Millet, Rice, and Isolation: Origins and Persistence of the World's Most Enduring Mega-State*

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Abstract

We empirically test a theory of endogenous formation and persistence of mega-states, using China as an example. We constructed a novel dataset to explore the relationship between the diffusion of agriculture, migratory distance, and social complexity-cum-historical presence of Chinese states across $1^\circ \times 1^\circ$ cells in eastern Asia. We find that cells that adopted agriculture earlier and were close to *Erlitou* – the earliest political center in eastern Asia – remained under Chinese control for longer and continue to be a part of China today. Conversely, early adopters located farther away had enough time to develop into independent states.

Keywords: State formation, Agriculture, Isolation, Social Complexity, Stickiness to China, Erlitou, East Asia

JEL Classification: F50, F59, H70, H79, N90, O10, R10, Z10, Z13

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1 Introduction

Since their emergence, states have been the main societal actors affecting social relations, development, and conflict (Claessen, 1978; Fukuyama, 2011; Boix, 2015). Understanding the emergence, evolution, and persistence of states is thus key to our understanding of human organization. Of particular interest are large persistent states, which have left lasting impacts on the contemporary institutional, cultural, ethno-linguistic, and religious landscape. In sharp contrast to the several mega-states (large-scale land-based empires) that emerged and disappeared in Western Asia and Europe, the Chinese state has unified a region almost the size of Europe (see Figure A.1), which in the course of more than two millennia between 221 BCE and today saw its *reemergence* over and over again.[1] During the same period, western Eurasia hosted diverse groups of peoples, never reconstituted its largest empire, remained home to numerous languages and religious groupings, and today struggles to build a unifying political framework. China's Han majority became the dominant ethnic group of a territory far exceeding their initial core region, making Mandarin the prevailing language of a fifth of the world's people.[2] Even if China's "excessive" unity contributed to its relative decline after the 18th Century, as many have suggested (e.g., Landes, 1999; Scheidel, 2019), the persistence of the country's scale into its era of late-20th Century resurgence makes it a force with few rivals in the current global economic and geostrategic order.

How did the first core state – the little dot as shown in panel (a) of Figure 1 – come into being in eastern Asia in the first place? More importantly, how did it *reproduce* and *expand* after periods of disintegration and gradually become the largest empire in eastern Asia in a period that spans more than three millennia from 1,700 BCE to 1,820 CE (the rest of the panels)? Specifically, what made some autochthonous states eventually lose their independence and become parts of an enormous empire, while others ended up as independent modern states?[3]

To address these questions related to the origins and evolution of state expansion in the context of eastern Asia and what eventually became China today, we propose and test empirically a theory of the formation and persistence of a mega-state in a spread-zone of agrarian society. We are the first to assemble the data that demonstrate that what grew to be the series of large empires from Qin to Qing to PRC was indeed the direct result of social and economic changes set in train by the world's second independently domesticated package of crops and animals supporting a fully agrarian society. As a general proposition, we hypothesize that the extent and persistence of this Sinitic state-building

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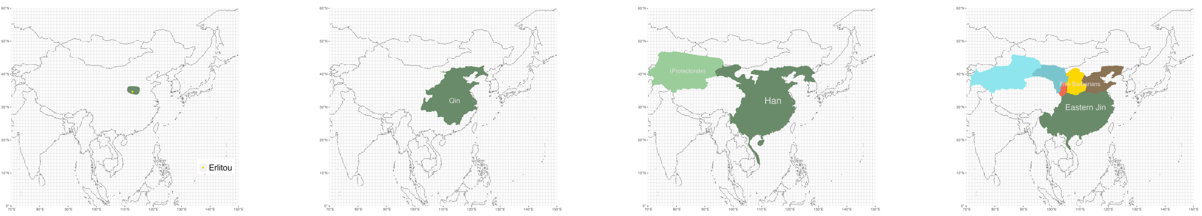
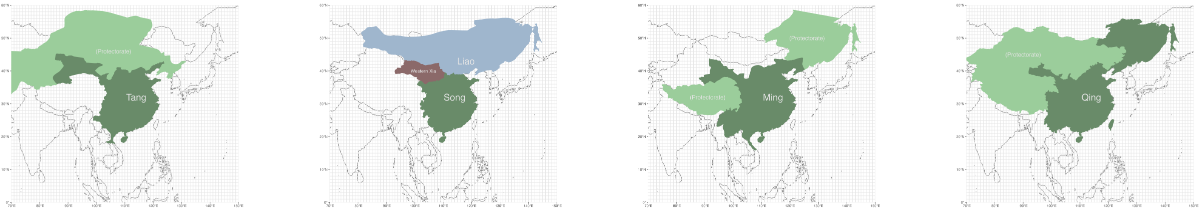
[1] Turchin et al. (2022) discuss three thresholds of large state size beginning with a 350,000 km^2 threshold crossed by Akkadia and the Shang dynasty, a 1,000,000 km^2 threshold crossed by Assyria and the Zhou dynasty, and a 3,000,000 km^2 threshold crossed by the Achaemenid, Mauryan, Roman and Eastern Han empires. They call the latter a "mega-empire", stating that the Old World usually had three such empires for the two millennia beginning in the late first millennium BCE. We use the term "mega-state" to refer to a polity of roughly the latter scale or larger.

[2] Due to differential rates of population growth, China's population has fallen from nearly a third of world population circa 1800. Illustrating their lesser stability of rulers and identities, the western lands that hosted Sumer, Akkad, Babylonia, and Assyria transitioned through Persian, Hellenic, Roman, Byzantine, Arab, Ottoman, and British rule, coming to be populated mainly by speakers of languages imported from the western steppe, Arabia and Central Asia, with much of their contemporary populations holding religious beliefs also imported from outside their immediate region.

[3] This paradox is perhaps best illustrated by the historical facts that once independent states ended up as parts of China's Guangdong and Yunnan provinces, while what were once parts of Sinitic empires ended up as the northern portions of the independent countries of Vietnam and Korea. Refer to the historical narrative in Section 2.4.



(a) Xia (ca.1700 BCE) (b) Qin (221 BCE) (c) Han (60 BCE) (d) Eastern Jin (395 CE)



(e) Tang (669 CE) (f) Song (1111 CE) (g) Ming (1409 CE) (h) Qing (1820 CE)

Figure 1: Historical States in Eastern Asia, 1700 BCE-1820 CE

project is determined by a "race" between two processes set off by i) the relative timing of the adoption of agriculture, and ii) the distance to other state-building projects. On the one hand, a state could arise independently ("autochthonously") as a consequence of the social-evolutionary changes that occur over the course of many centuries following the adoption and intensification of agriculture. On the other hand, a state could be imposed upon a place that arrives later at mature agrarianism, by expansion of states formed earlier near the region's original agrarian core.

Where in eastern Asia would agriculture most likely be adopted and diffused and complex societies and states evolved? We conjecture that complex societies were to evolve after the domestication of millet and rice in *clusters* of highly crop-suitable land, so-called "hotspots"[4] – a term that connotes both agricultural suitability and scale economy in cultivating the "package" of crops of eastern Asia. Holding other conditions constant, the earlier a region adopted an agricultural way of life, the sooner it would develop into a larger and more complex society, and subsequently a state. It is thus the *earliness* in adopting and diffusing the locally domesticated agricultural package in the hotspots for millet and rice that gave rise to the first state (condition 1). As the precursors of states (such as chiefdoms) emerged and competed with each other, conflicts arose between them, resulting in ever larger units, leading to the formation of the first states (Lattimore, 1940; Turchin, 2009; Turchin et al., 2013).[5] In the process, distant, isolated locations were better protected from annexation by the first state, to the extent that travel in ancient times was slow and difficult (condition 2). This geographic isolation thus afforded agricultural hotspots located further from the initial domestication core more time to travel further down their own path of independent state-building. And as these other – more distant – states evolved and expanded, they set limits to the expansion of the first state.

China's emergence and evolution as the core state in eastern Asia exemplifies this theory on a

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[4] As discussed further in Section 3.2.3, a hotspot is a cluster of highly crop-suitable locations, i.e, a group of locations all of which are very suitable for agriculture.

[5] Although we don't explicitly model conflicts among neighboring localities, the role of distance from the state-building core in our analysis can be thought of as a reduced form representation of such models.

continental scale. Specifically, we make use of eastern Asia's high geographic isolation from the rest of the Eurasian landmass's agriculturally productive zones and convenient transport corridors to conduct a quasi-natural experiment of history. Eastern Asia's relative isolation was of pivotal importance for two reasons. First, it enabled the Sinitic states and their immediate peripheries to experience a largely independent trajectory of political development all the way until the 19th century.[6] Second, isolation allowed eastern Asia to domesticate and diffuse its indigenous agricultural package and start down the path of complex agrarian civilization before the arrival of West Asian crops.[7] Precisely because complete transitions to a state took millennia,[8] earliness in establishing an agricultural way of life in a location of high agricultural potential within eastern Asia gave rise to the emergence of complex societies sooner, providing exceptional advantages for state building and expansion.

The continental isolation of eastern Asia and the diffusion of an indigenous crop package within it provides an ideal setting for testing our theory empirically at a sub-continental level, focusing on the rectangular eastern Asian region stretching from Afghanistan to the Pacific beyond Japan and from mid-latitude Siberia to the equator (see Figure 2). We partition this region into $1^\circ \times 1^\circ$ cells and compile a novel dataset with various measures of social complexity, presence of Sinitic states, number of years since agricultural adoption, agricultural suitability and hotspots, and distances to the first state-level society in eastern Asia, *Erlitou*, as well as a complete set of geographic and climatic controls.[9]

To account for the emergence of the first state in eastern Asia, our first goal, we regress the evolution of social complexity between 10,000 BCE-1 CE based on measures compiled by Peregrine (2003), distinguishing grid cells belonging to the region that became the first Chinese empire under the Qin dynasty, the Indus, or neither (i.e., the rest of eastern Asia), controlling for time and cell fixed effects.[10] We find that the cells of cultural regions that were subsequently incorporated into the Qin dynasty *diverged* from both the Indus and the rest of eastern Asia from around 6,000 BCE – a long time before the emergence of the first state at *Erlitou* – suggesting that the Qin mega-state had deep

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[6] And yet it was sufficiently connected to the rest of Eurasia to receive from it beneficial additions to its agriculture (wheat, sheep, goats, etc.), transport and military technology (horses, wheeled carts and metallurgical know-how), and other aspects of technology and culture shared across Eurasia; all of these allowed the Sinitic states to stand on a par with western Asia and Europe in technological and social sophistication between the 6th and 17th centuries CE (Morris, 2010).

[7] According to archaeologists, Eurasia as a whole saw only two independent agrarian revolutions of sufficient productive potential to have each given rise to populous agrarian civilizations reaching the stage of large polity formation: the Fertile Crescent of West Asia, and East Asia's agrarian core in what today is China (see, among others, e.g., Fuller, 2010; Larson et al., 2014). All other Eurasian and North African agrarian societies received the bulk of their domesticates from one or both of these core regions.

[8] Borcan et al. (2021) find that on average 3,400 years separate the first emergence of societies relying mainly on domesticates and the first emergence of a full state in eight pristine sites that include the Fertile Crescent, China, Mesoamerica, and the Andes. This specified sequence of development follows a long tradition of scholarship, which posits that the adoption of agriculture would give rise to larger populations and stratified societies and states (Boix, 2015; Diamond, 1997; Fukuyama, 2011; Carneiro, 1970; Galor, 2022). See Currie et al. (2020) for empirical modeling of the role of time since agriculture adoption.

[9] Located in western Henan Province along the middle Yellow River in today's North China (Figure 7), *Erlitou* is also considered the precursor of the Qin dynasty and China's original political center. While the claim of *Erlitou* being the capital of the mythic Xia dynasty remains contested, there is less dispute about *Erlitou* being the first state in eastern Asia and the region around it being where the earliest state building in China was concentrated.

[10] The pre-historic dataset that we constructed to measure social complexity contains rich information on size, location, degree of urbanization, population density, state hierarchy, etc. of identifiable cultures (refer to Section 3.3.2 for details).

historical roots. We then confirm that this divergence was driven by the geographic distribution of agricultural potential, using the hotspots for millet and rice as our independent variable. Specifically, millet hotspots diverged from the rest of eastern Asia from around 6,000 BCE, with rice hotpots catching up 2,000 years later. To identify this relationship causally, we exploit an event study that relies on the estimated dates of domestication and diffusion of these crops, and confirm that respective hotspots in and around where millet and rice were initially domesticated show a distinct increase in the level of social complexity in later centuries. In terms of magnitude, a one millennium earlier adoption of domesticated millet increased social complexity in a millet hotspot by more than one standard deviation and close to half of the mean in the next millennium.

We then turn to identify where *within* the millet hotspots the first Sinitic state would emerge, by analyzing a detailed panel dataset of complex societies with rich characteristics for location, size, duration, and archaeological culture that spans the period 7,000 – 221 BCE. In order to gauge the heterogeneous effects of earliness in adopting agriculture with respect to the scale economy effect of hotspots, we construct a typology of caloric suitability of hotspots (high vs. low) and years since agriculture adoption (YSA, early vs. late) within these hotspots.[11] Consistent with our expectations, we find that millet domestication had the largest effect in locations that adopted agriculture earlier and had high caloric suitability for the crop, suggesting that *Erlitou* and its surrounding sites were precisely the sub-region in eastern Asia where the earliest state-level society should have emerged, a finding consistent with the well-known historical fact that the Sinitic states expanded from a predominantly millet world (Ge, 2018; Chen and Kung, 2022; Diamond and Bellwood, 2003).[12]

Second, we set out to account for the evolution and reemergence of a core macro-state over the course of two millennia by documenting the historical expansion of China between 221 BCE and 1911 CE, or specifically shifts in Sinitic states' boundaries and presence for a total of 2,132 years across $1^\circ \times 1^\circ$ cells in eastern Asia. The specific dependent variable that we constructed for this novel analysis is a measure of a cell's "stickiness to China", which is the degree to which it was incorporated in, and controlled by, the Chinese state in the last two millennia. To ensure robustness we constructed three different proxies. The first is "territorial China", which is an indicator showing the length of time when the Chinese state had the apparent power to exercise military control over a territory. Given that territorial China does not imply the day-to-day presence and thus administrative capacity of the state, our second variable is "cadastral China", which is constructed by enumerating the county seats in each cell in each period as a proxy for its bureaucratic presence or specifically tax collection effort. We then combine the two into a single measure – "hybrid China". Together, these three indicators and a new index of Sinicization (see below) measure the duration and intensity of a cell's incorporation into the Sinitic states over time.

By applying a "survival analysis" over a typology of outcomes based on whether a cell adopted agriculture earlier and its proximity to *Erlitou*, we find that the Sinitic state tended to annex the

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[11] Previously, data for the adoption of agriculture at the grid cell level was available only for Europe (Pinhasi et al., 2005).

