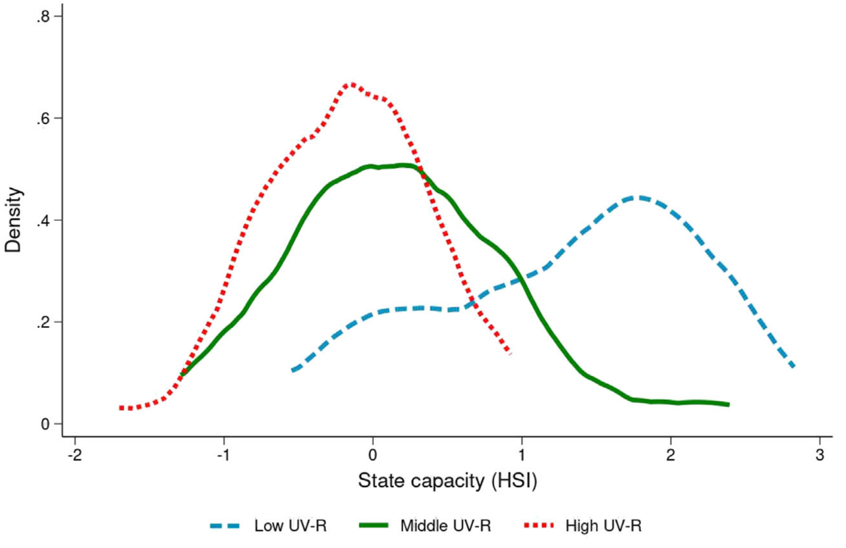

FIGURE 4 UV-R and state capacity. *Note*: The kernel density estimates are generated using an Epanechnikov kernel and the optimal smoothing parameter suggested by Silverman (1986, p. 48). [Colour figure can be viewed at wileyonlinelibrary.com]

4 | THE LINK BETWEEN UV-R AND STATE CAPACITY

4.1 | Model specification

In order to explore the reduced-form relationship between the degree of UV-R exposure and state capacity, I use the following model:

$$SC_i = \alpha + \beta \log(UV_i) + X_i' \varphi + \delta_r + \varepsilon_i, \tag{1}$$

where SC_i represents the average value of the state capacity index constructed by Hanson and Sigman (2021) in country *i* over the period 2000–2015, UV_i is the measure of UV-R exposure described in Section 3, X_i stands for a vector of variables controlling for additional factors assumed to influence on state capacity and UV-R, δ_r is a vector of regional fixed effects to capture unobserved heterogeneity[7] and ε is an heteroskedastic error term. The coefficient of interest throughout the paper is β, which captures the impact of UV-R exposure on state capacity. According to Hypothesis 1, I expect $\beta < 0$.

The use in the analysis of a cross-sectional set-up is primarily motivated by the high degree of persistence exhibited by the measure of state capacity over time. Namely, the correlation coefficient between the values of the HSI in 2000 and 2015 is .92. This suggests that the results of estimating model (1) are unlikely to depend on using an average of the HSI. In order to provide further evidence on this issue, in Section 4.3.4, I perform a robustness test that confirms that the relationship between the degree of UV-R exposure and state capacity is very similar across the various years of the period 2000–2015. The employment of a cross-sectional approach is also consistent with the standard estimation strategy adopted in earlier studies about the effect of UV-R on economic and institutional development (Andersen et al., 2016; Ang et al., 2018; Fredriksson & Mohanty, 2021; Vu, 2021). Indeed, as discussed

[7]The regional fixed effects are based on the World Bank's classification of countries, which includes North America, Latin America and the Caribbean, sub-Saharan Africa, Middle East and North Africa, Europe and Central Asia, South Asia and East Asia and Pacific.

in the previous section, the intertemporal changes in the intensity of UV-R over the last centuries have been very modest compared with the cross-country differences (Andersen et al., 2016; Cockell & Horneck, 2001). Model (1) is estimated for 143 countries, subject to data availability (see the Supporting Information for the list of countries).

The control variables in vector X have been selected in an attempt to minimize the risk that the estimate of β is capturing the influence from other determinants of state capacity that may also be correlated with UV-R. According to this strategy, I begin by controlling for absolute latitude and elevation. Figure 1 indicates that countries near the equator tend to have weaker states. One possible explanation for this apparent association between latitude and state capacity may have to do with the negative impact of tropical conditions on long-run development and state-building processes (Diamond, 1997; Gallup & Sachs, 2000; Olsson & Hibs, 2005). In turn, the elevation of a country above sea level may also affect state capacity. Indeed, Diamond (1997) points out the problems associated with the development of complex societies and state structures in mountainous regions. Controlling for absolute latitude and elevation is particularly relevant in our context because Figure 3 shows a significant latitude gradient in UV-R intensity, and high-altitude countries are also more exposed to UV-R. However, given that climatic conditions vary with both latitude and elevation, it is important to rule out any spurious association between UV-R and climatic conditions. To address this concern, I include additional control variables for average temperature and precipitation, the number of frost days per year and the share of a country's surface area located in the tropical climate zone.

Furthermore, vector X also includes an index of terrain ruggedness and the country's total area, two variables that may also affect state capacity. A rugged topography can increase the costs of cooperation, making it difficult to solve collective action problems and provide public goods, which is likely to constrain the development of state capacity (Jimenez-Ayora & Ulubaşoğlu, 2015). In the same line, a larger territory can be more challenging for the state to control. Using historical data, Stasavage (2009) shows that in Europe, smaller countries were more likely to have representative institutions and states with greater fiscal capacity, while Olsson and Hansson (2011) find a negative association between country size and rule of law in a sample of former colonies. The list of geographical controls in model (1) also includes the share of a country's total land area within 100 km of the coast or a navigable river as a proxy for trade costs, as well as an index of soil quality for agriculture. This latter variable, which is affected by climatic conditions, is used by Ashraf and Galor (2011) to control for agricultural productivity.

