Size, Resource Endowment and Survival of States

Kemal Kıvanç Aköz* S.P. Harish† Christopher Paik‡

Abstract

In this paper we explore the role of state size and resource endowment on state survival in Europe. We first find that there is a historically robust and positive relationship between state size and survival. We then assess the extent to which survival likelihood is associated with state size interacted with resource endowment. Our findings suggest that resource endowment has a differential impact on state survival depending on the size: large states endowed with more resources can increase their capacity and allocate them to augment their survival likelihood, while the opposite holds for small states.

*Higher School of Economics; E-mail: kivancakoz@gmail.com
†College of William and Mary; E-mail: spharish@wm.edu
‡NYU Abu Dhabi; E-mail: christopher.paik@nyu.edu

1 Introduction

How does the size of a sovereign state predict its likelihood of survival, and what are the differential impacts of resource endowment on the outcome? This question is particularly relevant for Europe where the literature has addressed the role of resource endowment and size on state capacity and survival(Stasavage, 2010; Besley and Persson, 2011; Jones, 1981; Tilly, 1992; Gennaioli and Hans-Joachim, 2015; Dincecco, 2010), but has yet to examine the relationship over different time spans and across the entire region.[1] Among the many factors that determine the size and longevity of states, natural barriers such as varying biogeography across latitudes (Diamond, 1997) and land quality for agriculture(Michaloupoulos, 2012) have been discussed as leading to foundation of societies with different lifestyles (agriculturists vs. hunter-gatherers, for example), and to the rise of ancient empires of varying sizes that aggregated around frontier steppes (Turchin, 2009). Taken together, these works suggest that state size and resource endowment may indeed matter in determining the development and longevity of states. In this paper we add to this literature by focusing on the interaction between resource endowment and scale of each polity on its survivability.

We first document the number of states in every century in Europe from 1 to 2000 AD using the Euratlas digital atlas (Nussli, 2011), and the changes in the state borders and the size of sovereign states that existed during this time period. We present both the descriptive statistics of state size, and then findings from simple duration analysis on the

[1]The case of European states is also of interest because other parts of the world historically exhibited different patterns in their size and duration. For example, despite the similar size, China has notably seen a relatively smaller number of states and demise of dynasties over the same time period (Ko et al., 2018). States in Central Asia were characterized as large nomadic empires rather than small, fractionalized territorial states (Blaydes and Paik, 2020).

survival likelihood of states. We calculate the size of each state in every century, and estimate the survival likelihood in each time period as a function of the size of these states, controlling for the period fixed effects. With this approach, we are able to determine the size at which a state may veer towards a split or extinction. Our findings show that the relationship between the size and the probability of the state's disappearance is negative, and suggests that within our observed sample of states in Europe (676 of them in total over 21 centuries), larger states generally fared better in terms of their longevity. Put another way, an increase in the area of a million square kilometers, about the average state size in Europe in 1 AD, is associated with a 67 percent decrease in the likelihood of disappearance. Furthermore, we find that the significance of this relationship is not limited to the 21-century time span we have in our data. It also appears to remain robust under different period cutoffs, based on significant moments in European state history (i.e. weakening and dissolution of the Roman Empire after 400 AD and rise of modern state formation from 1400 AD (Tilly, 1992)).

Next, in order to test how state size may interact with resource endowment for state survival, we utilize land suitability for agriculture as a proxy for resource endowment of the state. Agriculturally fertile lands have consistently been the source of contention and prized amongst states throughout history. Our proxy for resource endowment, measured as the fraction of land used for agriculture (Ramankutty et al., 2008), has a negative and statistically significant effect on the likelihood of state survival. The finding implies that being endowed with arable lands actually hinders the survival likelihood, as one can imagine struggles to keep the land to have led to the early demise of many states. At the same time, however, larger states appear to have benefitted from having more resources under their control. We find that a size increase of one million kilometers-squared in state covered with ideal land for agriculture is associated with a drop in the likelihood of state disappearance by 94 percent. On the other hand, a state increase in size by the same amount, when covered with completely infertile land, is also associated with a decrease in the likelihood of disappearance by just 13 percent but it is statistically insignificant. That is, rich agricultural endowment by itself is a threat to state survival, while larger states of fertile lands are better able to survive into the next century relative to those without the resources. We also find that the area variable by itself no longer has a significant effect on the likelihood of survival; the impact is determined instead by its interaction with land quality.

In sum, our empirical findings suggest that state size, resource endowment and state survival are all related with varying degrees of statistical significance and magnitude. We also provide a formal model in Appendix Section A2 to further explicate channels that explain state survival but are not explicitly controlled for in our empirical analysis. Specifically, our Random Aggressors Model introduces aggregate output and state military capacity as both endogenous outcomes of resource endowment and as crucial factors for state survival. Predictions from the model, which accounts for these factors, give support to the main findings, and help to address potential issues from omitted variables in our data.

2 Data Description

We use the Euratlas data to identify state size and survival duration (`http://www.euratlas.com/index.html`). It contains historical administrative boundaries in Europe for every century from the year 1 AD until 2000 AD. Layering these twenty maps gives us a timeline of state changes stretching over two millennia. While it would be ideal to record every change in state borders over finer time intervals, the 'capture shots' of state boundaries at the beginning of each century are still useful for our purposes. Importantly, it is unlikely that state changes took place systematically by the imposed century-intervals. There were a total of 504 states that existed in Europe during the past 2000 years. The average size of these states decreases as the number increases, and increases in periods of consolidation. In Appendix Section A1, we provide more description of the data and discuss some of the caveats as well as reasons for why the Euratlas is still useful in tracking each state's existence, its shape and size over different centuries.

3 Empirical Findings

We first use the standard Cox proportional hazards model (Box-Steffensmeier and Jones, 2004) to identify factors that influence the survival of states. Given that we only observe states when they do exist, the event of interest is the disappearance of states. We have a total of 676 states that existed during the time period 1 AD-2000 AD. Of these, the 70 states that still existed in the year 2000 AD are considered censored and hence a total of 606 states experienced the event. Figure 1 presents the Kaplan-Meir estimate without any covariates. It shows that the estimated survival probability drops below 50-percent within the first century of existence, and so the majority of the states do not survive more than two centuries.

Our main variable of interest is the geographic size of the state. We obtain each existing state's area in every century to determine the relationship between size and survival. The measure of area and its survival at a given time does not mean we posit a contemporaneous effect of size and survival. Since we are only able to measure survival at the turn of different centuries, the fact that we code the disappearance of a state in a given century means that it actually disappeared at some point over the next hundred years. In that sense, the timing of our measure of area comes consistently before the disappearance of the state.