[12] To be clear, we view the fact that initial domestication sites coincide with land of high productivity and other features favoring development of complex societies, as a feature of the eastern Asian case rather than a universal. Archaeologists find that key West Asian crops were domesticated in the hilly areas surrounding it before conditions for city state and state formation arose in lower Mesopotamia, to which those crops had diffused.

early adopters near *Erlitou* in the earlier stage of its state-building process (early/close), but tended to incorporate the late adopters also located close to *Erlitou* (late/close) thereafter (c. 618 CE). We explain this shift in the Sinitic state's expansion strategy as a possible consequence of the remotely-located early adopters having built up their own military capacity, and, thus ability to repel invasion. Exceptions notwithstanding, we also find that once annexed, cells – especially the early/close variant – tended to remain highly Sinicized throughout the entire period. But these are only the main effects. To substantiate the empirical validity of the "race" between the years since agriculture adoption (YSA) and autochthonous state building (distance from *Erlitou*), we interact the two in a regression analysis where the dependent variable is stickiness to China. We find that conditional on their distance from *Erlitou*, cells that adopted agriculture earlier were less likely to be absorbed by China because earlier adoption allowed these cells to start their own state-building projects earlier and become militarily stronger, deepening the negative effect of distance. Specifically, a one standard deviation increase in YSA decreases stickiness by about 0.26 standard deviation. Likewise, holding YSA constant, being one standard deviation farther away from *Erlitou* than the average location – i.e., more than 2 weeks of travel from it – were significantly less likely to become a part of China. Taken together, these findings provide empirical support to substantiate the theory of the "race" between agricultural diffusion and state expansion. To alleviate the concerns that our results might be driven by omitted factors correlated with the incentive to adopt agriculture and the location of *Erlitou*, we replaced them with their more exogenous proxies – hotspots or crop caloric suitability for YSA and the centroid of a cluster of proto-states for *Erlitou*, respectively – to check for robustness, and obtained strikingly similar results.[13]

By exploiting the unique empirical setting of eastern Asia's relative isolation from the rest of the Eurasian land mass, our study makes a contribution towards understanding how large states, in this case China, reemerged and expanded. As this continental isolation enables us to treat the emergence and diffusion of agriculture and states in eastern Asia independently from events elsewhere, our study also contributes to explaining why eastern Asia was able to reproduce a mega-state in the area that became China, and illuminates the determinants of its borders with other states. In this spirit, our study is related to Alesina and Spolaore (2005) endogenization of the size and borders of nations.

Our study also contributes to the growing literature on state formation. While this is an area of research in which many have made contributions (e.g., Wittfogel, 1957; Carneiro, 1970; Tilly, 1992; Olson, 1993; Diamond, 1997; Boix, 2015; Scott, 2017; Schönholzer, 2020; Mayshar et al., 2022; Allen et al., 2022), our study provides fresh insights into the fundamental elements behind state formation, expansion, and re-constitution in the context of eastern Asia. Our findings are consistent with Diamond's (1997) discussion of "how China became Chinese" due to the spread of its regional agricultural package, and with Mayshar et al.'s (2022) argument that cereal appropriability was crucial to state formation. However, we underscore the importance of the slow build-up of social change following adoption of agriculture by showing that years elapsed since initial adoption of agriculture is

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[13] In other words, although hotspots and caloric suitability for agriculture (CSI) are potentially orthogonal to the time of arrival of agriculture, in practice, they are highly correlated in our region. Indeed, the coincidence of concentrations of highly suitable soils with locus of first domestications plays a large part in explaining why state building remained centered close to the original domestication points for so long. In particular, Table C.1 demonstrates that millet and rice hotspots, and millet and rice CSI, are independently strong predictors of YSA (significant at the 1% level).

as important as having clusters of land with high agricultural potential for explaining the emergence of the first state in the eastern Asian context. While our study can be related to Carneiro's (1970) and Schönholzer's (2020) circumscription theory which views the interaction between geographically delimited concentrations of agricultural land and conflict as driving forces behind the emergence of states, expanses of agriculturally productive land without major natural barriers to the east, southeast and south of China's initial state-building core render their circumscription theme unimportant to the macro state-building phase on which we focus.[14] Although we do not explicitly model conflict in our analysis, our focus on state expansion takes as given military competition among polities extracting wealth where they can assert an internal monopoly on legitimate force, as analyzed in the voluminous literature that connects the role of external military threats or social conflict with state formation and expansion (Lattimore, 1940; Barfield, 1992, 2023; Turchin, 2009; Bai and Kung, 2011; Graff and Higham, 2012; Turchin et al., 2013; Gennaioli and Voth, 2015; Ko et al., 2018; Chen and Ma, 2020; Allen et al., 2022).

Our work also contributes to a fast-growing literature that endeavors to compare a unified China with a fragmented Europe. A particularly relevant work, in this context, is one that explores Diamond's (1997) "fractured-land" explanation of European disunity using historical simulations to test the role played by topography and other geographic features in accounting for this difference (Fernández-Villaverde et al., 2023). While our detailed analysis focuses on eastern Asia only, our interests overlap, and their evidence on the low geographic barriers to state expansion in China's core is complementary to our findings. However, both the underlying forces hypothesized to account for the China-Europe divergence and the analytical methods employed in reaching the conclusions differ fundamentally between our two studies. In particular, their study treats availability of a pan-Eurasian crop assemblage and of states of some size, with capacity determined only by resources, as constants throughout the period simulated, whereas we emphasize that eastern Asian civilization sprang from an initially independent agrarian transition, that time is important to social evolution, and that east Asian societies developed under a unique degree of isolation from the sphere of western agrarian and state diffusion. This permitted the region's state formation process to play out until recent centuries with little impact from the clashes of civilizations to its distant west. We also point out that eastern Asia's slightly later agricultural revolution and state building process can account for the agrarian civilizational offspring on the core state's eastern and southern peripheries being too immature to contest it until well into the modern era.

Finally, our study is clearly also relevant to the large literature on the "deep roots" of comparative development – a perspective that attributes variations in contemporary income, cultural traits, and institutions across space and time to various historical factors such as geography, human characteristics, and historical events (see, among others, e.g., Acemoglu et al., 2005; Ashraf et al., 2010; Ashraf and

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[14] Although variation of land quality, and the role of concentrations of high productivity land ("hotspots"), are central to our analysis, and while we also note how China's interface with the steppe played a persistent role in its long-term state-building, we abstract from circumscription given that the millennia of mega-state expansion and recreation are our ultimate focus. Schönholzer (2020) identifies early China as low in circumscription and concludes that later state expansion beyond the range of around 380,000 km^2 (his "Goldilocks" zone for early state formation) is not constrained to territory circumscribed by lower quality land. The area unified by the Qin dynasty was larger by a factor of three and the current PRC is several times larger.

Galor, 2013; Michalopoulos, 2012; Nunn, 2012; Spolaore and Wacziarg, 2013; Dell et al., 2018; Özak, 2018). Our specific contributions in this respect are two-fold. First, we provide a theory of the origins and reemergence of large mega-states using eastern Asia as example. Second, we test it empirically with a unique dataset constructed from a rich variety of historical sources, demonstrating how the initial core of Chinese state-building arose from the complexification of societies set in motion by the indigenous transition to agriculture based on the local domestication of millet and rice.

The remainder of our paper is organized as follows. In Section 2, we provide a historical background to facilitate the understanding of our analysis. In Section 3, we introduce our data sources and explain the construction of variables to be used in the empirical analysis. Section 4 presents the main empirical results behind the emergence of complex societies and *Erlitou* as the first state in eastern Asia. Section 5 discusses the main empirical findings on the evolution and re-emergence of the mega-state that became China. Section 6 concludes.

2 Historical Background and Conceptual Framework

2.1 Isolation

We begin our analysis with the stylized historical fact that within Eurasia, the west and east are separated from one another by a large expanse of difficult-to-traverse and agriculturally inhospitable terrain of very low caloric potential. Additionally, effective separation of the areas that became China and its peripheries from the Indian subcontinent provided it with a distinct advantage of geographic isolation.[15] This isolation was favorable to the construction and persistence of large states in eastern Asia, because, as the site of an agricultural revolution spawning agrarian social evolution independent of that in the West, it was spared the conflicts that afflicted west Eurasia, allowing it to mature into large state construction based almost entirely on indigenous domesticates.[16]

The presence of suitable precursor species and the enormity of geographic divide between the west and east led them to each develop their own separate cereal packages of agricultural diffusion. In particular, the two immense river valley systems in eastern Eurasia, the middle and lower portions of the Yangtze and Yellow river systems, including their numerous tributaries and smaller counterparts such as the Huai and Liao rivers, fostered the adoption and diffusion of millet and of wetland rice. Absence of impassable mountain or desert barriers between the river valleys allowed also for cultural contacts and diffusion and made possible the eventual amalgamation of small and mid-sized states. In Asia's west, agricultural societies emerged based on a varied suite of grains including wheat, oats, barley, and rye, near and around rivers draining into the Persian Gulf.[17] This pattern is clearly

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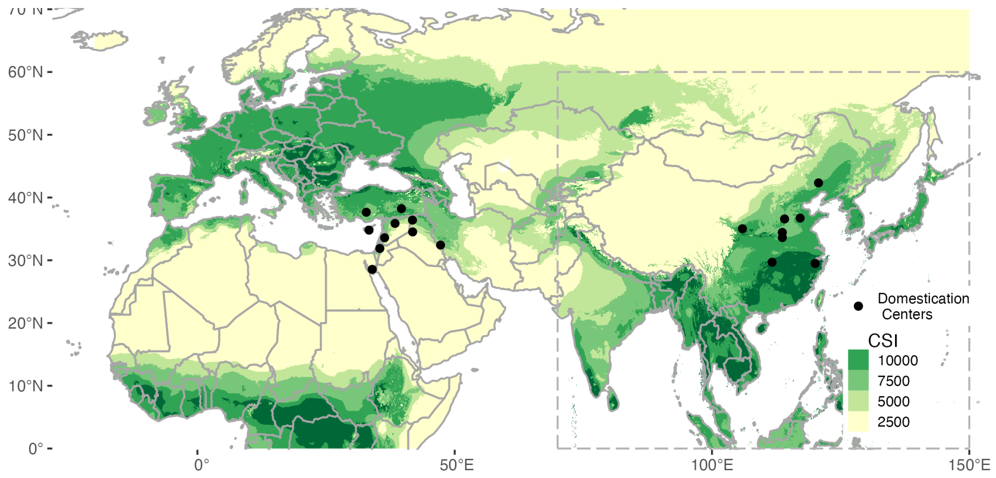
[15] Specifically, the distance between the vast expanses of the low fertility steppe, desert, and mountains between West Asia (today's Iraq and Iran) and the western edge of ancient China, and the latter's effective separation from the Indian subcontinent, together provided China with a distinct advantage of geographic isolation.

[16] In the process, there were no direct military challenges from the Greeks, Romans, Persians, Celts, Vikings, Arabs, etc. Alexander's troops mutinied when he wanted to penetrate further into Afghanistan/India. The sole great battle between a West Asian and an East Asian empire was that between the expanding Abbasid caliphate forces and China at Talas in today's Kyrgyzstan during the Tang dynasty, close to what continues to be the westernmost projection of Chinese state power.

[17] The West Asian agricultural package, including contributions from nearby Mediterranean and Black Sea regions,



*Rectangular area delimited by the dashed lines indicates boundaries of eastern Asian region (our sampled area).

Figure 2: Pre-1,500 Calories and Agriculture Domestication Centers

revealed in Figure 2, which depicts the earliest locations of domestication and the suitability of land for agriculture as measured by its caloric potential (Galor and Özak, 2015).[18]

2.2 Diffusion of Agriculture, Growth of Complex Societies, and State Emergence

The immediate consequence of the extent of their isolation is that the main crops of eastern and western Asia did not diffuse substantially between these regions during the first few thousand years of cultivation – periods that saw the gradual growth of settled populations and the emergence of complex societies independently in each region, despite the west beginning to domesticate grains up to two thousand years before the east. Regardless of timing, we consider the transition from foraging to settled agriculture (including animal husbandry) as one of the most important factors contributing to increases in technological and social complexity (see, among others, e.g., Asouti et al., 2013; Childe, 1951; Diamond, 1997; Dow and Reed, 2022). Every known early civilization that subsequently gave rise to cities, large empires, and a highly specialized occupational division of labor (as in soldiers, tax collectors, administrators, artisans, etc.), was preceded by a growing population that increasingly required a fixed abode, which in turn resulted from having adopted a suite of domesticated crops and animals and gradually improved agricultural techniques (Diamond, 1997).[19] Of course, it is only after a protracted period that appreciable changes in social complexity as marked by walled fortifications, elaborate elite burials, and sites of religious rituals, begin to unfold in the archaeological record of

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diffused outwards to southern Europe, North Africa, the region of present-day Iran, and the western Indian subcontinent before reaching the western outskirts of the millet and rice-growing east on the eve of the Erligang civilization (Stevens et al., 2016).

[18] Detailed definition of Caloric Suitability Indices (CSI) is in Section 3.2.3. One example (and consequence) of the separation of eastern and western agrarian societies that lasts to this day is the high prevalence of lactose intolerance in eastern Asia populations (Sahi, 1994).

[19] The Mesopotamian civilizations of Sumer, Akkad, Babylon and Assyria, the Mesoamerican civilizations of the Olmec, Maya, Toltec, and Aztec, and the first eastern Asian civilization in China, were each preceded by intensifying cultivation of cereals and pulses and domestication or management of animals (Boix, 2015). The Egyptian and Indus Valley civilizations mainly relied on crops and animals from the Fertile Crescent package that reached them by the early fourth millennium BCE (Allen, 1997; Murphy and Fuller, 2017).

each region (Borcan et al., 2021; Harris and Fuller, 2014).[20]

Unlike western Eurasia, which has had *shifting* heartlands in Mesopotamia, Egypt, Persia, and Europe, the later blossoming and more geographically isolated civilizations of eastern Asia remained, until recently, centered on a *fixed* core area that took off in terms of social complexity from around 6,000 BCE and earliest state-level civilization in 1,700 BCE. As the first state in eastern Asia, *Erlitou* and the region around it is considered the precursor of the Qin dynasty and indisputably where the earliest state-building activities were concentrated in China, which, in turn, was the culmination of an evolutionary process of competition between earlier proto-states and their unification in the region as a consequence of conflicts. Compared with the numerous proto-states that preceded it, *Erlitou* is considered the first polity in eastern Asia to have established a multi-level administrative hierarchy consisting of a single ruler who controlled a large territory through a hierarchy of local administrators, and had the largest urban center with a population of around 30,000 at its peak, most of whom were commoners.[21] Its economy was highly developed, with many regional centers specializing in manufacturing a variety of goods. Perhaps because of this highly specialized economy, *Erlitou* was already a highly stratified society as gauged by the sharp contrast in living standards between its elite and commoners (Liu and Xu, 2007). Geographically, *Erlitou* is located very close to the centroid of all proto-states within what later became China and the centroid of the eight earliest centers of millet and rice domestication (see panel (a) of Figure 1, Figure 7, and section 4). This early second millennium BCE state-building project at *Erlitou* presaged the much larger scale state-building projects that would retain roughly the same geographic heartland for over twenty-two hundred years. Moreover, it remained close to the capitals of the Sinitic states for the next three millennia.[22]

Based on the reviewed evidence, we hypothesize that the determinants of the location where the first state would emerge in the eastern Asian region, which in turn would give rise to successors that became the regional hegemon, are the suitability for agriculture, earliness of adoption of agriculture (allowing time for agrarian society to grow and mature), and proximity to rivers (facilitating population aggregation and contacts, and enjoying the advantages of alluvial soils). More specifically, we expect to see evidence of gradually increasing social complexity precisely at the earliest regional agricultural hotspots and the emergence of a state near the geographic center of a cluster of smaller complex population aggregations or proto-states that arise in these hotspots leading up to full-fledged state formation. Since millet appears to have been domesticated and diffused somewhat earlier than rice, our framework also predicts that full-fledged state emergence is more likely to occur in millet hotspots. By taking these factors into account, we can better understand the processes that contributed to the emergence of states in eastern Asia and their subsequent regional dominance.

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[20] In particular, it took thousands of years from early experimentation with the wild precursor plants to the gradual modification of crops by selective use of preferred grains as seed, the addition and improvements in methods of fertilization, weed control, and water management (Harris and Fuller, 2014).