Population diversity may also be related to state capacity (Besley & Persson, 2011; Singh & Vom Hau, 2014). The literature shows that diversity is often associated with heterogeneous preferences across ethnolinguistic groups, which can have adverse effects on the provision of public goods and the efficiency of government (Alesina et al., 1999; Easterly & Levine, 1997; La Porta et al., 1999). Diversity may also lead to the formation of ethnic factions that compete with each other for resources and political power, making it difficult to develop effective state structures. At the same time, it is possible that the level of UV-R is eventually correlated with the degree of ethnolinguistic diversity, which can in turn be influenced by geographical factors (Ahlerup & Olsson, 2012; Michalopoulos, 2012). In fact, the degree of ethnolinguistic diversity is characterized by a remarkable latitude gradient, which is also observed in the spatial distribution of UV-R (see Figure 3). This raises the possibility that our key explanatory variable, the measure of UV-R, may simply be picking up the influence of ethnolinguistic diversity on state capacity. In order to address this issue, I include in the baseline specification two indices of ethnolinguistic fractionalization and polarization obtained from Desmet et al. (2012) and based on data on the genealogical relationships among linguistic groups.[8] Moreover, I also control for an ancestry-adjusted index of genetic diversity drawn from Ashraf and Galor (2013a), as the evidence provided by these authors shows that genetic diversity is a fundamental determinant of the degree of ethnolinguistic fractionalization and polarization (Ashraf & Galor, 2013b).

[8]These indices were chosen in order to maximize the number of countries included in the analysis. Nevertheless, Table A3 in the Supporting Information shows that the results remain unaltered when I use other alternative measures of population diversity such as the number of ethnic groups compiled by Fearon (2003), as well as several indices of ethnolinguistic fractionalization and polarization constructed by Esteban et al. (2012) and based on the classification of ethnic groups in Fearon (2003), and in the information about linguistic groups provided by the Ethnologue project.

4.2 | Baseline results

Table 1 presents the results obtained when different versions of model (1) are estimated via ordinary least squares (OLS) with heteroskedasticity-robust standard errors. Focusing on the main aim of the paper, the estimates reveal that the coefficient of the measure of UV-R is in all cases negative and statistically significant at the 1% level. This implies that countries with higher exposure to UV-R tend to have weaker states, which is consistent with the first hypothesis formulated in Section 2 and the preliminary evidence provided by Figures 4 and A2. The bivariate estimate in column 1 of Table 1 indicates that UV-R alone accounts for over 50% of the variation in state capacity across countries, which is a remarkable finding for a cross-country regression. Including the various controls described in Section 4.1 in model (1) does not alter the observed relationship between UV-R and state capacity, showing the robustness of this result and ruling out the possibility of a spurious correlation due to the omission of these covariates. This is particularly important given that, as pointed out above, the different controls included in the baseline specification may be correlated with both state capacity and UV-R. Therefore, the estimates indicate that UV-R is a relevant factor in explaining the cross-country variation in state capacity and is not merely capturing the effect of other geographical and climatic characteristics. Figure 5 illustrates the reduced-form link between sunlight and state capacity with a partial regression plot based on all covariates.

Table 1 also shows that the association between latitude and state capacity observed in Figure 1 disappears once the intensity of UV-R is included in the analysis. That being said, it is important to note that while the controls are jointly significant (p value = .000), they have a modest effect on the partial correlation between UV-R and state capacity. Indeed, the coefficient of the measure of UV-R exposure remains relatively stable in terms of both magnitude and statistical significance across the various specifications of model (1) included in Table 1. Nevertheless, the geographical controls are highly correlated with UV-R. Table A4 in the Supporting Information reveals that when all the geographical controls are included simultaneously, they account for 94% of the cross-country variation in UV-R exposure.

The regression coefficient from the preferred specification in Table 1 (column 5) indicates that a 25% increase in the degree of UV-R exposure is associated with a 0.40-point decrease in the measure of state capacity, which is approximately the difference between the 50th and the 30th percentile of the cross-country distribution of state capacity. To get a more accurate idea of the magnitude of this effect, let us consider the case of Japan. Japan is a country characterized by a relatively low level of sunlight ($UV = 136.62$) and a strong state ($SC = 1.81$). The estimates reveal that if Japan had a degree of UV-R exposure equal to that of Uganda ($UV = 290.65$), its measure of state capacity would decrease by 1.35 points, placing it below the sample mean. These figures suggest that UV-R exerts a quantitatively relevant impact on state capacity.

The robustness of the coefficient estimates on UV-R to the inclusion of additional controls provides a first piece of evidence that omitted variables alone are not driving the observed relationship between sunlight and state capacity. However, although model (1) incorporates an extensive set of controls, the possibility of omitted variables cannot be completely ruled out. In order to examine in greater detail the importance of this potential problem, I use the methodology proposed by Altonji et al. (2005) and adapted to the continuous case by Bellows and Miguel (2009). The method is based on the idea that the amount of selection on the observed explanatory variables in a model provides a guide on the amount of selection on the unobserved variables. This allows for an assessment of how much larger the bias from unobserved heterogeneity needs to be compared with the bias from selection on observables to explain away the estimated coefficient of the variable of interest. This can be formalized by examining the magnitude of the absolute value of the ratio $\hat{\beta}^F/(\hat{\beta}^R - \hat{\beta}^F)$, where $\hat{\beta}^F$ is in our case the estimated coefficient on the measure of UV-R from the full specification of model (1) (column 5 in Table 1) and $\hat{\beta}^R$ is the estimated coefficient on this variable in the specification without controls (column 1 in Table 1). The resulting ratio shows that selection on unobservables would have to be nearly four times larger than selection on observables to fully attribute the estimated coefficient on the measure of UV-R to selection on unobservables. This result indicates that it seems rather unlikely that the relationship between UV-R and state capacity shown in Table 1 can be driven by unobserved heterogeneity.

TABLE 1 UV-R and state capacity: Baseline results.