Table 1 presents our first results. To account for instances of reincarnation (i.e. when a state disappears and then re-emerges), the standard errors are clustered at the state level and all models also include year fixed effects. The un-exponentiated coefficients in Table 1 are all negative and statistically significant, suggesting that the size of the state decreases the hazard rate of disappearance. In other words, we should expect that states with larger

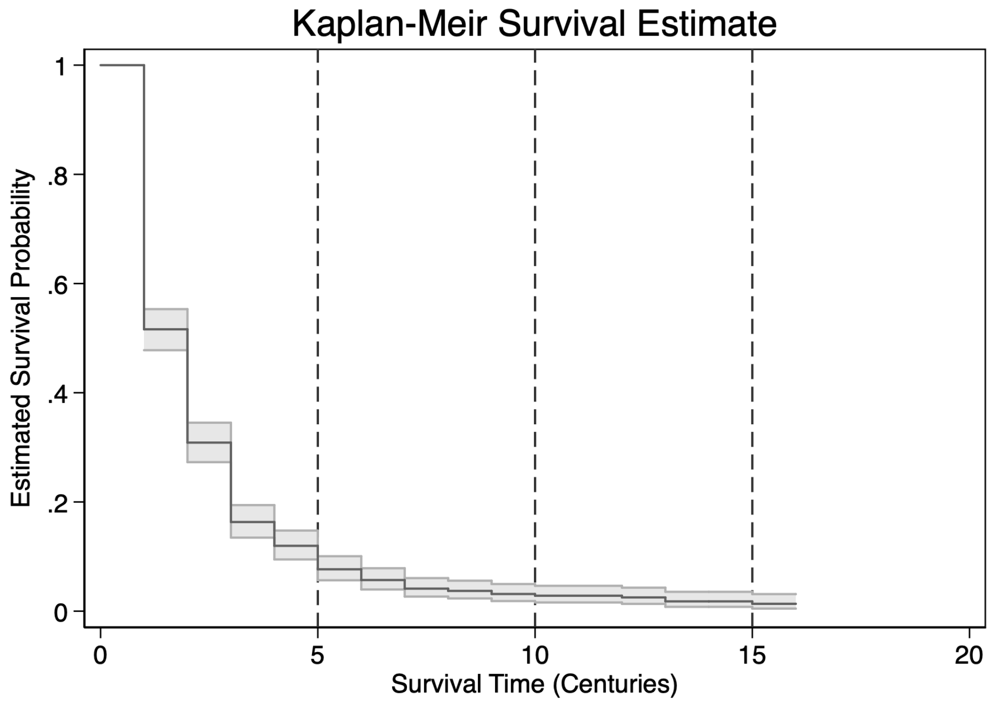

Figure 1: Baseline Kaplan-Meir Estimate

areas to survive longer. Using the coefficient in column one, we infer that an increase in a million sq km decreases the hazard rate of disappearance by 67%.

The relative importance of state size in its relationship with state survival likely changed over time. Small states, such as England and the Dutch Republic, as well as city-states in Italy were all at the forefront of economic development and institutional innovations but were not prominent in the first millennium. The fiscal and other institutional evolutions that came to define the enduring modern states in Euro also present compelling explanations that are unrelated to state size (for e.g. Stasavage, 2011; Cox, 2016). In the next columns, we present flexible time spans to look at the robustness of the empirical association across a few pivotal periods in European history. Column two for example looks at the period between 500 and 1000AD, after the apex of the Roman Empire around 400 AD and its gradual dissolution, leading to a spike in the number of states being formed afterwards (see Figure A1). Columns

Table 1: Baseline Results

	0-2000		500-1000		1400-2000		0-1400	
Area	-1.118***	-1.144***	-1.351**	-1.378**	-0.798**	-0.821**	-1.601***	-1.624***
	(0.263)	(0.271)	(0.554)	(0.564)	(0.330)	(0.340)	(0.407)	(0.413)
Land Suitability		0.283***		0.624***		0.169		0.342***
		(0.088)		(0.239)		(0.111)		(0.125)
Observations	1458	1458	366	366	699	699	902	902

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: The coefficients of area in the above models are un-exponentiated. In all models, the standard errors are clustered at the state level and include year fixed effects.

three and four look at the centuries at the beginning of modern state formation in 1400 AD according to Tilly (1992), and the subsequent periods afterwards. Across these different period cutoffs, we see that the relationship between state size and state survival remains similar. Figure 2 presents a similar set of exercises, in which we compare the effect of size on state survival across different time spans: 1-500 AD, 1-1000 AD, and 1-1500 AD against the benchmark, 1-2000 AD. Each coefficient estimate from Cox model remains negative and statistically significant.

We present a number of robustness tests of our main analysis and additional analyses in Appendix Section A3. First, we test the predictors in the Cox model to satisfy the associated proportionality assumption, sensitivity of our results to the inclusion of quadratic terms, use of log of the area variable, and the use of discrete time outcome variable. Second, we also present another graphical representation of the area and the survivability of states controlling for year fixed effects from 1 to 2000AD. The findings above suggest that there appears to be a negative and robust relationship between the size of a state and its likelihood of survival.

Given that resource endowment may interact with state size to have differential effects on the survival likelihood, Table 2 presents the results in which the land suitability measure, as a