[21] *Erlitou* had an urban center of three square kilometers (the palace area alone occupied 12,000 square meters) and direct interaction sphere that spread over 860 square kilometers (Liu et al., 2004). Through the diffusion of culture and technology, it had a profound impact on other civilizations that extended to as far as 1,500km (Xu, 2014). Some scholars even consider *Erlitou* the capital of the mythic Xia Dynasty, China's first, although there remains controversy around this (Xu, 2018).

[22] Only with the shift of the capital to Beijing beginning in the late 1,200s CE did the capital move on a long-term basis in a more northeasterly direction.

2.3 The Expansion of Sinitic States and Autochthonous State-building

With *Erlitou* as the center and supported by a potent agriculture, China's heartland hosted many states with competitive relationships after the emergence of the first state-level society. But it took another 1,500 years for a unified mega-state, the Qin Empire, to emerge. Formed by unifying the populations of already sizeable states based around the Yellow and Yangtze Rivers, the Qin, which at its peak covered approximately 30 percent of today's PRC, started its expansion soon after it was unified. To reduce threats from the steppe nomads, the Qin built a straight road linking central China and the northern steppe to transport its troops. To facilitate expansion to the south, it constructed the Lingqu Canal, a first link between the Yangzi River and Pearl River drainage basins. By this time, other autochthonous states were developing and competed with the nascent Sinitic state. For example, the future Chinese provinces of Yunnan, Fujian, Guangxi, Guangdong, and northern Vietnam in the south, were still home to independent states known as Ailao, Minyue, and Nanyue.[23] Likewise, the three contemporary northeastern provinces were the territory of the Sushen people and Buyeo state, while the Korean peninsula had the Old Gojoseon state, the Xiongnu tribal confederation inhabited the steppe, and current Xinjiang was composed of many city-states.

From Qin on, there was a long-term trend towards consolidating a heartland which remained under Sinitic states' rule for most of the time, forming larger empires amidst the waxing and waning of the buffer and peripheral areas, until its final expansion to the frontier zone, whereby stable control in the last dynasty – the Qing dynasty – was eventually achieved. Defined as areas in which China could exercise military control and had the apparent power to repel invaders, Figure A.2 shows the temporal change of China's territory (the green dashed line). In this long process, a mega-state in terms of geographical coverage reemerged persistently, as the territory that Qin built up at its peak remained under unified rule for 75 percent of the time during the subsequent 23 centuries. For another 12 percent of those years, this area was divided into two states – typically one northern and one southern – making it the heartland of what the world of recent centuries has called China. Figure 12(b) shows how culturally and institutionally Chinese this area was over the past two thousand years. In particular, the territory that was Qin maintained a high Sinicization level through time (refer to Section 3.3 for details, and Appendix F).

2.4 The "Race" between Agricultural Diffusion and State Expansion

Premised on the theory that we proposed in the introduction regarding the hypothetical "race" between agricultural diffusion and state expansion, our empirical analysis proceeds as follows. First, we set out to account for the diffusion of agriculture and the emergence of complex societies in eastern Asia, and to establish the role that domestication of millet and rice played in the early adoption and diffusion of agriculture in agricultural hotspots and the emergence of complex societies. We also show that the location where the earliest state, *Erlitou*, emerged can be predicted by these same forces. With *Erlitou*

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[23] Minyue (Fujian) and Nanyue (Guangdong and Guangxi) were conquered during the Western Han dynasty (c. 202 BCE - 8 CE), and Ailao (Yunnan) during the Eastern Han dynasty in 76 CE, respectively. Ailao however regained independence after some six hundred years as Nanzhao (c. 738-902 CE) and still later as Dali (c. 937-1253 CE). Yunnan was not permanently incorporated into the Chinese state until 1253 CE.

taken as "given", our analysis of the evolution or reemergence of a large state centered in the band of territory that includes *Erlitou* is guided by a framework in which two processes of diffusion – that of agrarian society, which began its diffusion across eastern Asia millennia earlier, and that of state-building per se, which first appeared at *Erlitou* – are "racing" to determine which will be decisive for local state formation in which parts of the region. If agriculture and the social changes it fostered lead to beginnings of state formation in places far enough from *Erlitou* to be free of the latter's control as local state capacity grows, a locality may retain an autochthonous state generated primarily by early diffusion of agriculture, rather than by expansion of the regional hegemon. But localities close enough to *Erlitou* are more likely to end up with states derived from state expansion rather than independent social evolution derived from diffusion of agriculture alone. The race between agricultural diffusion and state expansion as potential determinants of local political outcomes then morphs into a race between the expansion of the Sinitic state (Erlitou) and other autochthonous state-building projects – a competition that eventually determined the extent and persistence of the mega-state vis-à-vis its neighbors. Specifically, locations that adopted agriculture earlier, viz., *Erlitou*, should benefit from a head start in autochthonous state-building, allowing them to conquer others that have similarly adopted an agricultural way of life. However, if this earliest core state did not extend its power far enough and with sufficient rapidity, it created opportunities for distantly located societies to build their own states and resist incorporation into the enlarging core state.[24]

These processes can be illustrated more clearly by discussing two cases in which the expansion of the Chinese state encountered other autochthonous state-building projects: the Korean peninsula and Vietnam. Although both regions experienced periods of Chinese rule, these were intermittent and short-lived. These nascent states allowed their people to attain and keep distinct ethnolinguistic identities, coalesce around their independent state-building projects, and ultimately repel Chinese expansion.

In the Korean peninsula, the first state (Old Choson) was established around the 4th century BCE, and there is evidence of complex societies stretching back a few centuries earlier. The region was first conquered by Sinitic states three hundred years later. The peninsula, especially the northern part, experienced China's rule five times.[25] However, Korea did not become a part of China in the long run partly because some northerly portions were among the first places beyond what is currently China to adopt millet-based agriculture around 3,500 BCE. The relatively early adoption of agriculture gave them a head start, which resulted in local states co-existing with external rule in most periods. Indigenous languages and cultures were sustained, and the growing population and agricultural surplus favored local state-building projects. External events that weakened the Chinese empire created the opportunity for these local states to exercise more control and gain independence. For example, as

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[24] The historical stylized facts are consistent with this analytical framework. After the adoption of agriculture in central China no later than 6,500 BCE, it then took 4,000 years for the eastern Asian agrarian system to spread, intensify, and improve before the first state-level society emerged in *Erlitou* around 1,700 BCE, and another 1,500 years to form the first unified empire (the Qin Empire in 221 BCE). During the process, the eastern Asian agricultural package had spread from its initial zones of domestication into surrounding and distant areas such as Korea (3,500 BCE) and Vietnam (2,000 BCE), laying the foundations for populous agrarian societies in those regions where linguistic and cultural identities differed from that of China's heartland. Proto-states and early states started to appear in those same regions: in 850 BCE in Korea and 750 BCE in Vietnam (Borcan et al., 2018).

[25] Specifically in the Han, the Wei, the Western Jin, the Tang, and the Yuan dynasty.

the Western Jin confronted the instability that would cause its northern territories to break up into multiple kingdoms, the most notable of the Korean polities, the Koguryŏ (37 BCE-668 CE), conquered the Jin commanderies in 313 CE, leading to the waning of Chinese presence in Korea, and its full disappearance by the middle of the 4th century CE. There were other attempts to annex Korea during the Tang dynasty (618-907 CE) but they could only impose indirect control, setting up a protectorate general. But in fact the two indigenous states of Balhae (698-926 CE) in the north and Silla (57 BCE-935 CE) in the south had long controlled most of today's Korea.[26] From the late 1300s, a single Korean-based state was usually able to govern the whole peninsula, successfully fighting off a Japanese invasion in the late 1500s and two Manchu invasions in the early 1600s. Today, the Korean peninsula is one of the most ethnically homogeneous regions of the world, with its overwhelming majority speaking a language classified as "language isolate" (Lewis et al., 2009) or "Trans-Eurasian" language (Robbeets et al., 2021) rather than a member of the Sino-Tibetan language family.[27]

A similar pattern occurred to the south of China's core, where indigenous state formation had been going on long before its seizure by Sinitic states. The earliest verifiable united kingdom (Lạc) appeared between 1,000-500 BCE in the Red River Delta. This region contains some of the Asian mainland's most fertile agricultural land south of the North China Plain and adopted agriculture as early as 2,000 BCE. The Qin dynasty pushed southwards and at least nominally conquered the territories that became China's southernmost provinces. However, the state of Nam-Việt (Nanyue) which included much of present-day Guangxi and Guangdong provinces plus northern Vietnam, maintained independence from China between 207 and 111 BCE. A good part of northern Vietnam was under China's control until the 10th Century.[28] But rapid cultural assimilation was not to occur in what became Vietnam. Forces based in northern Vietnam initiated several uprisings against the rule of the Han and later Sinitic states, including the Trưng Sisters rebellion from 40-43 CE, the brief establishment of the independent Early Ly Dynasty from 544-602 CE, and several failed insurrections in the 7th through 9th centuries. Finally, in 938 CE, northern Vietnam established lasting local rule during the period of civil war in the Chinese empire following the Tang dynasty. While China briefly regained control of northern Vietnam for a twenty-year period during the Ming Dynasty, unification of Vietnam by rulers who appealed to its non-Chinese ethnic identity to resist incursions from the north made those decades the sole exception to local-based governance until colonization by France in the late 19th century. The Vietnamese language spoken throughout the resulting country is classified as being of the Austroasiatic family. What became the southern Chinese provinces were drawn steadily into China from the Han Dynasty onwards, though they remained linguistically diverse, with local dialects becoming recognizably Chinese in structure but remaining less easily intelligible to speakers of other Chinese dialects than were the dialects of China's north. Only Beijing-controlled mass education and mass media of the most recent decades

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[26] Balhae was followed by the semi-sinicized and "Manchuria"-centered Liao dynasty, which controlled the northern edge of China proper and that of the Korean peninsula. Liao rule was followed by overlordship by the Mongols during their rule in China as the Yuan dynasty.

[27] Robbeets et al. (2021) suggest that an independent center of domestication of broomcorn millet in the West Liao river valley led to a spread of farming in northeast Asia independent of that associated with Sino-Tibetan speaking farmers in north central China, giving rise to a "Trans-Eurasian" family of languages which includes Korean.

[28] During the Western Han dynasty, China also absorbed southern Vietnam.

have begun to alter this.[29]

3 Data

3.1 Geographic Coverage

We focus on the eastern part of Asia, which includes contemporary China and neighboring states, since until recently, this region was more influenced by the spread of east Asian domesticates and culture rather than west Asian equivalents, given their relative isolation from other early-developed zones in the same land mass (e.g., the band of agrarian societies running from west Asia to north Africa and southern Europe). Specifically, we mark off an area located between 70° and 150° east and 0° and 60° north, and split it into $1^\circ \times 1^\circ$ cells for our analysis.[30]

3.2 Key Independent Variables

3.2.1 Years Since the Adoption of Agriculture

To estimate the number of years since the adoption of agriculture (YSA), we used data on the spread of agriculture across Asia based on archaeobotanical evidence collected from 922 independent archaeological sites (Figure 3(a)). We constructed this measure following the methods employed by Pinhasi et al. (2005) and Silva et al. (2015). Specifically, we use the Inverse Distance Weighted (IDW) method to construct estimates of the timing of diffusion across our grid cells for each of the four original native eastern Asian grain crops – millet (foxtail, broomcorn) and rice (japonica and indica).[31] For cells lacking historical records, we interpolated the timing of the adoption of agriculture based on the sites and dates provided in the pertinent sources. Specifically, we predicted the date of the adoption of agriculture in a cell c as the weighted average of the date of neighboring cells that contain the relevant information. Doing so provides us with the information on the date of the adoption of agriculture in a given cell for each crop. We selected the earliest of the various crops and assign it to cell c.[32]

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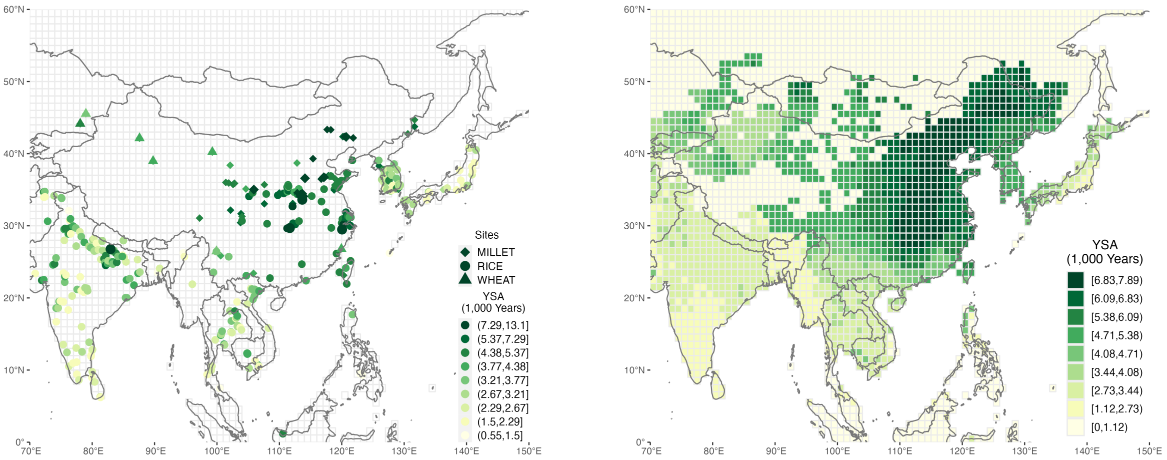
[29] In the early 1950s, less than half of the Chinese population, 41 percent, could understand standard Mandarin (Putonghua) (regardless of whether they could speak or not); this number rose to 90 percent after three decades. By 1984, still only half of the population could communicate (both understand and speak) in Mandarin (Putonghua); this number rose to 81 percent in 2020 (Chen, 1999; Ministry of Education of the People's Republic of China, 2004, 2020).

[30] This region includes more than 40 percent of Eurasia's longitude or 48 percent of Asia's. Its northern margins extend beyond the scope of traditional temperate farming, and it extends far enough south to include all of mainland Asia. Although this area includes portions of the Indian subcontinent that experienced earlier diffusion of West Asian agriculture than did the cells in which China emerged, we adopt the full rectangle in most analysis to avoid arbitrary boundaries. South Asia is controlled in some estimates by plate fixed effects.

[31] We also included wheat, but wheat was still a delicacy for elites rather than a staple in China as late as the 7th century CE, though it displaced millet as China's second major cereal centuries later. In any case wheat arrived too late for it to have any significant impact on YSA. Data on the diffusion of foxtail millet, broomcorn millet, and wheat are from Stevens and Fuller (2017), while those on the diffusion of rice are taken from the Rice Archaeological Database (Silva et al., 2015).

[32] We define neighboring cells as those located within a week of migratory distance from c, where the weights are a function of the inverse of the migratory distance to cell c. By definition, IDW can only predict values for cells within the convex hull generated by the set of all locations that have data in the original source (Figure G.1). Thus, to extend the interpolation to the full range of cells we study, we use out-of-sample predictions based on an OLS regression between YSA and a set of geographic and climatic variables, including distance from the original locations, using the sample of the interpolated data (see Appendix G).



(a) Adoption Sites

(b) Interpolation

Notes: (a) shows location and carbon-dated age of the agricultural sites by type of crop. (b) shows the spatial distribution of the interpolated data. Years shown are Before Present (BP).