	State capacity				
	(1)	(2)	(3)	(4)	(5)
Log UV-R	−1.316***	−1.288***	−1.107***	−1.367***	−1.782***
	(0.098)	(0.135)	(0.314)	(0.344)	(0.399)
Absolute latitude		0.020	0.006	−0.065	−0.079
		(0.073)	(0.086)	(0.083)	(0.081)
Elevation			−0.035	−0.041	0.038
			(0.089)	(0.090)	(0.107)
Temperature			−0.074***	−0.060**	−0.036
			(0.025)	(0.026)	(0.029)
Precipitation			0.250*	0.013	−0.098
			(0.135)	(0.149)	(0.160)
Frost days			−0.068***	−0.065***	−0.064***
			(0.018)	(0.017)	(0.017)
Tropical climate			−0.665***	−0.561**	−0.591**
			(0.236)	(0.245)	(0.254)
Terrain ruggedness			0.045	0.071	0.083
			(0.064)	(0.066)	(0.072)
Area			0.109*	0.082	0.013
			(0.061)	(0.064)	(0.064)
Distance to the nearest waterway			0.460*	0.345	0.283
			(0.243)	(0.241)	(0.278)
Land suitability for agriculture			0.380	0.293	0.244
			(0.250)	(0.238)	(0.302)
Ethnolinguistic fractionalization				−0.013	0.122
				(0.268)	(0.314)
Ethnolinguistic polarization				−0.292	−0.260
				(0.281)	(0.321)
Genetic diversity				−6.944***	−4.775
				(2.503)	(3.541)
Regional fixed effects	No	No	No	No	Yes
R^2	.512	.512	.638	.662	.687
Observations	143	143	143	143	143

Note: OLS estimates. The dependent variable is in all cases the state capacity index constructed by Hanson and Sigman (2021) (see Section 3 for further details). All regressions include a constant term (not displayed). Heteroskedasticity-robust standard errors in parentheses.
*$p < .1$, **$p < .05$, and ***$p < .01$.

In our case, the ratio described above is negative, which occurs when the observable controls are on average positively correlated with UV-R and negatively with state capacity (or vice versa). This suggests that the estimates in Table 1 are likely to be biased downward, assuming that the unobservables have similar correlation patterns as the

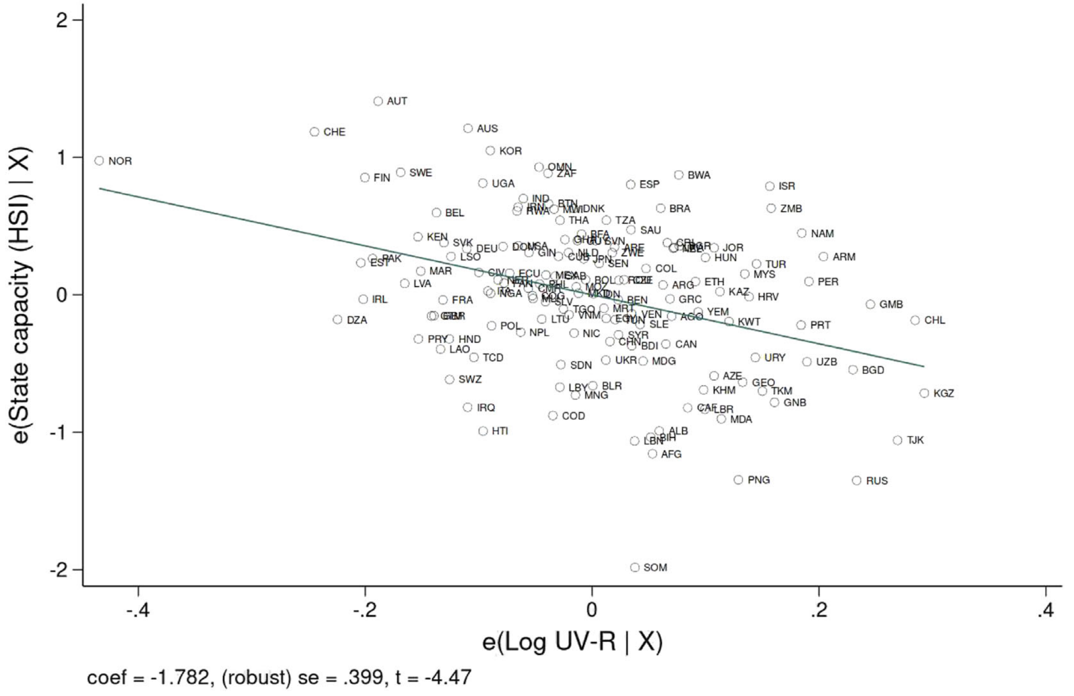

FIGURE 5 UV-R and state capacity: Partial regression plot. *Note*: Partial regression plot conditional on the full set of controls described in Section 4.1 and regional fixed effects.

observable controls. In order to confirm this issue, I now apply the approach proposed by Oster (2019). Building on the earlier work of Altonji et al. (2005) and Oster (2019) employs coefficient stability and R^2 movements when the observable controls are introduced in the model to assess the extent to which the results are robust to omitted variable bias. Using this methodology, I calculate the bias-adjusted treatment effect, which is -2.33.[9] This value implies an impact of UV-R on state capacity greater than that shown in column 5 of Table 1, confirming that the OLS estimates are, if anything, biased downward. I interpret this as a strong sign of robustness.[10]

4.3 | Robustness checks

Consistent with Hypothesis 1, the analysis has so far revealed the existence of a negative and statistically significant relationship between UV-R exposure and state capacity. In this section, I explore the robustness of this finding.

[9]Assuming that observable and unobservable controls are equally important in accounting for the association between UV-R and state capacity, the bias-adjusted treatment effect, $\hat{\beta}^*$, is calculated according to the following formula (Oster, 2019):

$$\hat{\beta}^* = \hat{\beta}^F - \left(\hat{\beta}^R - \hat{\beta}^F\right)\frac{R_{max} - R^F}{R^F - R^R},$$

where R_{max} is the R^2 of a hypothetical regression of state capacity on UV-R that includes both the observable and unobservable controls. In turn, R^F is the R^2 of the full specification of model (1), while R^R is the R^2 obtained from regressing state capacity on UV-R without controls. Following Oster (2019), I assume that $R_{max} = 1.3R^F$. Nevertheless, the conclusions are similar if $R_{max} = 1\left(\hat{\beta}^* = -2.62\right)$.

[10]I consider that reverse causality is not a concern in this context, as there is no reason to assume that state capacity might influence the intensity of UV-R. In fact, the direct evidence provided by Andersen et al. (2016, SI pp. 3–5) highlights that (local) economic activity does not influence (local) UV-R.