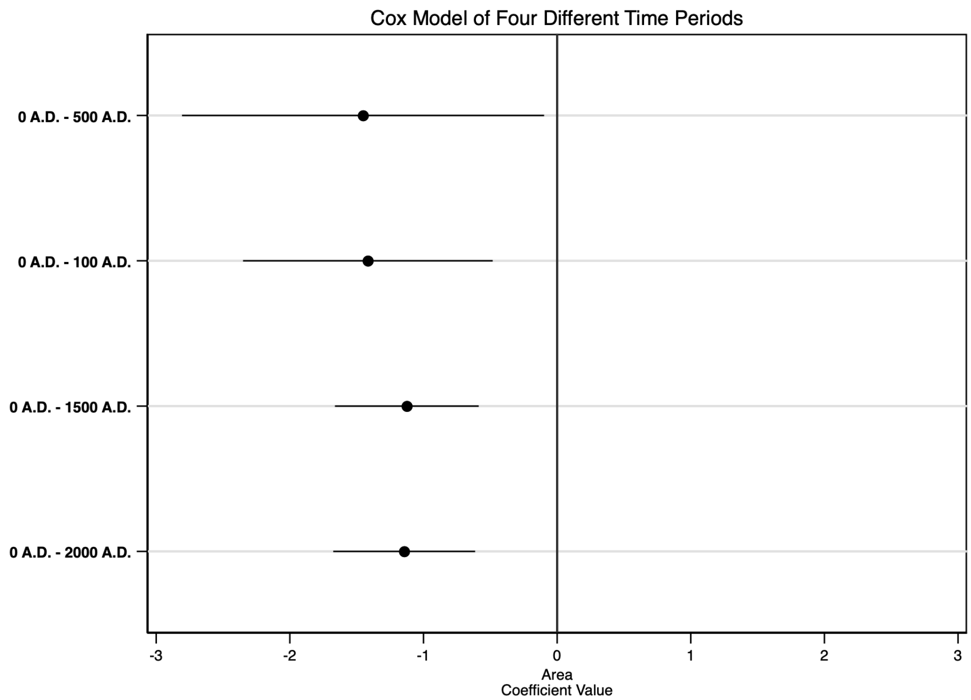

Figure 2: Size and Survival in Different Periods

Table 2: Baseline Results with Land Suitability

	(1) 0-2000	(2) 500-1000	(3) 1400-2000	(4) 0-1400
Area X LandSuit	-2.712***	-2.724	-3.595***	-2.006
	(0.988)	(2.138)	(1.267)	(1.457)
Area	-0.144	-0.242	0.338	-0.760
	(0.337)	(0.819)	(0.319)	(0.641)
Land Suitability	0.384***	0.778***	0.271**	0.422***
	(0.092)	(0.258)	(0.113)	(0.135)
Observations	1458	366	699	902

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: In all models, the standard errors are clustered at the state level and include year fixed effects.

proxy for resource endowment, is interacted with the area. The findings from Table 2 suggest that the area variable by itself no longer has significant effect on the likelihood of survival; the impact is determined instead by its interaction with resource endowment. Column one for example suggests a size increase of one million kilometers-squared in state covered with 100 percent fertile land is associated with a drop in the likelihood of state disappearance by 94.2% percent. On the other hand, a state increase in size by the same amount, when covered with zero fertile land, is also associated with a decrease in the likelihood of disappearance of 13% but it is statistically insignificant.[2] In other words, larger states are more likely to survive when endowed with agricultural lands. At the same time, however, we find that the land quality variable has a negative, independent effect on the likelihood of survival. A change in the state land quality from zero to one (completely barren land to 100 percent agricultural land) leads to an increase in the likelihood of the state's disappearance by approximately 33 percent. This finding suggests that being endowed with resources, proxied by land quality for agriculture, is detrimental to the state survival as it likely becomes the source of aggression. At the same time, however, we find that for large states, having more resources helps with its survival.

4 Conclusion

Historical records of state borders over centuries provide us with an opportunity to investigate the relationship between state size and state survival, an important question that continues to be relevant today as resources become scarce and border disputes continue to persist. Based on the set of state boundary maps of Europe for every century between 1 and 2000 AD, we show that (1) larger states are more likely to survive, and (2) while resource endowment proxied by agricultural land suitability is negatively associated as the state survival, larger

[2]Appendix SectionA4 provides details of the calculation of the substantive effects.

states fare better than smaller states. These findings shed some light on the state formation and duration process in Europe, and warrant future research on testing the same under other geographic contexts (ex. China and Central Asia) for more generalizable implications.

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Online Appendix
(Not for Publication)

June 12, 2020

Contents

A1 Data Sources & Description

For state size and state duration we use Euratlas available from `http://www.euratlas.com/index.html`. Euratlas contains historical administrative boundaries in Europe for every century from the year 1 AD until 2000 AD. Each map at the turn of a century captures all the extant states of Europe, and is meant to represent a period in history that, along with twenty other layers of maps, creates a timeline of state changes stretching over two millennia. Our unit for the time interval is the century, and we essentially assume that each interval gives an average representation of state size and population over a hundred years.[1].

Since we are interested in the survivability of states, we first describe the number of states that existed over time. There were a total of 504 states that existed in Europe during the past 2000 years. Figure A1 shows the number of states at the turn of each century. In the year 1 AD, there were only 10 states that existed in the region. This number increased as new states were formed over time. However, this process was not always linear. The total number of states peaked in 1300 AD with a total of 158 states. The peak in 1300 AD is followed by a period of state formation as discussed by Tilly [1985], in which we see consolidation of states and a decrease in the number. By 1900 AD this process appears to have reached the end with just 29 states.

An important caveat in using the Euratlas digital maps is that each state survival is inevitably based on how states are specifically defined and borders drawn in these digital maps. While these maps have been used extensively in the literature [Blaydes and Chaney, 2013, Stasavage, 2010, 2014, Blaydes and Paik, 2016, Harish and Paik, 2019, Abramson, 2017], there remain debates on the actual number of states and their boundaries in certain regions. As an example, the Euratlas sample identifies a maximum of 158 sovereign states in a given century over the time span, in contrast to Tilly [1975] who claims that in 1500 there were 500 independent political units in Europe. Most of the under-counting is in the Rhineland, which consisted of several hundred small states from the Kingdom of the Romans and the Small States of the Holy Roman Empire after the

[1] While it would be ideal to record every change in state borders over finer time intervals, we believe that the "capture shots" of state boundaries at the beginning of each century are still useful for our purpose. Importantly, it is unlikely that state changes took place systematically by the imposed century-intervals. That is, the observations in the beginning of each century would not lead to a bias leading to an outcome somehow different from those observed over some other time intervals (such as mid-century intervals, for example)

Great Interregnum (1254 to 1273). In the Euratlas, the Kingdom of the Holy Roman Empire as a single entity encompasses approximately 400 small lordships and principalities within the territory, whose boundaries were in some cases unknown. Because these data are absent and this area was amongst the wealthiest throughout history, we acknowledge that the results from treating it as one entity may bias the likelihood of small states' survival downward. This, for example, may explain why survival of small city states in the "age of the territorial state" between 1500 and 1800, as documented in Abramson [2017], is not readily apparent in our results.[2]