Figure 3: Years Since the Adoption of Agriculture

Since agriculture can only be adopted in regions habitable by humans, we adjusted our predictions for areas where the geo-climatic conditions would not support human existence (Burke et al., 2017; Wren and Burke, 2019; Xu et al., 2020). Specifically, we identify geo-climatic conditions that would not support a population density larger than two people per square kilometer in the year 1 CE. Figure G.2 shows that the relationship between geography and population density changes dramatically around this cutoff. Using a logistic regression, we estimate the probability that a cell has a population density below this threshold as a function of the level and square of its latitude, elevation, ruggedness, mean temperature, mean precipitation, extreme temperatures, temperature volatility, precipitation volatility, optimal caloric suitability, length of fallow season, and dummies that identify the ventiles in which population density was low. We consider cells to be uninhabitable if we predict them to be uninhabitable with 95 percent or higher probability. Appendix D.3.3 shows the robustness of our results to this assumption and variations in the construction of our measure.[33] Figure 3(b) shows the predicted spatial distribution of the timing of YSA, where years are measured Before Present (BP), i.e., before 1,950 CE.

3.2.2 Migratory Distance from the Earliest State - *Erlitou*

The ability of states to expand geographically by projecting military power onto a region depends crucially on its relative isolation from other competing states. To estimate the distance of each cell from *Erlitou*, we use the Human Mobility Index (HMI), a measure that estimates the minimal travel time between two given cells based on human biological, geographical, and pre-modern technological constraints (i.e., before the availability of steam power), and allowing for a wide range of activities

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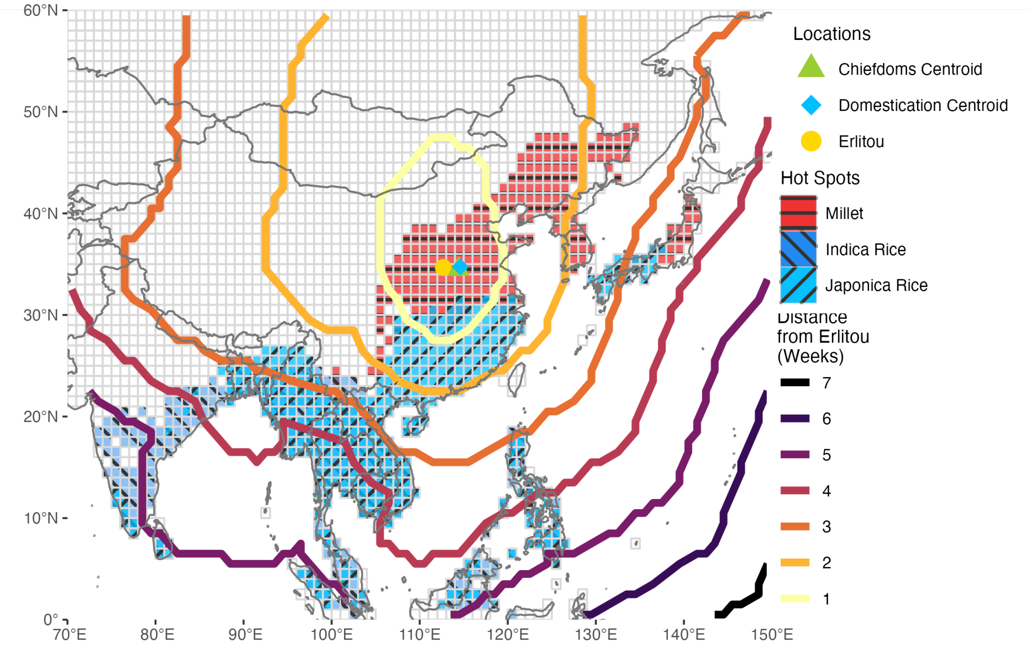
[33] In particular, not accounting for habitability or using coarser temporal aggregation does not affect our results qualitatively. Similarly, varying the parameters of the IDW algorithm, the types of sites included, or accounting for clustering of sites does not qualitatively alter our results either. In fact, we tried over 20 variations of our algorithm and the correlation among the various YSA measures is above 0.85. See Appendix G.

such as the sending of army troops, conducting trade, or establishing communications, etc. (Özak, 2010, 2018).[34] In particular, Özak (2010, 2018) shows that migratory (time) distances and routes based on HMI are strongly correlated with historical travel times and routes based on various modes of transportation including army movements, diplomatic mail delivery, and trade routes. Figure 4 depicts the location of *Erlitou* and the iso-time curves of migratory distances to it.



Notes: Colored circle, triangle and diamond depict location of earliest state and centroids of sites of early state-building and crop domestication. Shaded areas represent millet and rice hotspots. Lines represent iso-time curves to *Erlitou* at 1 week intervals.

Figure 4: HMI Distance from *Erlitou* and Crop Hotspots

Our other controls related to distance also use HMI for construction. The isolation between China and other powerful states in the western part of the land mass is of particular importance, especially if the two were expanding simultaneously (Ashraf et al., 2010). To account for the effect of isolation on state building, we construct the level of isolation from the rest of Afro-Eurasia for each cell, by taking the average of the pairwise HMI distance between cell c and all other cells in Afro-Eurasia. In addition, given the importance of river transport, we also measure a cell's HMI distance to major rivers in eastern Asia,[35] particularly the inland waterways, which were the most important transport network before the modern era (Elvin, 1973).

3.2.3 Millet and Rice Hotspots and Domestication

On the assumption that concentrations of lands suitable for cultivating millet and rice are those where complex societies were more likely to emerge and spread, we must identify their spatial distribution. We identify these clusters of agriculturally suitable land using data on caloric (agricultural) suitability

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[34] We use HMI with seafaring for the construction of our distance measures, as travel between *Erlitou* and Japan, Taiwan, and other locations all entailed a sea route.

[35] To construct HMI distance to rivers, we focus on rivers with stream order higher than 5 in the river data from Natural Earth Vectors, available at Natural Earth. For each cell we assign the travel time to the closest river.

provided by Galor and Özak (2015, 2016), which captures the potential caloric output obtainable from each crop based on cultivation methods and agro-climatic conditions before 1,500 CE.[36]

The ability to produce calories from agriculture was a necessary but not sufficient condition for the development of social complexity and state expansion. Only clusters of spatially concentrated agriculturally suitable land, so called suitability "hotspots" – i.e., groups of cells with above-average agricultural suitability – could generate "agglomeration" effects with greater potential to increase social complexity than did single suitable cells in isolation. In a nutshell, the economies of scale conferred by hotspots facilitated the diffusion of agricultural ways of life and the corresponding emergence of complex societies and expanding states. Hotspots should thus be understood as a fixed geographic endowment, as opposed to YSA, which represents the cumulative effect of the adoption of agriculture. Using the local Moran-I statistic of each cell (Anselin, 1995, 2001), we identified the locations of millet and rice hotspots in eastern Asia, which are depicted in Figure 4. Specifically, given a cell i and its 8 direct neighboring cells, N_i, its local Moran-I statistic can be obtained by computing $I_i = z_i \sum_{j \in N_i} w_{ij} z_j$, where $z_i = (x_i - \bar{x})$ measures the difference between the suitability of cell i, x_i, and the average suitability, $\bar{x}$, w_{ij} is the weight of each neighbor, which we set equal to 1. I_i measures whether a cell i and its neighbors have extreme levels of suitability. We use conditional permutations of the data to construct a reference distribution for I_i to test whether $I_i > 0$. A cell is a hotspot if I_i is significantly larger than 0, $z_i > 0$, and $\sum_{j \in N_i} w_{ij} z_j > 0$ (Anselin, 1995, 2001). We use a significance level of 0.25% to determine the statistical significance of I_i. Thus, hotspots include only highly productive cells that have highly productive neighbors, and for which with a high level of confidence we reject the hypothesis that there is no local spatial clustering (i.e., $I_i \leq 0$). Figure 4 depicts the location of the hotspots for rice and millet.[37]

Our empirical strategy also requires data on the date of domestication of these two crops. Although, throughout we will identify domestication or "onset of domestication" with these specific dates as if the process occurred at a specific moment in time, it is important to note that the domestication of crops is a prolonged and continuous process (Larson et al., 2014; Silva et al., 2015; Stevens and Fuller, 2017). This process took many centuries, sometimes stretching for millennia, to be completed, through which wild varieties were first collected, then cultivated, and finally domesticated, resulting in genetically and morphologically modified varieties, which allowed societies to become fully dependent on agriculture. Thus, there is no one specific instant in which domestication happened. We interpret our dates as the approximate dates at which significant reliance on the crop began to diffuse within a wider region, which usually meant domesticated varieties were sufficiently genetically and morphologically different from wild varieties. Based on archaeological evidence, we use the years 7,000BCE and 5,000BCE for millet and rice respectively. Specifically, these years are cut-offs of the oldest 5th percentile in

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[36] Since Galor and Özak (2015, 2016) use modern data to produce their estimates, one potential concern is that their estimates do not correctly capture past conditions. Reassuringly, their estimates are constructed in order to reflect agricultural practices pre-1500 CE and are based on agro-climatic conditions orthogonal to human intervention. Moreover, Turchin et al. (2021) find that historical and modern data across 30 macro-regions in the world have a correlation of 0.84.

[37] For rice hotspots, we can distinguish between japonica (mainly cultivated and domesticated in China) and indica rice (mainly cultivated and domesticated in India). In our main empirical analyses, we will only distinguish between rice (without distinction) and millet, while the appendix provides results distinguishing between millet and each type of rice.

the distribution of carbon-14 dates across sites in our archaeo-botanical dataset (Stevens and Fuller (2017) for millet, Silva et al. (2015) for rice). Importantly, these dates are in line with estimates in the literature about the period in which the morphological and genetic domestication of these two crops was underway (although still short of complete) and the diffusion to wider areas had started (Doust and Diao, 2017; Gutaker et al., 2020; Fuller et al., 2010; Fuller, 2011).

3.3 Dependent Variables

3.3.1 Stickiness to China

To construct a novel variable measuring the stickiness to China, we measured the number of years each cell has been a part of a Sinicized state. Specifically, we constructed three measures – territorial, cadastral, and hybrid.

A cell is judged to be included in "territorial China" if it is located within lands over which a Chinese dynasty of the time asserted control. To construct this measure, we digitized a set of historical maps originally collected by Tan (1982) and augmented by Gu and Shi (1993) and Zhou (2017) for a period of two millennia. Altogether, there are 99 maps, each covering an average period of approximately 22 years (Figure A.3).[38] Based on these maps, we code territorial China based on whether or not the Sinitic states exercised military control and had the apparent power to repel invaders in cell c in year t (T_{ct}). However, these boundaries and the shifts that occurred between dynasties are silent on both the type of rule (direct versus indirect) and the degree of Sinicization (i.e., how culturally and institutionally Chinese a dynasty was). To account for these effects, we weight the territorial control in each year by i) distinguishing regions according to whether they were under direct rule (R_{ct}=1) or not (R_{ct}=0.5) when T_{ct}=1,[39] and ii) the degree of Sinicization in the polity controlling cell c in year t (abbreviated as SI, ranging from 0 to 1).[40] For cell c in year t, territorial China is defined as

$$\bar{T}_{ct} = T_{ct} \cdot R_{ct} \cdot SI_{ct}. \tag{1}$$

By summing $\bar{T}_{ct}$ over 2,132 years ($\bar{T}_c = \sum_t \bar{T}_{ct}$), we compute cell c's stickiness to China in "territorial" terms. We define $\bar{T}_c$ as the total number of years that cell c falls within China's border, taking into account both the "type of rule" (direct versus indirect) and level of Sinicization. Figure 5(a) depicts the spatial distribution of territorial China $\bar{T}_c$. In our sample, 73 percent of the cells were conquered by China at least once (Table B.1, column (1)), 43 percent of the cells were ruled by Sinitic states for more than 500 years, and 54 percent of the cells are in the PRC today.

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[38] Based on Tan (1982), the China Historical Geographic Information System (CHGIS) digitized the boundary information but only for the late Qing (c. 1820 and 1911). In addition to digitizing all the maps compiled by Tan, we further digitized those documented by Gu and Shi (1993) and Zhou (2017).

[39] Conceptually, the latter resembles the current autonomous regions of China, although the central government typically exerted less control over such areas before the advent of modern modes of communication and transportation. Indirectly ruled areas were recognized by different terminologies between dynasties. For example, Xinjiang was the "Xiyu Protectorate" in the Western Han dynasty and was a "Dependency" in the Qing dynasty before 1844.

[40] The detailed coding procedure is explained in Appendix F and the resulting Sinicization Index is shown in Figure F.2, respectively. To give a sense of SI's values, we note here that the Liao and Jin dynasties of the 11^{th} and 12^{th} centuries CE attain SI scores of about 0.65, the (Mongol) Yuan dynasty of the following century receives an SI score slightly below 0.6, the Tang and Ming dynasties receive SI = 1, and the Manchu-based Qing dynasty receives SI = 0.75.

An obvious limitation of territorial China is that it may fail to capture fully the *presence* of the Sinitic state; e.g., after conquering a region a dynasty's army may have retreated and left it to be ruled indirectly, with no settled population and taxation resulting therefrom.[41] To reflect the presence of the Sinitic states with fiscal and other administrative functions, we construct an alternative measure called "cadastral China" to indicate how intensely a cell was governed by a Sinitic state, using county seats as a proxy. To construct this measure, we built upon CHGIS Version 6, augmenting it with data from Zhou (2017) to include i) counties located outside of the boundaries of today's PRC, and ii) counties established by less-Sinicized dynasties (e.g., the Liao and the Jin).[42] Specifically, after confirming whether or not a cell contains a county seat, i.e., C_{ct}=1 if it does and 0 if it does not, we counted their actual number in cell c in year t to account for the varying strength of the state presence (e.g., N_{ct}=5 if cell c has five counties in year t). Thus, Sinitic states presence in year t in cell c is

$$\bar{C}_{ct} = C_{ct} \cdot N_{ct}. \tag{2}$$

By summing $\bar{C}_{ct}$ over time ($\bar{C}_c = \sum_t \bar{C}_{ct}$), we obtain cell c's stickiness defined in terms of cadastral China. We define $\bar{C}_c$ as the total number of years that cell c has a county present multiplied by the number of counties therein (as weight). Figure 5(b) shows the spatial distribution of cadastral China $\bar{C}_c$, where about 17 percent of the cells had one or more county seats at least once (see Table B.1, column (1)), and about 15.7 percent of the cells are in today's PRC.

Territorial and cadastral China capture two different aspects of state-building. Territorial China emphasizes the territory where China could project its military influence, while cadastral China reflects the actual presence of state bureaucracy (county seats) or the fiscal capacity of the Chinese state. For robustness, we combine the two in "hybrid China" by replacing the "type of rule" (R_{ct}) in territorial China with the existence of county seats (C_{ct}) in cadastral China.[43] Hence, in each period and for each cell,

$$\bar{H}_{ct} = T_{ct} \cdot C_{ct} \cdot SI_{ct}. \tag{3}$$

By summing $\bar{H}_{ct}$ over time ($\bar{H}_c = \sum_t \bar{H}_{ct}$), we can obtain cell c's stickiness defined in terms of hybrid China. Figure 5(c) shows the spatial distribution of hybrid China $\bar{H}_c$, while Figure A.5 shows the distribution of hybrid China stickiness at the provincial and national level.