4.3.1 | Outliers and influential countries

As a first robustness test, I examine the potential impact of outliers and influential observations on the estimates in Table 1. This may be important, as Figure 5 raises the possibility that the observed association between UV-R and state capacity could be partially driven by two countries, Norway and Somalia. However, column 1 of Table A5 in the Supporting Information shows that the effect of UV-R on state capacity remains virtually unchanged when these two countries are removed from the sample. Moreover, I calculate each country's DFBETA statistic for the index of UV-R, which is a measure of the difference in the estimated coefficient for this variable (scaled by the estimated standard error of the coefficient) when the country in question is included and when it is excluded from the sample. According to the rule of thumb proposed by Belsley et al. (1980), I remove from the analysis all countries for which $|DFBETA_i| > 2/\sqrt{n}$, where n is the sample size. When this cut-off is applied, 12 countries are influential in the specification of model (1) with the full set of controls. Column 2 of Table A5 reveals that the coefficient of the measure of UV-R continues to be negative and statistically significant at the 1% level once these countries are dropped from the analysis. To confirm this finding, I also use median regression as an alternative way to identify the possible influence of potential outliers. Column 3 of Table A5 indicates that the observed link between UV-R exposure and state capacity holds when this method is used to estimate model (1).

I now investigate the impact of the countries with the lowest and highest levels of UV-R exposure and state capacity on the results. To do so, I remove from the sample the countries whose measures of UV-R exposure and state capacity fall below (above) the 5th (95th) percentile of the distribution of these variables. Columns 4–7 of Table A5 indicate that removing these countries does not affect the observed relationship between UV-R exposure and the state's ability to implement its goals and policies.

4.3.2 | Alternative measures of state capacity

The results presented in Table 1 could be influenced by the choice of the specific measure of state capacity used as the dependent variable in model (1). In order to check whether this is the case, I now repeat the previous analysis using alternative measures of state capacity instead of the index proposed by Hanson and Sigman (2021). To that end, I utilize four aggregate indicators that, like the HSI, are designed to measure state capacity in a comprehensive manner, taking into account its multidimensional nature (Vaccaro, 2023). The four indicators are the State Fragility Index (SFI) developed by the Centre for Systematic Peace, the Index of State Capacity constructed by O'Reilly and Murphy (2022) (OMI), the Fragile States Index (FSI) produced by the Fund for Peace and the Government Effectiveness Index (GEI) included in the World Bank's Worldwide Governance Indicators. The SFI measures the state's 'capacity to manage conflict, make and implement public policy, and deliver essential services' (Marshall & Elzinga-Marshall, 2017, p. 51). The OMI is based on 'data from the Varieties of Democracy dataset on fiscal capacity, a state's control over its territory, the rule of law, and the provision of public goods used to support markets' (O'Reilly & Murphy, 2022, p. 713). The FSI aims to provide information about 'a state's capacities and pressures which contribute to levels of fragility and resilience' (Fund for Peace, 2019, p. 33). In turn, the GEI captures 'perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies' (Kaufmann et al., 2011, p. 223).

Table 2 shows the results obtained when the full specification of model (1) is estimated again, using as the dependent variable the various indicators of state capacity described above, instead of the index of Hanson and Sigman (2021). In all cases the coefficient of the measure of UV-R exposure remains negative and significant. This is consistent with the information provided by Table 1 and indicates that the observed relationship between UV-R and state capacity does not depend on the specific measure used to capture the state's ability to attain its policy goals.

TABLE 2 Alternative measures of state capacity.

	State Fragility Index (SFI)[a] (1)	State Capacity Index (OMI) (2)	Fragile States Index (FSI)[a] (3)	Government effectiveness (GEI) (4)
Log UV-R	−28.440***	−2.848***	−48.129***	−1.801***
	(9.822)	(0.692)	(10.595)	(0.391)
Geographical controls	Yes	Yes	Yes	Yes
Population diversity controls	Yes	Yes	Yes	Yes
Regional fixed effects	Yes	Yes	Yes	Yes
R^2	.746	.526	.669	.660
Observations	143	143	143	143

Note: OLS estimates. See Section 4.3.2 and the Supporting Information for further details about the various measures of state capacity. All regressions include a constant term (not displayed), as well as the complete set of geographical and population diversity controls described in Section 4.1. Heteroskedasticity-robust standard errors in parentheses.
[a]The index has been rescaled, so that higher values indicate higher state capacity.
**p* < .1, ***p* < .05, and ****p* < .01.

To complement the information provided by these aggregate indicators, I repeat the previous analysis using several measures focused on the two broad types of state capabilities identified by Besley and Persson (2009, 2010, 2011): fiscal capacity and legal capacity. Fiscal capacity has to do with the existence of the necessary infrastructure—in terms of administration, monitoring and enforcement—that allows the state to extract revenue from broad tax bases, while legal capacity refers to the state's ability to provide regulation and legal services, such as the protection of property rights or the enforcement of contracts (Besley & Persson, 2009, 2010, 2011; Dincecco & Katz, 2016; Jimenez-Ayora & Ulubaşoğlu, 2015; Tilly, 1990). To quantify the extractive capacity of the state, I use the ratio of total tax revenue to GDP, the share of revenue from income taxes in total taxes and a measure of fiscal capacity drawn from the Varieties of Democracy dataset capturing the extent to which the state is able to fund itself through taxes of greater administrative complexity. To measure legal capacity, I employ three different proxies. From the World Bank's Worldwide Governance Indicators, I take the indices of Rule of Law and Regulatory Quality. Furthermore, I also use an indicator of impartial public administration included in the Varieties of Democracy dataset. The results of this additional robustness test are presented in Table A6 in the Supporting Information, and they reveal a negative and significant relationship between UV-R and the various measures just described.[11]

4.3.3 | Historical and proximate determinants of state capacity

As mentioned earlier, countries with higher UV-R exposure may have faced a historical disadvantage in developing complex societies and centralized states due to their geographical characteristics (Andersen et al., 2016; Diamond, 1997). This disadvantage may have persisted over time, resulting in weaker states in these countries at present (Bockstette et al., 2002). In the previous analysis, I have addressed this concern by controlling for an extensive set of geographical factors that may be relevant for long-run development. To further investigate this issue, I

[11]Table A7 in the Supporting Information displays the pairwise correlations between the various indicators employed in this section and the state capacity measure proposed by Hanson and Sigman (2021).

now control for the timing of the Neolithic Revolution, which is considered a key catalyst for state formation (Boix, 2015; Borcan et al., 2021; Diamond, 1997). According to the traditional argument, the Neolithic Revolution, which began around 10,000 BCE in the Fertile Crescent in the Middle East and led to the transition from a hunter-gatherer lifestyle to sedentary agriculture, played a crucial role in the institutionalization of power relations within societies and allowed polities to increase their fiscal capacity through the collection of tax revenues (Ang, 2015). To complement the information provided by the timing of the Neolithic Revolution, I also add to the baseline specification an index constructed by Borcan et al. (2018) that captures the presence of state institutions within modern-day country borders from 3500 BCE forward. Moreover, I also control for other historical measures of economic development in the preindustrial era that have been found to be relevant in explaining current outcomes such as population density, urban population and the level of technology adoption in 1500 CE (Acemoglu et al., 2002; Comin et al., 2010). The results of this analysis are presented in columns 1–5 of Table 3. With the only exception of the level of urbanization in 1500 CE, none of these variables appear to have a significant effect on current state capacity. Importantly, their inclusion in the analysis does not modify the observed link between UV-R and state capacity. The size of the estimated coefficient of the measure of UV-R exposure is in fact very similar to that of the baseline specification in all cases.