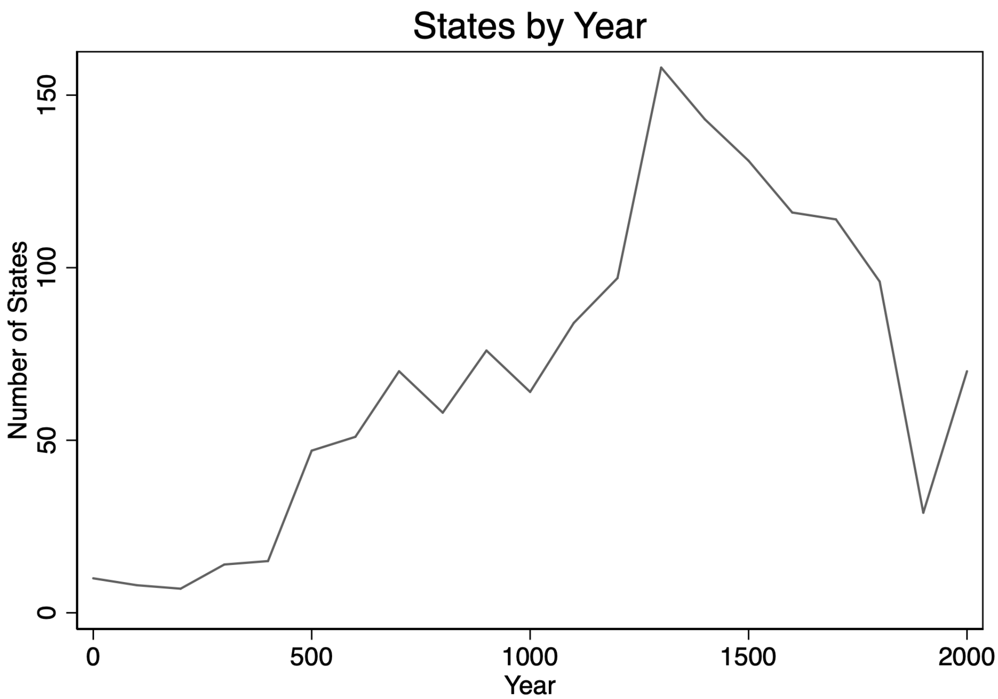

Figure A1: States by Year

With this in mind, the Euratlas is still useful in tracking each state's existence, its shape and size over different centuries. For instance, a state may have existed right from 1 AD and survived for many centuries before disappearing completely. The Roman Empire is a case in point - it existed from 1 AD till 1400 AD in the Euratlas before it disintegrated into a number of smaller states.

[2]In the following we address this issue by confining our analysis between 1 and 1400 AD (before the expansion period of territorial states in Europe). We find that the empirical pattern within the shorter time span remains similar to looking at the period between 1 to 2000 AD. Running the same exercise but omitting the Kingdom of the Holy Roman Empire from the sample also yields essentially the same set of results.

Another possibility is that a state emerges at some point in history and survives all the way to the present day. England fits this pattern when it first appeared in the year 700 AD and has survived since then. A third possibility is that a state existed for a few centuries before disappearing and reappearing again. For example, Bulgaria first appeared in the year 700 AD and lasted till 1000 AD; it then disappeared for two centuries before reappearing during 1200 AD and 1300 AD; it disappeared again, before reappearing in 1900 AD and continues to exist today. Since the states that reappear may not be the same as the previous ones except in name, we treat such reincarnations as the emergence of a new state.[3] Taking these reincarnations into account, our sample consists of a total of 676 states during the period from 1 AD to 2000 AD.

Different states existed with different durations in our sample. While the majority of them existed for just one century, some have existed for many centuries. Some of the longer surviving states are Denmark, France and Spain; these states first appear in 500 AD in their incipient forms and have survived until the present day. The existence of these states does not mean they were always named similarly or were of the same size over time. For example, Denmark was known as Danes between 1600 AD 1800 AD and Dani in 500 AD. In 1400 AD it was known as the Kalmar Union- union of kingdoms of Denmark, Sweden and Norway, which Denmark occupied in its entirety by 1500 AD. In 500 AD the area of Danish state was 19,000 sq km and this increased to 40,000 square sq km by 2000 AD. During the period of the Kalmar Union, the size of the Danish state was 268,000 sq km in 1400 AD and 274,000 sq km in 1500 AD, in contrast to the much smaller geographic area that the country claims as its own today (excluding Greenland). As explored further in our model below, one of the ways to survive as a state would have been to relinquish part of its land under conflict. The average size of the Danish state was 85,000 sq km with a standard deviation of 64,000. Figure A2 shows how the average area of states changed over the last twenty centuries. As expected, the average size decreases as the number of states increases, and the average size increases in periods of consolidation.[4]

[3] That said, we also account for such reincarnations in our analysis by clustering the standard errors at the original state level.

[4] We also note here that neither France nor Spain retained their current borders from all the way back to 500 AD. Franci, the predecessor to France, only occupied a part of modern-day France, and the rest were occupied by the Kingdom of Tolosa, Armorica, Britannia and Cornugallia. Euratlas codes the Kingdom of Tolosa (also known as the Kingdom of the Visigoths with Euric the king considered to be the first monarch of Spain) as the predecessor of Spain,

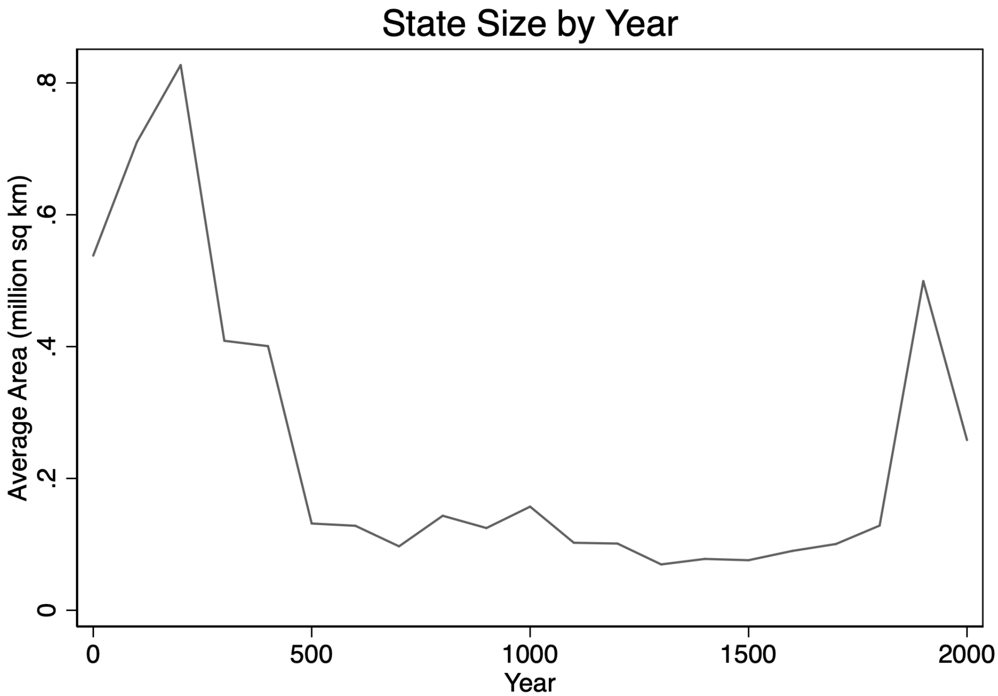

Figure A2: Average Area by Year

Given the rapid market integration and democratization over the past century, it is not surprising that the average size of countries has decreased while the number of them increased since.[5] Further back, however, we see fluctuating patterns over the course of history. In 1 AD, for example, there were 10 entities in Europe with the average size of 900,300 sq km, while in 2000 AD there were 70 of them with an average size of 454,000 sq km. The maximum number of states in existence in the same region was 158 in 1300 AD with an average size of 143,000 sq km.