3.3.2 Prehistoric Development

We use the level of social complexity as our first measure of prehistoric development. We do so by constructing a panel of the level of social complexity between 10,000 BCE and 1,000 BCE across eastern Asia based on *The Atlas of Cultural Evolution (ACE)*, which maps the borders of major

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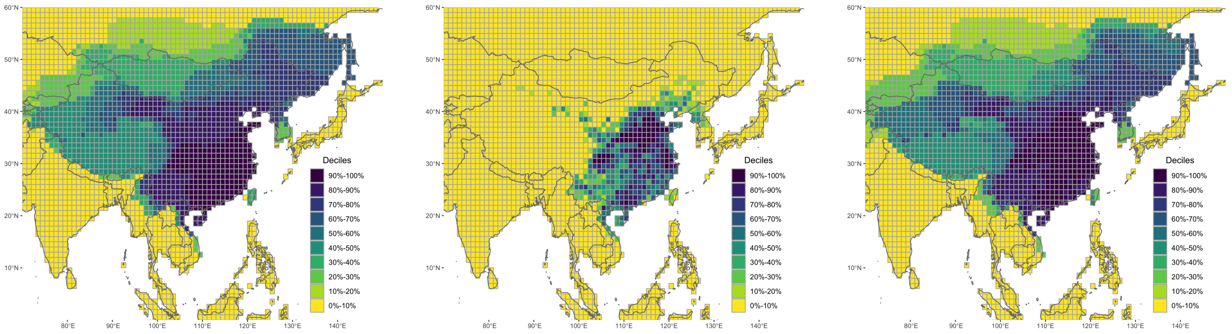
[41] We also cannot rule out that the maps used reflect the perceptual and political biases of dynastic proclamations and historians, since the sources relied on are Chinese and not all boundaries are sure to have been mutually agreed, nor was there always an undisputed sovereign with whom to reach such an agreement.

[42] The examples illustrate that less-Sinicized dynasties were typically founded by people of non-Han ethnicity. Figure A.4 shows the distribution of the counties contained in CHGIS (in yellow) and the counties missing in CHGIS we geocoded from Zhou (2017) (in green).

[43] Unlike earlier, C_{ct} is set to 0.5 for a cell within a Sinitic state, but without a county seat.



(a) Territorial (b) Cadastral (c) Hybrid

Notes: Spatial distribution of stickiness to China based on (a) military power, (b) taxation and bureaucracy, and (c) both. Authors computations. See text for details.

Figure 5: Stickiness to China

cultural traditions around the world (Peregrine, 2003).[44] Using 3,000 BCE as an example, Figure 6(a) shows the distribution of major cultural traditions (dark gray borders) in our area of analysis. For each ACE cultural tradition, we employ ten measures as proxies for its stage of development according to *ACE*; they include: reliance on agriculture, population density, political integration above the band or small settlement, social stratification, fixity of settlements, writing system, use of money, technology level, urbanization, and transportation. Each of these measures takes on a value between 1 and 3.[45] As a summary measure, we take the average of all ten characteristics to construct an index to reflect their average level of social complexity over time. Figure 6(a) depicts the level of social complexity across cultural traditions in 3,000 BCE and Figure 6(b) the mean level of social complexity between 10,000-1,000 BCE across cells.

We complement this data with a second prehistoric measure that identifies the location, size, duration, and culture of complex societies within the area of contemporary China. Specifically, we employ data from Xu (2018), which provides the most comprehensive and systematic dataset documenting the emergence and growth of states in the Chinese context. Unlike other datasets that use scant and scattered evidence of human remains/art/burial monuments/etc. to infer the existence of complex societies, Xu compiles data on over 1,000 wall- or trench-enclosed sites of complex societies between 7,000-221 BCE located within the borders of today's China. He categorizes archaeological reports to extract direct and accurate evidence about the location, size, duration of existence, and local archaeological culture (it belongs to) of these archaeological sites.[46] We digitized this data and created a panel of the presence and features of complex societies in each cell across time (Figure 7). Unfortunately, there do not seem to exist datasets on complex societies with quality comparable to Xu (2018) for regions outside China that would allow the construction of a panel for our full sample. Thus, given the geographical coverage of our panel, when we use it, we restrict our sample to cells located in the

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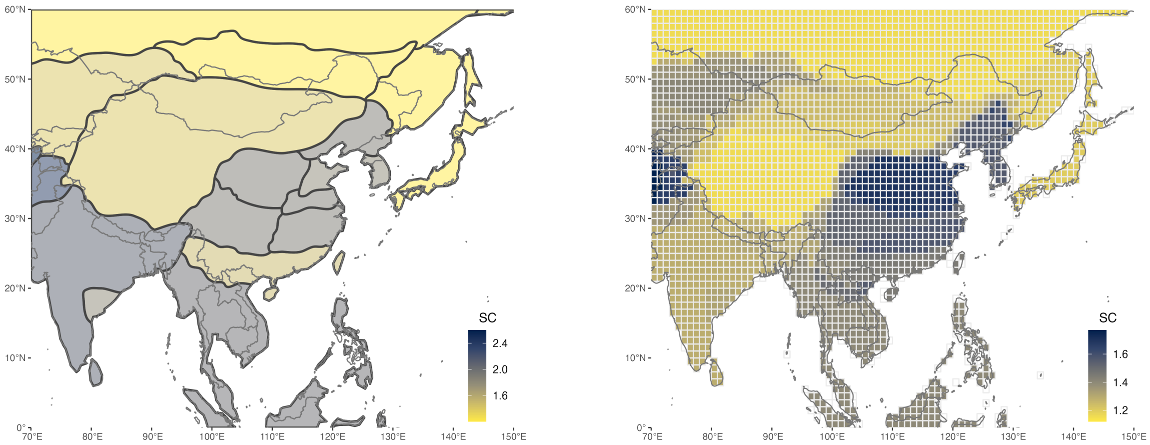
[44] We use the term *cultural traditions* to refer to what Peregrine (2001, 2003) define as archaeological traditions, i.e., "a group of populations sharing similar subsistence practice, technology, and forms of socio-political organization, which are spatially continuous over a relatively large area and which endure temporally for a relatively long period." During our period of analysis, the number of ACE cultural traditions in eastern Asia averaged between nine and nineteen.

[45] Table E.1 in Appendix E shows the coding scheme in *ACE*.

[46] The local archaeological cultures employed in this dataset are more finely-grained than the cultural traditions identified in ACE.



(a) Social Complexity in 3,000 BCE (b) Average Social Complexity (10,000-1,000 BCE)

Notes: (a) depicts the level of social complexity in 3,000 BCE across ACE cultural traditions (polygons) in ACE. (b) shows the average social complexity across cells between 10,000-1,000 BCE. Authors computations.

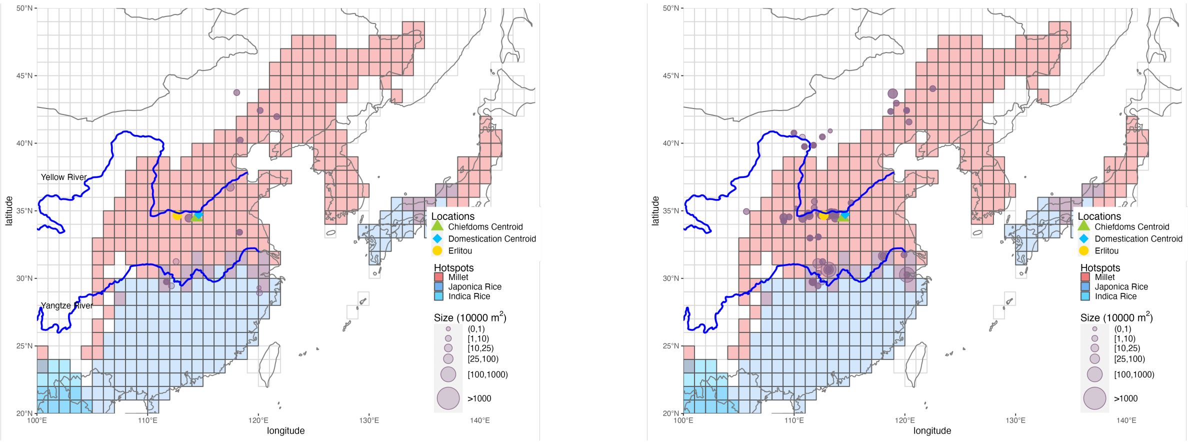
Figure 6: Social Complexity (10,000-1,000 BCE)

contemporary PRC. We complemented Xu (2018)'s panel data using the cross-section of archaeological sites located outside China from Whitehouse and Whitehouse (1975). This allows us to generate an additional cross-sectional dataset of complex societies covering the full range of eastern Asia (Figure A.6). Data limitations in Whitehouse and Whitehouse (1975) preclude the construction of a panel for all of eastern Asia.

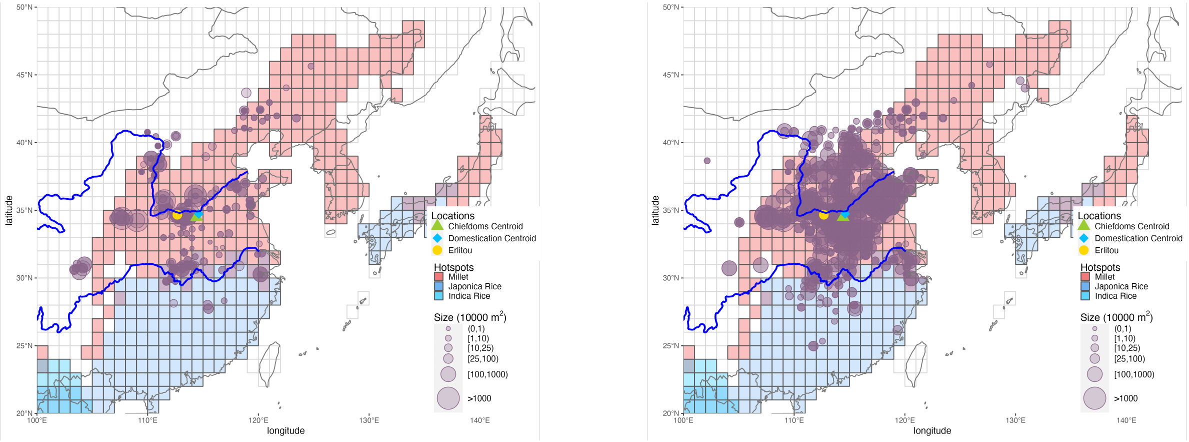
4 The Emergence of the Earliest State

Before examining our proposed "race" between the expansion of the earliest-starting mega-state and the emergence and survival of neighboring autochthonous states resulting from prior diffusion of the agrarian way of life from its regional core, we examine the evidence on our hypothesis about initial state formation – that the expansion of the agricultural way of life triggered the emergence of complex societies, particularly early state-building projects, in clusters of land highly productive of millet and/or rice cultivation in eastern Asia, and that these early complex societies (especially chiefdoms and proto-states) predict the rise of the first Sinitic state. This requires us to examine i) the divergence in social complexity between agricultural hotspots and the rest of eastern Asia (outside hotspots), and ii) the singular importance of millet hotspots in fostering the emergence of complex societies in general and the rise of *Erlitou* – the region's earliest known supra-local political center – in particular .

We begin by examining the evolution of social complexity between 10,000 BCE-1 CE using our full sample. We first explore whether the cells of cultural regions that were subsequently incorporated into the Qin dynasty *diverged* from both the Indus (another major early civilization in eastern Asia) and the rest of eastern Asia, which would suggest that the Qin mega-state had deep historical roots. We then analyze whether this divergence was driven by the geographic distribution of agricultural potential in the hotspots for millet and rice. In particular, we assign each cell in eastern Asia to one of three macro-regions (future Qin/Indus/neither) and crop hotspots (millet/rice/neither). For the macro-



(a) 7,000-5,000 BCE (b) 5,000-3,000 BCE



(c) 3,000-1,000 BCE (d) 1,000-221 BCE

Notes: Figure depicts location and size of complex societies across time. Complex societies appear and grow in hotspots for millet and rice. Circles show location and size of society. Shaded areas depict millet and rice hotspots. Colored geometries show the location of the earliest state and centroids of sites of early state-building and crop domestication.

Figure 7: Evolution of Complex Societies (7,000-221 BCE)

regions analysis, we assign each cell to either Qin, the macro-region corresponding to the boundaries of China's first unified empire, Indus, shorthand for the large part of the Indian subcontinent contained within our study area, or neither, i.e., all remaining cells in our sample.[47] The hotspots for our main analysis are millet hotspot, rice hotspot, and neither. We then conducted our analysis by estimating the following equation using Ordinary Least Squared (OLS)

$$Y_{ikt} = \alpha + \sum_{k} \beta_{tk} \cdot region_k \cdot t + \gamma_t + \gamma_i + \varepsilon_{ikt}, \tag{4}$$

where Y_{ikt} is the social complexity measure introduced in the previous section, i.e., the unweighted average of 10 indicators selected to measure the level of social complexity in cell i in macro-region/hotspot k in period t; γ_t and γ_i are a complete set of period and cell-level fixed effects, $region_k$ is a dummy

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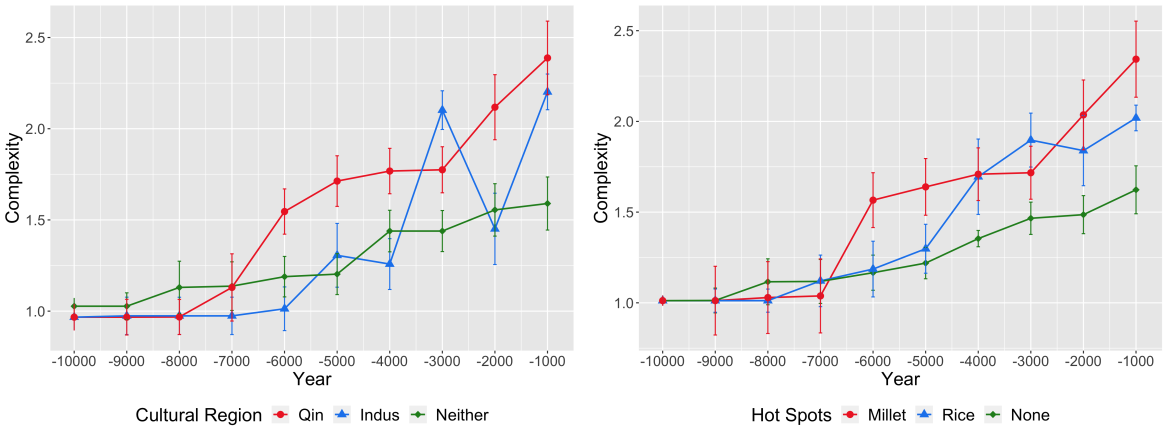
[47] It is illuminating to distinguish not only future Qin but also the area in which the Indus Valley civilization flourished and enjoyed agricultural and trade contacts with west Asia between the 4th and 2nd millennia BCE.

variable indicating whether a cell belongs to the region k=Qin, Indus, or neither (i.e., the rest of eastern Asia), and ε_{ikt} is the error term. Since this analysis is based on our cell-level disaggregation of ACE data, we account for the dependence between observations by clustering the standard errors at both the (ACE) cultural tradition and period levels.[48] Our estimates, reported in Figure 8(a), show that the regions that subsequently became the Qin Empire diverged from both the Indus region and the rest of eastern Asia around 6,000 BCE – a long time before the emergence of the first state at *Erlitou*. While this result strongly suggests that the Qin Empire had deep historical roots in regions that diverged early from the rest of eastern Asia, it does not explain what drove this divergence.

Our theory suggests that a key determinant of this divergence is the geographic distribution of millet and rice hotspots, from which social complexity probably evolved. To verify this, we perform a parallel analysis in which, rather than partitioning cells into k = Qin, Indus, or neither, we use the partition k = millet hotspot, rice hotspot, or neither. We find that millet hotspots also diverged from the rest of eastern Asia from around 6,000 BCE, with rice hotspots catching up after 4,000 BCE as shown in Figure 8(b). We conduct analysis which further distinguishes between the hotspots of japonica and indica rice, and find that japonica rice hotspots (China-based) caught up with millet hotspots after 4,000 BCE, and indica rice (India-based) hotspots did so after 3,000 BCE (Figure C.1). Moreover, a similar pattern with millet hotspots and the regions that will become the Qin diverging from the rest of eastern Asia ahead of the rest is present in all individual social complexity indicators that underlie our main measure (Figure C.2).[49,50]



(a) Regions

(b) Crop Hotspots

Figure 8: Evolution of Social Complexity by Regions and Hotspots

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[48] These results are robust to accounting for spatial autocorrelation at various distances, clustering at cell and period levels, or at the ACE cultural tradition level.