One potential concern regarding the interpretation of the results in Table 1 has to do with the possibility that the measure of UV-R exposure could be spuriously correlated with non-UV-R related diseases that tend to be more prevalent in areas of the world with higher exposure to UV-R. To investigate this issue, I test the robustness of the results by adding to the baseline specification an index of historical pathogen prevalence derived from Murray and Schaller (2010) and based on epidemiological data. The index covers seven infectious diseases (malaria, typhus, dengue, leishmaniasis, schistosomiasis, trypanosomiasis and filariasis) and reflects the pathogen environment populations had to face in the early-to-mid 20th century. As a result, the index is not affected by the health advancements that occurred in many countries after the Second World War, which reduces the potential for reverse causality between contemporary epidemiological data and state capacity. As shown in column 6 of Table 3, there is a negative and significant association between historical pathogen prevalence and state capacity. This means that countries with higher historical pathogen burden tend on average to have weaker states. However, including this additional control variable does not alter the previously observed relationship between UV-R intensity and state capacity.

A large and influential body of research has highlighted the long-lasting effects of European colonization on economic and institutional outcomes (Acemoglu et al., 2001, 2002; Dell, 2010; Olsson, 2009), which suggests that colonial legacies may also influence state capacity (Dincecco & Wang, 2022; Kohli, 2004). This may be potentially important, as the intensity of UV-R is 108% higher in former colonies due to their geographical location. In view of this, there exists the possibility that the measure of UV-R could actually be capturing the effects of European colonization on state capacity. In order to determine whether this is the case, I include in model (1) a dummy variable that takes the value of one if the country in question was ever colonized by European powers and zero otherwise. Column 7 of Table 3 indicates that this variable does not contribute to explaining the observed variation in present-day state capacity once I control for UV-R exposure and the remaining covariates. Nevertheless, the observed relationship between UV-R and state capacity still holds. The specification in column 7 also includes an interaction between the UV-R measure and the dummy variable for former colonies, which confirms that UV-R does not have a differential effect on state capacity in former colonies.

State capacity may also be affected by the process of political and economic transition experienced by former communist countries (Beck & Laeven, 2006; Fritz, 2003).[12] In fact, new states were established in the former Soviet Republics and former Yugoslavia, as well as in Slovakia. In many of these recently formed countries, the transition process led to weak states with low-quality institutions and problems in maintaining public infrastructure and services, especially in rural areas (Carothers, 2002; Fritz, 2003). While the situation has improved in recent years in some countries, in others, such as Turkmenistan or Azerbaijan, low levels of state capacity still persist. Nevertheless,

[12] I thank an anonymous referee for drawing my attention to this point.

TABLE 3 Robustness to controlling for historical determinants of state capacity.

	State capacity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log UV-R	−1.672***	−1.714***	−1.713***	−1.373***	−1.785***	−1.530***	−1.786***	−1.161***
	(0.433)	(0.417)	(0.406)	(0.503)	(0.487)	(0.414)	(0.398)	(0.357)
Neolithic transition timing	−0.182							
	(0.151)							
State history		0.204						
		(0.511)						
Population density in 1500 CE			0.036					
			(0.061)					
Urbanization in 1500 CE				0.021*				
				(0.012)				
Technology adoption in 1500 CE					−0.092			
					(0.390)			
Historical pathogen prevalence						−0.325**		
						(0.160)		
Former colony							−1.185	
							(3.371)	
Log UV-R × Former colony							0.228	
							(0.628)	
Transition country								−1.362
								(1.320)
Log UV-R × Transition country								0.117
								(0.283)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population diversity controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 3 (Continued)

	State capacity							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.712	.697	.692	.739	.773	.697	.687	.731
Observations	134	138	142	80	107	143	143	143

Note: OLS estimates. The dependent variable is in all cases the state capacity index constructed by Hanson and Sigman (2021) (see Section 3 for further details). All regressions include a constant term (not displayed), as well as the complete set of geographical and population diversity controls described in Section 4.1. Heteroskedasticity-robust standard errors in parentheses.

*$p < .1$, **$p < .05$, and ***$p < .01$.

column 8 of Table 3 shows that, conditional on UV-R and the baseline controls, state capacity levels are not different in transition countries. Importantly, UV-R continues to have a negative and significant impact on state capacity. Furthermore, the coefficient estimate for UV-R interacted with a dummy variable for transition countries is not statistically significant, which indicates that UV-R does not have a differential effect on state capacity in these countries.

As mentioned in the introduction, the literature has identified various proximate determinants of state capacity, including income per capita, democracy and internal and external conflicts (Besley & Persson, 2008, 2011; Dincecco & Prado, 2012; Wang & Xu, 2018). However, these factors have not been considered in the previous analysis, which could impact the observed link between UV-R and state capacity. To explore this possibility, I now include in the baseline specification the level of GDP per capita, a well-known democracy index from the Polity5 Project and the incidence of internal and external conflicts. It is important to note that the results of this analysis should be interpreted cautiously. Although I have used lagged values of these variables (see the Supporting Information for further details), the persistence of state capacity over time implies that they could be influenced by the state's ability to achieve its policy goals, potentially leading to a reverse causation problem (Andersen et al., 2014; Dincecco & Prado, 2012). Furthermore, these proximate determinants of state capacity are highly interdependent and are 'bad controls' in the sense that they can be considered as outcomes of UV-R exposure (Angrist & Pischke, 2009, p. 64). In fact, Andersen et al. (2016) and Ang et al. (2018) have shown that UV-R has a negative impact on economic activity and the quality of political institutions. These arguments explain why these proximate determinants of state capacity have not been included in the baseline specification of model (1). However, Table 4 reveals that the coefficient of the measure of UV-R exposure continues to be negative and statistically significant at the 1% level when I control

TABLE 4 Robustness to controlling for proximate determinants of state capacity.