while Gallaecia and Vasconia also occupied parts of current Spain. In Euratlas, a sovereign state change primarily means a change in the authority that governs the region and its population; dynastic changes or ruler turnovers are usually not considered as state changes [Nussli, 2011]. Both the Euratlas data and our formal model in this paper thus mainly look at foreign invasions and conquests as the main driving factors of state demise. Harish and Paik [2019] further clarify some of the other issues in Euratlas, such as the need to define sovereign states in Europe where the nature of the state likely changed over the period covered by the data.

[5] Alesina and Spolaore [1997] and Alesina et al. [2000] for example provide theoretical models to predict that democratization, economic integration and trade liberalization all increase the number of states.

A2 The Random Aggressors Model

In this section, we formalize the economic and military production decisions of a sovereign state to provide the intuition behind the different effects of resource endowment on state survival depending on the state size. In our model we identify and compare two proposed main channels that resources determine a sovereign state's survival state: first, more resources make the state more attractive for opposing factions within the state or external enemies; second, more resources enable the sovereign state to build stronger military capacity, which would increase the chances of winning a conflict.[6]

A2.1 The Environment

We consider a setting in which a sovereign state rules a land of size $L > 0$. The land that the state rules is embodied with per-unit natural resources $A > 0$. The resources could either be used in the production of economic output or in building military capacity. Let ϕ be the share of resources devoted to military production. The economic output is given as follows

$$Y(A, L, \alpha_Y, k_Y, \phi) = k_Y((1-\phi)AL)^{\alpha_Y}, \tag{1}$$

where $k_Y > 0$ is the productivity factor, $\alpha_Y > 0$ is the returns to scale parameter. AL is the total resources that a country can control. In this case, A is the per area unit resources or the share of the land that is arable in agricultural societies.[7]

[6] Our approach differs from other works on the state size [Alesina and Spolaore, 2005], in which the focus remains on explaining the number of states, rather than on the impact of the size on the survival of the states. As in the empirical setting we do not endogenize the size of the land under the state rule, but rather focus on the survival likelihood of the state given the size.

[7] This economic production assumes that every unit/district in a country has the same share of productive land. However, a reinterpretation of A as the α_Y-power average of district specific shares enables us to use the same production function for the more general treatment of heterogeneous districts. To see this let L be the number of districts of the country, and the district specific shares of productive land is given as $\{A_1, \ldots, A_L\}$. Then, let A be defined as the following aggregation of district specific shares:

$$A = \left(\frac{1}{L}\sum_{i=1}^{L} A_i^{\alpha}\right)^{\frac{1}{\alpha}}.$$

Then the term $(AL)^{\alpha_Y}$ in the economic production function would be equal to $\sum A_i^{\alpha}$, which captures the heterogeneous production a country might have. Note that this also allows one to embed variations in the average quality of per land unit in our model. A potential omitted factor here is the population; here we are concerned with the aggregate, not per-capita production, and the level of military capacity is determined by the state's total production. Introducing heterogeneity in population does not alter the main implications of our model.

The military capacity is produced as follows

$$M(A, L, \alpha_M, k_M, \phi) = k_M(\phi AL)^{\alpha_M}, \tag{2}$$

where k_M and α_M are the corresponding production parameters for military production. Note that we allow for the possibility that the productivity of resources in military production could be different from theirs in economic production.

Military capacity is useful in case there is a conflict with an aggressor. The outcome of the conflict depends probabilistically on the military capacity of the state and that of the aggressor. To model the effectiveness of the military capacity against aggressors, we use a contest function that defines the winning probability. We assume that large states have additional options available to them in the battlefield against the aggressors. An example to such strategies include strategic retreating to both optimize the geographical conditions of the battlefield and reducing the ability of the aggressor of mobilization of further resources for the conflict. One of the well-known examples to the usage of such strategies is the Russian retreat during initial phases of the French invasion of Russia in 1812. Despite major losses, the Russian army was ultimately successful in stopping the advances by the French army and win over them. To capture such additional advantages of the large states in conflict, we assume that the contest function also depends on the size of the state. In particular, we assume that the probability that a state with military capacity M wins a conflict against an aggressor with military capacity M_E is

$$\rho(M, M_E, \gamma) = \begin{cases} \frac{\underline{\theta} M^\gamma}{\underline{\theta} M^\gamma + M_E^\gamma} & \text{if } L < \bar{L} \\ \frac{\bar{\theta} M^\gamma}{\bar{\theta} M^\gamma + M_E^\gamma} & \text{otherwise,} \end{cases} \tag{3}$$

where $\gamma > 0$ is the parameter that captures the effectiveness of military capacity in the war field. As γ increases, the effectiveness (the contribution of military capacity in winning the war) of small military capacity ($M < M_E$) reduces, while the effectiveness of large military capacity increases. $\bar{\theta}$ and $\underline{\theta}$ are additional parameters that measure the effectiveness of the military capacity during conflict, and we assume that $\bar{\theta} > \underline{\theta}$. The differential impact of $\bar{\theta}$ compared to $\underline{\theta}$ on the winning probability is meant to capture the additional advantages that a large state might have against its aggressors.

An aggressor initiates a conflict with the sovereign state if the expected return from conflict exceeds the cost of conflict. Let $D > 0$ denote the constant cost of war for an aggressor. The expected benefit of conflict would be the economic output produced by the sovereign state, which is $Y(A, L, \alpha_Y, k_Y, \phi)$. We assume that formation of any resources requires a minimum concentration of resources and land so that the economic output that is produced within any state exceeds the cost of conflict D. This assumption implies that for any state, there is a positive probability that an aggressor might initiate a conflict with the expectation of capturing valuable resources.