[49] The temporary overtaking in complexity of the Qin and millet hotspot cells by Indus, rice, and in particular indica rice hotspot cells in 3,000 BCE, reflects the uptick in complexity indicators due to the rise of the large and sophisticated Indus Valley cities, which, nevertheless, did not leave evidence of any over-arching state structure, and also lack strong cultural connection to later empires on the sub-continent.

[50] The exact timing of the divergence in the underlying measures varies as can be expected given the different components. For example, the presence of writing systems or records cannot predate the emergence of some of the other indicators. The only two components where the non-hotspots regions have an initial head-start are technology and fixity. Figure C.3 shows similar results hold when distinguishing between indica and japonica rice.

These results lend credence to the hypothesized positive influence of millet and rice in general, and their hotspots in particular, on the emergence of social complexity in early eastern Asia. To identify this relationship in a more causal manner, we employ an event study design that relies on the approximate dates of the domestication of these crops. Specifically, for both millet and rice, we compare the evolution of social complexity between their respective hotspots and non-hotspots before and after their domestication based on the following specification

$$Y_{itk} = \alpha + \sum_{n=-\underline{J}}^{\overline{J}} \beta_{ikt}\mathbb{I}(t=n) + \gamma_t + \gamma_i + \varepsilon_{ikt}, \tag{5}$$

where, as before, Y_{ikt} denotes the level of social complexity for cell i in region k=millet (or japonica/indica rice) hotspot, or non-hotspot in period t; γ_t and γ_i stand for a complete set of the period and cell-level fixed effects, $\mathbb{I}(t=n)$ indicates whether the period t is $n = -J, \ldots, J$, where J indicates the number of periods relative to the onset of millet/rice domestication.[51] Figures 9(a)-(b) show that the domestication of these two crops is associated with an increase in the level of social complexity in their respective hotspots.[52,53] In particular, the mean social complexity during this period in millet hotspots and non-hotspots was 1.3 with a standard deviation of 0.35, which means the domestication of millet increased social complexity in the millet hotspots by more than 1 standard deviation and close to half the mean in the next millennium. In order to provide causal estimates, we need to assume that hotspots and non-hotspots would continue to evolve along similar paths (parallel trends assumption), and that no other treatment took place. While the parallel trends assumption is not testable, estimates in the periods before the domestication of the crops are not statistically different from zero, suggesting this assumption may hold in this setting. Moreover, by restricting the sample to only those periods before the domestication of these crops (especially millet), we find no differences between hotspots and non-hotspots. And if we analyze millet and rice separately, we further ensure that our estimates are not affected by issues related to heterogeneity or staggered adoption. Despite all these robustness checks, our estimates might still be biased by the treatment of cells in rice hotspots

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[51] See again section 3.2.3 for our dating of the domestication of the two crops as beginning at the point at which the 5th percentile of oldest archaeologically attested evidence for each crop is reached in our millet and rice data sources, respectively. The estimated dates are 7,000 BCE for millet and 5,000 BCE for rice, without distinction by variety. Although some archaeobotanical references place the oldest morphologically domesticated finds of the two crops much closer to one another in time, the preponderance of evidence (summarized, for example, in Larson et al., 2014, Fig. 2) is that millet was spreading as a crop beginning to undergo domestication considerably earlier than rice.

[52] Figure C.4 replicates the analysis but distinguishes between japonica and indica rice. In Figure C.5, we report the results of all underlying indicators one at a time. Specifically, the domestication of millet and rice are associated with an increase in population density (Figures C.5(a)-(b)), urbanization (Figures C.5 (c)-(d)), political integration (Figures C.5(e)-(f)), social stratification (Figures C.5(g)-(h)), technology (Figures C.5(i)-(j)), and fixity (Figures C.5(k)-(l)) in their hotspots.

[53] Note well that the year of millet domestication (as determined by the methodology discussed in section 3.2.3) is roughly two thousand years prior to that of rice domestication. Thus, all gains in social complexity reported to the right of the "year = 0" line are occurring roughly two millennia later in rice hotspots than in those for millet. Presence of apparent effects of domestication for complexity as early as year 0 may reflect the facts that pre-domestication cultivation of crop variants not yet archaeologically proven to display morphological evidence of domestication preceded full domestication dates, and that our procedure for selecting the domestication event date implies that 5% of the archaeologically reported sites for each crop bear dates before our identified year of domestication onset. The responsiveness of complexity indicators to the estimated domestication dates for both crops provides some prima facia reassurance that domestication year estimates are relatively accurate.

that were actually suitable for millet, and vice versa. This would create potential biases due to some cells in hotspots being treated before their crop was domesticated, or treated more than once as the other crop was domesticated. Reassuringly, excluding the cells in millet (rice) hotspots that are among the most suitable for rice (millet), and thus are most prone to causing biases, does not alter the results qualitatively, although it increases the estimated causal effect (Figure C.7). Moreover, excluding cells that may benefit from the domestication of the other crop further increases the likelihood of the parallel trends assumption, by limiting the introduction of one crop to affect the hotspots of the other. Moreover, estimating the effect of crop domestication in hotspots under alternative assumptions similarly does not change the results (Figure C.8). In particular, analyzing millet and rice hotspots jointly, and accounting for staggered treatment, in fact strengthens our results.

Next, we employ the panel of archaeological data on complex societies' location, size, duration, and local archaeological culture between 7,000-221 BCE. We replicate the event study design but this time using the number of complex societies and local archaeological cultures as our outcomes. A major advantage of this data is its high spatial granularity, which means we do not need to disaggregate it, unlike the previous data. Still, we continue to cluster standard errors at the (ACE) cultural tradition level, to account for any potential correlation between observations. Given data limitations, our sample is confined to cells located in the PRC only. Figures 9(c)-(f) show that the domestication of these two crops is associated with an increase in the number of sites (Figures 9(c)-(d)) and number of local archaeological cultures in their hotspots (Figures 9(e)-(f)).[54] These results suggest that the domestication of millet and rice in eastern Asia, and its subsequent adoption in the crops' respective hotspots, was essential for state formation. However, the effect is only significant for millet, suggesting that millet played a more central role than rice did in the initial growth of social complexity.[55] This result can also be gleaned from Figure 7, which shows that both the number and size of complex societies grew steadily over time in mainly the millet hotspots. As these small political units competed with one another, the intensified conflict would be likely to lead to the formation of larger political units - proto-states and even states.

These results support the hypothesis that the domestication of these crops and the adoption of agriculture in hotspots, especially millet hotspots, played a fundamental role in the emergence of social complexity. Yet, they do not fully predict *where* within the millet hotspots the earliest state should emerge. To explore this question, we analyze the heterogeneous effects of agricultural suitability and years since agricultural adoption within hotspots. Figure 10(a) depicts their joint distribution within each type of hotspot. Focusing on millet hotspots, we differentiate cells according to whether agriculture was adopted early/late (i.e., above/below the median number of years since agricultural adoption in millet hotspots) and whether agricultural suitability is high/low (i.e., above/below the median caloric crop suitability in millet hotspots). Figure 10(b) shows the evolution of social complexity across these different groups. Clearly, an earlier adoption of agriculture played a larger role in the evolution of social complexity than agricultural suitability within millet hotspots per se. By comparing the

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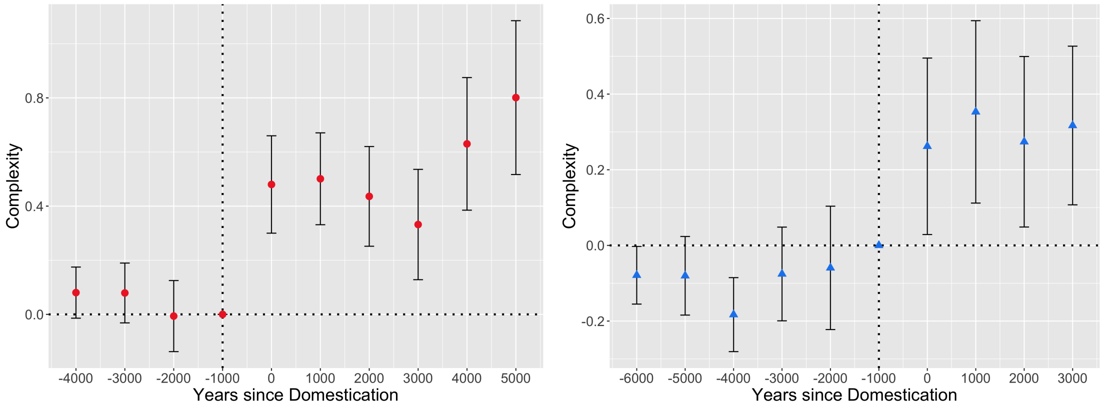
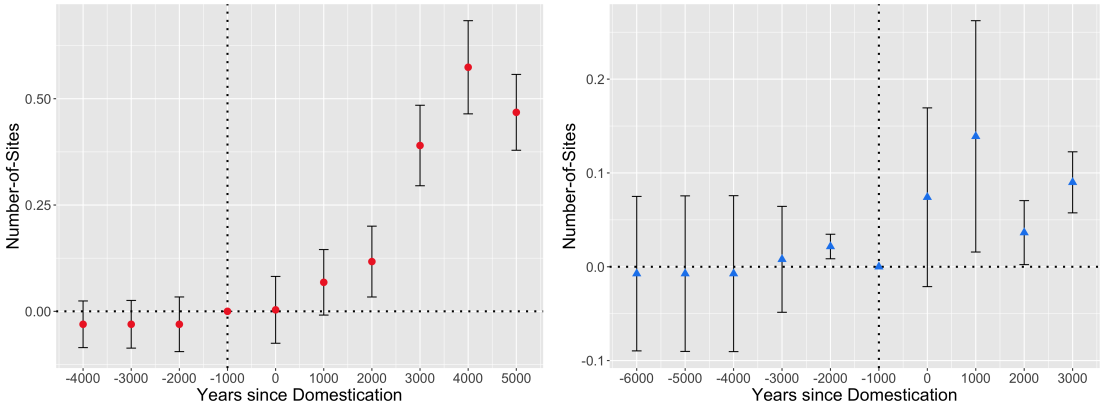
[54] We also report results for the number of sites weighted by their settlement size (Figure C.6(a)-(b)), and both their duration of existence and size (Figure C.6(c)-(d)).

[55] While complex societies also existed in the rice-producing areas especially after the third millennium BCE, there were more in the millet hotspots.


Social Complexity

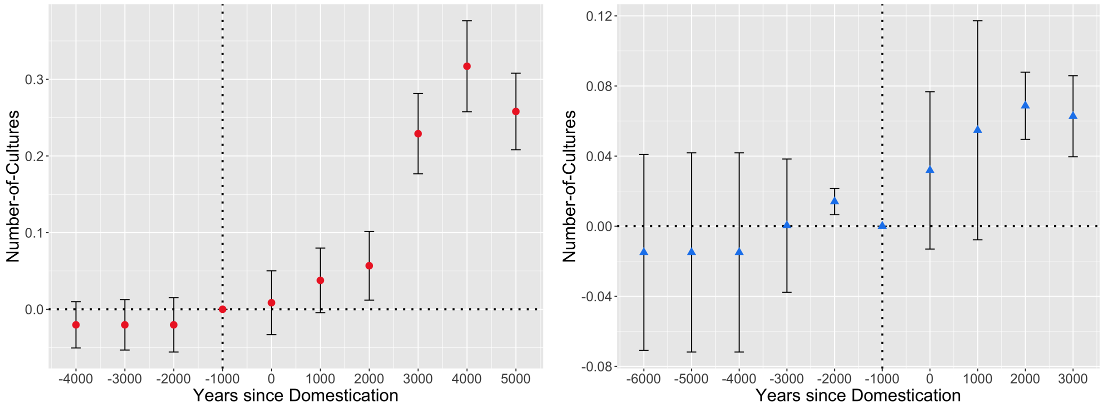
(a) Millet Hotspots

(b) Rice Hotspots


Number of Complex Societies

(c) Millet Hotspots

(d) Rice Hotspots

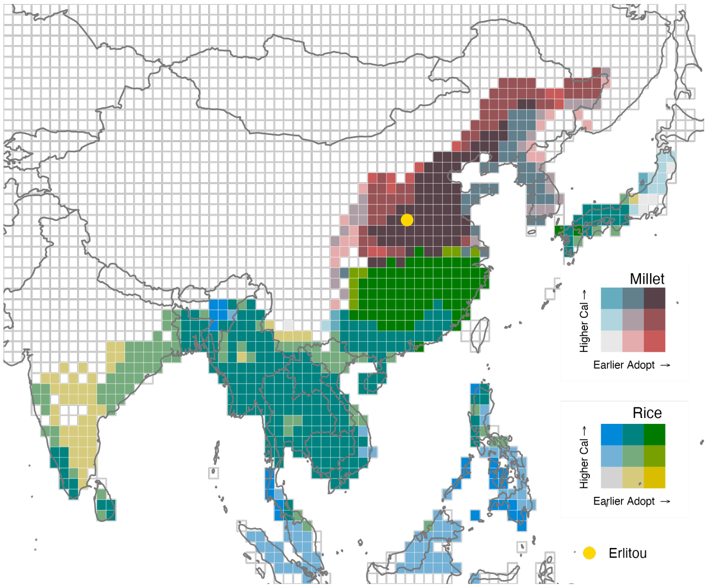

Number of Local Archaeological Cultures

(e) Millet Hotspots

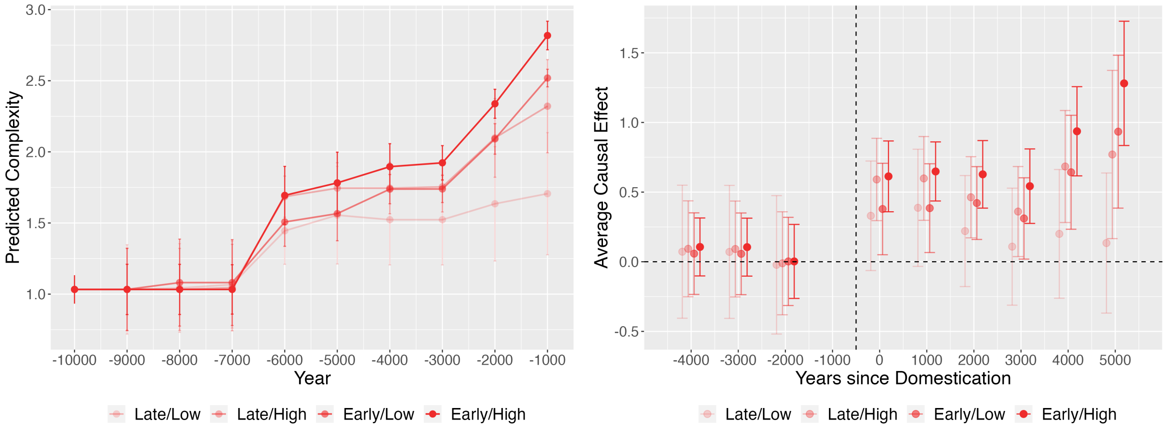
(f) Rice Hotspots

Figure 9: Event Study of the Impact of the Onset of Domestication on Complex Societies

effect of the domestication of millet on the evolution of social complexity in each subgroup within the millet hotspots relative to the non-hotspots, Figure 10(c) provides a causal confirmation of this



(a) Early/Late Agriculture and High/Low Productivity within Hotspots



(b) Millet Hotspots - Heterogeneity

(c) Millet Hotspots - Heterogeneity

Figure 10: Agricultural Adoption and Productivity Heterogeneity within Hotspots

relationship.[56,57] It is now clear that the domestication of millet had the largest effects in locations with the earliest adoption of agriculture and greatest suitability. Thus, it is in this particular sub-region that we should expect the earliest state-building activity in eastern Asia to emerge. In fact, it is precisely in this sub-region that *Erlitou* emerged, as Figure 10(a) clearly shows – a finding that resonates well with the well-known historical fact that the Sinitic states were expanded from a predominantly "millet-world" to a "rice-world".