	State capacity				
	(1)	(2)	(3)	(4)	(5)
Log UV-R	−0.879***	−1.311***	−1.639***	−1.756***	−0.726***
	(0.326)	(0.335)	(0.388)	(0.400)	(0.276)
GDP per capita	0.353***				0.265***
	(0.048)				(0.047)
Democracy		0.056***			0.038***
		(0.010)			(0.010)
Internal conflicts			−0.636**		−0.232
			(0.247)		(0.209)
External wars				−0.007	−0.504
				(0.033)	(0.478)
Geographical controls	Yes	Yes	Yes	Yes	Yes
Population diversity controls	Yes	Yes	Yes	Yes	Yes
Regional fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	.798	.744	.703	.694	.825
Observations	140	143	139	142	135

Note: OLS estimates. The dependent variable is in all cases the state capacity index constructed by Hanson and Sigman (2021) (see Section 3 for further details). All regressions include a constant term (not displayed), as well as the complete set of geographical and population diversity controls described in Section 4.1. Heteroskedasticity-robust standard errors in parentheses.

$^{*}p < .1$, $^{**}p < .05$, and $^{***}p < .01$.

for GDP per capita, democracy and the incidence of internal and external conflicts, confirming that the observed association between UV-R and state capacity is not driven by the omission of these variables. The results for the proximate determinants of state capacity are in general consistent with those reported in the literature. The estimates indicate that countries with higher GDP per capita and more democratic political systems tend to have stronger states. Meanwhile, the incidence of internal conflicts is negatively linked to state capacity. However, this later variable is not statistically significant in the regression that includes all the additional controls.

4.3.4 | Other robustness tests

As is typical in the literature, in the analysis conducted thus far, countries are treated as isolated units, ignoring possible interactions between them and assuming that observations are spatially independent. However, Figure 2 shows that the measure of state capacity is not randomly distributed across space. In contrast, there appear to be spatial clusters of countries with similar levels of state capacity, while there are relatively few cases where a country shows a markedly distinct performance from its neighbours. This suggests that the effectiveness of a state in one country may be influenced not only by its internal characteristics but also by the level of state capacity in neighbouring countries, which often share similar geographical and historical backgrounds, as well as ethnic and cultural ties. These spatial effects may arise for various reasons. For example, there is evidence that internal political instability, which is particularly detrimental to state capacity, often spreads across the borders of neighbouring countries (Bosker & de Ree, 2014; Grechyna, 2018). At the same time, in the context of the ongoing process of globalization, countries must compete with their neighbours to attract foreign capital and business (Kelejian et al., 2013). In this scenario, countries may have incentives to invest in state capacity in response to the decisions made by neighbouring countries. Additionally, when neighbouring countries have effective states, citizens in a country may be more likely to demand a strong state from their own politicians (Acemoglu et al., 2015). The potential existence of these spatial effects implies that model (1) may be misspecified and provide biased estimates of the effect of UV-R on state capacity. To examine whether spatial autocorrelation is driving the observed association between UV-R and state capacity, I re-estimate the baseline model using the Conley (1999) correction of the standard errors. To that end, I consider different cut-off distances (500, 1000, 1500, 2000 and 2500 km) above which spatial interactions between countries are assumed to be negligible. As shown in Table A8 in the Supporting Information, the Conley standard errors are very similar to the ordinary robust standard errors used thus far, and the previous findings regarding the impact of UV-R exposure on state capacity remain unaffected.

I also conduct several additional robustness tests that confirm the previous findings. Figure A3 in the Supporting Information indicates that the main results remain virtually unchanged when the dependent variable of model (1) is measured for each year between 2000 and 2015, which provides evidence of the persistence of the impact of UV-R on state capacity. Additionally, Table A9 in the Supporting Information shows the robustness of the results when an extended set of geographical controls is included in the baseline model and when an alternative definition of the regional fixed effects is used.

5 | UV-R AND STATE CAPACITY: THE ROLE OF CULTURE

The analysis conducted thus far shows that countries with higher UV-R exposure are more likely to have weaker states. As argued in Section 2, this result may be explained by the influence of UV-R exposure on the adoption of individualistic–collectivist cultural values, which could in turn affect state capacity (Hypothesis 2). In this section, I examine the empirical validity of this hypothesis.

With this aim, I utilize a widely employed measure of individualism constructed by Hofstede (2001) that captures the level of interdependence among members of a society. Specifically, the Hofstede's index of individualism measures the extent to which people are expected to look after themselves and their immediate family only, as opposed to a situation where individuals belong to cohesive groups that provide support in exchange for loyalty. This index reflects the idea that individualistic societies tend to prioritize personal freedom, achievement and status, while collectivist societies place more emphasis on harmony and conformity (Ezcurra, 2021). The Hofstede's index has been validated in numerous studies (Hofstede, 2011; Oyserman et al., 2002; Schimmack et al., 2005). The index ranges from 0 to 100, with higher scores reflecting a more individualistic society. Figure A4 in the Supporting Information displays a world map of Hofstede's individualism scores. According to this measure, the more individualistic countries are the United States, Australia and the United Kingdom, while the most collectivist are Guatemala, Ecuador and Panama.

In order to investigate whether the individualistic–collectivist cultural dimension provides a convincing explanation for the reduced-form results obtained in the previous section, I begin by examining the link between the measure of UV-R exposure and the Hofstede's index of individualism. The estimates in columns 1–3 of Table 5 indicate the existence of a negative and significant relationship between both variables, illustrated by the partial regression plot displayed in Figure A5 in the Supporting Information. This implies that countries with higher UV-R exposure tend to be characterized by a lower degree of individualism, which is consistent with the arguments put forward in Section 2 and the findings of Fredriksson and Mohanty (2021). In line with the results of these authors, Table A10 in the Supporting Information shows that the prevalence of cataracts is higher in countries with greater levels of UV-R exposure (Andersen et al., 2016; Ang et al., 2018). However, the estimates do not reveal a significant association between skin cancer and UV-R at the country level, after including the baseline controls and the median age of the population in the analysis. At the same time, in line with the evidence provided by Fredriksson and Mohanty (2021), the results in Table A10 also show that the prevalence of cataracts has a negative and significant influence on the measure of individualism, reducing the impact of UV-R exposure on the Hofstede's index. Table A11 in the Supporting Information confirms that the link between cataracts and individualism is not affected by the inclusion in the analysis of a set of tropically clustered diseases that are epidemiologically independent of UV-R. The diseases considered in this robustness test are malaria, trachoma, hookworm disease and HIV/AIDS.