The expected payoff of conflict to an aggressor is

$$\frac{M_E^\gamma}{M_E^\gamma + \theta M^\gamma} Y - D \geq 0 \Leftrightarrow$$
$$M_E^\gamma \geq \frac{D\theta M^\gamma}{Y - D} \Leftrightarrow M_E \geq \left(\frac{D\theta M^\gamma}{Y - D}\right)^{\frac{1}{\gamma}} \equiv \underline{M_E}. \tag{4}$$

Since our focus in this paper is the survival rate of sovereign states against aggressors, we do not endogenize the military capacity of the aggressor. Instead, we assume that the military capacity of an aggressor is determined by a probability distribution over $[0, \infty)$, of which the cumulative distribution function is $G(\cdot)$ and probability density function is $g(\cdot)$. We assume that the probability distribution of military capacity of an aggressor is independent of the winning probability ρ, defined above in equation (3).

In this model, our main motivation is concerned with the conflicts initiated by external aggressors. However, the survival of states do not exclusively depend on the external threats. Fractionalization among elites or ethnic groups, and mass political movements within countries may trigger collapse of sovereign states as well. Even though the dynamics behind the emergence of internal threats could be different from that of external threats, the role that military capacity and economic resources take in the survival of states against internal threats could be similar.[8] When

[8] In our empirical findings, we only present reduced-form outcomes of survivals of states and do not identify internal threats apart from external ones.

the governing elite expropriates large amount of economic resources but has a low central military capacity, the likelihood of other factions of elites to strike against the governing elite and possibly ignite a destructive civil/internal conflict increases. Moreover, in such cases external forces may form alliances with internal opposition. The parallels between the incentives of internal opposition and external aggressors therefore make the conflict likelihood function given in equation (4) relevant for internal threats as well. Finally, the dependence of the winning probability, as defined in (3), on the size might also be relevant for internal threats as well. When a state is exceedingly large, strong oppositions against the governing elites may find it safer to concentrate their campaign to a region in the state that is far from the capital. In many cases, large states continue to survive against exceedingly strong internal threats because the governing elite may simply give away peripheral regions to stay in power. Examples include the survival of the Roman and Ottoman Empires after several episodes of separation or loss of peripheral regions.[9]

A2.2 Survival Likelihood and The Military Share

There are two cases to be considered for the survival of a sovereign state. The first case is when there is no aggression. This is the case, in which an aggressor does not find it preferable to attack the sovereign state since the cost of conflict is too high. The ex-ante probability of this case is the probability that condition (4) does not hold; that is,

$$P(M_E < \underline{M_E}) = G(\underline{M_E}) = G\left(\left(\frac{DM^\gamma}{Y-D}\right)^{\frac{1}{\gamma}}\right).$$

The second case is when the aggressor prefers to attack but the sovereign state survives the conflict. The probability of this case is

$$\int_{\underline{M_E}}^{\infty} \rho(M, M_E, \gamma) g(M_E) dM_E.$$

[9] One of the limitations of our model is the impact of the time-dependent economic shocks to the survival. To exemplify, sudden drops in economic output may trigger mass political uprisings against the government. This alternative explanation for uprisings and downfall of states presents a potential caveat in our model and empirical findings. Unforeseen economic shocks have often been linked to violent outcomes (see Miguel et al. [2004], for example). While our model and empirical analysis do not address these exogenous shocks (apart from inclusion of century-fixed effects), we treat them as random occurrences in history, which do not bias our result in a systematic way.

That is, the total probability of all cases where the aggressor has the military capacity $M_E > \underline{M_E}$ and the state survives the conflict against an aggressor with the military capacity M_E.

Let ψ denote the probability of survival, which is defined as

$$\psi(M, Y, \underline{M_E}, D, \gamma) = G(\underline{M_E}(M, Y, D, \gamma)) + \int_{\underline{M_E}(M,Y,D,\gamma)}^{\infty} \rho(M, M_E, \gamma) g(M_E) dM_E. \tag{5}$$

Resources determine the survival probability ψ via multiple indirect channels. Resources immediately increase the military capacity M and the economic output Y. Output's effect on survival probability is negative, since output decreases the military capacity threshold for the aggressor $\underline{M_E}$ and therefore increases the likelihood of aggression. This reduces survival probability. On the other hand, the state's own military capacity M increases the survival probability both by reducing the likelihood of an aggression and by increasing the probability of winning in case there is aggression. Therefore, the net effect of the resources on the survival probability depends on the relative importance of the economic attraction affect, which is captured by the first term in (5), and military capacity effect, which is captured by the second term in (5).

In a reduced from, we can decompose the two channels by which the resources affect the survival probability as follows:[10]

$$\frac{\partial \psi}{\partial A} = \frac{\partial \psi}{\partial Y}\frac{\partial Y}{\partial A} + \frac{\partial \psi}{\partial M}\frac{\partial M}{\partial A}, \tag{6}$$

where it is straightforward to show that

$$\frac{\partial \psi}{\partial Y} < 0, \quad \frac{\partial Y}{\partial A} > 0, \quad \frac{\partial \psi}{\partial M} > 0, \quad \frac{\partial M}{\partial A} > 0.$$

The net effect of resources, then, depends on the relative efficiency of resources in production of military capacity compared to economic output. To quantify the net effect of resources, we consider some numerical examples in the Subsection A2.3 below.

Finally, we allow for the endogeneity of the military share by assuming that the state chooses

[10] See Appendix A for the calculations of the partial derivatives below.

the military share optimally to maximize the expected economic output; that is,

$$\max_{\phi} \psi(M, Y(A, L, \alpha_Y, k_Y, \phi), \underline{M_E}, D, \gamma) Y(A, L, \alpha_Y, k_Y, \phi)$$

A2.3 Numerical Examples

We make some parametric and functional assumptions for carrying out the numerical calculations.

The probability distribution for the aggressor's military capacity is exponential. That is, $g(M_E) = \exp(-1.25 * M_E)$ and $G(M_E) = 1 - \exp(-1.25 * M_E)$. The productivity parameters $k_M = 2$, $k_Y = 1.5$. Effectiveness of military capacity in winning the war, $\gamma = 0.5$.

We let the size of state vary between 0.75 and 4, and set the threshold $\bar{L} = 1$. To test the nonlinear effect of size of state on the survival probability, we set $\alpha_M = 0.5$, $\alpha_Y = 0.4$. In our calculations, we also allow for the endogeneity of the military share.