There are likely myriad reasons why it was in the millet areas that more complex societies emerged initially, and, perhaps because of that, were poised to absorb the south subsequently. The spread of at

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[56] Note again the key role of time in allowing changes in social complexity to unfold as discussed in footnote 8 and Currie et al. (2020).

[57] While the figure plots the coefficients for all groups jointly, the analysis is performed one group at a time to ensure this heterogeneity does not bias our estimates.

least partially domesticated millet began about 2,000 years earlier than rice. It began to diffuse earlier and more widely than rice because millet is a drought-resistant crop and as such is significantly less demanding on irrigation and labor requirements (see Heuzé et al. (2015), Table C.2 columns (1)-(2), Figure C.9), and yet capable of providing a similar amount of calories as rice before the technology to crop rice several times a year was developed – a technology that did not arise until long after the Sinitic states were established (Figure C.10). The earlier and wider geographical spread of millet thus effectively gave rise to a greater geographic scope for conflict, providing the pre-conditions for the emergence of a more complex, hierarchical society. As much of the millet-dominated areas were located in the north – a region that had the most frequent interactions with nomadic pastoralist societies – these evolutionary forces were reinforced with greater vigor there, with military skills such as horse riding and archery being expediently adopted from their nomadic neighbors (Turchin et al., 2016; Su, 2016).[58]

Finally, we use our cross-sectional archaeological data on the location of complex societies covering our full sample (Figure A.6) as a robustness check. Specifically, we examine the effect due to the interaction of hotspots and earlier adoption of agriculture on the number of complex societies in a cell and its proximity to *Erlitou* (defined as being located within one week of HMI distance), respectively, by estimating the following equation using a spatial-error model to alleviate concerns about spatial autocorrelation (Anselin, 2001):[59]

$$Y_i = \beta_0 + \sum_k \beta_k Hotspot_{ik} \cdot YSA_i + \gamma_k Hotspot_{ik} + \beta_1 YSA_i + \delta_k' C_i' + \varepsilon_i, \tag{6}$$

where, Y_i denotes the (inverse hyperbolic sine of the) number of complex societies in cell i or whether it is located within one week HMI distance from *Erlitou*; $Hotspot_{ik}$ denotes whether cell i is located in hotspot k=millet (or rice); YSA_i is years since the adoption of agriculture in cell i; and C_i' is a set of basic geographic and climatic characteristics of cell i.[60]

The results reported in Table 1 suggest that being in a millet hotspot has a large and significantly positive association with both the number of complex societies and proximity to *Erlitou.* In terms of magnitude, a millet hotspot increases the number of complex societies by 49 percent (column (1)) and the probability of being close to *Erlitou* by nearly 18 percentage points (column (7)). The early adoption of agriculture is positively associated with both the number of complex societies and proximity to *Erlitou* (columns (2) and (8)).[61] Finally, in columns (3) and (9), we interact hotspots with years since agricultural adoption (YSA) to explore variations within hotspots. In the case of millet, the

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[58] That the best horses for military purposes were long procured from lands to China's north and northwest and were better adapted to northern climates may have added to the advantage, as well.

[59] We use a 500km neighborhood for the results presented in the main body of the paper. As we show in Appendix C.4.1, the results are robust to varying the size of the neighborhood, as well as using OLS with corrections for spatial autocorrelation (Colella et al., 2019). See Appendix C.4.2.

[60] Main controls include absolute latitude, longitude, land size, elevation, temperature (monthly average mean), precipitation (monthly average mean), terrain ruggedness, and distance to coast. All specifications control for tectonic-plate fixed effects. Detailed data sources are provided in Appendix E. To simplify the interpretation of the results, we standardize all variables to have a mean of zero and a standard deviation of one.

[61] In terms of magnitude, a one standard deviation increase in YSA increases the number of complex societies by 5 percent and the probability of being close to the *Erlitou* by about 3 percentage points.

Table 1: Hotspots and the Emergence of the First East Asian State

	Complex Society						Distance to Erlitou (≤ 1 week)			
	Number (IHS)				Presence (Dummy)		Dummy			
	Full			PRC	Full	PRC	Full			PRC
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Millet Hotspot	0.49***	0.45***	-0.56***	-0.82***	-0.27***	-0.38***	0.18***	0.16***	-0.38***	-0.41***
	(0.03)	(0.03)	(0.09)	(0.12)	(0.06)	(0.08)	(0.02)	(0.02)	(0.05)	(0.08)
Rice Hotspot	-0.12***	-0.11***	-0.14***	-0.59***	-0.09***	-0.32***	-0.06***	-0.05***	-0.06***	-0.37***
	(0.03)	(0.03)	(0.03)	(0.10)	(0.02)	(0.06)	(0.02)	(0.02)	(0.02)	(0.07)
Agricultural Adoption (YSA)		0.05***	0.03***	0.03	0.02***	0.02*		0.03***	0.03***	0.04***
		(0.01)	(0.01)	(0.02)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Millet Hotspot × YSA			0.72***	1.36***	0.38***	0.69***			0.39***	0.53***
			(0.06)	(0.13)	(0.04)	(0.08)			(0.03)	(0.09)
Rice Hotspot × YSA			0.08***	0.65***	0.12***	0.60***			0.01	0.41***
			(0.03)	(0.09)	(0.02)	(0.06)			(0.02)	(0.07)
Plate Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.30	0.30	0.35	0.53	0.28	0.50	0.25	0.25	0.29	0.41
Observations	2779	2779	2779	969	2779	969	2779	2779	2779	969

Notes: IHS denotes inverse hyperbolic sine transformation has been applied. All variables except hotspot indicators are standardized to have mean 0 and standard deviation 1. Main controls include longitude, latitude, land size, elevation, temperature, precipitation, ruggedness, and distance to coast. In all Full columns we additionally account for an archaeological source fixed effect. Spatially autocorrelated disturbances considered within 500kms. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

positive and significant association is driven primarily by this interaction. In terms of magnitude, cells that were in a millet hotspot *and* adopted agriculture earlier by one standard deviation have 72 percent more complex societies and 39 percentage-points higher probability of being within one week of HMI distance from *Erlitou*. Simply put, complex societies were more likely to appear in millet hotspots to which agriculture had diffused earlier. The interaction between rice and YSA has a similarly significant but considerably smaller effect on complex societies but not distance from *Erlitou*.[62] To put these results in perspective, it is worth pointing out that all cells in millet hotspots have an above average number of years since agricultural adoption. Thus, even though the main effect is negative (column (3)), the marginal effect is positive for distribution in the data. Figure 11 depicts these marginal effects and the distribution of the number of years since agricultural adoption across hotspots. As shown, the marginal effect is always positive within millet hotspots and is larger for cells in millet hotspots where agriculture was adopted earlier. Figure 7 further confirms their importance by showing that

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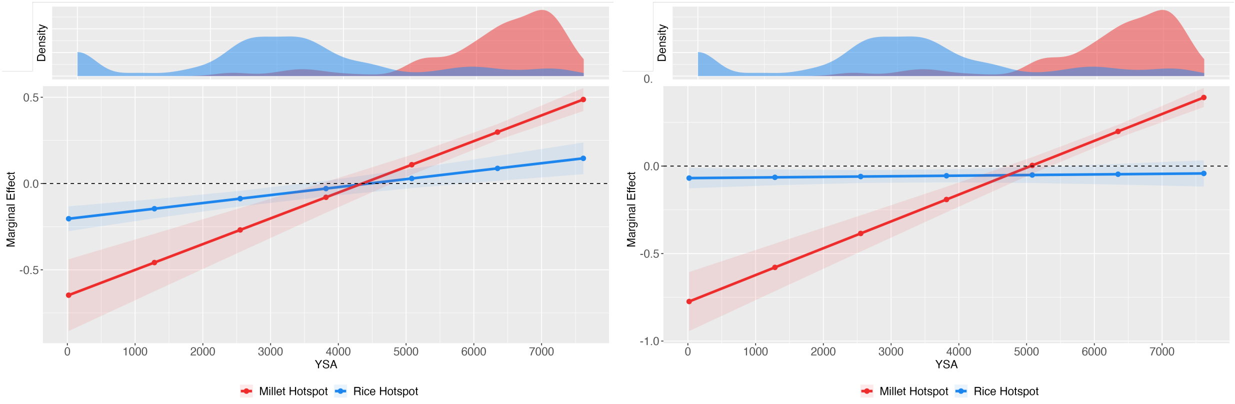
[62] We further confirm the combined importance of millet hotspots and adoption of agriculture for the emergence of early states using semi-partial R-squares, which are computed to show the share of the total variation in the outcome variable that is uniquely associated with an independent variable after removing any common variation with other controls in the regression. As shown in Table C.2, millet hotspots and years since the adoption of agriculture have the largest semi-partial R-squared in the analysis. In particular, the unique variation associated with the two variables explains between 1.5-2 times as much as the unique variation associated with all other controls combined in the full specifications (columns (5) and (11).

state-building activity was concentrated around *Erlitou*, and in millet hotspots close to the centroid of the earliest millet and rice domestication centers. Moreover, the centroid of all proto-states located in the current PRC is in fact located in the *same* cell as the centroid of the earliest domestication centers, less than 160km from *Erlitou*.[63] Data limitations in Whitehouse and Whitehouse (1975) preclude the construction of a panel for all of eastern Asia. Unfortunately, there do not seem to exist datasets on complex societies with quality comparable to Xu (2018) for regions outside China. We use several robustness checks to alleviate the concern of inconsistency in data quality, including controlling for data sources, using Xu (2018) only (Column (4), (6), and (10)), and using a dummy variable for the presence of complex societies in a cell instead of the total number of complex societies to reduce biases due to differences in the quality and coverage between data sources (Column (5)).



(a) Number of Sites

(b) Distance to *Erlitou* (≤ 1 week)

Figure 11: Marginal Effect of Years Since Agricultural Adoption within Hotspots

In summary, our empirical results strongly support the proposition that: i) in terms of the level of social complexity, millet hotspots began to diverge as early as 6,000 BCE, while rice hotspots caught up around 4,000 BCE; ii) in terms of the presence and features of complex societies, millet hotspots had more (larger, and more long-lasting) complex societies and cultural heterogeneity; and iii) within millet hotspots, it was in cells that adopted agriculture earlier (and had higher productivity) where the earliest state-building took place. These conditions provided fertile ground for the emergence of the first state in eastern Asia.

5 The Making of a Mega-state

To put the expansion of what became the Chinese mega-state from its original center (Erlitou) in perspective, we use a "survival analysis" to compute the probability that a cell would be annexed for the first time into the growing empire over time. To conceptualize this analysis, we first classified cells according to whether they are i) the "early adopters" (defined by whether they are estimated to have adopted agriculture before the end of the second millennium BCE), and ii) "proximate cells" (defined

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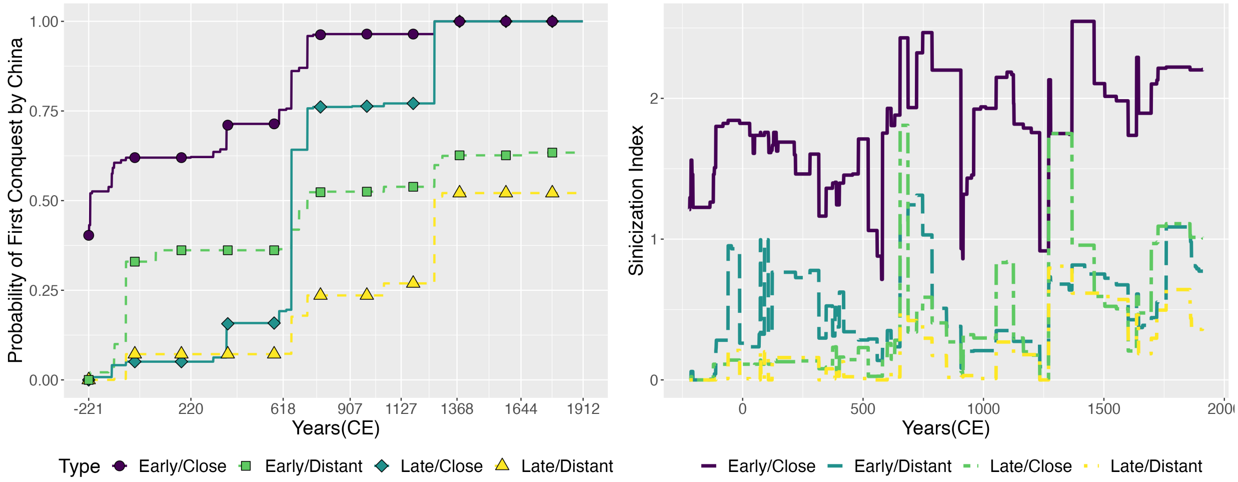
[63] The centroid of proto-states in the pre-*Erlitou* years (3,500-1,700 BCE) is calculated based on the location of sixty proto-states enclosed by trenches and sixty-seven proto-states enclosed by walls. See Xu (2018).

by whether they could be reached from *Erlitou* within two weeks of travel). We then constructed the following typology for the analysis: early/close, early/distant, late/close, and late/distant.[64] Reported in Figure 12(a), the hazard ratio shows that the Sinitic states had a tendency to annex the early adopters (purple circle and green square) at the earlier stage of state-building. Stated differently, early adopters closer to *Erlitou* (purple circles) were more likely to be absorbed by the Sinitic states at the earlier stage. At later stages (c.618 CE), the hazard ratio shows that the core state was more successful in incorporating the late adopters located close to it (blue diamonds) than the early adopters located farther away (green squares), probably because over time the early/distant cells (the green squares) had already developed states with sufficient military capacity to resist China's annexation. Importantly, cells located close to *Erlitou* that adopted agriculture earlier not only became a part of Sinitic states earlier but remained highly Sinicized throughout the last two millennia (Figure 12(b)). Although the expansions of "China"-ruled territory took place in bursts interrupted by periods of contraction, each period of growth continued to orient around essentially the same heartland predominated by groups of close/early cells.



(a) Probability of the First Conquest by China

(b) Persistence of China

Figure 12: Incorporation into and Persistence of China

Based on the above findings we turn to examine the effect of the interaction between the timing of the adoption of agriculture and distance from *Erlitou* on stickiness to China.[65] We hypothesize that, while the effect of early agricultural adoption on stickiness to China is significant and positive, being located at places less easily accessible from *Erlitou* is expected to reverse this effect. The interaction term should be negative and significant ($\beta_1 < 0$), reflecting the beneficial effect of the early adoption

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[64] The division points put roughly equal numbers of cells in each category. The cut-off for early adoption is 3,000 BP, equivalent to 1,050 BCE.