TABLE 5 UV-R, individualism and state capacity.

	Individualism			State capacity		
	(1)	(2)	(3)	(4)	(5)	(6)
Log UV-R	−28.864***	−32.208***	−67.300***	−1.010**		0.125
	(2.318)	(11.720)	(15.344)	(0.456)		(0.484)
Individualism					0.016***	0.017***
					(0.003)	(0.004)
Geographical controls	No	Yes	Yes	Yes	Yes	Yes
Population diversity controls	No	Yes	Yes	Yes	Yes	Yes
Regional fixed effects	No	No	Yes	Yes	Yes	Yes
R^2	.521	.615	.708	.786	.840	.840
Observations	90	90	90	90	90	90

Note: OLS estimates. In columns 1–3, the dependent variable is the Hofstede's index of individualism (see Section 5), while in columns 4–6, the dependent variable is the state capacity index constructed by Hanson and Sigman (2021) (see Section 3). All regressions include a constant term (not displayed). The regressions in columns 2–6 include the complete set of geographical and population diversity controls described in Section 4.1. Heteroskedasticity-robust standard errors in parentheses.

*$p < .1$, **$p < .05$, and ***$p < .01$.

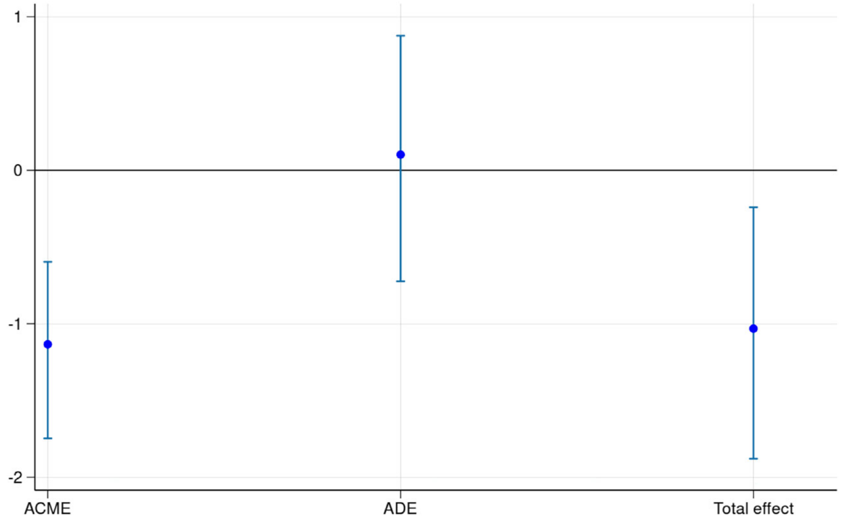

FIGURE 6 UV-R, individualism and state capacity: Mediation analysis. *Note*: Point estimates (average) of the effect of UV-R on state capacity with their corresponding 90% confidence intervals and the Hofstede's index of individualism as mediating variable. The analysis also includes the complete set of geographical and population diversity controls described in Section 4.1, as well as regional fixed effects. ACME refers to the average causal mediation effect, while ADE is the average direct effect. The results are based on 500 simulations. See Imai et al. (2010) for further details. [Colour figure can be viewed at wileyonlinelibrary.com]

Column 4 of Table 5 reports the reduced-form estimate of the effect of UV-R on state capacity in the (smaller) sample of countries for which there are data on the Hofstede's index (see Figure A4 for further details). Despite the considerable reduction in sample size, the observed negative association between UV-R and state capacity still holds. Furthermore, column 5 of Table 5 shows a positive and significant association between the index of individualism and state capacity. In line with the arguments laid down in Section 2, this indicates that countries with more individualistic cultures are more likely to have stronger states. If the hypothesis formulated in this paper is correct, and the individualistic–collectivist dimension of culture can be considered a valid transmission channel, then including the Hofstede's index in the baseline specification should reduce the effect of UV-R exposure on state capacity, in terms of coefficient size and/or its statistical significance. This issue is examined in column 6 of Table 5. As can be seen, the coefficient of the index of individualism remains positive and significant at the 1% level, while the point estimate of UV-R becomes statistically insignificant.[13] Consistent with Hypothesis 2, this suggests that the effect of UV-R on state capacity takes place through the individualistic–collectivist dimension of culture. This conclusion is further supported by the results of a mediation analysis based on the procedure outlined in Imai et al. (2010), which shows that the index of individualism fully mediates the observed relationship between UV-R exposure and state capacity (see Figure 6).

Consistent with the second hypothesis formulated in Section 2, the earlier findings suggest that the individualistic–collectivist cultural dimension acts as a transmission channel connecting UV-R exposure and state capacity. Nevertheless, one potential concern regarding the interpretation of the results in Table 5 has to do with the possibility that the index of individualism might be capturing the impact of other cultural traits on state capacity. Importantly, Fredriksson and Mohanty (2021) provide evidence indicating that populations with a higher prevalence of cataracts tend to exhibit a preference for risk aversion. Furthermore, these authors also document the existence of a negative association between risk aversion and individualism at the country level. In view of this, I control for

[13]Figures A6 and A7 in the Supporting Information show the corresponding partial regression plots.

TABLE 6 UV-R, individualism and state capacity: The effect of other cultural variables.