Under these assumptions, the net effect of resources on the survival probability is illustrated in Figure A3

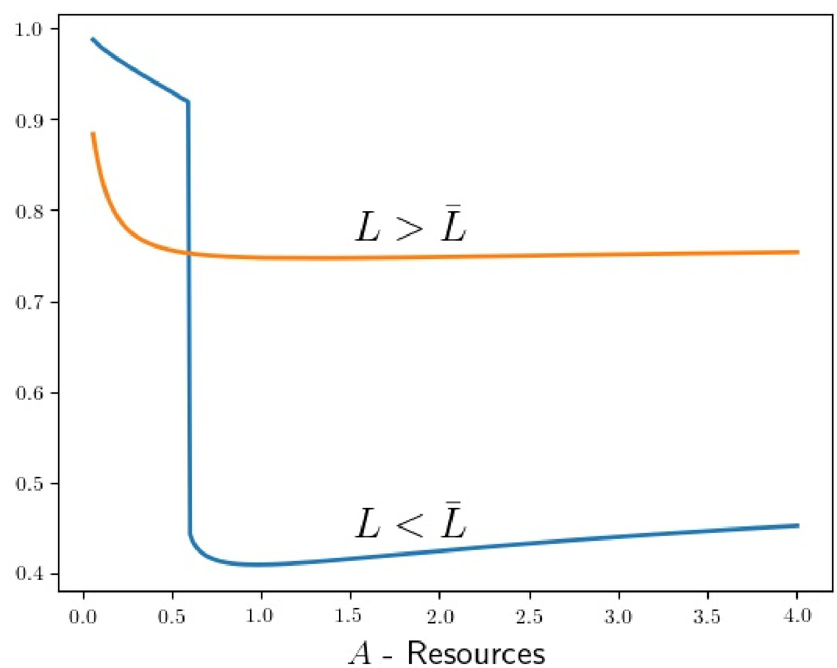

Figure A3: Net Effect of Resources on Survival

For small states ($L \leq \bar{L}$), higher resources increase the appeal of the economy for foreigner aggressors more than it contributes to the effectiveness of military capacity. That is, the first term in (6) is greater in magnitude than the second term for smaller states. Therefore, the net effect of the resources on the survival probability is negative. For larger states the opposite is true: the second term is greater in magnitude than the first, or military capacity is much more effective, and thus higher resources increase the survival probability.

A2.4 Calculation of the Effect of Resources

In this subsection, we calculate the effect of resources on the survival probability fixing the military share. We first calculate the "appeal effect" of the resources on the survival probability. This effect is realized by the role of resources in the production of economic output, and therefore in its effect in increasing the expected benefit to any aggressor of initiating a conflict.

Note that economic output effects the survival probability only through the threshold $\underline{M_E}$. For any military capacity $M > 0$

$$\frac{\partial \psi}{\partial \underline{M_E}} = g(\underline{M_E}) - \rho(M, \underline{M_E}, \gamma) g(\underline{M_E}) > 0,$$

since the winning probability $\rho \in (0, 1)$. While,

$$\frac{\partial \underline{M_E}}{\partial Y} = -\frac{1}{\gamma} \frac{\underline{M_E}}{Y - D} < 0.$$

Combining the two calculations above,

$$\frac{\partial \psi}{\partial Y} = \frac{\partial \psi}{\partial \underline{M_E}} \frac{\partial \underline{M_E}}{\partial Y} < 0.$$

Economic productivity of resources is

$$\frac{\partial Y}{\partial A} = \alpha_Y k_Y ((1 - \phi) L)^{\alpha_Y} A^{\alpha_Y - 1} > 0.$$

On the other hand, the impact of military is twofolds. Military capacity works both as deterrent, by reducing the incentives for an aggressor to initiate a conflict, and as instrument for winning a conflict, by increasing the winning probability. The total impact of military on the survival probability can be calculated as

$$\frac{\partial \psi}{\partial M} = g(\underline{M_E})\frac{\partial \underline{M_E}}{\partial M}(1-\rho(M,\underline{M_E},\gamma)) + \int_{\underline{M_E}}^{\infty} \frac{\partial \rho}{\partial M} g(M_E) dM_E > 0,$$

while

$$\frac{\partial \underline{M_E}}{\partial M} = \left(\frac{D}{Y-D}\right)^{\frac{1}{\gamma}} > 0.$$

The contribution of resources to the military capacity is

$$\frac{\partial M}{\partial A} = \alpha_M k_M (\phi L)^{\alpha_M} A^{\alpha_M - 1} > 0$$

To assess the net effect of resources more closely, we can write the decomposition of the change in survival probability given in equation (6) as follows:

$$\frac{\partial \psi}{\partial A} = \frac{\partial \psi}{\partial \underline{M_E}}\left(\frac{\partial \underline{M_E}}{\partial M}\frac{\partial M}{\partial A} + \frac{\partial \underline{M_E}}{\partial Y}\frac{\partial Y}{\partial A}\right) + \frac{\partial \psi}{\partial \rho}\frac{\partial \rho}{\partial M}\frac{\partial M}{\partial A}. \tag{7}$$

Therefore, a necessary condition for the positivity of the net effect of resources on survival probability is that

$$\frac{\partial \underline{M_E}}{\partial M}\frac{\partial M}{\partial A} + \frac{\partial \underline{M_E}}{\partial Y}\frac{\partial Y}{\partial A} > 0. \tag{8}$$

A3 Robustness Checks

In this section, we discuss robustness for our baseline results. First, since we use the Cox model, the predictors in the model need to satisfy the associated proportionality assumption. We test for this using the non-zero slope of scaled Schoenfeld residuals on time in a generalized linear model. Figure A4 presents graphs for area and land suitability with the scaled Schoenfeld residuals on the function of time. Since the slope of the residuals are similar to zero, we are confident that our main results satisfy the proportionality assumption.