[65] In Appendix D.1 we examine the determinants of the Chinese state's long-run presence in a territory without taking into account this interaction, which is central to our hypothesis. First, we study the correlates of ever becoming part of China (the extensive margin). Then, we analyze the determinants of the level of stickiness, conditional upon (ever) being a part of territorial China in the first place (the intensive margin). The results support the independent roles distance from *Erlitou* and years since the adoption of agriculture played. Furthermore, isolation from the rest of Afro-Eurasia increased stickiness to China, as it prevented invasions by emerging states from the West Asian, Mediterranean and European, and South Asian core areas.

of agriculture on autochthonous state-building and eventual autonomy for those in locations not easily accessible from *Erlitou*. We estimate the following equation using a spatial error model[66]

$$Y_i = \beta_0 + \beta_1 YSA_i \times Distance\ Erlitou_i + \beta_2 YSA_i + \beta_3 Distance\ Erlitou_i + \beta_k' C_i' + \varepsilon_i, \qquad (7)$$

where Y_i is the inverse hyperbolic sine transformation of the (hybrid) stickiness to China for cell i over the 221 BCE to 1,911 CE period. YSA_i denotes years since cell i adopted of agriculture, $Distance\ Erlitou_i$ is HMI distance from *Erlitou* (reflecting how isolated a cell is from *Erlitou*). C_i' is the set of characteristics of cell i, which includes a set of fixed effects to account for heterogeneity across geological plates, unobserved heterogeneity across regions ever claimed by China, basic geo-climatic controls,[67], a set of additional controls such as its isolation from the rest of the Eurasian land mass, its HMI distance to major rivers in eastern Asia, whether it is located in millet/rice hotspots, and its caloric suitability from cultivating millet/rice. We estimate this equation for each of the three measures of stickiness to China – territorial, cadastral, and hybrid, respectively.

Table 2 presents our regression results based on our hybrid stickiness to China measure.[68] Column (1) shows estimates of the interaction between YSA and distance from *Erlitou*, and confirms the significance of the predicted negative coefficient. This result implies that, conditional on their distance from *Erlitou*, cells that adopted agriculture earlier were less likely to be absorbed by China. Similarly, holding YSA constant, cells that were closer to *Erlitou* were more likely to be incorporated into China. Together, these results suggest that the "race" between the growth of local state-building projects that started with the adoption of the agricultural way of life, on the one hand, and the expansion of the power-projection capabilities of the successors to the earliest states, on the other, determined the broad patterns of the expansion of a mega-state in eastern Asia during the last 2,200 years.

The results of section 4 suggest that there is no reverse causality in this estimation since both the emergence of *Erlitou* and the adoption of agriculture preceded the emergence of the Chinese state. In addition, we controlled for a large set of geographical characteristics, including the determinants of the location of *Erlitou*, agricultural productivity, and the diffusion of technology, people, and states from other regions. While we cannot completely rule out omitted variable bias, the estimated coefficient in column (1) is 50 percent larger in absolute value than in a similar regression that only includes the interaction and main effects of the distance to *Erlitou* and YSA, as well as agricultural suitability, and identifiers for hotspots. Importantly, the additional controls add 30 percent to the overall explanatory power of the model. Using statistics on the selection on observables and unobservables (Altonji et al., 2005; Oster, 2019), we find that the degree of omitted variable bias is low and is unlikely to explain the magnitude of the estimated interaction term. In particular, the omitted factors have to be 2-3 times more strongly and negatively correlated with the interaction term than the included controls to account

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[66] We use a spatial error model with a cut-off of 500km to correct for spatial correlation. Our results are robust to using other cutoffs (250km, 750km, and 1,000km) as well as using OLS with corrections for spatial autocorrelation following Colella et al. (2019).

[67] YSA_i is measured as years before 1950 as is standard in archaeobotany. Refer to footnote 60 for details of C_i'.

[68] Tables D.2 and D.3 show the results for our cadastral and territorial measures. Our main analysis captures both the extensive and intensive margins. Tables D.5-D.7 show the results for the intensive margin, i.e., excluding cells with zero stickiness. Given the large number of zeros and the wide range in our stickiness data, we perform an inverse hyperbolic sine transformation, which, while similar to a log-transformation, does not introduce biases in its handling of zeros.

Table 2: Heterogeneous Effects of Distance and Agricultural Adoption on Hybrid China

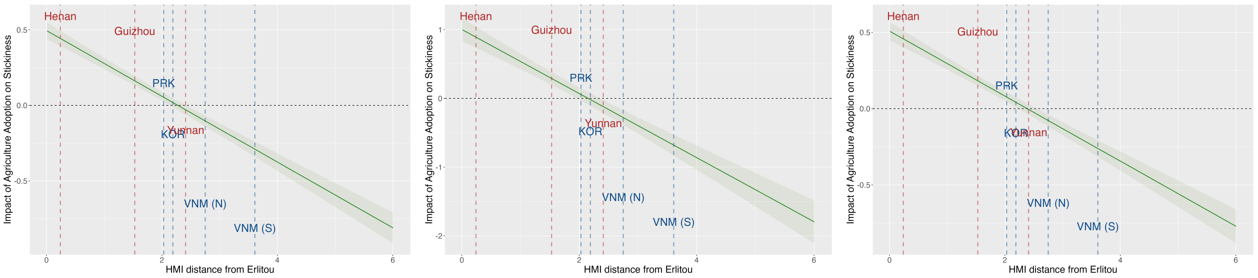
	Stickiness to China (Hybrid)				
	(1)	(2)	(3)	(4)	(5)
Distance from Erlitou × Agricultural Adoption (YSA)	-0.26***				
	(0.02)				
Distance from Proto-states Centroid × Agricultural Adoption (YSA)		-0.26***			
		(0.02)			
Distance from Domestication Centroid × Agricultural Adoption (YSA)			-0.26***		
			(0.02)		
Distance from Erlitou × Millet Hotspot				-0.53***	
				(0.06)	
Distance from Erlitou × Rice Hotspot				-0.43***	
				(0.04)	
Distance from Erlitou × Millet CSI					-0.20***
					(0.02)
Distance from Erlitou × Rice CSI					-0.22***
					(0.02)
Agricultural Adoption and Distance Main-Effects	Yes	Yes	Yes	Yes	Yes
Plate Fixed-Effects	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes
Advanced Controls	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.96	0.96	0.96	0.96	0.97
Observations	2779	2779	2779	2779	2779

Notes: The dependent variable is the inverse sine transformation of stickiness to China. All variables except hotspot indicators are standardized to have mean 0 and standard deviation 1. Main controls include longitude, latitude, land size, elevation, temperature, precipitation, ruggedness, and distance to coast. Advanced controls include isolation (from the rest of continent), HMI distance to major rivers in eastern Asia, whether located in millet/rice hotspots, and caloric suitability for millet/rice (CSI). All columns additionally account for any time-invariant unobserved heterogeneity in regions that were never claimed by a Chinese state using a dummy. Spatially autocorrelated disturbances considered within 500kms. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

for the estimated effect. Moreover, following Oster (2019), we estimated the bias-corrected effect, which provides the estimated effect under the assumption that the unobservables are as strongly correlated with the interaction term as the included controls. This bias-corrected point estimate is negative and a third larger in absolute value, suggesting that the main results are not significantly biased due to omitted variables.

Figures 13(a)-(c) show the marginal effect of YSA on the three stickiness measures based on the specification in Column (1) of Table 2. Consistent with our hypothesis, for cells located close to *Erlitou*, earlier adoption of agriculture increased stickiness to China. But for cells located farther away, the impact of YSA on stickiness becomes negative. Specifically, for cells located closer to *Erlitou* by one standard deviation (compared to the average location), a one standard deviation increase in YSA increases stickiness by 0.26 standard deviations. The opposite outcome occurs for cells located farther away from *Erlitou*. Similarly, Figures D.4(a)-(c) show the marginal effect of the distance from

Erlitou.[69] As expected, given the prevailing technological (transport) constraints, the marginal effect of distance is invariably negative. Moreover, the earlier adoption of agriculture deepens the negative effect of distance even further, because earlier adoption allowed them to start their own state-building projects earlier and thus become militarily stronger. In context, the positive impact of early adoption of agriculture on stickiness turns negative at *precisely* the distances that other eastern Asian states - Korea, Vietnam, Myanmar, Japan, Cambodia, Laos, and Thailand - emerged. This result helps to elucidate the emergence of agrarian societies outside China's core, which started their own state-building projects well after the initial expansion of states around *Erlitou* and persisted into modern times as neighbors rather than provinces of China.



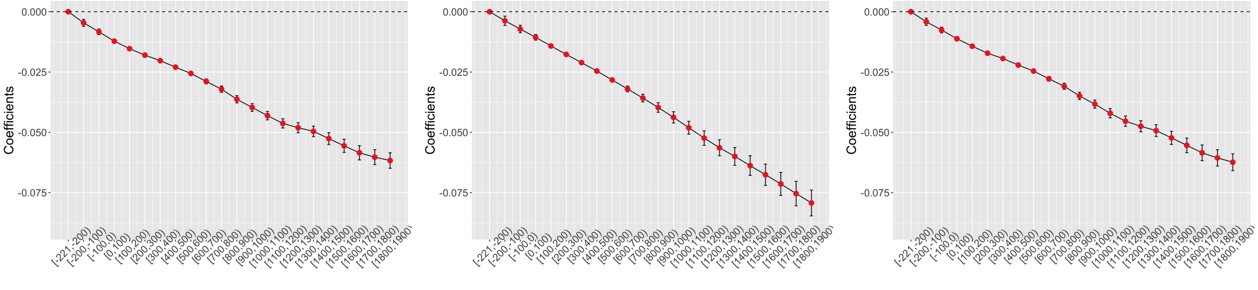
(a) Territorial (b) Cadastral (c) Hybrid

Figure 13: Heterogeneous Effects of YSA

To further confirm this result, we examine the evolution of stickiness to China every century between 221 BCE-1,911 CE, by estimating the following equation

$$Y_{it} = \beta_1 YSA_i \cdot t + \beta_2 Distance\ Erlitou_i \cdot t + \beta_3 YSA_i \cdot Distance\ Erlitou_i \cdot t + \gamma_t + \gamma_i + \varepsilon_{it}, \tag{8}$$

where γ_i and γ_t are cell and period fixed effects. Figure 14 presents the coefficients of the interaction terms $\beta_3 \cdot t$ and shows that this coefficient is negative in all periods. The results are consistent with the significantly negative effect of the interaction term in the cross-sectional analysis. Moreover, this interaction becomes increasingly negative over time reflecting the cumulative effect of these forces.



(a) Territorial (b) Cadastral (c) Hybrid

Figure 14: Heterogeneous Effects of YSA and Distance on Stickiness (every 100 Years)

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[69] Figure D.5 and Figure D.6 establishes that qualitatively similar results hold for all three measures when focusing on the intensive margin only.

While these results support our hypothesis consistently, a concern is that the distance from *Erlitou* is probably endogenous. To alleviate this concern, we replace distance from *Erlitou* with more exogenous proxies for the location of the first state – namely, the distance from the centroid of a cluster of proto-states and of the earliest millet and rice domestication centers, respectively. Columns (2) and (3) in Table 2 present the results of these analyses and find identical significant and negative effects. This result is inline with our analysis in section 4, which established that the location of *Erlitou* was determined by the regions within millet hotspots that adopted agriculture earliest. Another concern is that the results may be confounded by unobserved factors that affect the incentive to adopt agriculture; examples include the cultural similarity between populations, seasonality, and climate shocks (Ashraf and Galor, 2013; Matranga, 2021; Bai, 2022). To alleviate this concern, we replace YSA by its more exogenous determinants, namely millet and rice hotspots and caloric suitability measures, or agricultural potency in short, and interact the distance from *Erlitou* with these alternative measures. Column (4) of Table 2 reports the result of interacting distance from *Erlitou* with a dummy indicator of whether a cell was in a millet or rice hotspot, and shows similarly significant and negative effects on stickiness. In addition, we find the same negative significant result in column (5), in which we interact distance from *Erlitou* with the caloric suitability (CSI) for millet and rice, respectively.[70] These results are in line with our proposed hypothesis, especially given the strong correlations across cells between CSI or hotspot presence, on the one hand, and YSA, on the other, making the former reasonably exogenous representations of the latter.[71] On the whole, these results provide strong empirical support for our theory that early agricultural adoption and distance from *Erlitou* are the two key determinants of Sinitic state expansion and its limits. In particular, Sinitic states were not able to incorporate and exercise persistent control over regions where agriculture was adopted earlier and whose locations were sufficiently far away from them – specifically necessitating more than 2 weeks of HMI distance of travel from *Erlitou*. Put differently, places to which the East Asian agricultural package had diffused earlier, located further from its points of origin in the heart of today's China, escaped incorporation into the mega-state centered at the old agrarian core.

6 Conclusion

The reasons behind a large, unified China and a fragmented Europe have long been a subject of intense debate. In this paper, we address the specific question of why China emerged and persisted in eastern Asia as a large core state and why some polities, which once existed independently in history, ended up as a part of this enormous empire while others became separate modern states. To do so, we begin by providing a context for understanding how the isolated geography and fertility of eastern Asia, the birthplace of a prodigious agrarian package, gave rise to an independent trajectory

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[70] Figures D.9(a)-(c) show the marginal effect of hotspots on stickiness for full sample, and Figures D.9(d)-(f) show the marginal effect when focusing on the intensive margin only.

[71] In other words, although hotspot and CSI information are potentially orthogonal to the time of arrival of agriculture, in practice, they are highly correlated in our region. Indeed, the coincidence of concentrations of highly suitable soils with locus of first domestications plays a large part in explaining why state building remained centered close to the original domestication points for so long. In particular, Table C.1 demonstrates that millet and rice hotspots, and millet and rice CSI, are independently strong predictors of YSA (significant at the 1% level).

of agricultural civilization there. These circumstances led to the emergence of complex societies and the first state at *Erlitou*, in the core of what later became the heartland of China based on the Qin Empire. It is in this context that we proposed and empirically tested a theory of endogenous formation and persistence of large states. Our hypothesis centers around the relative timing of the diffusion of agriculture across regions in eastern Asia and their distance to each other as key determinants of the competition between *Erlitou*, the earliest state that became China, and neighboring autochthonous state-building projects in the rest of eastern Asia. In this process, millet and later rice played a decisive role as they provided the potency required of an agrarian civilization, from which hierarchical, complex societies emerged, leading to the formation of states. In doing so, we confirmed that the center of state-building remained effectively coterminous with the location of the earliest agrarian societies within the eastern Asian region. This contrasts with western Eurasia, where the centers of state-building shifted across vast distances between the first states, the classical era, and modern times (Olsson and Paik, 2020).

Our approach towards accounting for the China-Europe divergence is unique as we do not rely on regional geography as the sole explanatory variable. Instead, we argue that eastern Asia was different from the West because of its relative isolation – a condition that permitted its independent indigenous agrarian revolution, evolving social complexity, and state formation process to play out until recent centuries in near isolation from the clashes of civilizations to its west. Moreover, eastern Asia's slightly later agricultural revolution and state-building process also help to account for the agrarian civilizational offspring on the core state's peripheries being too immature to contest it until well into the modern era. Though not testing each of these propositions directly, we show strong evidence that i) the region's largest state emerged in the same zone where its independent agricultural package had, ii) indigenous cereal crops can account for the region's early state formation, iii) this zone remained the center of its largest state-building project until the 20th century, iv) the diffusion of China's agricultural package to culturally diverse and geographically distant areas preceded large-scale state-building at the core, and v) whether territories beyond China's relatively small early core entered the present age as provinces of the original core state or as independent nations is substantially explained by the interaction between the earliness of their adoption of agriculture and their proximity to the core. This particular finding supports our conception of a "race" between the social evolution set off by agricultural diffusion, giving rise to states autochthonously, and the diffusion of the initial large state-building project through the gradual projection of power from the original regional center. While not unlimited, that projection of power and repeated reconstitution from the same core area help to explain the persistence and continuity of the world's most populous and most politically and linguistically unified country to the present day.

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