	State capacity												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Log UV-R	−0.025	0.204	0.176	0.178	0.131	0.274	0.187	0.099	−0.066	−0.609	−0.595	−0.487	−0.298
	(0.478)	(0.591)	(0.476)	(0.564)	(0.561)	(0.549)	(0.517)	(0.423)	(0.505)	(0.537)	(0.512)	(0.550)	(0.608)
Individualism	0.019***	0.017***	0.018***	0.017***	0.018***	0.018***	0.018***	0.019***	0.010***	0.011***	0.012***	0.011***	0.016***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.005)
Uncertainty avoidance	0.005												
	(0.003)												
Willingness to take risks		−0.008											
		(0.268)											
Trust			0.427										
			(0.443)										
Positive reciprocity				0.183									
				(0.253)									
Negative reciprocity					0.192								
					(0.206)								
Altruism						0.175							
						(0.246)							
Long term orientation							0.003						
							(0.004)						
Masculinity								−0.006**					
								(0.003)					
Egalitarianism									0.596*				
									(0.336)				

TABLE 6 (Continued)

	State capacity												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Harmony										−0.127			
										(0.213)			
Mastery											0.330		
											(0.333)		
Hierarchy												−0.062	
												(0.168)	
Religiosity													−0.173
													(0.329)
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population diversity controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.847	.870	.851	.873	.873	.873	.845	.850	.881	.870	.871	.869	.841
Observations	90	59	71	59	59	59	77	90	60	60	60	60	60

Note: OLS estimates. The dependent variable is in all cases the state capacity index constructed by Hanson and Sigman (2021) (see Section 3 for further details). All regressions include a constant term (not displayed), as well as the complete set of geographical and population diversity controls described in Section 4.1. Heteroskedasticity-robust standard errors in parentheses.

$^*p < .1$, $^{**}p < .05$, and $^{***}p < .01$.

two measures that aim to capture the degree of risk aversion in the sample countries: the index of uncertainty avoidance developed by Hofstede (2001) and an indicator of the willingness to take risks drawn from Falk et al. (2018). I also control for the level of generalized interpersonal trust in a country's population, which is a variable commonly used in the literature to capture the concept of social capital and that has played a key role in the discussion on the relationship between culture, economic performance and institutional development (Tabellini, 2010). In addition to general trust, the analysis also includes other variables associated with different aspects of impersonal prosociality, such as positive and negative reciprocity, and altruism. Furthermore, I add to the model other cultural dimensions identified by Hofstede (2001) and Schwartz (1994) such as long term orientation, masculinity, egalitarianism, harmony, mastery and hierarchy. Finally, I also include a measure of the degree of religiosity in the population.[14] Table 6 indicates that, except for masculinity and egalitarianism, none of the additional variables considered exert a significant effect on state capacity. However, the coefficient of the Hofstede's index holds positive and significant in all cases. This suggests that the observed association between individualism and state capacity is not a spurious correlation resulting from the omission of other cultural dimensions potentially important in this context, which strengthens the validity of the proposed transmission channel between UV-R and state capacity.

Another potential concern when interpreting the results in columns 5 and 6 of Table 5 is that the measure of individualism may be endogenous. Indeed, the causality between individualism and state capacity may go in both directions. While the present paper hypothesizes that the individualistic–collectivist cultural dimension affects state capacity, it is also possible that the ability of the state to attain its policy goals could influence a country's culture. For instance, a context characterized by a persistently weak state may lead people to rely more heavily on in-group ties, thereby reinforcing collectivist values. In addition to this reverse causality problem, the Hofstede's index may be subject to measurement error, which has the potential to bias the OLS estimates downwards. Moreover, we cannot rule out the presence of omitted variable bias. To address these problems, I employ an IV approach. In particular, following the strategy adopted by Gorodnichenko and Roland (2017, 2021) and Ezcurra (2021), I use two instruments for the measure of individualism: the degree of historical pathogen prevalence and the Mahalanobis distance between the frequency of blood types A and B in a given country and their frequency in the United States, which is the most individualistic country in our sample.[15] The results of this additional robustness test are presented in Table A13 in the Supporting Information. Importantly, the coefficient of the measure of individualism remains positive and significant, with a magnitude similar to the OLS estimates in columns 5 and 6 of Table 5, while the relationship between UV-R exposure and state capacity continues to be non-significant. This suggests that the previous results are not driven by the potential endogeneity of the measure of individualism.

6 | CONCLUDING REMARKS

In order to enhance our understanding of the deep determinants of state capacity, this paper has examined the effect of the degree of UV-R exposure on a state's ability to achieve its policy goals. The results show that the intensity of UV-R is a strong predictor of cross-country differences in state capacity. Countries with higher UV-R exposure tend to have weaker states. This finding remains unchanged after controlling for different variables that may be correlated with both UV-R and state capacity, including an extensive set of geographical, historical and contemporary factors. In fact, the observed link between sunlight and state capacity is not driven by potential outliers and is robust to the employment of alternative measures of state capacity, estimation methods and other sensitivity checks. The analysis also reveals that the individualistic–collectivist dimension of culture acts as a transmission channel that connects UV-R and state capacity. The estimates show that a lower degree of UV-R exposure leads to the adoption of individualistic values, which in turn promote the development of state capacity.

[14]See the Supporting Information for a detailed definition and sources of all the cultural variables used in this robustness test. Table A12 shows the pairwise correlations between the Hofstede's index of individualism and these variables.

[15]See Gorodnichenko and Roland (2017, 2021) and Ezcurra (2021) for a detailed discussion on the rationale for employing these instruments.

The results of the paper contribute to the literature on the origins of state capacity. Up until now, the vast majority of this literature has focused on the role of factors such as external wars, internal political stability, democracy, ethnic diversity or colonial legacies. Undoubtedly, these determinants are important in explaining the emergence and persistence of effective and strong states. Nevertheless, the present paper also shows that a significant proportion of the variation in state capacity across countries can be attributed to deeply rooted geographical factors. Specifically, this research reveals that the degree of UV-R exposure is one of these factors. This is something that policymakers should consider when determining how to strengthen state structures. In particular, our results suggest that the effectiveness of policies designed to promote the development of state capacity may be influenced by the intensity of UV-R. Nevertheless, the adverse and long-lasting effects of geography are frequently overlooked by policymakers. This could help explain why many countries located around the equator, where UV-R intensity is higher, tend to have weak states persistently over time.

The results of this study raise new questions for future research. While this work has established the unconditional effect of UV-R on a state's ability to achieve its policy goals, the impact of sunlight may be contingent on the presence of other geographical or historical factors. Future research should explore the empirical relevance of these potential interaction effects in order to complement the findings of the paper. Furthermore, it would be interesting to examine the link between UV-R and state capacity using subnational data. This would allow us to remove the influence of national-level political institutions and cultural values through country fixed effects, while also controlling for relevant local geographical correlates of UV-R and regional state capacity. Further research is also required to delve deeper into the impact of UV-R on the various elements that constitute state capacity. Moreover, future studies may investigate the role of different aspects of the individualistic-collectivist dimension of culture in explaining the link between UV-R and state capacity. Only by pursuing these research directions, we will be able to attain a fuller understanding of the nature of the relationship between UV-R and state capacity.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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