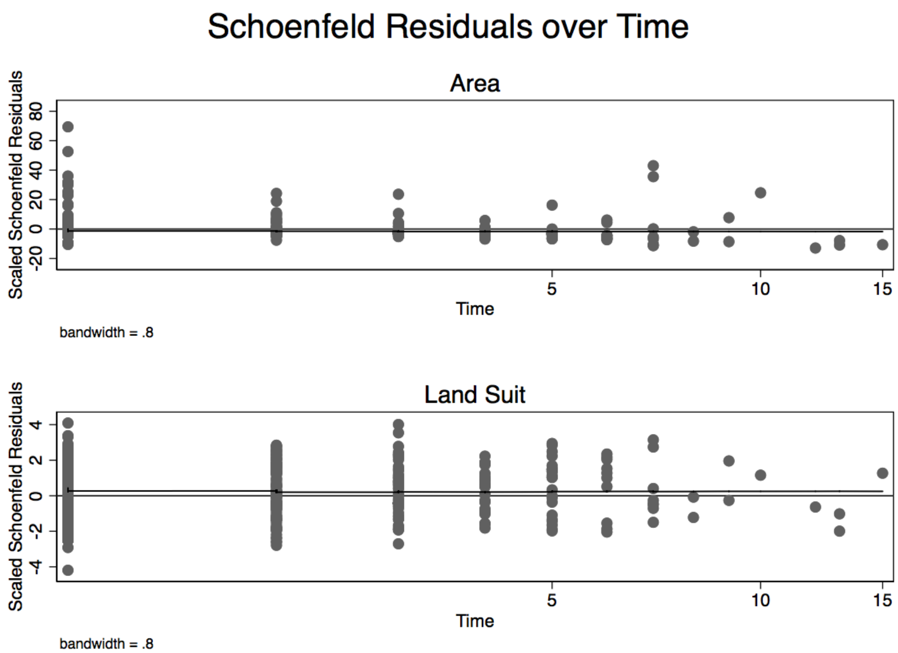

Figure A4: Proportionality Test

It is possible that area does not have a linear relationship with the survival of states. In order to check for a possible quadratic effect, we include the squared term of area in the model. If there is a possible quadratic U-shaped relationship, we would expect the squared term to have a positive sign and remain statistically significant along with the main area variable. Models 1 and 2 in Table A2 show that while the the main area variable continues to have a negative sign and is statistically significant, the squared term of area is positive but statistically insignificant. Another possibility is to use logarithmic form of area as the main predictor variable. The results Models 3 and 4 of Table A2 show that our results hold even when we use log of the area variable. We use the original form of area since it is easier to interpret the magnitude of the association with the duration of existence. One of the assumptions of the Cox model is that time is continuous [Box-Steffensmeier

Table A1: Robustness Tests

	(1)	(2)	(3)	(4)	(5)	(6)
Area	-1.143***	-1.199***			-2.229***	-2.263***
	(0.407)	(0.409)			(0.500)	(0.522)
Area Squared	0.021	0.046				
	(0.158)	(0.150)				
Land Suitability		0.284***		0.401***		0.367*
		(0.088)		(0.089)		(0.197)
Ln(Area)			-0.049***	-0.069***		
			(0.016)	(0.017)		
Constant					0.041	-0.123
					(0.081)	(0.116)
lnsig2u					-0.833***	-0.868***
					(0.315)	(0.318)
Observations	1458	1458	1458	1458	1458	1458

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2: *

Note: Models 1 and 2 present results for the quadratic effect of area on survival. Models 3 and 4 present results for the effect of the log functional form of area on survival. Models 5 and 6 presents results assuming time is discrete.

and Jones, 2004]. Since we are only measuring the existence of the state and all other covariates once every hundred years, it is possible to think of the time to event as discrete in nature. In order to account for this aspect, we estimate discrete-time survival models using the maximum likelihood method [Jenkins, 1995]. Specifically, We fit a binary dependent variable multiple regression model where the dependent variable is whether the state disappeared in a given century. Models 5 and 6 of Table A2 presents the results of this estimation. We can see that our main area variable is negative and statistically significant in all models.

A3.1 Predicted Survival Estimates

Figure A5 presents a yet another graphical representation of the area and the survivability of states controlling for year fixed effects from 1 to 2000AD. As the area increases from 0 to the 50^{th} percentile and to the 75^{th} percentile, the predicted survival estimate also increases correspondingly.

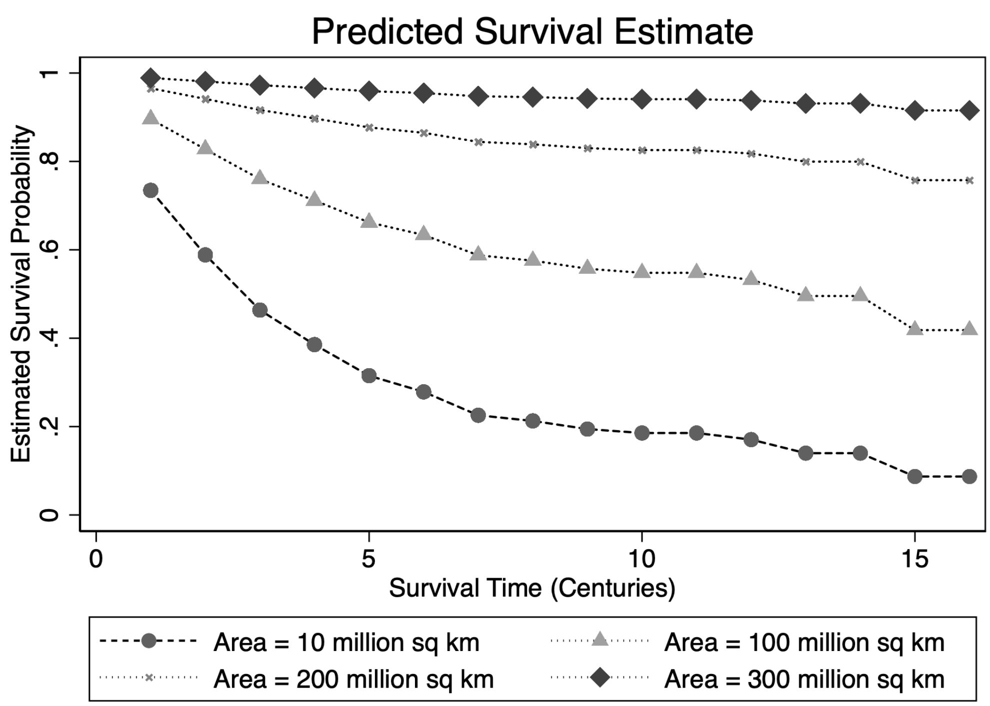

Figure A5: Predicted Survival Estimates

A4 Calculation of Substantive Effects

In this section, we provide detailed information on the calculation of the substantive effect of area from the Cox models. From Table 2 in the main paper, the percentage increases are calculated as follows. When the state is covered with 100 percent fertile land (i.e. the fraction of agricultural land out of total is equal to one), a unit increase in the area (in millions of kilometers) yields a hazard ratio equal to exp(-2.712154 -.1439949) = 0.057. The rate of disappearance is thus decreased by 94.2 percent with a unit increase in area. When the state is covered with zero fertile land, a unit increase in the area yields a hazard ratio equal to exp(-.1439949) = 0.866, or a decrease of 13 percent.

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